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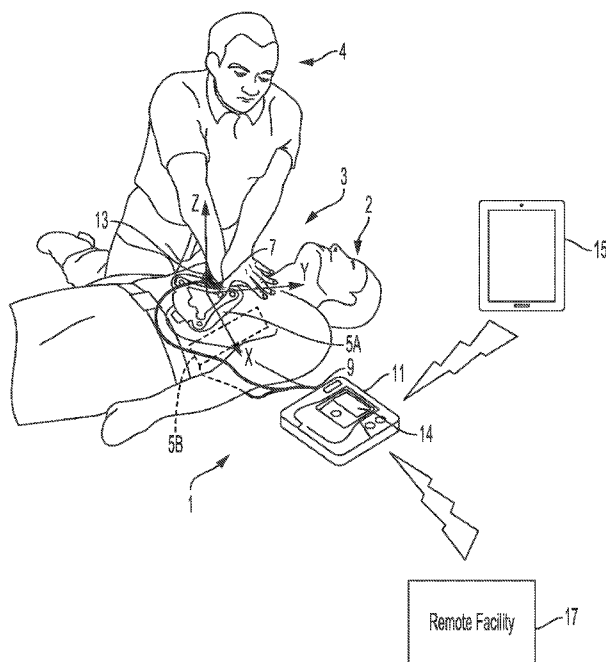


FIG. 1

(57) Abstract: A medical system for assisting a user in providing resuscitation care for a patient includes: a first motion sensor; a second motion sensor; an output device; and at least one processor. The at least one processor is configured to: receive and process signals from the first and second motion sensors to measure motion of the first and second motion sensors, determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range, determine whether the second motion sensor is positioned at a second orientation having an angle that falls within a second acceptable orientation range, and in response to a determination that the angle of the first orientation falls within the first acceptable orientation range and the angle of the second orientation falls within the second acceptable orientation range, cause the output device to provide chest compression feedback for the user based on the motion of the first and second motion sensors.

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MEDICAL SYSTEM FOR DETERMINING PLACEMENT OF A RESUSCITATION ASSEMBLY AND PROVIDING APPROPRIATE CHEST COMPRESSION FEEDBACK

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Patent Application No. 63/487,114 filed February 27, 2023, and entitled “Medical System for Determining Placement of a Resuscitation Assembly and Providing Appropriate Chest Compression Feedback”, the disclosure of which is hereby incorporated by reference in its entirety.

BACKGROUND

Field

[0002] The present disclosure is related to cardiac resuscitation and, more specifically, to systems and techniques for assisting rescuers in performing cardio-pulmonary resuscitation.

Description of Related Art

[0003] Defibrillators are commonly used to treat Sudden Cardiac Arrest by applying a defibrillating shock to the heart of a cardiac arrest patient via electrodes placed on the chest of the patient. The ECG signal of a cardiac arrest patient, properly measured and analyzed, provides a strong indication of whether the patient’s heart is exhibiting a shockable rhythm or a non-shockable rhythm. A shockable rhythm refers to an aberrant ECG signal where a defibrillation shock is advised for restoration of a normal heartbeat, while a non-shockable rhythm refers to an ECG signal where a defibrillation shock is not advised. Ventricular fibrillation, for example, is a shockable rhythm, while pulseless electrical activity is an example of a non-shockable rhythm. Defibrillators are also capable of treating other dysrhythmias (irregular heartbeats), such as atrial fibrillation, bradycardia, and tachycardia. An ECG signal may be obtained through electrodes placed on the chest of the patient, and the defibrillating or cardioverting shock may be applied through the same electrodes.

[0004] During resuscitation, treatment protocols recommended by the American Heart Association and European Resuscitation Council advise for the rescuer to regularly check the patient's pulse or to evaluate the patient for signs of circulation. If no pulse or signs of circulation are present, the rescuer may be often instructed to perform CPR on the victim for an appropriate period of time between shock analyses, where CPR involves applying both chest compressions and ventilations to the victim. Chest compressions and/or ventilations may be monitored during the course of CPR, for example, through systems and technologies that incorporate real-time CPR feedback (e.g., REAL CPR HELP® marketed by ZOLL®).

Medical Corporation) and which may implement resuscitation assemblies (e.g., CPR-D-PADZ[®], CPR STAT-PADZ[®] marketed by ZOLL[®] Medical Corporation) having a sensor for obtaining CPR related information for manual CPR providers. For example, ZOLL's CPR-D-PADZ[®] and CPR STAT-PADZ[®] include a pair of electrode pads and a chest compression sensor.

SUMMARY

[0005] The system and methods disclosed in the present disclosure advantageously improves chest compression feedback by determining the placement of the resuscitation assembly on the patient prior to providing chest compression feedback in order to provide the most accurate chest compression feedback as possible to the rescuer.

[0006] According to one aspect of the present disclosure, a medical system for assisting a user in providing resuscitation care for a patient includes: a first motion sensor; a second motion sensor; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device. The at least one processor is configured to: receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the second motion sensor, determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range, determine whether the second motion sensor is positioned at a second orientation having an angle that falls within a second acceptable orientation range, in response to a determination that the angle of the first orientation falls within the first acceptable orientation range and the angle of the second orientation falls within the second acceptable orientation range, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor, and in response to a determination that either the angle of the first orientation falls outside of the first acceptable orientation range or the angle of the second orientation falls outside of the second acceptable orientation range, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

[0007] According to another aspect of the present disclosure, a medical system for assisting a user in providing resuscitation care for a patient includes: a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy; a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy; an output

device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device. The at least one processor is configured to: receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and the motion of the second motion sensor, determine whether oscillatory motion of the second motion sensor is greater than a threshold sufficient to initiate anterior-posterior chest compression feedback, and cause the output device to provide the anterior-posterior chest compression feedback based on the motion of the first motion sensor and the motion of the second motion sensor based at least in part on the determination that the oscillatory motion of the second motion sensor is greater than the threshold sufficient to initiate the anterior-posterior chest compression feedback.

[0008] According to another aspect of the present disclosure, a medical system for assisting a user in providing resuscitation care for a patient includes: a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy; a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device. The at least one processor is configured to: receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the second motion sensor; determine whether the motion in a first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor; determine whether the motion in the first direction of the first motion sensor is greater than the motion in a second direction and a third direction of the first motion sensor; and cause the output device to provide anterior-posterior chest compression feedback based on the motion of the first motion sensor and the motion of the second motion sensor based at least in part on the determination that the motion in the first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor and further based at least in part on the determination that the motion in the first direction of the first motion sensor is greater than the motion in the second direction and the third direction of the first motion sensor. The motion in the second direction and the third direction is different than the motion in the first direction.

[0009] According to another aspect of the present disclosure, a medical system for assisting a user in providing resuscitation care for a patient includes: a first motion sensor; a second motion sensor; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device. The at least one processor is configured to: identify a resuscitation mode of the system as one of a pediatric or

adult resuscitation mode, receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the second motion sensor, determine whether the first motion sensor and the second motion sensor are correctly positioned to provide anterior-posterior chest compression feedback, cause the output device to provide the anterior-posterior chest compression feedback based on the determination that the first motion sensor and the second motion sensor are correctly positioned to provide the anterior-posterior chest compression feedback, when the resuscitation mode is identified as adult, cause the output device to provide anterior-anterior chest compression feedback based on a determination that at least one of the first motion sensor or the second motion sensor are incorrectly positioned, and when the resuscitation mode is identified as pediatric, cause the output device to provide the anterior-posterior chest compression feedback based on a determination that the first motion sensor and the second motion are correctly positioned following an initial determination that the first motion sensor and the second motion are incorrectly positioned.

[0010] According to another aspect of the present disclosure, a medical system for assisting a user in providing resuscitation care for a patient includes: a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy; a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device. The at least one processor is configured to: receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the second motion sensor, determine whether chest compressions have been initiated based on the motion from at least one of the first motion sensor or the second motion sensor, determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range in response to a determination the chest compressions have been initiated, determine whether oscillatory motion of the second motion sensor is greater than a threshold sufficient to initiate anterior-posterior chest compression feedback in response to a determination that the angle of the first orientation falls within the first acceptable orientation range, and cause the output device to provide the anterior-posterior chest compression feedback based on the motion of the first motion sensor and the motion of the second motion sensor based at least in part on the determination that the oscillatory motion of the second motion sensor is greater than the threshold sufficient to initiate the anterior-posterior chest compression feedback.

[0011] According to another aspect of the present disclosure, a medical system for assisting a user in providing resuscitation care for a patient includes: a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy; a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device. The at least one processor is configured to: receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and the motion of the second motion sensor, determine an orientation of the first motion sensor to ensure that the first motion sensor is positioned on the anterior portion of the patient's anatomy within substantially 30 degrees to 60 degrees with respect to gravity, determine an orientation of the second motion sensor to ensure that the second motion sensor is positioned on the posterior portion of the patient's anatomy with substantially 15 degrees to 45 degrees with respect to the first motion sensor, cause the output device to provide chest compression feedback for the user based on the motion from the first motion sensor and the second motion sensor in response to a determination that the first motion sensor is positioned on the anterior portion of the patient's anatomy within substantially 30 degrees to 60 degrees with respect to gravity and a determination that the second motion sensor is positioned on the posterior portion of the patient's anatomy with substantially 15 degrees to 45 degrees with respect to the first motion sensor.

[0012] Various aspects of the dual sensor implementations for providing resuscitative chest compression feedback are disclosed in one or more of the following numbered clauses:

[0013] Clause 1: A medical system for assisting a user in providing resuscitation care for a patient, comprising: a first motion sensor; a second motion sensor; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to: receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the second motion sensor, determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range, determine whether the second motion sensor is positioned at a second orientation having an angle that falls within a second acceptable orientation range, in response to a determination that the angle of the first orientation falls within the first acceptable orientation range and the angle of the second orientation falls within the second acceptable orientation range, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second

motion sensor, and in response to a determination that either the angle of the first orientation falls outside of the first acceptable orientation range or the angle of the second orientation falls outside of the second acceptable orientation range, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

[0014] Clause 2: The medical system of clause 1, wherein the first motion sensor is positioned in a non-inverted orientation if the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range and the second motion sensor is positioned at a non-inverted orientation if the second motion sensor is positioned at a second orientation having an angle that falls within the second acceptable orientation range.

[0015] Clause 3: The medical system of clause 1 or clause 2, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 60 degrees.

[0016] Clause 4: The medical system of any of clauses 1-3, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 45 degrees.

[0017] Clause 5: The medical system of any of clauses 1-4, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 30 degrees.

[0018] Clause 6: The medical system of any of clauses 1-5, wherein the first motion sensor is positioned in an inverted orientation if the first motion sensor is positioned at a first orientation having an angle that falls outside of the first acceptable orientation range and the second motion sensor is positioned at an inverted orientation if the second motion sensor is positioned at a second orientation having an angle that falls outside of the second acceptable orientation range.

[0019] Clause 7: The medical system of any of clauses 1-6, wherein, in response to a determination that either the angle of the first orientation falls outside of the first acceptable orientation range or the angle of the second orientation falls outside of the second acceptable orientation range, causing the output device to provide a prompt to the user to check a placement of the first motion sensor and the second motion sensor.

[0020] Clause 8: The medical system of any of clauses 1-7, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

[0021] Clause 9: The medical system of any of clauses 1-8, wherein the signals from the first motion sensor and the second motion sensor comprise a first component and a second component.

[0022] Clause 10: The medical system of clause 9, wherein the first component of the signals corresponds to a positional motion of the first motion sensor and the second motion sensor and the second component of the signal corresponds to an oscillatory motion of the first motion sensor and the second motion sensor.

[0023] Clause 11: The medical system of clause 9 or clause 10, wherein the first component of the signals is used to determine whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range and the second motion sensor is positioned at a second orientation having an angle that falls within the second acceptable orientation range.

[0024] Clause 12: The medical system of any of clauses 9-11, wherein the at least one processor is further configured to: determine whether the oscillatory motion of the second motion sensor is greater than a threshold sufficient to initiate chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

[0025] Clause 13: The medical system of any of clauses 1-12, wherein the at least one processor is further configured to: invert the signal received from the first motion sensor in response to a determination that the angle of the first orientation falls outside of the first acceptable orientation range, and cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

[0026] Clause 14: The medical system of clause 13, wherein the chest compression feedback comprises guidance for prompting a user to check or adjust the angle of the first orientation to fall within the first acceptable orientation range.

[0027] Clause 15: The medical system of any of clauses 1-14, wherein the at least one processor is further configured to: determine whether the motion in a first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor, and determine whether the motion in the first direction of the first motion sensor is greater than the motion in a second direction and a third direction of the first motion sensor, the motion in the second direction and the third direction being different than the motion in the first direction.

[0028] Clause 16: The medical system of clause 15, wherein the at least one processor is further configured to: in response to a determination that the motion in the first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor and the motion in the first direction of the first motion sensor is greater than the

motion in the second direction and the third direction of the first motion sensor, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor, and in response to a determination that either the motion in the first direction of the first motion sensor is less than the motion in the first direction of the second motion sensor or the motion in the first direction of the first motion sensor is less than the motion in the second direction and the third direction of the first motion sensor, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

[0029] Clause 17: The medical system of any of clauses 1-16, wherein the at least one processor is further configured to: determine an angle of the second motion sensor with respect to gravity, compare the angle of the second motion sensor with a threshold angle, and in response to a determination that the angle of the second motion sensor is less than a threshold angle, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

[0030] Clause 18: The medical system of any of clauses 1-17, wherein the at least one processor is further configured to: receive a signal representative of electrical impedance in a chest of the patient; determine whether the signal is greater than a threshold value; and in response to a determination that the signal is greater than the threshold value, determining whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range and determining whether the second motion sensor is positioned at a second orientation having an angle that falls within the second acceptable orientation range.

[0031] Clause 19: The medical system of any of clauses 1-18, wherein the at least one processor is further configured to: process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

[0032] Clause 20: The medical system of clause 19, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

[0033] Clause 21: The medical system of clause 19 or clause 20, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

[0034] Clause 22: The medical system of any of clauses 19-21, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

[0035] Clause 23: The medical system of any of clauses 19-22, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

[0036] Clause 24: The medical system of any of clauses 1-23, further comprising: a first electrode assembly configured to provide electrotherapy for the patient, and a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly, wherein the first motion sensor is provided with the first electrode assembly, and the second motion sensor is provided with the second electrode assembly.

[0037] Clause 25: The medical system of clause 24, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

[0038] Clause 26: The medical system of clause 24 or clause 25, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

[0039] Clause 27: The medical system of any of clauses 24-26, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

[0040] Clause 28: The medical system of any of clauses 1-27, wherein the at least one processor and the output device are provided in an external defibrillator.

[0041] Clause 29: A medical system for assisting a user in providing resuscitation care for a patient, comprising: a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy; a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to: receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and the motion of the second motion sensor, determine whether oscillatory motion of the second motion sensor is greater than a threshold sufficient to initiate anterior-posterior chest compression feedback, and cause the output device to provide the anterior-posterior chest compression feedback

based on the motion of the first motion sensor and the motion of the second motion sensor based at least in part on the determination that the oscillatory motion of the second motion sensor is greater than the threshold sufficient to initiate the anterior-posterior chest compression feedback.

[0042] Clause 30: The medical system of clause 29, wherein the oscillatory motion signals are representative of movement of the second motion sensor over a given time period.

[0043] Clause 31: The medical system of clause 29 or clause 30, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

[0044] Clause 32: The medical system of any of clauses 29-31, wherein the at least one processor is further configured to: determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range, determine whether the second motion sensor is positioned at a second orientation having an angle that falls within a second acceptable orientation range, and in response to a determination that the angle of the first orientation falls within the first acceptable orientation range and the angle of the second orientation falls within the second acceptable orientation range, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

[0045] Clause 33: The medical system of clause 32, wherein the at least one processor is further configured to: in response to a determination that either the angle of the first orientation falls outside of the first acceptable orientation range or the angle of the second orientation falls outside of the second acceptable orientation range, cause the output device to provide anterior-anterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

[0046] Clause 34: The medical system of clause 32 or clause 33, wherein the at least one processor is further configured to: receive a signal representative of electrical impedance in a chest of the patient; determine whether the signal is greater than a threshold value; and in response to a determination that the signal is greater than the threshold value, determining whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range and the second motion sensor is positioned at a second orientation having an angle that falls within the second acceptable orientation range.

[0047] Clause 35: The medical system of any of clauses 29-24, wherein the at least one processor is further configured to: determine whether the motion in a first direction of the first motion sensor is greater than the motion in the first direction of the second motion

sensor, and determine whether the motion in the first direction of the first motion sensor is greater than the motion in a second direction and a third direction of the first motion sensor, the motion in the second direction and the third direction being different than the motion in the first direction.

[0048] Clause 36: The medical system of clause 35, wherein the at least one processor is further configured to: in response to a determination that the motion in the first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor and the motion in the first direction of the first motion sensor is greater than the motion in the second direction and the third direction of the first motion sensor, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor, and in response to a determination that either the motion in the first direction of the first motion sensor is less than the motion in the first direction of the second motion sensor or the motion in the first direction of the first motion sensor is less than the motion in the second direction and the third direction of the first motion sensor, cause the output device to provide anterior-anterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

[0049] Clause 37: The medical system of any of clauses 29-36, wherein the at least one processor is further configured to: determine an angle of the second motion sensor with respect to gravity, compare the angle of the second motion sensor with a threshold angle, and in response to a determination that the angle of the second motion sensor is less than a threshold angle, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

[0050] Clause 38: The medical system of any of clauses 29-37, wherein the at least one processor is further configured to: process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

[0051] Clause 39: The medical system of clause 38, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

[0052] Clause 40: The medical system of clause 38 or clause 39, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

[0053] Clause 41: The medical system of any of clauses 38-40, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

[0054] Clause 42: The medical system of any of clauses 38-41, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

[0055] Clause 43: The medical system of any of clauses 29-42, further comprising: a first electrode assembly configured to provide electrotherapy for the patient, and a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly, wherein the first motion sensor is provided with the first electrode assembly, and the second motion sensor is provided with the second electrode assembly.

[0056] Clause 44: The medical system of clause 43, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

[0057] Clause 45: The medical system of clause 43 or clause 44, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

[0058] Clause 46: The medical system of any of clauses 43-45, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

[0059] Clause 47: The medical system of any of clauses 29-46, wherein the at least one processor and the output device are provided in an external defibrillator.

[0060] Clause 48: A medical system for assisting a user in providing resuscitation care for a patient, comprising: a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy; a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to: receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the

second motion sensor; determine whether the motion in a first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor; determine whether the motion in the first direction of the first motion sensor is greater than the motion in a second direction and a third direction of the first motion sensor, the motion in the second direction and the third direction being different than the motion in the first direction; cause the output device to provide anterior-posterior chest compression feedback based on the motion of the first motion sensor and the motion of the second motion sensor based at least in part on the determination that the motion in the first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor and further based at least in part on the determination that the motion in the first direction of the first motion sensor is greater than the motion in the second direction and the third direction of the first motion sensor.

[0061] Clause 49: The medical system of clause 48, wherein the at least one processor is further configured to: cause the output device to provide anterior-anterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor in response to a determination that either the motion in the first direction of the first motion sensor is less than the motion in the first direction of the second motion sensor or the motion in the first direction of the first motion sensor is less than the motion in the second direction and the third direction of the first motion sensor.

[0062] Clause 50: The medical system of clause 48 or clause 49, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

[0063] Clause 51: The medical system of any of clauses 48-50, wherein the at least one processor is further configured to: determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range, determine whether the second motion sensor is positioned at a second orientation having an angle that falls within a second acceptable orientation range, and in response to a determination that the angle of the first orientation falls within the first acceptable orientation range and the angle of the second orientation falls within the second acceptable orientation range, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

[0064] Clause 52: The medical system of clause 51, wherein the at least one processor is further configured to: in response to a determination that either the angle of the first

orientation falls outside of the first acceptable orientation range or the angle of the second orientation falls outside of the second acceptable orientation range, cause the output device to provide anterior-anterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

[0065] Clause 53: The medical system of clause 51 or clause 52, wherein the at least one processor is further configured to: receive a signal representative of electrical impedance in a chest of the patient; determine whether the signal is greater than a threshold value; and in response to a determination that the signal is greater than threshold value, determining whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range and the second motion sensor is positioned at a second orientation having an angle that falls within the second acceptable orientation range.

[0066] Clause 54: The medical system of any of clauses 48-53, wherein the at least one processor is further configured to: determine an angle of the second motion sensor with respect to gravity, compare the angle of the second motion sensor with a threshold angle, and in response to a determination that the angle of the second motion sensor is less than a threshold angle, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

[0067] Clause 55: The medical system of any of clauses 48-54, wherein the first direction corresponds to a height of the patient when lying in a supine position, the second direction corresponds to a width of the patient when lying in the supine position, and the third direction corresponds to a length of the patient when lying in the supine position.

[0068] Clause 56: The medical system of any of clauses 48-55, wherein the first direction, the second direction, and the third direction are orthogonal to each other.

[0069] Clause 57: The medical system of any of clauses 48-56, wherein the at least one processor is further configured to: process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

[0070] Clause 58: The medical system of clause 57, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

[0071] Clause 59: The medical system of clause 57 or clause 58, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

[0072] Clause 60: The medical system of any of clauses 57-59, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

[0073] Clause 61: The medical system of any of clauses 57-60, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

[0074] Clause 62: The medical system of any of clauses 48-61, further comprising: a first electrode assembly configured to provide electrotherapy for the patient, and a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly, wherein the first motion sensor is provided with the first electrode assembly, and the second motion sensor is provided with the second electrode assembly.

[0075] Clause 63: The medical system of clause 62, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

[0076] Clause 64: The medical system of clause 62 or clause 63, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

[0077] Clause 65: The medical system of any of clauses 62-64, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

[0078] Clause 66: The medical system of any of clauses 48-65, wherein the at least one processor and the output device are provided in an external defibrillator.

[0079] Clause 67: A medical system for assisting a user in providing resuscitation care for a patient, comprising: a first motion sensor; a second motion sensor; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to: identify a resuscitation mode of the system as one of a pediatric or adult resuscitation mode, receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the second motion sensor, determine whether the first

motion sensor and the second motion sensor are correctly positioned to provide anterior-posterior chest compression feedback, cause the output device to provide the anterior-posterior chest compression feedback based on the determination that the first motion sensor and the second motion sensor are correctly positioned to provide the anterior-posterior chest compression feedback, when the resuscitation mode is identified as adult, cause the output device to provide anterior-anterior chest compression feedback based on a determination that at least one of the first motion sensor or the second motion sensor are incorrectly positioned, and when the resuscitation mode is identified as pediatric, cause the output device to provide the anterior-posterior chest compression feedback based on a determination that the first motion sensor and the second motion are correctly positioned following an initial determination that the first motion sensor and the second motion are incorrectly positioned.

[0080] Clause 68: The medical system of clause 67, wherein the resuscitation mode of the system is determined based on an identification signal produced by an identification component associated with the resuscitation assembly.

[0081] Clause 69: The medical system of clause 68, wherein the identification component comprises at least one of a memory and a resistor from which the identification signal is based.

[0082] Clause 70: The medical system of any of clauses 67-69, wherein the resuscitation mode of the system is determined based on a selection by the user.

[0083] Clause 71: The medical system of any of clauses 67-70, wherein the anterior-posterior chest compression feedback is based from the motion of the first motion sensor and the motion of the second motion sensor.

[0084] Clause 72: The medical system of any of clauses 67-71, wherein the anterior-anterior chest compression feedback is based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

[0085] Clause 73: The medical system of any of clauses 67-72, wherein, when the resuscitation mode is identified as adult, the output device is configured to continue providing the anterior-anterior chest compression feedback based on the determination that at least one of the first motion sensor or the second motion sensor are incorrectly positioned until a signal representative of electrical impedance in a chest of the patient is determined to be greater than a threshold value.

[0086] Clause 74: The medical system of clause 73, wherein the at least one processor is further configured to: when the resuscitation mode is identified as pediatric, cause the output device to provide the anterior-anterior chest compression feedback based on a determination

that the first motion sensor and the second motion are incorrectly positioned, determine whether the first motion sensor and the second motion sensor are correctly positioned to provide anterior-posterior chest compression feedback without determining whether a signal representative of electrical impedance in a chest of the patient is greater than a threshold value, and cause the output device to provide the anterior-posterior chest compression feedback based on a determination that the first motion sensor and the second motion are correctly positioned.

[0087] Clause 75: The medical system of any of clauses 67-74, wherein determining whether the first motion sensor and second motion sensor are correctly positioned comprises at least one of: determining whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range; determining whether the second motion sensor is positioned at a second orientation having an angle that falls within a second acceptable orientation range; determining whether oscillatory motion of the second motion sensor is greater than a threshold; determining whether motion in a first direction of the first motion sensor is greater than motion in the first direction of the second motion sensor; determining whether the motion in the first direction of the first motion sensor is greater than motion in a second direction and a third direction of the first motion sensor; determining an orientation of the first motion sensor to ensure that the first motion sensor is positioned on an anterior portion of the patient's anatomy within substantially 45 degrees with respect to gravity; and determining an orientation of the second motion sensor to ensure that the second motion sensor is positioned on the posterior portion of the patient's anatomy within substantially 30 degrees with respect to gravity.

[0088] Clause 76: The medical system of any of clauses 67-75, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

[0089] Clause 77: The medical system of any of clauses 67-76, wherein the at least one processor is further configured to: process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

[0090] Clause 78: The medical system of clause 77, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

[0091] Clause 79: The medical system of clause 77 or clause 78, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

[0092] Clause 80: The medical system of any of clauses 77-79, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

[0093] Clause 81: The medical system of any of clauses 77-80, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

[0094] Clause 82: The medical system of any of clauses 67-81, further comprising: a first electrode assembly configured to provide electrotherapy for the patient, and a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly, wherein the first motion sensor is provided with the first electrode assembly, and the second motion sensor is provided with the second electrode assembly.

[0095] Clause 83: The medical system of clause 82, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

[0096] Clause 84: The medical system of clause 82 or clause 83, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

[0097] Clause 85: The medical system of any of clauses 82-84, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

[0098] Clause 86: The medical system of any of clauses 67-85, wherein the at least one processor and the output device are provided in an external defibrillator.

[0099] Clause 87. A medical system for assisting a user in providing resuscitation care for a patient, comprising: a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy; a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to: receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the

second motion sensor, determine whether chest compressions have been initiated based on the motion from at least one of the first motion sensor or the second motion sensor, determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range in response to a determination the chest compressions have been initiated, determine whether oscillatory motion of the second motion sensor is greater than a threshold sufficient to initiate anterior-posterior chest compression feedback in response to a determination that the angle of the first orientation falls within the first acceptable orientation range, and cause the output device to provide the anterior-posterior chest compression feedback based on the motion of the first motion sensor and the motion of the second motion sensor based at least in part on the determination that the oscillatory motion of the second motion sensor is greater than the threshold sufficient to initiate the anterior-posterior chest compression feedback.

[00100] Clause 88: The medical system of clause 87, wherein the first motion sensor is positioned in a non-inverted orientation if the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range.

[00101] Clause 89: The medical system of clause 87 or clause 88, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 60 degrees.

[00102] Clause 90: The medical system of any of clause 87-89, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 45 degrees.

[00103] Clause 91: The medical system of any of clauses 87-90, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 30 degrees.

[00104] Clause 92: The medical system of any of clauses 87-91, wherein the first motion sensor is positioned in an inverted orientation if the first motion sensor is positioned at a first orientation having an angle that falls outside of the first acceptable orientation range.

[00105] Clause 93: The medical system of any of clauses 87-92, wherein, in response to a determination that the angle of the first orientation falls outside of the first acceptable orientation range, causing the output device to provide a prompt to the user to check a placement of the first motion sensor.

[00106] Clause 94: The medical system of any of clauses 87-93, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

[00107] Clause 95: The medical system of any of clauses 87-94, wherein the signals from the first motion sensor and the second motion sensor comprise a first component and a second component.

[00108] Clause 96: The medical system of clause 95, wherein the first component of the signals corresponds to a positional motion of the first motion sensor and the second motion sensor and the second component of the signal corresponds to the oscillatory motion of the first motion sensor and the second motion sensor.

[00109] Clause 97: The medical system of clause 96, wherein the first component of the signals is used to determine whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range.

[00110] Clause 98: The medical system of clause 96 or clause 97, wherein the second component of the signal is used to determine whether chest compressions have been initiated.

[00111] Clause 99: The medical system of any of clauses 87-99, wherein the at least one processor is further configured to: determine whether the second motion sensor is at a second orientation having an angle that falls within a second acceptable orientation range, and in response to a determination that the angle of the first orientation falls within the first acceptable orientation range and the angle of the second orientation falls within the second acceptable orientation range, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

[00112] Clause 100: The medical system of clause 99, wherein the at least one processor is further configured to: in response to a determination that either the angle of the first orientation falls outside of the first acceptable orientation range or the angle of the second orientation falls outside of the second acceptable orientation range, cause the output device to provide anterior-anterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

[00113] Clause 101: The medical system of any of clauses 87-100, wherein the at least one processor is further configured to: determine whether the motion in a first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor, and determine whether the motion in the first direction of the first motion sensor is greater than the motion in a second direction and a third direction of the first motion sensor, the motion in the second direction and the third direction being different than the motion in the first direction.

[00114] Clause 102: The medical system of clause 101, wherein the at least one processor is further configured to: in response to a determination that the motion in the first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor and the motion in the first direction of the first motion sensor is greater than the

motion in the second direction and the third direction of the first motion sensor, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor, and in response to a determination that either the motion in the first direction of the first motion sensor is less than the motion in the first direction of the second motion sensor or the motion in the first direction of the first motion sensor is less than the motion in the second direction and the third direction of the first motion sensor, cause the output device to provide anterior-anterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

[00115] Clause 103: The medical system of any of clauses 87-102, wherein the at least one processor is further configured to: determine an angle of the second motion sensor with respect to gravity, compare the angle of the second motion sensor with a threshold angle, and in response to a determination that the angle of the second motion sensor is less than a threshold angle, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

[00116] Clause 104: The medical system of any of clauses 87-103, wherein the at least one processor is further configured to: receive a signal representative of electrical impedance in a chest of the patient; determine whether the signal is greater than a threshold value; and in response to a determination that the signal is greater than threshold value, determining whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range.

[00117] Clause 105: The medical system of any of clauses 87-105, wherein the at least one processor is further configured to: process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

[00118] Clause 106: The medical system of clause 105, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

[00119] Clause 107: The medical system of clause 105 or clause 106, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

[00120] Clause 108: The medical system of any of clauses 105-107, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

[00121] Clause 109: The medical system of any of clauses 105-108, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

[00122] Clause 110: The medical system of any of clauses 87-109, further comprising: a first electrode assembly configured to provide electrotherapy for the patient, and a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly, wherein the first motion sensor is provided with the first electrode assembly, and the second motion sensor is provided with the second electrode assembly.

[00123] Clause 111: The medical system of clause 110, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

[00124] Clause 112: The medical system of clause 110 or clause 111, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

[00125] Clause 113: The medical system of any of clauses 110-112, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

[00126] Clause 114: The medical system of any of clauses 87-113, wherein the at least one processor and the output device are provided in an external defibrillator.

[00127] Clause 115: A medical system for assisting a user in providing resuscitation care for a patient, comprising: a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy; a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to: receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and the motion of the second motion sensor, determine an orientation of the first motion sensor to ensure that the first motion sensor is positioned on the anterior portion of the patient's anatomy within substantially 30 degrees to 60 degrees with respect to gravity, determine an

orientation of the second motion sensor to ensure that the second motion sensor is positioned on the posterior portion of the patient's anatomy with substantially 15 degrees to 45 degrees with respect to the first motion sensor, and cause the output device to provide chest compression feedback for the user based on the motion from the first motion sensor and the second motion sensor in response to a determination that the first motion sensor is positioned on the anterior portion of the patient's anatomy within substantially 30 degrees to 60 degrees with respect to gravity and a determination that the second motion sensor is positioned on the posterior portion of the patient's anatomy with substantially 15 degrees to 45 degrees with respect to the first motion sensor.

[00128] Clause 116: The medical system of clause 115, wherein the at least one processor is further configured to: cause the output device to provide chest compression feedback for the user based on the motion from the first motion sensor without contribution from the motion of the second motion sensor in response to the determination that the first motion sensor is positioned on the anterior portion of the patient's anatomy within substantially 30 degrees to 60 degrees with respect to gravity and a determination that the second motion sensor is not positioned on the posterior portion of the patient's anatomy with substantially 15 degrees to 45 degrees with respect to the first motion sensor.

[00129] Clause 117: The medical system of clause 115 or clause 116, wherein the at least one processor is further configured to: cause the output device to withhold chest compression feedback in response to a determination that the first motion sensor not positioned on the anterior portion of the patient's anatomy within substantially 30 degrees to 60 degrees with respect to gravity and a determination that the second motion sensor is not positioned on the posterior portion of the patient's anatomy with substantially 15 degrees to 45 degrees with respect to the first motion sensor.

[00130] Clause 118: The medical system of any of clause 115-117, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

[00131] Clause 119: The medical system of any of clause 115-118, wherein the at least one processor is further configured to: process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

[00132] Clause 120: The medical system of clause 119, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

[00133] Clause 121: The medical system of clause 119 or clause 120, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

[00134] Clause 122: The medical system of any of clauses 119-121, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

[00135] Clause 123: The medical system of any of clauses 119-122, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

[00136] Clause 124: The medical system of any of clauses 115-123, further comprising: a first electrode assembly configured to provide electrotherapy for the patient, and a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly, wherein the first motion sensor is provided with the first electrode assembly, and the second motion sensor is provided with the second electrode assembly.

[00137] Clause 125: The medical system of clause 124, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

[00138] Clause 126: The medical system of clause 124 or clause 125, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

[00139] Clause 127: The medical system of any of clauses 124-126, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

[00140] Clause 128: The medical system of any of clauses 115-127, wherein the at least one processor and the output device are provided in an external defibrillator.

[00141] These and other features and characteristics of the present disclosure, as well as the methods of operation and functions of the related elements of structures and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following description and the appended claims with reference to the accompanying drawings, all of which form a part of this specification, wherein like reference numerals designate corresponding parts in the various figures. It is to be expressly

understood, however, that the drawings are for the purpose of illustration and description only and are not intended as a definition of the limit of the subject matter presented herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[00142] FIG. 1 illustrates a rescuer performing CPR compressions on an adult patient utilizing a resuscitation assembly in accordance with some embodiments;

[00143] FIG. 2 is a top plan view of a resuscitation assembly for use with an adult patient in accordance with the present disclosure;

[00144] FIGS. 3A and 3B illustrate placement of an example of a resuscitation assembly in accordance with the present disclosure on a cardiac arrest victim;

[00145] FIG. 4 illustrated an alternative placement of the resuscitation assembly of FIGS. 3A and 3B in accordance with the present disclosure on a cardiac arrest victim;

[00146] FIG. 5 illustrates placement of another example of a resuscitation assembly in accordance with the present disclosure on a cardiac arrest victim;

[00147] FIGS. 6A and 6B illustrate placement of an example of a resuscitation assembly in accordance with the present disclosure on a pediatric cardiac arrest victim;

[00148] FIGS. 7A and 7B illustrate placement of an example of a resuscitation assembly in accordance with the present disclosure on an infant cardiac arrest victim;

[00149] FIGS. 8A-8E are perspective views of resuscitation assemblies in accordance with various embodiments of the present disclosure;

[00150] FIG. 9 is a graph of the components of signal produced by a motion sensor in accordance with the present disclosure;

[00151] FIGS. 10A and 10B are a flow chart of an exemplary process used for determining an initial placement the electrode assemblies of a resuscitation assembly in accordance with some embodiments;

[00152] FIG. 11 is a flow chart of an exemplary process used for providing chest compression feedback if the electrode assemblies of a resuscitation assembly are determined to be used on an adult patient in accordance with some embodiments;

[00153] FIG. 12 is a flow chart of an exemplary process used for providing chest compression feedback if the electrode assemblies of a resuscitation assembly are determined to be used by a pediatric patient in accordance with some embodiments;

[00154] FIGS. 13A-13D are perspective views is motion sensors of a resuscitation assembly in a non-inverted state (FIGS. 13A and 13C) and an inverted state (FIGS. 13B and 13D) in accordance with the present disclosure;

[00155] FIGS. 13E and 13F are schematic views of a motion sensor positioned at various orientations in accordance with the present disclosure;

[00156] FIG. 14 is a chart illustrating various correct placement positions of the electrode assemblies of the resuscitation assembly and the type of CPR feedback that is generated by the system in accordance with the present disclosure;

[00157] FIG. 15 is a chart illustrating various incorrect placement positions of electrode assemblies of the resuscitation assembly having a single motion sensor and the type of CPR feedback that is generated by the system in accordance with the present disclosure;

[00158] FIG. 16 is a chart illustrating various incorrect placement positions of electrode assemblies of the resuscitation assembly having dual motion sensors and the type of CPR feedback that is generated by the system in accordance with the present disclosure;

[00159] FIG. 17 is a chart illustrating various incorrect placement positions of pediatric electrode assemblies of the resuscitation assembly having dual motion sensors and the type of CPR feedback that is generated by the system in accordance with the present disclosure;

[00160] FIG. 18 is a flow chart of an exemplary process used for providing chest compression feedback in accordance with the present disclosure embodiments;

[00161] FIG. 19 is chart illustrating allowable orientations of the anterior motion sensor and the posterior motion sensor in order to provide accurate chest compression feedback in accordance with the present disclosure;

[00162] FIG. 20 is chart illustrating the type of chest compression feedback that is provided based on the orientations of the anterior motion sensor and the posterior motion sensor in accordance with the present disclosure;

[00163] FIG. 21 is chart illustrating the various orientation configurations for the anterior motion sensor and the posterior motion sensor in order to provide anterior-posterior chest compression feedback in accordance with the present disclosure;

[00164] FIG. 22 illustrates a rescuer performing CPR compressions on an adult patient utilizing a resuscitation assembly in accordance with the present disclosure;

[00165] FIG. 23 is a side schematic view of compressions being applied to a patient utilizing a resuscitation assembly in accordance the present disclosure; and

[00166] FIG. 24 is a schematic view of a medical system in accordance with the present disclosure.

DETAILED DESCRIPTION

[00167] The present disclosure relates to a system for assisting a user in providing chest compressions to a patient. The system and methods described in the present disclosure allow for more accurate chest compression feedback to be provided to a rescuer based on the placement of the electrode pads on the patient.

[00168] The American Heart Association (AHA) and the European Resuscitation Council (ERC) have established guidelines for the performance of CPR, which more recently recommend compression depths of 2.0 to 2.4 inches on adults with rates of 100 to 120 compressions per minute (cpm), compression depths between 5.0-6.0 cm for children 8-18 years of age, compression depths of at least one-third the diameter of the chest for children under 8 years of age, compression depths of about 5.0 cm for children 1-8 years of age, or compression depths of about 4.0 cm for infants less than 1 year of age. Accordingly, accurate measurement of depth and rate of chest compressions during Cardiopulmonary resuscitation (CPR) is a valuable feedback tool for both trained and untrained rescuers to ensure adequate compression depth and rate and the above guidelines require high accuracy from chest compression sensor measurements. Compression quality is quantified by placing an accelerometer anteriorly on the chest and calculating depth and rate from the measured acceleration. This information is then provided to the rescuer via an output device as chest compression feedback. Chest compression feedback utilizing a single anteriorly positioned motion sensor to measure compression depth may be referred to hereinafter as single sensor chest compression feedback or anterior-anterior chest compression feedback. However, inaccuracies in depth calculations may arise from several potential sources including, but not limited to: external motion of the patient (such as ambulance motion), compressible layers such as foam, clothing, or hair between the sensor and the patient while compressions are being performed, and chest compressions being performed while the patient is on a compressible surface such as a mattress or other soft surface that could give rise to otherwise inaccurate compression depth measurements.

[00169] One proposed solution to reduce the influence of patient motion unrelated to chest compression motion is to add a second accelerometer located posteriorly. The posterior accelerometer would measure any external movement and compression of a mattress. The difference in motion between anterior and posterior electrodes would allow the calculation of true compression depth into the chest. Resuscitation assemblies utilizing a pair of motion sensors to provide feedback to a user that improve accuracy, detection, and/or correction in determining resuscitation related parameters have been developed as disclosed in United

States Patent No. 10,406,345, entitled “Dual Sensor Electrodes for Providing Enhanced Resuscitation Feedback,” assigned to the assignee of the present application, and United States Patent Application Publication No. 2021/0228441, entitled “Dual Sensor Implementations for Providing Resuscitative Chest Compression Feedback,” assigned to the assignee of the present application, which are each hereby incorporated by reference in their entirety. Chest compression feedback utilizing anteriorly and posteriorly positioned motion sensors at least to measure compression depth may be referred to hereinafter as dual sensor chest compression feedback or anterior-posterior chest compression feedback.

[00170] However, the use of such systems requires the rescuer to properly position the resuscitation assembly including the first and second motion sensors on the patient in order to obtain accurate feedback utilizing both of the sensors. In stressful emergency situations, rescuers may inadvertently place motion sensors of an electrode resuscitation assembly in incorrect positions. For example, it may be possible that rescuers incorrectly place the anterior motion sensor on the patient in a flipped, inverted, or otherwise angled configuration beyond a predetermined threshold such that it would give rise to inaccurate compression depth readings. In such situations, when the anterior motion sensor is incorrectly flipped on the chest, then during compressions, the signal may be improperly inverted with a negative sign such that subtraction between posterior sensor signals and anterior sensor signals would be inaccurate. Accordingly, in this example, it may be more appropriate to provide signal sensor compression feedback by simply calculating compression depth using the magnitude of compression depth as measured using signals from the anterior motion sensor, without contribution of signals from the posterior motion sensor that is misplaced. In some embodiments, a prompt may be provided for a user to check placement of the sensor so as to give rise to more accurate compression depth measurement readings. This prompt may provide instructions to the user to adjust placement of the sensor so that it is positioned at a location to provide accurate compression depth measurement readings. In addition, a prompt may be provided to the user indicating that the sensor is inverted or flipped. For example, the prompt may provide guidance to a user to check or adjust the angle of the orientation of the sensor to fall within an acceptable orientation range. Or in another example, the posterior motion sensor may be placed on the patient at an angled position. In such a case, particularly when the motion sensor is angled beyond a predetermined threshold, it may also be more appropriate to provide signal sensor compression feedback by simply calculating compression depth using the magnitude of compression depth as measured using signals from the anterior motion sensor, without contribution of signals from the posterior motion sensor.

However, in other cases, as noted herein, when placed at particular angled configurations, rotational correction may be employed so as to result in accurate compression depth readings. Nevertheless, in certain instances, more accurate feedback may be provided using a single motion sensor depending on the position of the motion sensors on the patient. That is, when correctly placed, compression feedback may be preferable using signals from both anterior and posterior placed motion sensors; however, when incorrectly placed, it may be preferable in some cases to use signals from a single motion sensor (e.g., anterior placed). The present disclosure has been developed in order to determine the placement of the resuscitation assembly on the patient so as to provide accurate and appropriate chest compression feedback as possible to the rescuer. Such determination(s) of sensor placement may occur prior to and/or during chest compression feedback.

[00171] According to one aspect of the present disclosure, the system comprises: a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy; a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy; an output device; and at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to: receive and process signals from the first motion sensor and the second motion sensor to measure motion (e.g., acceleration) of the first motion sensor and motion of the second motion sensor, determine whether chest compressions have been initiated based on the motion from at least one of the first motion sensor or the second motion sensor, determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range in response to a determination the chest compressions have been initiated, determine whether oscillatory motion of the second motion sensor is greater than a threshold sufficient to initiate anterior-posterior chest compression feedback in response to a determination that the angle of the first orientation falls within the first acceptable orientation range, and cause the output device to provide the anterior-posterior chest compression feedback based on the motion of the first motion sensor and the motion of the second motion sensor based at least in part on the determination that the oscillatory motion of the second motion sensor is greater than the threshold sufficient to initiate the anterior-posterior chest compression feedback. The at least one processor may be further configured to: determine whether the second motion sensor is positioned at a second orientation having an angle that falls within a second acceptable orientation range, and in response to a determination that the angle of the first orientation falls within the first acceptable orientation range and the angle of the second orientation falls within the second

acceptable orientation rang, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor. The at least one processor may also be configured to: determine whether the motion in a first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor, and determine whether the motion in the first direction of the first motion sensor is greater than the motion in a second direction and a third direction of the first motion sensor. The at least one processor may be further configured to: determine an angle of the second motion sensor with respect to gravity, compare the angle of the second motion sensor with a threshold angle, and in response to a determination that the angle of the second motion sensor is less than a threshold angle, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

[00172] In addition, the system for assisting the user in providing chest compressions to the patient of the present disclosure may be incorporated into a resuscitation assembly that may be used for a wide variety of patients in need of resuscitation, such as for small (e.g., pediatric, infant) or large (e.g., adult) patients. In various embodiments, the resuscitation assemblies may include at least a pair of electrode assemblies usable for monitoring ECG of the patient and/or providing electrotherapy to the patient (e.g., defibrillation upon detection of a shockable ECG rhythm), along with the first and second motion sensors (e.g., accelerometers).

[00173] Resuscitation assemblies and systems described herein may provide for improved resuscitation over prior devices and methods, for example, by providing more accurate chest compression feedback based on the placement of the motion sensors on the patient. In various embodiments, when anterior and posterior motion sensors are placed correctly on the patient in appropriate anterior and posterior positions, then compression feedback may be provided using signal inputs from both anterior and posterior motion sensors; however, when one or more motion sensors are placed incorrectly on the patient, then unless a suitable correction for the misplacement is employed, then it may be preferable for compression feedback to be provided using signal inputs from the anterior motion sensor without contribution of signals from the posterior motion sensor. In such a situation of incorrect sensor placement on the patient, compression feedback using signal inputs from both anterior and posterior motion sensors may be less accurate or preferable than compression feedback calculated from just using signal inputs from the anterior motion sensor. Accordingly, such

systems may advantageously provide improved feedback on whether chest compressions are appropriately applied.

[00174] FIG. 1 illustrates an example of an emergency situation, which includes a caregiver or rescuer 4 administering manual chest compressions to a patient 2 in need of acute care. A medical system 1 comprises a resuscitation assembly 3 including a pair of electrode assemblies 5A, 5B and a chest compression sensor 7 positioned between the caregiver's hands and the patient 2 during chest compressions. The resuscitation assembly 3 is connected via cables 9 to a computing device 11, to assist the rescuer 4 in delivering high quality chest compressions. In the illustrated example, the computing device 11 is illustrated as a defibrillator, such as a ZOLL Medical R Series or X Series Monitor Defibrillator, which can operate as an AED, a semi-automatic defibrillator (SAD), and/or a manual defibrillator with a monitor, and can also be used for cardioverting and pacing (where electrical pulses are delivered through the patient's chest according to a vector at least partially determined by placement of the pads, so as to stimulate the heart to contract), through cables 9. However, in alternative embodiments, the computing device 11 comprises one or more of a patient monitor, or a handheld or mobile computing device such as a tablet computer or "smartphone" (i.e., a device that is typically handheld and comprises an integrated broadband Wi-Fi and or cellular network connection). The chest compression sensor 7 may comprise a housing 13 that protects or otherwise supports a motion sensor encased within the housing 13. Various embodiments illustrating how the motion sensor may be provided within the housing 13 are described further below and in greater detail in United States Patent No. 10,406,345 and United States Patent Application Publication No. 2021/0228441.

[00175] The computing device 11 may be configured to communicate with another computing device (e.g., tablet computer) 15. The computing device 11 and/or other computing device 15 may comprise at least one processor that is configured to receive and process signals from the motion sensor(s) disposed with the housing 13, and to estimate one or more resuscitation parameters based on signals from the motion sensors. Such resuscitation parameters may comprise, for example, chest compression depth, chest compression rate and/or chest compliance

[00176] Upon estimation of the resuscitation parameter(s), the computing device 11 may provide an output to a rescuer (e.g., person administering chest compressions, administrator, etc.) to provide feedback output to the rescuer on how to improve and/or maintain within one or more predetermined target ranges. Generally speaking, for chest compressions, target parameters can comprise compression rate, compression depth, and compression cycle

duration. In some examples, the American Heart Association (AHA) and the European Resuscitation Council (ERC) have established guidelines for the performance of CPR by recommending compression depths of 2.0 to 2.4 inches on adults with rates of 100 to 120 compressions per minute (cpm), compression depths between 5.0-6.0 cm for children 8-18 years of age, compression depths of at least one-third the diameter of the chest for children under 8 years of age, compression depths of about 5.0 cm for children 1-8 years of age, or compression depths of about 4.0 cm for infants less than 1 year of age.

[00177] Such targets and ranges can be varied depending upon a selected protocol. For instance, the computing device 1 can be configured to direct rescuers to provide a number of compressions (e.g., about 30 compressions, or another suitable number) and then to pause compressions while delivering a specified number of ventilations (e.g., 2 ventilations). Target parameters can be predetermined and stored in memory located on the computing device 21, entered manually by the rescuer prior to beginning the resuscitation activity, or automatically calculated by the computing device based, for example, on characteristics of the patient and/or rescuer. For example, target compression depth can be based on a size or weight of the patient. In other examples, target compression rate and depth can be selected based on skill of the rescuer. In other examples, target parameters can be received from an external source, such as an external computer or another medical device. For example, the target parameters can be based on a treatment protocol received from another medical device, such as a defibrillator, automated external defibrillator, or ventilator, or from a remote facility 17 (e.g., a remote computer, a computer network, a central server, a hospital, etc.). Additionally, information may be transmitted to the remote facility 17 for storage in a database, immediate analysis, and/or for later review of actions performed during the rescue.

[00178] Typically, the computing device 11 provides feedback output in the form of a visual display 19 (e.g., graphical instructions, color changes, text, numbers, etc.), audible sounds (e.g., voice prompts, tones, alarms, etc.), haptic feedback (e.g., vibrations, tactile feedback), and/or any other suitable manner of providing recommended actions to the rescuer.

[00179] With reference to FIG. 2 and with continued reference to FIG. 1, the resuscitation assembly 3 comprises a first electrode assembly 5A associated with a first motion sensor 21 and a second electrode assembly 5B associated with the second motion sensor 5. As shown in FIGS. 3A and 3B, the first electrode assembly 5A may be placed at an anterior position (e.g., over the sternum) of the patient 2 and the second electrode assembly 5B may be placed on a posterior position (e.g., on the back, opposite the anterior placed electrode) of the patient, i.e.,

in an A-P (anterior-posterior) position. In such a placement orientation, the first and second electrode assemblies 5A, 5B are positioned in a manner that forms a vector for electrotherapy (e.g., defibrillation) to be transmitted through the heart. The motion sensors 21, 23 in this placement orientation are also able to track movement of anterior and posterior regions of the thorax. Accordingly, the accuracy of chest compression depth may be improved relative to single sensor configurations, for example, in cases where the patient is placed on a soft, compressible surface during chest compressions.

[00180] Alternatively, as shown in FIG. 4, the first electrode assembly 5A may be placed on an anterior position of the patient and the second electrode assembly 5B may be placed on a side position of the patient, i.e., in an A-A (anterior-anterior) position. In this placement orientation, the first and second electrode assemblies 5A, 5B are also positioned in a manner that forms a vector for electrotherapy (e.g., defibrillation) through the heart. In such a context, it may be advantageous to be able to track the movement of each of the electrode assemblies as they are coupled to the patient. Tracking such movement may be helpful so as to identify the placement position and also be able to provide guidance for the caregiver depending on the placement position (e.g., whether A-P or A-A) and/or whether to adjust how the electrode/sensor assemblies are placed if not properly positioned. For example, if the electrode/sensor assemblies are placed in a configuration that is neither A-P nor A-A, then a patient monitor/defibrillator or other feedback device may provide instructions for the caregiver to move one or more of the components (e.g., electrodes and/or sensors), or simply alert the caregiver to the possibility that the electrode/sensors assemblies are misplaced. As further discussed herein, the motion sensor may be detached from the electrode assembly such that even when the electrodes are placed in the A-A position, the motion sensors may be placed so that one of the motion sensors is located on the anterior of the thorax and the other of the motion sensors is located on the posterior of the thorax, so as to provide more accurate chest compression depth information.

[00181] As described herein, each electrode assembly placed on the patient may incorporate a chest compression sensor, for example first and second motion sensors 21, 23 (e.g. accelerometers, velocity sensors, ultrasonic sensors, infrared sensors, other sensors for detecting displacement). In certain examples, the motion sensors may be three-axis accelerometers. Three-axis accelerometers may be able to provide signals that further determine relative orientation of their respective electrode assemblies by measuring parameters indicative of motion along each axis, in addition to determining chest compression parameters. While an accelerometer senses acceleration or gravity, motion or

displacement of the accelerometer can be determined through a series of calculations, such as double integration, filtering and/or other appropriate processing steps.

[00182] As discussed herein, by incorporating motion sensors in both electrode assemblies, resuscitation related parameters may be more accurately determined than would otherwise be the case if one electrode assembly incorporated a motion sensor. For instance, the electrode assemblies may serve as reference points for one another, based on their respective displacement and orientation. Accordingly, the manner in which the electrode assemblies (e.g., electrode pads) are placed and/or how they move relative to one another may inform the type of instructions output to a rescuer. As an example, discussed further below, based on their orientation and/or distance relative to one another, it can be determined whether the electrode assemblies are placed in an A-A or A-P position, or not in any recommended position at all. In addition, based on the pattern of movement of both electrode assemblies, the type of surface on which the patient resides can be determined, or the angle with respect to the vertical axis (when the patient is lying down) at which chest compressions are being administered can also be estimated. Additional details of dual sensor electrodes and the manner in which such electrodes operate can be found in United States Patent No. 10,406,345.

[00183] The resuscitation assembly of FIG. 2 is configured to be operatively connected to the computing device 11 through a connector 25 and the cable 9. As discussed above, the computing device 11 in certain examples may be a defibrillator. The defibrillator 11 is operable to generate a defibrillating shock and deliver that shock to the patient through the electrode assemblies 5A, 5B. In one example, the defibrillator can include an ECG monitor and display 19 for analyzing the ECG signals obtained through the electrode pad and displaying the ECG waveform to a user. The display can also provide the user with feedback regarding chest compressions.

[00184] With continued reference to FIG. 2, the resuscitation assembly 3 includes two (or more) electrode assemblies 5A, 5B that each may include a flexible electrode pad 27, 29 having a therapy side configured to be coupled to the patient. In addition, first electrode assembly 5A further includes the first motion sensor 21 as described hereinabove. The first motion sensor 21 is attached to a side of the electrode pad 27 opposite the therapy side at an attachment region 31. The first motion sensor 21 may be attached to a side of the electrode pad 27 in any suitable manner such as, but not limited to, the use of a double sided adhesive pad, hook and loop fasteners, snap attachment, stitching, permanent adhesive, or other arrangement. The first motion sensor 21 may be fixedly or removably coupled to the flexible

electrode pad 27. The electrode pad 27 and first motion sensor 21 may be attached at attachment region 31 by any suitable method, for example, at the point of attachment, the electrode pad 27 and the housing 13 of the first motion sensor 21 may be formed of the same material (e.g., foam padding), mechanically coupled (e.g., interlocking), stapled, sutured, stitched, non-adhesively coupled (e.g., placement within a pocket or pouch designed to receive the sensor and its respective housing), adhesively coupled, or otherwise adhered (e.g., using hook and loop fasteners) or coupled. For example, as shown in FIG. 2, the first motion sensor 21 and the electrode pad 27 are directly attached to one another along the attachment region 21.

[00185] In addition, the location of the first motion sensor 21 with respect to the electrode pad 27 is aimed at providing proper positioning of the first motion sensor 21 above the sternum of the patient and the flexible electrode pad 27 above the heart for the majority of the population. In order to provide proper electrode pad and motion sensor positioning for those cases where the patient is larger than the placement that the standard design provides, the first motion sensor 21 may be designed to be removed from the flexible electrode pad 27. Since chest compressions are a mechanically stressful action onto the electrode assembly 5A, the mechanisms for separating the first motion sensor 21 from the flexible electrode pad 27 must be secure enough so that it would not detach during the administration of chest compressions, yet easy enough to engage such that when desired, it would be simple to separate the first motion sensor 21 from the flexible electrode pad 27. Non-limiting examples of suitable attachment mechanisms between the first motion sensor 21 and the flexible electrode pad 27 are perforations along the attachment region 31, hook and loop fasteners for holding the motion sensor in place on the flexible electrode pad yet allowing for easy detachment and reattachment when needed, and an adhesive layer connected the housing 13 of the first motion sensor 21 to a side of the electrode pad 27 opposite the therapy side.

[00186] The second motion sensor 23 is embedded within the flexible electrode pad 29. Accordingly, the second motion sensor 23 is made as thin as possible so that it can be effectively hidden in the electrode pad 29 and to minimize pressure points and discomfort to a patient lying on it. The first electrode assembly 5A is intended to be positioned on an anterior portion of the thorax of the patient, such as the sternum, and the second electrode assembly 5B is intended to be positioned on a posterior portion of the thorax of the patient. In addition, the resuscitation assembly 3 shown in FIG. 2 is sized and shaped to be used with adult patients. While the second motion sensor 23 is illustrated in FIG. 2 as being completely enclosed within the flexible electrode pad 29, this is not to be construed as limiting the

present disclosure as the second motion sensor 23 may be partially embedded within the flexible electrode pad 29. For example, the second motion sensor 23 and its housing may be at least partially exposed. In such examples, the motion sensor and encasement may be constructed to be removable, repositioned and/or replaced.

[00187] The flexible electrode pads 27, 29 may be any type of electrode suitable for use in defibrillation, and generally includes a conductor, such as tin, silver, AgCl or any other suitable conductive material, provided at the therapy side; a conductive electrolyte gel, such as a hydrogel; and lead wires to connect the conductor to the cable 9. The flexible electrode pads 27, 29 of electrode assemblies 5A, 5B may be similar in their layered construction, although as illustrated in FIG. 2, the lateral shapes of the pads may vary depending on where the pads are to be placed on the patient. For instance, the electrode pad 27 of electrode assembly 5A is shown to have a triangular shape with rounded edges, providing for relatively easy placement on the chest area of a patient's thorax, while the electrode pad 29 of electrode assembly 5B is shown to be rectangular with rounded edges, providing for more intuitive alignment with the spine on the back area of the patient's thorax than would otherwise be the case for other shapes. Further details of the flexible electrode pads can be found in United States Patent No. 5,330,526, entitled "Combined defibrillation and pacing electrode," which is assigned to the assignee of the present application and is hereby incorporated by reference in its entirety.

[00188] With continued reference to FIG. 2, the first motion sensor 21 of electrode assembly 5A may be configured to enable a rescuer to apply chest compressions thereto. In this case, the first motion sensor 21 of resuscitation electrode assembly 5A is offset from the center of the conductive material of the electrode pad 27 so that the conductive material is more likely to remain undamaged during chest compressions. In addition, an upper surface of the first motion sensor 21 of electrode assembly 5A can include graphics, such as a cross-shaped marking (not shown), that serves to guide a user to properly place the first motion sensor 21 at a suitable anterior position over the sternum of the patient.

[00189] By providing a suitable motion sensor in both the anteriorly positioned electrode assembly 5A and the posteriorly positioned electrode assembly 5B, the signals obtained therefrom can be processed by control circuitry provided in the computing device 11, such as a defibrillator, to provide information that enhances overall resuscitation care to the patient. For example, data from both motion sensors may be processed to determine more accurate compression depth, particularly when compressions are performed on a compressible surface

and/or when, on an infant, a rescuer wraps his/her hands around the infant's chest and squeezes from both the front and back, as will be discussed in greater detail hereinafter.

[00190] As one mechanism to ensure proper placement of the electrode assemblies 5A, 5B of the resuscitation assembly onto the patient's anatomy, one or both of the electrode assemblies, or a substrate connected to the assemblies, may be provided with pictograms, diagrams, or printed instructions 33 describing the correct position for the electrode assemblies 5A, 5B. For example, pictograms, diagrams, or printed instructions 33 may be provided on an upper surface of the first motion sensor or the side of the flexible electrode pads 27, 29 opposite the therapy side. In addition, signals from the motion sensors 21, 23 may be utilized by the processor of the computing device 11 to prompt the user in the manner in which the resuscitation assemblies, including the electrode assemblies 5A, 5B, should be placed as discussed in United States Patent Application Publication No. 2016/0279405, entitled "ECG and Defibrillator Electrode Detection and Tracking System and Method," which is hereby incorporated by reference in its entirety.

[00191] While an example and configuration of an electrode assembly incorporating motion sensors has been described hereinabove, this is not to be construed as limiting the present disclosure as various other examples and configurations have been envisioned in which each of the electrode assemblies includes at least one motion sensor. For instance, various other configurations have been envisioned for use with various patients. With reference to FIG. 5, another example of a resuscitation assembly comprises a first electrode assembly 6A, a second electrode assembly 6B having a motion sensor 35, and a motion sensor 37 configured as a CPR pad associated with the first electrode assembly 6A. Electrode assemblies 6A, 6B may be placed in an A-A position with electrode assembly 6A positioned on an upper right side of a chest of the patient between the shoulder and the sternum and the electrode assembly 6B positioned on a lower left side of the chest of the patient over lower ribs of the patient.

[00192] In certain forms of treatment, rather than placement in the A-A position shown in FIGS. 4 and 5, a rescuer may place the first electrode assembly and the second electrode assembly in an A-P position as shown in FIGS. 3A and 3B. In some cases, placement of electrode assembly 6A on the patient's sternum area (as may happen during a rescue) and electrode assembly 6B on the patient's back may lead to an ECG signal that appears inverted and/or the pacing vector associated with the electrode placement may be oriented in an undesirable direction through the heart. In such instances, when electrode assemblies are placed in an A-P position as shown in FIGS. 3A and 3B, or other configuration that may lead

to an inverted ECG signal and/or pacing vector oriented in an undesirable direction, the system may be configured to provide desirable corrections to the ECG signal and/or pacing vector to orient it in the preferred direction. Or, the system may prompt the rescuer to place the pads in an orientation that gives rise to a more intuitive ECG signal and/or pacing vector with preferred directionality.

[00193] By providing the electrode assemblies 6A, 6B with motion sensors 35, 37, the processor used in the computing device 11 can be configured to determine the location of each of the electrode assemblies 6A, 6B based on the orientation of the motion sensors 35, 37 and/or distance relative to one another as described hereinabove. If the processor determines that first electrode assembly 6A is positioned on the patient's sternum and the electrode assembly 6B on the patient's back based on the signals from the motion sensors 35, 37, for some embodiments, the processor can invert or otherwise adjust the ECG signal such that it is displayed correctly on the display 19 of the computing device and adjust the pacing vector (e.g., reverse the direction of the pacing vector) such that it is provided in the correct direction.

[00194] With reference to FIGS. 6A and 6B, a resuscitation assembly for use with a pediatric patient is illustrated. This resuscitation assembly includes a pair of electrode assemblies 600, 602. Electrode assembly 600 is configured to be attached anteriorly to the pediatric patient's chest and is similar in construction as electrode assembly 5A described hereinabove. The electrode assembly 600 may include a flexible electrode pad 610 having a therapy side (not shown) configured to be coupled to the pediatric patient 2 and substantially conform to the patient's anatomy. The therapy side includes conductive material (not shown), facing toward the body of the pediatric patient 2, adapted to provide therapeutic treatment to the patient. The electrode assembly 600 may further include a motion sensor 601 positioned within a sensor casing 607. The sensor casing 607 may be coupled to the electrode pad 610 by positioning the sensor casing 607 on an upper surface of the electrode pad 610 along an attachment portion thereof. Electrode assembly 602 is configured to be attached posteriorly to a patient's back (see FIG. 6B). The electrode assembly 602 may include a flexible electrode pad 604 having a therapy side (not shown) configured to be coupled to the patient 2 and substantially conform to the patient's anatomy. The therapy side includes conductive material (not shown), facing toward the body of the patient 2, adapted to provide therapeutic treatment to the patient.

[00195] The electrode assembly 602 may further include a motion sensor 603 positioned within a sensor casing 605. The sensor casing 605 may be coupled to the electrode pad 604

by positioning the sensor casing 605 on an upper surface of the electrode pad 604 at a bottom extension portion 606. The extension portion 606 may form a pouch or other receptacle within which the sensor casing 605 may be disposed. In some embodiments, the sensor casing 605 is optionally removable from the pouch, and may be placed at any suitable location on or near the patient. A securing portion 608 may be positioned over the sensor casing 99 to secure the sensor casing 99 on the upper surface of the electrode pad 604 at the bottom extension portion 606. In such a configuration, the sensor casing 99 may be removably secured between the upper surface of the bottom extension portion 606 and the bottom surface of the securing portion 608, thereby allowing the sensor to be easily replaced and/or moved to another location.

[00196] It can be appreciated that the sensor casing and the electrode pad may be removably coupled by any suitable manner. As discussed above, the electrode pad may have a pouch or receptacle for holding the sensor casing in place, yet the sensor casing may be easily separated therefrom when desired. In one example, the backing of the electrode pad may have perforations, a slightly scored or nicked region, cut marks, etc. that allow for tearing of a weakened region so that the sensor may be removed. The electrode pad may further include a suitable adhesive so that the sensor may be reattached or coupled thereto. In another example, the sensor may be adhered to an upper surface of the electrode pad backing where the backing includes a liner material such that the sensor may be peeled off and adhered elsewhere. Alternatively, the sensor casing and the electrode pad may have complementary coupling components, for example, hook and loop fasteners, mutually attracting magnets, other fastening elements, etc. Or, the sensor casing may have an adhesive material that allows for repositioning from the electrode pad to a different surface (e.g., patient's skin). In further embodiments, the adhesive for attaching the sensor to the electrode pad and/or surface of the patient may be effective in moist environments, such as in neonatal situations where birthing fluid is present. For example, a moisture activated or water-based adhesive may be employed such that when the sensor casing is peeled off the pad and reattached, the adhesive is more effective in adhering to the point of contact.

[00197] With reference to FIGS. 7A and 7B, an example of a resuscitation assembly for use with neonatal patients is illustrated. This resuscitation assembly is designed specifically for use on an infant during CPR procedures. The resuscitation assembly comprises a pair of electrode assemblies 700, 702. Electrode assembly 700 is configured to be attached anteriorly to the pediatric patient's chest. The electrode assembly 700 may include a flexible electrode pad 704 having a therapy side (not shown) configured to be coupled to the infant patient 2

and substantially conform to the patient's anatomy. The therapy side includes conductive material (not shown), facing toward the body of the infant patient 2, adapted to provide therapeutic treatment to the patient. The electrode assembly 700 may further include a motion sensor 703 positioned within a sensor casing 705. The sensor casing 705 may be coupled to the electrode pad 704 by positioning the sensor casing 705 on an upper surface of the electrode pad 704 at a bottom portion thereof.

[00198] Electrode assembly 702 is configured to be attached posteriorly to a patient's back (see FIG. 7B). The electrode assembly 702 may include a flexible electrode pad 706 having a therapy side (not shown) configured to be coupled to the infant patient 2 and substantially conform to the patient's anatomy. The therapy side includes conductive material (not shown), facing toward the body of the infant patient 2, adapted to provide therapeutic treatment to the patient. The electrode assembly 702 may further include a motion sensor 703 positioned within a sensor casing 705. The sensor casing 705 may be coupled to the electrode pad 706 by positioning the sensor casing 705 on an upper surface of the electrode pad 706 at a bottom extension thereof.

[00199] While various examples and configurations of the electrode assemblies incorporating motion sensors have been described hereinabove, this is not to be construed as limiting the present disclosure as various other examples and configurations have been envisioned in which each of the electrode assemblies includes at least one motion sensor. For instance, various other configurations have been envisioned for use with pediatric patients, infant patients, and adult patients as disclosed in United States Patent No. 10,406,345 and United States Patent Application Publication No. 2021/0228441.

[00200] With reference to FIGS. 8A-8E, various configurations of resuscitation assemblies may be provided in which the motion sensors are connected to the electrode pads, either fixedly or removably, or provided separately from the electrode pads. In addition, resuscitation assemblies may be provided with a single motion sensor provided with the anterior electrode pad or both the anterior and posterior electrode pad may be provide with a motion sensor.

[00201] For instance and with reference to FIG. 8A, the electrode pads 804A, 804B of electrode assemblies 802A, 802B of a resuscitation assembly 800A may be placed in a certain configuration, such as an A-A position where one electrode pad 804A that includes a motion sensor 806A positioned on an upper surface thereof is placed on the sternum and another electrode pad 804A that does not include a motion sensor is placed on the side of the

patient. Cables 808 may be used to connect the electrode assemblies 802A, 802B and the motion sensor 806A.

[00202] Alternatively and with reference to FIG. 8B, a resuscitation assembly 800B may include a first electrode assembly 802A and a second electrode assembly 802B, with the first electrode assembly 802A including an electrode pad 804A and motion sensor 806A that are separate from one another, yet may each be connected to the overall system (e.g., via a cable 808 or wireless connection). In addition, the second electrode assembly 802B includes an electrode pad 804B, without a motion sensor, that is connected to the overall system via a cable 808. In some embodiments, a sensor casing containing the motion sensor, where the sensor casing is provided as a small protective covering, may be coupled to a patient, separate or separable from the remainder of the electrode assembly. As an example, the sensor casing and/or motion sensor may include an adhesive or other material that allows the sensor to be attached to and detached from the body, apart from the electrode pad.

[00203] Such a configuration, as shown in FIG. 8B, where the motion sensor 806A can be freely attached to and detached from the body separate from the electrode pad 804A may be relevant if it is preferable for the location of compressions to vary, or if it is otherwise desirable for the motion sensor to be positioned at a location away from the electrode pad. For example, if a patient has had chest surgery, with wounds that do not allow for standard pad placement, it may be advantageous to a separately attachable motion sensor 806A independent of the electrode pad 804A to be attached at any suitable location. Or, in some cases, adjusting the location at which chest compressions is applied may give rise to increased levels of blood circulation.

[00204] With reference to FIGS. 8C and 8D, resuscitation assemblies may be provided with both motion sensors associated with both the anterior and posterior electrode pads. For example, with specific reference to FIG. 8C, the electrode pads 804A, 804B of electrode assemblies 802A, 802B of a resuscitation assembly 800C may be placed in a certain configuration, such as an A-A position where one electrode pad 804A that includes a motion sensor 806A positioned on an upper surface thereof is placed on the sternum and another electrode pad 804B having a separate motion sensor 806B is placed on the side of the patient. In such a situation, the separate motion sensor 806B can be placed on the back or other suitable location of the patient, for example, to obtain more accurate or precise chest compression data even though the electrode pad 804B is placed on the patient's side. Cables 808 may be used to connect the electrode assemblies 804A, 804B and motion sensors 806A, 806B.

[00205] Alternatively, as shown in FIG. 8D, a resuscitation assembly 800D includes a first electrode assembly 802A and a second electrode assembly 802B each having an electrode pad 804A, 804B and motion sensor 806A, 806B that are separate from one another, yet may each be connected to the overall system (e.g., via a cable 808 or wireless connection). In some embodiments, a sensor casing containing the motion sensor, where the sensor casing is provided as a small protective covering, may be coupled to a patient, separate or separable from the remainder of the electrode assembly. As an example, the sensor casing and/or motion sensor may include an adhesive or other material that allows the sensor to be attached to and detached from the body, apart from the electrode pad. Such a configuration, as shown in FIG. 8D, where motion sensors 806A, 806B can be freely attached to and detached from the body separate from the electrode pad 804A, 804B may be relevant if it is preferable for the location of compressions to vary, or if it is otherwise desirable for the motion sensor to be positioned at a location away from the electrode pad.

[00206] Alternatively, as shown in FIG. 8E, the motion sensors 806A, 806B may be completely separate from the electrode pads 804A, 804B. For example, as shown, the electrode pads 804A, 804B may be connected to a system for providing electrotherapy through the electrode pads, and the motion sensors 806A, 806B may be separately connected to a system for obtaining signals from the motion sensors, for determining one or more parameters related to chest compressions, such as chest compression depth, rate and/or velocity.

[00207] The at least one processor for processing of signals arising from the motion sensor(s) in order to measure motion of the motion sensor(s) may be disposed at any suitable location, such as within a defibrillator, laptop computer, desktop computer, tablet, server at a remote location, or smartphone. Such processing may include, for example, integrating acceleration signals to result in displacement information, or subtracting posterior acceleration or displacement information from anterior acceleration or displacement information. Other types of processing and analysis may be possible. In an example, the processor(s) may be disposed in defibrillator, monitor, computing device, or other medical treatment apparatus. Accordingly, signals from the motion sensor(s) may be transmitted (e.g., wirelessly or through a cable) to the processor(s) on the medical treatment apparatus for analysis and, e.g., feedback. Alternatively, for signals transmitted via a wired cable system, the processor(s) may be disposed within a reusable portion of the cable system. For instance, as discussed herein, the sensor casing, motion sensor and associated cable may form a disposable assembly. This disposable assembly may be plugged into a reusable cable which

is, in turn, in electrical communication with a corresponding medical treatment apparatus (e.g., defibrillator, monitor, etc.). By incorporating the processor(s) for processing the signals arising from the motion sensor(s) within the reusable cable, processing of such signals may occur quickly and efficiently without unnecessary bandwidth usage from the more complex medical treatment apparatus. As a result, the processor(s) within the reusable cable may send one or more processed signals to the medical treatment apparatus (e.g., defibrillator, monitor, CPR system) and/or back to the motion sensor and sensor casing. The medical treatment apparatus may collect the processed signals for further data analysis, reporting, or other function(s). In some cases, the sensor casing itself may incorporate circuitry that receives the processed compression information and provides an appropriate level of feedback to the user (e.g., LED, display, audio signal for guiding or assisting the user in performing CPR). In other embodiments, the processor(s) may be provided with the disposable assembly, for example, located within the sensor casing or associated cable. As an example, the motion sensor and the processor(s) for processing signals from the motion sensor may be provided on the same circuit chip. Communication between the motion sensor(s) and associated processor(s) may be digital and/or analog in nature.

[00208] In one non-limiting embodiment of the present disclosure, the motion sensors are three-axis accelerometers as described hereinabove. The three-axis accelerometers provide signals that determine relative orientation of their respective electrode assemblies by measuring parameters indicative of motion along each axis. The processors analyze the signal from three-axis accelerometers to determine the orientation of the electrode assemblies. With reference to FIG. 9, a typical signal produced by a three-axis accelerometer includes a DC component shown by graph 900 and an AC component shown by graph 902. The DC component of the signal corresponds to a positional motion of the motion sensor. In other words, the DC component can be utilized by the processor to determine a change in position of the motion sensor at a given time. The AC component of the signal, on the other hand, corresponds to an oscillatory motion or energy of the motion sensor as shown by graph 902. In other words, the AC component can be utilized by the processor to determine a level of energetic movement of the motion sensor over time, which in some situations may be a preferable signal to use in addition to or in place of the DC component, which in some cases may be undesirably subject to drift. Graph 904 illustrates a combined signal that includes both the AC component and the DC component. This signal illustrates the positional offset of the motion sensor as well as the oscillatory movement of the motion sensor.

[00209] The AC component of the signal may provide for reliable orientation determinations as described in further detail hereinafter.

[00210] As noted herein, resuscitation assemblies described herein may be used with electrode assemblies thereof placed in the A-P position, the A-A position, or both, or in another position (e.g., lateral-lateral position). Resuscitation assemblies may be configured to perform a number of functions, including for example, defibrillation (e.g., hands free defibrillation energy according to energy levels set by a suitable defibrillator), ECG monitoring (e.g., for at least 24 hours), noninvasive temporary pacing (e.g., 1-8 hours of hands free noninvasive pacing energy, at approximately 75 mA/150 ppm or approximately 140 mA/180 ppm), transmitting chest compression data to a medical treatment apparatus (e.g., defibrillator, monitor, CPR system), code readiness self-testing, expiration dating, having at least a 24 month shelf life. With respect to code readiness self-testing, the electrodes of the resuscitation assembly may be pre-connected to a defibrillator (e.g., hospital defibrillator such as the R SERIES defibrillator provided by ZOLL Medical) so that the assembly is ready for use at any time. During the code readiness self-testing, the defibrillator may automatically test for the presence of correct cables and electrodes, and verify the type, condition and/or expiration date of the electrode(s), without requiring the electrodes to be disconnected. For the electrode assemblies, according to IEC 60601-2-4 cls.201.108.1.1, the AC small signal impedance of the electrodes is 3 kOhms or less at 10 Hz, and 5 Ohms or less at 30 kHz, and the AC large signal impedance is 3 Ohms or less at a 200 J biphasic defibrillation. According to IEC 60601-2-4 cls.201.108.1.4, the defibrillation recovery offset is 750 mV or less following a 200 J biphasic defibrillation at 4 and 60 seconds, and according to IEC 60601-2-4 cls.201.108.1.6, the DC offset voltage is 100 mV or less following a 200 J biphasic defibrillation.

[00211] In certain non-limiting embodiments, the resuscitation assemblies may be single use disposable and used on certain types of patients. Such patients with which the resuscitation assemblies are intended for use may include pediatric patients 0-8 years in age and less than 55 lbs (25 kg), adult patients greater than 8 years old and more than 55 lbs, or both types of patients. Motion sensors (anterior or posterior) associated with the resuscitation assemblies may be constructed to withstand at least 150 lbs of compression force or more applied directly thereto, and at least 200 compressions per minute. Such motion sensors may further be able to withstand the weight of a patient's body, in addition to the compression force.

[00212] The systems of the present disclosure may be utilized to provide feedback for a user regarding resuscitation activities (e.g., chest compressions, ventilations) being performed on the patient so that the rescuer may perform those resuscitation activities with improved accuracy. While embodiments of the medical system is described below with regard to the exemplary resuscitation assembly 3 shown in FIGS. 2, 3A, 3B, and 4 and the resuscitation assembly shown in FIGS. 6A and 6B, any suitable resuscitation assembly may be utilized such as, but not limited to, the resuscitation assemblies illustrated in FIGS. 5, 7A, 7B, and 8A-8E. More specifically, in operation, a rescuer may place the electrode assemblies 5A and 5B of the resuscitation assembly 3 in an A-P orientation (see FIGS. 3A and 3B, for example), with the electrode assembly 5A being positioned on the patient's sternum and the electrode assembly 5B being positioned on the patient's back. Alternatively, as shown in FIG. 4, the electrode assemblies 5A and 5B of the resuscitation assembly are positioned on the patient in an A-A orientation. Specifically, in such a configuration, the electrode assembly 5A is positioned on a right side of a chest of the patient 2 between the armpit and the sternum, with the portion of the electrode assembly comprising the motion sensor placed substantially above the sternum. The electrode assembly 5B is an apex electrode assembly and is positioned on a left side of the chest of the patient 2 over lower ribs of the patient 2. In either configuration, the motion sensors 21, 23 of the electrode assemblies 5A, 5B may be provided as three-axis accelerometers as described hereinabove such that acceleration in the x, y, and z directions (see FIG. 1) is measured simultaneously with each of two sensors incorporated within respective electrode assemblies.

[00213] With reference to FIGS. 10A and 10B, a flow chart illustrating the manner in which at least one embodiment of the at least one processor determines the placement of the electrode pads is provided. As an initial step, the processor determines whether the electrode assemblies 5A, 5B are provided on the patient 2 at block 1000 by receiving a signal from the electrode assemblies 5A, 5B representative of electrical impedance. When the impedance between the electrode pads is excessively high (insufficient current is able to flow there between), then it may be determined that the electrode pads are not properly coupled to the patient; and when the impedance between the electrode pads is sufficiently low (where current is able to flow between the electrodes), then it may be determined that the electrode pads are properly coupled to the patient. Accordingly, the processor compares this signal to a threshold value and, if the electrical impedance is below the threshold value, confirms that conductivity through the patient 2 is sufficient and determines that the electrode assemblies 5A, 5B are provided on the patient 2. The electrical impedance may be determined to exceed

the threshold value if, for example, the electrode pads of the electrode assemblies 5A, 5B are not positioned to make sufficient contact with the patient's skin due to interference by clothing or hair or if one of the electrode assemblies 5A, 5B is not positioned on the patient. The electrical impedance may also be determined to exceed the threshold in situations where the electrode assemblies 5A, 5B are connected to the medical system but remain in the package prior to use.

[00214] Thereafter, at block 1002, the processor determines whether the resuscitation assembly 3 is configured for adult patients or pediatric patients. For example, the resuscitation assemblies disclosed herein may also include one or more components that allow for the processor of a medical system to identify whether the resuscitation assembly is configured for pediatric resuscitation or adult resuscitation, or whether the resuscitation assembly has one or more motion sensor inputs (e.g., a single sensor or multiple sensors). In some cases, the resuscitation assembly may include a memory chip for identifying the type of electrode assemblies, resistor (e.g., approximately 2.9 kOhm patient identification resistor for pediatric electrode assemblies, approximately 1.3 kOhm patient identification resistor for adult electrode assemblies), or other suitable identification component that is analyzed and from which an identification signal may be transmitted. This identification signal may provide information for the system to determine what type of resuscitation assembly is being used. As an example, a resuscitation assembly in accordance with the present disclosure may be connected to a defibrillator or monitor, and the system, using an associated processor, may analyze and/or receive an identification signal based on the identification component of the resuscitation assembly. Where the identification component is a resistor, the system may run a current through the resistor, and based on the resulting voltage, the type of resuscitation assembly may be identified. Alternatively, where the identification component is a memory chip, the system may read whether the resuscitation assembly is pediatric or adult based on the contents of the memory. In another non-limiting example, the resuscitation assembly may not include such an identification component. In such instances, the processor defaults to adult pad placement at block 1004 (see FIG. 10B). If the rescuer identifies the patient as being a pediatric patient, the rescuer can use an input (e.g., button, touchscreen, switch, soft keys, rotational dial, user interface, etc.) provided on the medical system to manually change the system to pediatric pad placement as shown by block 1006.

[00215] Thereafter, the processor obtains a default placement of electrode assemblies 5A, 5B at blocks 1008 and 1010, respectively. As mentioned above, the electrode assemblies 5A, 5B are identified by the at least one processor as having one or more motion sensor inputs.

This can be accomplished either through the use of the identification component or manually entered by the rescuer. If the electrode assemblies 5A, 5B are identified as having a single sensor, then they are identified as Anterior-Anterior (A-A) electrode assemblies at blocks 1012 and 1014, and the processor is configured to provide single motion sensor CPR feedback to the user. Such electrode assemblies are shown in FIGS. 8A and 8B. When the electrode assemblies 5A, 5B are identified as A-A electrode assemblies, then motion sensor positioned on an anterior portion of the patient's chest is used to provide chest compression feedback to the user. In instances where the resuscitation assembly includes one motion sensor such as shown in rows 1400 and 1402 of FIG. 14, it will be identified as an A-A electrode assembly even if the electrode assemblies are positioned in an anterior-posterior orientation on the patient 2 as shown in row 1402 of FIG. 14, for example. With reference to FIG. 15, if the rescuer incorrectly positions the electrode assemblies on the patient, such that the motion sensor is provided in an inverted position as shown in FIG. 13B where the lower side 1302 faces away from the patient, the processor may be configured to invert the signal provided by the motion sensor and provide chest compression feedback to the user based on the motion of the motion sensor whether the electrode assemblies are positioned on the patient in an anterior-anterior configuration (see row 1500) or an anterior-posterior configuration (see row 1502). In the case where the motion sensor is placed in an inverted position (e.g., at 180 degree angle), the angle of the motion sensor with respect to gravity is greater than an associated threshold such that the angle of orientation falls outside of an acceptable orientation range for measuring compression depth. However, if the motion sensor is detached from the electrode assembly and positioned on the side of the patient where chest compressions are not occurring, such positioning would not allow for meaningful signals from the motion sensor to be obtained by the processor; in such a situation, the processor is configured to provide no instructions to the output device to provide chest compression feedback to the user (see row 1504).

[00216] More specifically, and with reference to FIG. 13E, the motion sensor 21 may be considered to be provided within an acceptable orientation range if the angle of the motion sensor 21 with respect to gravity is between 0 degrees and ± 45 degrees. In such instances, the motion sensor 21 may be considered to be in a non-inverted orientation with the upper side 1300 facing away from the patient. The motion sensor denoted by the solid lines illustrates the angle of the motion sensor 21 with respect to gravity being at 0 degrees. The angle of the motion sensor 21 may also be considered to be in a non-inverted orientation if it is slightly tilted (e.g., the angle of the motion sensor 21 with respect to gravity is between about -45

degrees and 45 degrees) as shown by the motion sensors 21 shown in phantom in FIG. 13E. With reference to FIG. 13F, the motion sensor 21 may be considered to be provided within an unacceptable orientation range if the angle of the motion sensor 21 with respect to gravity is between about 135 degrees and about 180 degrees (or between -135 degrees and -180 degrees). In such instances, the motion sensor 21 may be considered to be in an inverted orientation with the upper side 1300 facing toward the patient and the lower side 1302 facing away from the patient. The motion sensor denoted by solid lines illustrates the angle of the motion sensor with respect to gravity being 180 degrees. In addition, with continued reference to FIG. 13F, the motion sensor may also be considered to be provided with an unacceptable orientation range if the angle of the motion sensor 21 is between about 46 degrees and 134 degrees (or between -46 degrees and -134 degrees). In such instances, the motion sensor 21 may be considered to be tilted as shown by the motion sensors shown in phantom in FIG. 13F. The above description is not to be construed as limiting the present disclosure as the acceptable orientation range may be provided if the angle of the motion sensor 21 with respect to gravity is between about -30 degrees and 30 degrees or between about -60 degrees and 60 degrees.

[00217] If the electrode assemblies 5A, 5B are identified as having two motion sensors, then they are identified as Anterior-Posterior (A-P) electrode assemblies at blocks 1016 and 1018, and the processor is configured to provide dual motion sensor CPR feedback to the user. When A-P electrode assemblies are identified, the processor performs additional steps to confirm whether the electrode assemblies are actually positioned on the patient by the rescuer in an anterior-posterior orientation as shown in FIGS. 3A and 3B, for example, to provide accurate dual sensor chest compression feedback to the rescuer. These additional steps are described with reference to FIG. 11 for adult patients and FIG. 12 for pediatric patients. The reason for these additional steps is that even if dual motion sensor electrode assemblies are utilized, these electrode assemblies may not be properly positioned on the patient by the rescuer to provide accurate dual sensor chest compression feedback. In such instances, the processor instructs the system to provide single sensor chest compression feedback as will be discussed in greater detail hereinafter.

[00218] The processor is also configured to receive the electrical impedance signal from the electrode assemblies 5A, 5B once the default pad placement is determined. The processor then compares this signal to a threshold value and, if the electrical impedance is below the threshold value, confirms that conductivity through the patient 2 is sufficient at blocks 1020. If it is determined that electrical impedance is above the threshold value indicating that the

electrode assemblies 5A, 5B have fallen off or are improperly adhered to the patient 2, the processor provides a signal to an output device associated with the medical system to provide an instruction to the rescuer to confirm that the electrode assemblies 5A, 5B are securely positioned on the patient and returns to block 1000 (see blocks 1022), restarting the process logic afresh. Such steps are referred to hereinafter as an impedance reset. This occurs when the system detects that the electrode assemblies 5A, 5B have been removed from the patient and either repositioned or replaced with new electrode assemblies.

[00219] With reference to FIG. 11, if the electrode assemblies 5A, 5B have been identified as adult A-P electrode assemblies, the processor then performs additional steps to confirm whether the electrode assemblies are actually positioned on the patient by the rescuer in an anterior-posterior orientation as shown in FIGS. 3A and 3B, for example, to provide accurate dual sensor chest compression feedback to the rescuer. It can be appreciated that if the electrode assemblies 5A, 5B are identified as adult A-P electrode assemblies integrated with dual motion sensors and if they are improperly positioned, then absent appropriate correction algorithms in place, the dual sensor feedback provided may be problematically inaccurate. At block 1024, the processor determines whether the motion sensor 23 associated with the posterior electrode assembly 5B is positioned at an orientation having an angle that falls outside of an acceptable orientation range (i.e., such as at an inverted orientation). The processor receives and processes signals from the motion sensor 23 to measure motion of the motion sensor 23. As discussed hereinabove, with reference to FIG. 9, the signals from motion sensor 23 includes an AC component representative of oscillatory motion of the motion sensor 23 and a DC component representative of positional motion of the motion sensor 23. In order to determine whether the motion sensor 23 is inverted, the DC component of the signal may be utilized by the processor within a predetermined time period after placement of the electrode assemblies 5A, 5B on the patient 2. This time period may be anywhere from 1-5 seconds, 1-10 seconds, or 1-15 seconds. Alternatively, the processor may determine that the motion sensor 23 is positioned at an orientation having an angle that falls outside of an acceptable orientation range by measuring an angle of the motion sensor 23 based on either or both of DC component and the AC component of the signals provided by the motion sensor 23. If the processor determines that the motion sensor 23 is provided in an orientation that falls outside of an acceptable orientation range, such as an inverted orientation, then the processor confirms that an output device associated with the medical system should provide chest compression feedback to the rescuer at block 1026 utilizing the signals from the motion sensor 21 positioned on an anterior portion of the patient's chest.

Such a situation occurs when the electrode assemblies 5A, 5B are placed on the chest of a patient 2 in an anterior-anterior configuration as shown in row 1406 of FIG. 14 and in FIG. 4. In some embodiments, since the posterior motion sensor 23 is inverted, the chest compression feedback provided to the rescuer is calculated using signals from the anterior motion sensor 21, without contribution from signals from the posterior motion sensor 23. However, in other embodiments, when it is determined that the posterior motion sensor 23 is inverted, the signals from posterior motion sensor 23 may be corrected with an algorithmic inversion, resulting in the correct posterior sensor signal such that dual compression sensor feedback may still be employed.

[00220] If it is determined that the posterior motion sensor 23 is positioned according to an acceptable orientation (e.g., in a non-inverted manner), such as shown in row 1404 of FIG. 14 and FIGS. 3A and 3B, then the processor determines whether the rescuer has commenced providing chest compressions to the patient 2 based on the motion of the motion sensors 21, 23 at block 1028. For example, if the motion of the sensors in the Z direction is determined to be indicative of a chest compression, the number of chest compressions are then determined over a period of time. For example, the period of time may be 5 seconds, 10 seconds, or 15 seconds, for instance. If the number of chest compressions are greater than a predetermined threshold, then the processor provides an indication that chest compressions have commenced. In addition, additional processing steps are utilized to accurately determine that the motion of the motion sensors 21, 23 corresponds to a chest compression rather than noise caused by external motion of the patient (such as ambulance motion).

[00221] If the processor determines that chest compressions have commenced, the processor then determines whether the motion sensor 21 associated with the anterior electrode assembly 5A is positioned at an orientation having an angle that falls outside of an acceptable orientation range (i.e., such as at an inverted orientation) at block 1030. For instance, since the motion sensor 21 may be configured to be detached from the electrode assembly 5A as discussed hereinabove, a rescuer may detach the motion sensor 21 and inadvertently or inappropriately flip the motion sensor during use. With reference to FIGS. 13A and 13B, an adult anterior motion sensor 21 is illustrated in a non-inverted orientation (i.e., with the upper side 1300 facing away from the patient and the lower side 1302 facing toward the patient) and in an inverted orientation (i.e., with the upper side 1300 facing toward the patient and the lower side 1302 facing away from the patient), respectively. The processor receives and processes signals from the motion sensor 21 to measure motion of the motion sensor. As discussed hereinabove, with reference to FIG. 9, the signals from motion

sensor 21 include an AC component representative of oscillatory motion of the motion sensor 21 and a DC component representative of positional motion of the motion sensor 21. In order to determine whether the anterior motion sensor 21 is inverted, the DC component of the signal is utilized by the processor to determine whether the motion sensor 21 is provided in an inverted orientation. Alternatively, the processor may determine that the motion sensor 21 is positioned at an orientation having an angle that falls outside of an acceptable orientation range by measuring an angle of the motion sensor 21 based on either or both of DC component and the AC component of the signals provided by the motion sensor 21. If it is determined that the motion sensor 21 is in an orientation that falls outside of an acceptable orientation range, such as an inverted orientation, then the processor may confirm that an output device associated with the medical system should provide chest compression feedback to the rescuer at block 1026 by inverting the signals from the motion sensor 21 positioned on an anterior portion of the patient's chest. Such a situation may occur when the electrode assemblies 5A, 5B are placed on the chest of a patient 2 in a configuration as shown in row 1600 of FIG. 16 (with the electrode assemblies 5A, 5B being positioned in an anterior-posterior configuration as shown in FIGS. 3A and 3B) or when the electrode assemblies 5A, 5B are placed on the chest of a patient 2 in a configuration as shown in row 1602 of FIG. 16 (with the electrode assemblies 5A, 5B being positioned in an anterior-anterior configuration as shown in FIG. 4).

[00222] If it is determined that the anterior motion sensor 21 is positioned in a non-inverted manner, such as shown in row 1404 of FIG. 14 where the sensor is positioned according to an appropriate orientation, the processor then determines, at block 1032, whether oscillatory motion of the posteriorly positioned motion sensor 23 is greater than a threshold sufficient to initiate anterior-posterior chest compression feedback using the AC component of the signal obtained by the motion sensor 23. For instance, if too little, insufficient or no motion of the posterior motion sensor 23 is detected, the medical system then returns to step 1024. The threshold may be set at any suitable value such as an acceleration detection that is equivalent to at least 0.5 inches of displacement. In certain embodiments, the threshold may be set to at least 0.3 inches of displacement and in other embodiments the threshold may be set to at least 0.1 inches of displacement. In some embodiments, anterior-posterior chest compression feedback employing motion signals from both the anterior motion sensor 21 and the posterior motion sensor 23 (e.g., where subtraction of the posterior displacement from the anterior displacement is performed) may be provided regardless of how small the signals are from the posterior motion sensor 23.

[00223] Optionally, if it is confirmed that the oscillatory motion of the posteriorly positioned motion sensor 23 is greater than a threshold, the processor may then be configured to determine, at block 1034, whether oscillatory motion of the motion sensor 21, positioned on an anterior portion of the patient 2, in the z-direction shown in FIG. 1 is greater than the oscillatory motion of the motion sensor 23, positioned on a posterior portion of the patient 2, in the z-direction. Such a check may be appropriate so as to confirm that the motion being experienced by both sensors is due to appropriate chest compression motion. If the sensors are used as indicated, the posterior sensor would be expected to track motion of the overall patient (e.g., including motion due to a compressible mattress or environment with motion artifact), and the motion of the anterior sensor would be expected to be the same motion as that experienced by the posterior sensor in addition to the motion due to the chest compressions; accordingly, as inquired by the logic in block 1034, it would be expected that z-direction motion of the anterior sensor should be larger than z-direction motion of the posterior sensor. This check rules out extraneous conditions, such as for example, movement of the patient (which can be particularly problematic with pediatric patients that are lifted and moved around) and also rules out small oscillatory magnitudes where noise characteristics may make the z-direction motion of the posterior sensor slightly larger. If the first motion sensor 21 and the second motion sensor 23 are positioned as shown in row 1404 of FIG. 14, this condition will be met. However, this condition will not be met if the motion sensor 23 is positioned on an anterior portion of the patient's chest as shown in row 1406 of FIG. 14 or if the motion sensor 21 is inappropriately positioned on the patient's side as shown in rows 1604 and 1606 of FIG. 16. In addition, the processor may further be configured to determine, at block 1034, whether the oscillatory motion in the z-direction of the anteriorly positioned motion sensor 21 is greater than the oscillatory motion in x-direction and the y-direction of the motion sensor 21 (see FIG. 1). This logic demonstrates another verification check, where if chest compressions are being performed appropriately, then the anterior sensor is physically being used as a CPR compression tool, such that compressions are applied normally to the surface of the sensor. Such a physical implementation entails motion normal to the sensor plane (perpendicular to the chest) to be larger than motion in the planar directions (parallel to the chest). If this check is not met, then it is likely that the patient is in experiencing a physically extraordinary circumstance, such as falling, chaotic transport, going down stairs, being picked up and accommodated (e.g., for pediatric situations), among other possible situations where motion is likely not actual CPR motion. If the first motion sensor 21 is positioned as shown in rows 1404 or 1406 of FIG. 14, this condition will be met.

However, this condition will not be met if the motion sensor 21 is positioned on the patient's side as shown in rows 1604 and 1606 of FIG. 16. Indeed, such checks are provided so as to confirm that the sensors are appropriately positioned according to proper placement and orientation indications, and also to confirm that the motion characteristics are reliable. If there is enough motion, and such checks are not met, then for various embodiments, the medical system may be confirmed to default to anterior-anterior (single sensor) chest compression feedback, for the current CPR episode. For example, when appropriate A-P confirmation for dual sensor feedback is not met for the particular CPR episode is not met, then A-A single sensor feedback may be provided until the next CPR episode, upon which the same set of logic checks may be performed again. During a typical resuscitation protocol, CPR episodes may be intermittently paused so as to check for a patient pulse and/or to determine whether the patient requires a defibrillation shock, and then once such pulse and ECG checks are performed, then subsequent CPR episodes may be performed. For purposes of the present disclosure, it may be appropriate to initiate the logic for determining the type of chest compression feedback for each CPR episode.

[00224] For certain embodiments, if the processor determines that either the oscillatory motion in the z-direction of the anterior motion sensor 21 is less than the oscillatory motion in the z-direction of the posterior motion sensor 23 or the oscillatory motion in the z-direction of the anterior motion sensor 21 is less than the oscillatory motion in the x-direction and the y-direction of the anterior motion sensor 21, the processor may be configured to confirm that an output device associated with the medical system should provide chest compression feedback to the rescuer at block 1026 based on the motion of the anterior motion sensor 21 positioned on an anterior portion of the patient's chest without contribution from the motion of the posterior motion sensor 23.

[00225] If the processor determines that the oscillatory motion in the z-direction of the anterior motion sensor 21 is greater than the oscillatory motion in the z-direction of the posterior motion sensor 23 and the oscillatory motion in the z-direction of the anterior motion sensor 21 is greater than the oscillatory motion in the x-direction and the y-direction of the anterior motion sensor 21, the processor may be configured to determine, as provided at block 1036, an angle of the motion sensor 23 positioned on the posterior portion of the patient 2 with respect to gravity and compare the angle with a threshold angle. In various embodiments, the threshold angle is about 30 degrees, about 40 degrees, about 50 degrees, or about 60 degrees. For certain embodiments, such an angle may be calculated using the oscillatory AC component of the motion signal. While in various embodiments, orientation

of the sensors is checked with respect to gravity, in other embodiments, the orientation angle of both anterior and posterior sensors may be calculated, and a determination may be made of the axis of motion for the CPR therapy (which may differ from the direction of gravity). The orientation angle of each sensor may then be compared against the reference axis (axis of motion for the CPR therapy), rather than with respect to gravity. In some embodiments, the orientation angle of the anterior sensor may be considered as the reference axis (axis of motion for the CPR therapy), and the orientation threshold checks and/or angular corrections for the posterior sensor orientation angle may be with respect to this reference axis. For example, as shown in FIG. 21, when the anterior sensor 21 is oriented as shown in solid lines and the posterior sensor 23 is oriented as shown in solid lines, then the reference axis 2101 corresponds to the direction of gravity and the axis of motion for CPR therapy as denoted by arrow 2100. On the other hand, if the anterior sensor 21a or 21b is oriented as shown by the dotted lines, then the reference axis 2103 or 2105 is provided at the orientation angle of the anterior sensor 21a, 21b and corresponds to the axis of motion for the CPR therapy as denoted by arrows 2102 and 2104. In such instances, the orientation threshold checks and/or angular corrections for the orientation angle of the posterior sensor 23a or 23b may be performed with respect to the reference axis 2103 or 2105. If the processor determines that the angle of the motion sensor 23 is greater than the threshold angle, the processor confirms that an output device associated with the medical system should provide chest compression feedback to the rescuer at block 1026 based on the motion of the anterior motion sensor 21 positioned on an anterior portion of the patient's chest without contribution from the motion of the posterior motion sensor 23.

[00226] In accordance with the embodiment illustrated in Fig. 11, if the processor determines that the angle of the posterior motion sensor 23 with respect to gravity is less than the threshold angle, the processor confirms that the orientation is acceptable (e.g., non-inverted) for purposes of providing dual sensor chest compression feedback. Accordingly, upon determination that the angle of orientation of the posterior motion sensor 23 falls within acceptable orientation parameters, an output device associated with the medical system may provide chest compression feedback to the rescuer at block 1038 based on the motion of the anterior motion sensor 21 positioned on an anterior portion of the patient's chest and the posterior motion sensor 23 positioned on a posterior portion of the patient.

[00227] For some embodiments, even if the processor determines that the angle of the posterior motion sensor 23 with respect to gravity is less than an associated threshold angle where rotational correction is still applicable, the processor may be configured to make a

correction based on a rotation matrix. Since the posterior motion sensor 23 may be configured as a three-axis accelerometer, it can measure acceleration in three dimensions. Accordingly, it is possible to determine a baseline orientation of the posterior motion sensor 23 and then rotate the posterior motion sensor 23 to be within the threshold angle (i.e., about 30 degrees) with respect to gravity.

[00228] For certain cases, the rotation of a baseline vector of the posterior motion sensor 23 may be determined by averaging a quiet period with no movement. From these vectors the angles (α , β , γ) between the posterior motion sensor 23 and gravity are calculated. A rotation matrix is then calculated to first rotate the reference vector around the Z-axis by an angle γ (see Equation 1 below) and then rotate the vector again around the X-axis by an angle α (see Equation 2 below). Each measurement on the posterior motion sensor 23 is multiplied by the rotation matrix $R_x R_z$.

$$\text{Equation 1} \quad R_z = \begin{bmatrix} \cos(\gamma) & -\sin(\gamma) & 0 \\ \sin(\gamma) & \cos(\gamma) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\text{Equation 2} \quad R_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\alpha) & -\sin(\alpha) \\ 0 & \sin(\alpha) & \cos(\alpha) \end{bmatrix}$$

[00229] After the rotation is performed, the processor can then control an output device associated with the medical system to provide chest compression feedback to the rescuer at block 1038 based on both the motion of the anterior motion sensor 21 positioned on an anterior portion of the patient's chest and the posterior motion sensor 23 positioned on a posterior portion of the patient (i.e., anterior-posterior chest compression feedback). Or, in some cases, if the processor determines that the angle of the posterior motion sensor 23 with respect to gravity is greater than the associated threshold angle, then it may be the case that single sensor compression feedback is provided; for example, if the angle of the posterior motion sensor 23 falls outside of an acceptable orientation range, then single sensor (A-A) chest compression feedback may be provided using signals from the anterior motion sensor 21, without contribution from the signals from the posterior motion sensor 23. Alternatively, if the processor determines that the angle of the posterior motion sensor 23 with respect to gravity is greater than the associated threshold angle, the processor may also be configured to make a correction based on a rotation matrix, as discussed above. Indeed, for some

embodiments, regardless of the angle of orientation of the motion sensors, the processor may be configured to make an appropriate rotational correction.

[00230] The processor may also be configured to receive the electrical impedance signal from the electrode assemblies 5A, 5B once the type of chest compression feedback is determined. The processor may compare this impedance signal to a threshold value for determining sufficient conductivity and, if the electrical impedance is below the threshold value, confirms that conductivity through the patient 2 is sufficient at blocks 1040, so as to determine that the electrode assemblies 5A, 5B are properly adhered to the patient. If it is determined that electrical impedance is above the threshold value indicating that the electrode assemblies 5A, 5B have fallen off the patient 2 or are otherwise positioned such the impedance is too high for an electrical current to flow there through, the processor provides a signal to an output device associated with the medical system to provide an instruction to the rescuer to confirm that the electrode assemblies 5A, 5B are securely positioned on the patient and returns to block 1000 (see blocks 1042). Such steps are referred to hereinafter as an impedance reset. This occurs when the system detects that the electrode assemblies 5A, 5B have been removed from the patient and either repositioned or replaced with new electrode assemblies. In some embodiments, the impedance signal from the electrode assemblies 5A, 5B may be further used as a way to cross-correlate valid and invalid compressions. That is, to determine whether a CPR compression episode is occurring, then in addition to motion sensor signals, impedance signals may be used as an additional check. For instance, when chest compressions are occurring, both impedance measurements and motion sensor signals may be observed to exhibit sinusoidal behavior, in synchrony; whereas road noise or other sources of CPR sensor motion error tend to not be captured by such sinusoidal oscillations in the electrical impedance of the electrode assemblies 5A, 5B. Such a check may allow for both the impedance and motion (e.g., acceleration, displacement, etc.) signals to be used to confirm and/or disconfirm whether a CPR compression episode is occurring.

[00231] With reference to FIG. 12, for certain embodiments, if the electrode assemblies 600, 602 are identified as pediatric A-P electrode assemblies, such as shown in FIGS. 6A and 6B, the processor may be configured to perform additional steps to confirm whether the electrode assemblies are actually positioned on the pediatric patient by the rescuer in an anterior-posterior orientation as shown in FIGS. 6A and 6B, for example, to provide accurate dual sensor chest compression feedback to the rescuer. For particularly small patients, such as infants or neonates, where more shifting or movement may occur in a resuscitation as compared to that of larger patients, it may be preferable to perform additional checks to see

whether the motion sensors are placed appropriately. At block 1044, the processor determines whether the motion sensor 603 associated with the posterior electrode assembly 602 is positioned in an inverted orientation, or otherwise falls outside of an acceptable angle of orientation range. The processor receives and processes signals from the motion sensor 603 to measure motion of the motion sensor 603. As discussed hereinabove, with reference to FIG. 9, the signals from motion sensor 603 include an AC component representative of oscillatory motion of the motion sensor 603 and a DC component representative of positional motion of the motion sensor 603. In order to determine whether the motion sensor 603 is inverted, or otherwise falling outside of an acceptable angle of orientation range, the DC component of the signal is utilized by the processor within a predetermined time period after placement of the electrode assemblies 600, 602 on the patient 2. This time period may be anywhere from 1-5 seconds, 1-10 seconds, or 1-15 seconds. Alternatively, the processor may determine that the motion sensor 603 is positioned at an orientation having an angle that falls outside of an acceptable orientation range by measuring an angle of the motion sensor 603 based on either or both of DC component and the AC component of the signals provided by the motion sensor 603. If the processor determines that the motion sensor 603 is provided in an orientation that falls outside of an acceptable orientation range, such as an inverted orientation, then the processor confirms that an output device associated with the medical system should provide chest compression feedback to the rescuer at block 1046 utilizing the signals from the anterior motion sensor 601 positioned on an anterior portion of the patient's chest. In some embodiments, since the posterior motion sensor 603 is inverted, the chest compression feedback provided to the rescuer is calculated using signals from the anterior motion sensor 601, without contribution from signals from the posterior motion sensor 603. However, in other embodiments, when it is determined that the posterior motion sensor 603 is inverted, the signals from posterior motion sensor 603 may be corrected with an algorithmic inversion, resulting in the correct posterior sensor signal such that dual compression sensor feedback may still be employed.

[00232] If it is determined that the posterior motion sensor 603 is positioned in a non-inverted manner or otherwise falling within of an acceptable angle of orientation, such as shown in row 1408 of FIG. 14 and FIGS. 6A and 6B, then the processor determines whether the rescuer has commenced providing chest compressions to the patient 2 based on the motion of the motion sensors 601, 603 at block 1048. For example, if the motion of the sensors in the Z direction is determined to be indicative of a chest compression, the number of chest compressions are then determined over a period of time. The period of time may be 5

seconds, 10 second, or 15 seconds, for instance. If the number of chest compressions are greater than a predetermined threshold, and/or if morphological features of the motion signal fall within appropriate criteria for determining that the signal is indicative of chest compressions, then the processor provides an indication that chest compressions have commenced. In addition, additional processing steps are utilized to accurately determine that the motion of the motion sensors 601, 603 corresponds to a chest compression rather than noise caused by external motion of the patient (such as ambulance motion or other such external sources of noise).

[00233] Once the processor determines that chest compressions have commenced, the processor may then determine whether the motion sensor 601 associated with the anterior electrode assembly 600 is positioned at an orientation having an angle that falls outside of an acceptable orientation range (i.e., such as at an inverted orientation) at block 1050. For instance, since the anterior motion sensor 601 may be configured to be detached from the electrode assembly 600 as discussed hereinabove, a rescuer may detach the anterior motion sensor 601 and, over the course of the resuscitation event, inadvertently flip the motion sensor during use. With reference to FIGS. 13C and 13D, a pediatric anterior motion sensor 601 is illustrated in a non-inverted orientation (i.e., with the upper side 1300 facing away from the patient and the lower side 1302 facing toward the patient, see Fig. 13C) and in an inverted orientation (i.e., with the upper side 1300 facing toward the patient and the lower side 1302 facing away from the patient, see Fig. 13D), respectively. The processor receives and processes signals from the anterior motion sensor 601 to measure motion of the motion sensor. As discussed hereinabove, with reference to FIG. 9, the signals from anterior motion sensor 601 include an AC component representative of oscillatory motion of the motion sensor 601 and a DC component representative of positional motion of the anterior motion sensor 601. In order to determine whether the anterior motion sensor 601 is inverted, the DC component of the signal may be utilized by the processor to determine whether the anterior motion sensor 601 is provided in an inverted orientation. . Alternatively, the processor may determine that the motion sensor 601 is positioned at an orientation having an angle that falls outside of an acceptable orientation range by measuring an angle of the motion sensor 601 based on either or both of DC component and the AC component of the signals provided by the motion sensor 601. If it is determined that the motion sensor 601 is in an orientation that falls outside of an acceptable orientation range, such as an inverted orientation, then the processor may confirm that an output device associated with the medical system should provide chest compression feedback to the rescuer at block 1046 by inverting the signals

from the motion sensor 601 positioned on an anterior portion of the patient's chest. Such a situation occurs when the electrode assemblies 600, 602 are placed on the chest of a pediatric patient 2 in configuration as shown in row 1704 of FIG. 17.

[00234] If it is determined that the anterior motion sensor 601 is positioned in a non-inverted manner or otherwise falling within an acceptable angle of orientation, such as shown in row 1408 of FIG. 14, the processor then determines, at block 1052, whether oscillatory motion of the posteriorly positioned motion sensor 603 is greater than a threshold sufficient to initiate anterior-posterior chest compression feedback using the AC component of the signal obtained by the motion sensor 603. For instance, if too little, insufficient or no motion of the posterior motion sensor 603 is detected, the medical system may return to block 1044. The threshold may be set at any suitable value such as an acceleration detection that is equivalent to at least 0.5 inches of displacement. In certain embodiments, the threshold may be set to at least 0.3 inches of displacement and in other embodiments the threshold may be set to at least 0.1 inches of displacement. In some embodiments, anterior-posterior chest compression feedback employing motion signals from both the anterior motion sensor 601 and the posterior motion sensor 603 (e.g., where subtraction of the posterior displacement from the anterior displacement is performed) may be provided regardless of how small the signals are from the posterior motion sensor 603.

[00235] For certain embodiments, if it is determined that the oscillatory motion of the posteriorly positioned motion sensor 603 is greater than a threshold for determining sufficiency of movement indicative of chest compressions, the processor then determines, at block 1054, whether oscillatory motion of the anterior motion sensor 601, positioned on an anterior portion of the patient 2, in the z-direction shown in FIG. 1 is greater than the oscillatory motion of the posterior motion sensor 603, positioned on a posterior portion of the patient 2, in the z-direction. If the first motion sensor 601 and the second motion sensor 63 are positioned as shown in row 1408 of FIG. 14, this condition will be met. However, this condition will not be met if the motion sensor 603 is positioned on an anterior portion of the patient's chest or if the motion sensor 603 is positioned on a lateral portion of the patient's chest as shown in rows 1700 and 1702 of FIG. 17, which are examples of unorthodox, mistaken, or otherwise non-indicated pad placements. If both motion sensors 601, 603 are positioned on lateral portions of the patient's chest as shown in row 1700 of FIG. 17, then the medical system will not provide any chest compression feedback due to the unreliability of the signals provided by the motion sensors in such a configuration. However, if the rescuer detaches the motion sensor 601 and places it on an anterior portion of the chest as shown in

row 1702 of FIG. 17, the system can provided chest compression feedback based on the motion of the motion sensor 601 without contribution from the motion of the motion sensor 603 if the motion sensor 603 is miss-positioned.

[00236] In addition, the processor may further determine, at block 1054, whether the oscillatory motion in the z-direction of the anteriorly positioned motion sensor 601 is greater than the oscillatory motion in x-direction and the y-direction of the motion sensor 601 (see FIG. 1). If the first motion sensor 21 is positioned as shown in rows 1408 of FIG. 14 and 1702 of FIG. 17, this condition will be met. However, this condition will not be met if the motion sensor 601 is positioned on the patient's side as shown in row 1700 of FIG. 17.

[00237] If the processor determines that either the oscillatory motion in the z-direction of the anterior motion sensor 601 is less than the oscillatory motion in the z-direction of the posterior motion sensor 603 or the oscillatory motion in the z-direction of the anterior motion sensor 601 is less than the oscillatory motion in the x-direction and the y-direction of the anterior motion sensor 601, the processor may confirm that an output device associated with the medical system should provide chest compression feedback to the rescuer at block 1046 based on the motion of the anterior motion sensor 601 positioned on an anterior portion of the patient's chest without contribution from the motion of the posterior motion sensor 603. As discussed herein, during chest compressions that are naturally envisioned for sensors placed as indicated for use, oscillatory motion in the z-direction of the anterior motion sensor 601 are expected to be greater than oscillatory motion in the z-direction of the posterior motion sensor 603; and oscillatory motion in the z-direction of the anterior motion sensor 601 are expected to be greater less than oscillatory motion in the x-direction and the y-direction of the anterior motion sensor 601.

[00238] If the processor determines that the oscillatory motion in the z-direction of the anterior motion sensor 601 is greater than the oscillatory motion in the z-direction of the posterior motion sensor 603 and the oscillatory motion in the z-direction of the anterior motion sensor 601 is greater than the oscillatory motion in the x-direction and the y-direction of the posterior motion sensor 601, the processor then determines, at block 1056, an angle of the motion sensor 603 positioned on the posterior portion of the patient 2 with respect to gravity and compares the angle with a threshold angle. In various embodiments, the threshold angle is about 30 degrees, about 40 degrees, about 50 degrees, or about 60 degrees. For certain embodiments, such an angle may be calculated using the oscillatory AC component of the motion signal. While in various embodiments, orientation of the sensors is checked with respect to gravity, in other embodiments, the orientation angle of both anterior and posterior

sensors may be calculated, and a determination may be made of the axis of motion for the CPR therapy (which may differ from the direction of gravity). The orientation angle of each sensor may then be compared against the reference axis (axis of motion for the CPR therapy), rather than with respect to gravity. In some embodiments, the orientation angle of the anterior sensor may be considered as the reference axis (axis of motion for the CPR therapy), and the orientation threshold checks and/or angular corrections for the posterior sensor orientation angle may be with respect to this reference axis. If the processor determines that the angle of the posterior motion sensor 603 is greater than the threshold angle (excessively tilted), the processor confirms that an output device associated with the medical system should provide chest compression feedback to the rescuer at block 1046 in accordance with single sensor compression feedback, based on the motion of the anterior motion sensor 601 positioned on an anterior portion of the patient's chest without contribution from the motion of the motion sensor 603.

[00239] Though, if the processor determines that the angle of the motion sensor 603 is less than the threshold angle (not excessively tilted), the processor confirms that an output device associated with the medical system should provide chest compression feedback to the rescuer at block 1058 in accordance with dual sensor compression feedback, based on the motion of the motion sensor 601 positioned on an anterior portion of the patient's chest and the motion sensor 603 positioned on a posterior portion of the patient. In addition, the processor may be configured to make a correction based on a rotation matrix as discussed hereinabove.

[00240] The processor may also be configured to receive the electrical impedance signal from the electrode assemblies 600, 602. The processor compares this signal to a threshold value and, if the electrical impedance is below the threshold value, confirms that conductivity through the patient 2 is sufficient at blocks 1060 so as to enable current to pass through the patient. If it is determined that electrical impedance is above the threshold value indicating that the electrode assemblies 5A, 5B have fallen off or otherwise not properly adhered to the patient 2 so as to allow sufficient current to pass through the patient, the processor provides a signal to an output device associated with the medical system to provide an instruction to the rescuer to confirm that the electrode assemblies 5A, 5B are securely positioned on the patient and returns to block 1000 (see blocks 1062). Such steps are referred to hereinafter as an impedance reset. This occurs when the system detects that the electrode assemblies 5A, 5B have been removed from the patient and either repositioned or replaced with new electrode assemblies.

[00241] In addition, in the pediatric flow chart of FIG. 12 unlike the adult flow chart of FIG. 11, the processor may be configured to perform additional steps once it is determined to provide single sensor chest compression feedback at block 1046 in order to confirm that dual sensor chest compression feedback may actually be appropriate. That is, despite a finding that single sensor compression feedback is to be provided, the logic in Fig. 12 for pediatric assemblies provides for a path in which the system may switch to dual sensor compression feedback. The reason is that when a pediatric patient is being treated, it is more likely that anterior-posterior chest compression feedback is applicable and compression depths calculated from both anterior and posterior motion sensors may provide for a higher degree of accuracy. As one method of providing CPR chest compressions to a pediatric patient is to squeeze the patient's thorax from both sides (e.g., using encircling hands such that the caregiver pushes fingers in the back as well as thumbs at the top), the amplitude on both sensors may independently vary, leading to a placement check failure. Accordingly, it is sometimes necessary to further check whether anterior-posterior chest compression feedback is applicable. In addition, it is more likely that a small patient, such as a baby will be moved and shifted, in ways that result in angles detected that may suggest the back sensor is inverted, which would cause the system to more readily confirm that single sensor chest compression feedback is appropriate.

[00242] Therefore, once the processor determines that single sensor chest compression feedback is appropriate at block 1046, the logic provides a path to provide dual sensor chest compression feedback at block 1058. For instance, the processor continues to determine whether a CPR episode has commenced at block 1064 in the manner described hereinabove with regard to block 1048. If no CPR episode has been detected, the medical system continues to be set to provide single sensor chest compression feedback at block 1046. On the other hand, if a CPR episode is detected, then the processor determines whether the motion sensor 603 is inverted or otherwise falling outside an acceptable orientation range at block 1066 as described with regard to block 1044. If the motion sensor 603 is determined to be inverted, the medical system continues to be set to provide single sensor chest compression feedback at block 1046. Otherwise, the processor is configured to determine whether the motion sensor 601 is inverted at block 1068 as described above with regard to block 1050. If the motion sensor 601 is determined to be inverted, the medical system continues to be set to provide single sensor chest compression feedback at block 1046. Otherwise, the processor is configured to determine where the oscillatory motion of the sensor 603 is above a threshold at block 1070 as described above with regard to block 1052. If the oscillatory motion of the

motion sensor 603 is insufficient, the system then returns to block 1044. If the oscillatory motion of the motion sensor 603 is greater than the threshold, then the processor is configured to determine an angle of the motion sensor 603 and compare the angle to a threshold angle at block 1072 in the manner described with regard to block 1056. If the angle of the motion sensor 603 is greater than the threshold, the medical system continues to be set to provide single sensor chest compression feedback at block 1046. However, if the angle of the motion sensor 603 is less than the threshold, conditions are met for the medical system to provide dual sensor chest compression feedback at block 1058, despite an initial confirmation to provide single sensor chest compression feedback at block 1046.

[00243] In addition, with reference to FIG. 18 and whether adult or pediatric resuscitation assemblies are utilized, once it is established that anterior-posterior or dual sensor chest compression feedback is appropriate at blocks 1038 and 1058, the processor will continuously process the signals obtained from the motion sensors to determine whether a CPR episode has commenced at block 1074 as described hereinabove with regard to blocks 1028 and 1048. If a CPR episode has commenced, the processor will determine whether the motion sensor positioned on the anterior portion of the patient's chest has been inverted at block 1076. If the motion sensor positioned on the anterior portion of the patient's chest is determined to be non-inverted or otherwise falling within an acceptable orientation range, the system will continue to provide anterior-posterior or dual sensor chest compression feedback at blocks 1038 and 1058. If the motion sensor positioned on the anterior portion of the patient's chest is determined to be inverted or otherwise falling outside the acceptable orientation range, the system will change to providing anterior-anterior or single sensor chest compression feedback at blocks 1026 and 1046. The reason for these steps performed by the processor is that during the application of chest compressions, the anterior motion sensor may become inverted due to the application of chest compressions by the rescuer directly on the motion sensor; and by virtue of the ability for the sensor to be physically detached from the electrode assembly and erroneously misplaced in the inverted position prior to or during the course of chest compressions. While in some cases, it may be a default for single sensor compression feedback to remain once confirmed, however, for certain embodiments, the type of feedback may switch between single sensor compression feedback and dual sensor compression feedback in real-time over the course of the resuscitation event as it is determined which type of feedback is appropriate.

[00244] With reference to FIGS. 19-21, the at least one processor is further configured to receive and process signals from the motion sensor 21 associated with electrode assembly 5A

and the motion sensor 23 associated with the electrode assembly 5B to measure motion of the motion sensor 21 and the motion of the motion sensor 23; determine an orientation of the motion sensor 21 to ensure that the first motion sensor is positioned on the anterior portion of the patient's anatomy within substantially 45 degrees with respect to gravity as shown in cell (a) of FIG. 19; and determine an orientation of the motion sensor 23 to ensure that the motion sensor 23 is positioned on the posterior portion of the patient's anatomy within substantially 30 degrees with respect to the motion sensor 21 as shown in cell (b) of FIG. 19. In other embodiments, an orientation of the motion sensor 21 is determined to ensure that it is positioned within 30 degrees with respect to gravity and in still other embodiments, an orientation of the motion sensor 21 is determined to ensure that it is positioned within 60 degrees with respect to gravity. Likewise, in some embodiments, an orientation of the motion sensor 23 is determined to ensure that it is positioned within 45 degrees with respect to the motion sensor 21, and in still other embodiments, an orientation of the motion sensor 23 is determined to ensure that it is positioned within 60 degrees with respect to the motion sensor 21.

[00245] More specifically, the processor of the medical system is configured to use the orientation of the anterior motion sensor 21 and posterior motion sensor 23 to determine electrode assembly placement and to calculate if a rotation of the anterior motion sensor 21 and/or the posterior motion sensor 23 is needed to provide accurate chest compression feedback. In order for the electrode assembly placement detection to be executed by the processor, the processor may first wait for a "quiet time" (i.e., a short period of time where no motion is detected (within thresholds)). This "quiet time" is provided so that the signal from motion sensors 21, 23 settles to ensure that orientation, rather than motion, is characterized by the signal. In another embodiment, the "quiet time" can be eliminated by filtering the sinusoidal signal provided by the motion sensors 21, 23 to remove high oscillations and then averaging the signals.

[00246] The processor, based on the signals provided by the motion sensor 21, checks the orientation of the anterior motion sensor 21 to ensure it is within about ± 45 degrees with respect to gravity as shown in FIG. 19. Since the motion sensor 21 may be configured to be detached from the electrode assembly 5A as described hereinabove, if a user detaches the anterior motion sensor 21 and mistakenly inverts it prior to performing chest compressions, the data obtained from the motion sensor 21 will be inverted. As described hereinabove, the processor may be configured to determine such an inversion and correct the data, thereby yielding allowable orientations of the anterior motion sensor 21 with respect to gravity. The

allowable orientations of the anterior motion sensor 21 with respect to gravity may be from about ± 30 degrees to about ± 60 degrees on the top and bottom planes of the motion sensor 21. In one particular embodiment, the allowable orientations of the anterior motion sensor 21 with respect to gravity may be ± 45 degrees on the top and bottom planes of the motion sensor 21.

[00247] The processor may also be configured to determine an orientation of the posterior motion sensor 23 to ensure it is within about ± 15 degrees to about ± 45 degrees with respect to the anterior motion sensor 21. In one example, the processor determines an orientation of the posterior motion sensor 23 to ensure it is within about ± 30 degrees with respect to the anterior motion sensor 21 as shown schematically by cell (b) of FIG. 19. In most of the resuscitation assemblies described hereinabove, the posterior motion sensor 23 is embedded into the electrode assembly 5B and can be oriented according to how the electrode assembly 5B is oriented. Accordingly, the processor is configured to cause an output device to provide chest compression feedback for the user based on the motion from the motion sensor 21 and the motion sensor 23 in response to a determination that the motion sensor 21 is positioned on the anterior portion of the patient's anatomy within substantially 45 degrees with respect to gravity and a determination that the motion sensor 23 is positioned on the posterior portion of the patient's anatomy within an acceptable range with respect to the motion sensor 21.

[00248] With reference to FIG. 20, for some embodiments, the processor identifies placement of the electrode assemblies 5A, 5B as anterior-posterior (A-P) if the orientation of the anterior motion sensor 21 and the posterior motion sensor are within acceptable orientation ranges. For example, an acceptable orientation range of the anterior motion sensor 31 is about ± 30 degrees with respect to gravity to about ± 60 degrees with respect to gravity. In one embodiment, the acceptable orientation range may be about ± 45 degrees with respect to gravity. In one example, an acceptable orientation range of the posterior motion sensor 23 is within about ± 15 degrees with respect to the anterior motion sensor 21 to about ± 45 degrees with respect to the anterior motion sensor 21. For example, the acceptable orientation range of the posterior motion sensor may be about ± 30 degrees with respect to the anterior motion sensor. Placement of the electrode assemblies 5A, 5B is identified as anterior-anterior (A-A) if the orientation of the anterior motion sensor 21 is within about ± 30 degrees with respect to gravity to about ± 60 degrees with respect to gravity and if the orientation of the posterior motion sensor 23 is outside about ± 15 degrees with respect to the anterior motion sensor 21 to about ± 45 degrees with respect to the anterior motion sensor 21. In one embodiment, placement of the electrode assemblies 5A, 5B is identified as anterior-anterior

(A-A) if the orientation of the anterior motion sensor 21 is within about ± 45 degrees with respect to gravity and if the orientation of the posterior motion sensor 23 is outside about ± 30 degrees with respect to the anterior motion sensor 21. Placement the electrode assemblies 5A, 5B is identified as Other (i.e., lateral-lateral, etc.) and no chest compression feedback is provided if the orientation of the anterior motion sensor 21 is outside about ± 45 degrees with respect to gravity, irrespective of the orientation of the posterior motion sensor 23. For example, the anterior motion sensor 21 may be determined to be positioned on the side of a patient if the angle of the anterior motion sensor is determined to be in a range of about ± 46 degrees with respect to gravity to about ± 135 degrees with respect to gravity.

[00249] With reference to FIG. 21, since the preferred acceptable sensor orientations for the anterior motion sensor 21 are based on the orientation with respect to gravity, while the ones for the posterior motion sensor 23 are based on the orientation with respect to the anterior motion sensor 21, the resulting preferred acceptable sensor placement range can have a complicated set of permitted combinations. The FIG. 21 illustrates all positions permitted by the tolerance ranges.

[00250] Once the system and associated processor(s) determines the type of resuscitation assembly that is connected and the placement of the resuscitation assembly, various resuscitation-related features of the system are adjusted accordingly to suit the therapy, such as electrotherapy, CPR parameters, user interface display, shock analysis, and/or other aspects of resuscitative therapy. For instance, if the system detects that a pediatric assembly is in use, the system may set the defibrillation energy level to be lower than if the system detected an adult assembly. Alternatively, depending on whether a pediatric or adult resuscitation assembly is detected, the user interface for providing CPR feedback may be altered. For example, when detecting that an adult assembly has been connected, the user interface may provide estimated chest compression depth and rate values for the rescuer, and also provide instructions for the rescuer to apply chest compressions within a certain range of depth (e.g., 2.0-2.4 inches) and rate (e.g., 100-120 cpm), according to current clinical guidelines. However, when detecting that a pediatric assembly has been connected, the user interface may provide estimated chest compression depth and rate values, without instructing the rescuer on the proper application of chest compressions, for example allowing a trained rescuer to administer chest compressions to the patient without instructions. Further, the shock analysis algorithm applied may differ depending on whether the system detects a pediatric or adult resuscitation assembly. For instance, the pediatric shock analysis algorithm can be calibrated to analyze a child's ECG signal rather than an adult's ECG signal such that

the defibrillator can make a more accurate determination of whether a shock should be delivered to the pediatric patient. In general, the defibrillator can measure the ECG baseline content, QRS rate, width and variability, amplitude, and temporal regularity and determine whether a shockable rhythm exists. For the pediatric patient, one or more of the measured values can be different for a shockable rhythm than for the adult patient.

[00251] As described hereinabove, the systems of the present disclosure may be utilized to provide feedback to a user regarding resuscitation activities (e.g., chest compressions, ventilations) being performed on the patient by the rescuer with improved accuracy. More specifically, with reference to FIG. 22, in operation, a rescuer 2200 may place the electrode assemblies 5A and 5B (located posteriorly and therefore not seen in FIG. 22) of the resuscitation assembly 3 in an A-P orientation, with the first electrode assembly 5A being positioned on the adult patient's sternum and the second electrode assembly 5B being positioned on the patient's back. Alternatively, the electrode assemblies of the resuscitation assembly may be positioned on the patient in an A-A orientation. Specifically, in such a configuration, one electrode assembly is positioned on a right side of a chest of the patient 2 between the armpit and the sternum, with the portion of the electrode assembly comprising the motion sensor placed substantially above the sternum. The other resuscitation assembly is an apex electrode assembly and is positioned on a left side of the chest of the patient 2 over lower ribs of the patient 2. In either configuration, the motion sensors of the electrode assemblies may be provided as three-axis accelerometers as described hereinabove such that acceleration in the x, y, and z directions is measured simultaneously with each of two sensors incorporated within respective electrode assemblies. Alternatively, the motion sensors of the electrode assemblies may be provided as six-axis accelerometer and gyroscope such that acceleration in the x, y, and z directions can be measured along with yaw, pitch, and roll. The use of such a sensors allows the orientation to be measured along with the above-described determinations.

[00252] Once the electrode assemblies 5A, 5B included with the resuscitation assembly 3 of the present disclosure are properly placed, they are operatively connected to a computing device, such as a defibrillator 2202 having control circuitry (not shown) and an output device, such as display 2204 and/or a speaker (not shown), to provide output to a user. Such assemblies may be connected via cables 9, or alternatively one or more of the motion sensors may be operatively coupled to the defibrillator and/or other devices using wireless technology (e.g. Bluetooth, WiFi, radio frequency, near field communication, etc.). The control circuitry used in the defibrillator 2202 may be any suitable computer control system, and may be

disposed within the housing of the defibrillator 2202. Alternatively, the control circuitry may be disposed within an associated defibrillator, within an associated mechanical chest compression device, or it may be a general purpose computer or a dedicated single purpose computer. The control circuitry may comprise the at least one processor described hereinabove and at least one memory including program code stored on the memory, where the computer program code is configured such that, with the at least one processor, when run on the processor, it causes the processor to perform the functions described throughout this disclosure. These functions include interpreting the signals from the motion sensors 21, 23, and/or signals produced by other sensors, to determine compression depth, and produce signals indicative of the calculated compression depth, and operate outputs such as speakers or displays to provide feedback to a rescuer. In addition, once the electrode assemblies 5A, 5B are operatively connected to the defibrillator 2202, the processor performs the steps described hereinabove to determine the placement of the electrode pads and provide instructions to the output device to provide the correct chest compression feedback based on the motion from either the motion sensor 21 or both the motion sensors 21, 23.

[00253] In one example, the output device of the defibrillator 2202 provides information about patient status and CPR administration quality during the use of the defibrillator 2202. The data is collected and displayed in an efficient and effective manner to a rescuer. For example, during the administration of chest compressions, the output device may display on display 2204 information about the chest compressions.

[00254] The information about the chest compressions may be automatically displayed in display 2204 when compressions are detected. The information about the chest compressions displayed may include indications for estimated values of rate 2206 (e.g., number of compressions per minute) and depth 2208 (e.g., depth of compressions in inches or millimeters). Information about chest compressions displayed on display 2204 may also include an intuitive indication of the quality of chest compressions, for example, a perfusion performance indicator (PPI) 2210. The PPI 2210 may be provided as a graphical indicator, such as a shape (e.g., a diamond) that fills according to whether the rate and/or depth of compressions are within target range(s), to provide feedback regarding both the rate and depth of compression. The entire indicator is filled when compressions are performed at a particular target range for rate (100-120 CPM) and the depth of compressions falls within 2.0-2.4 inches. As the velocity and/or depth decreases below the acceptable limit, the amount that is filled decreases. The PPI 2210 provides a visual indication of the quality of the CPR so that the rescuer can aim to keep the PPI 2210 fully filled. That is, the rate and depth of

compressions may be provided as inputs for whether the graphical PPI 2210 fills, indicating that the overall quality of compressions at that particular moment is acceptable. The rate and depth of compressions can be determined by analyzing readings from the motion sensors 21, 23. Displaying the actual rate and depth data (in addition to or instead of an indication of whether the values are within or outside of an acceptable range) is believed to provide useful feedback to the rescuer. For example, if an acceptable range for chest compression depth is between 2.0-2.4 inches, providing the rescuer with an indication that his/her compressions are only 0.5 inches, can allow the rescuer to determine how to correctly modify his/her administration of the chest compressions.

[00255] More specifically, the control circuitry of the defibrillator 2202 is operatively connected to and programmed to receive and process signals from the motion sensors 21, 23 of the electrode assemblies 5A and 5B to determine whether at least one of a chest compression depth and rate during administration of CPR falls within a desired range. The output device of the defibrillator 2202 then provides feedback instructions to the rescuer 2200 to maintain the chest compression depth and rate during CPR within the desired range.

[00256] With the electrode assemblies 5A and 5B positioned in an anterior-posterior position as shown in FIG. 22, in one example, the chest compression depth is calculated by subtracting a distance traveled by the motion sensor 5 of the second electrode assembly 63 from a distance traveled by the motion sensor 3A of the first electrode assembly 61. Additional details on the manner in which chest compression depth is calculated is found in United States Patent No. 10,406,345. In addition, along with compression depth, other parameters may be calculated using information obtained from the motion sensors 3A, 5. For example, based on the motion signals recorded from the motion sensors of the electrode assemblies of the resuscitation assembly of the present disclosure, processing circuitry in a system for providing resuscitation assistance may receive and process the recorded data to determine: 1) whether a patient is being transported; 2) the overall orientation of the patient; 3) whether the electrode assemblies are provided in A-A orientation or an A-P orientation; 4) the type of surface upon which a patient is placed; 5) a rate of ventilations for a patient; 6) whether the source of compressions is from an automated compression device or manually provided; and/or 7) type of manual compression technique being used (e.g., two thumbs with encircling hands, two fingers pushing downward, palm compressions, active compression-decompressions, lateral-lateral compressions, etc.). Additional details of the manner in which the processing circuitry performs such calculations is provided in disclosed in United States Patent No. 10,406,345.

[00257] In one exemplary, non-limiting embodiment, it is common for a patient to be lying on a substantially rigid surface (e.g., a floor, gurney, backboard) prior to initiating chest compressions. However, if the patient is not on such a surface and is instead on a compressible surface (e.g., adults in hospitals are commonly treated on compressible surfaces, and mattresses for pediatric patients mattress can be especially compressible, even more so than adult mattresses), such as a soft mattress, the rescuer may need to perform more intense work to achieve the required compression depth. As a result, the rescuer may either have difficulty achieving sufficient compression depth and/or fatigue quickly. Or, without the feedback mechanism, the rescuer may have the impression of reaching a sufficient depth without actually achieving it when the whole body of the patient is moving downward with the compressible surface.

[00258] With reference to FIG. 23, a patient 2 is illustrated as being positioned on a compressible surface 2300, such as a mattress, where an electrode assembly 5A having a motion sensor 21 is positioned anteriorly and an electrode assembly 5B having a motion sensor 23 is positioned posteriorly. In operation, chest compressions are performed on the patient by a rescuer as denoted by arrow F. The measured displacement (d_A) obtained by motion sensor 21 of electrode assembly 5A includes not only the displacement of the compression into the chest (d_1) but also the displacement caused by deformation of the compressible surface (d_P). As discussed hereinabove, this can lead to an overestimation of compression depth. By providing a motion sensor in both the anteriorly positioned electrode assembly 5A and the posteriorly positioned electrode assembly 5B, this overestimation of the compression depth may be corrected to provide a more accurate determination of chest compression depth. The actual compression depth can be calculated by subtracting the displacement of the motion sensor 23 of the electrode assembly 5B (i.e., the secondary sensor) from the displacement of the motion sensor 21 of the electrode assembly 5A (i.e., the primary sensor). More specifically, the displacement of the motion sensor 21 of the electrode assembly 5A corresponds to displacement d_A in FIG. 23 and includes both the displacement of the compression into the chest (d_1) and the displacement caused by deformation of the compressible surface (d_P). The displacement of the motion sensor 23 of the electrode assembly 5B measures the displacement caused by deformation of the compressible surface (d_P). Accordingly, by subtracting the displacement caused by deformation of the compressible surface (d_P) from the displacement of the motion sensor 21 of the electrode assembly 5A ($d_A = d_1 + d_P$), the actual compression depth, corresponding to displacement of the compression into the chest (d_1) can be obtained.

[00259] In addition, by incorporating a motion sensor 21, 23 in both the anteriorly positioned electrode assembly 5A and the posteriorly positioned electrode assembly 5B, a motion sensor 21, 23 is provided on both the chest and back of the patient 2. The processor of the defibrillator 2202 is operatively connected to and programmed to receive and process signals from the motion sensors 21, 23 of the electrode assemblies 5A and 5B and may determine whether the patient is positioned on a compressible surface. More specifically, the motion sensor 21 of the electrode assembly 5A may produce a first signal representative of acceleration caused by compressions and the motion sensor 21 of the electrode assembly 5B may produce a second signal representative of other types of accelerations, such as acceleration due to movement on a compressible surface. These signals are then processed to determine whether the amount of displacement arising from the compressible surface meets a threshold great enough to recommend that the surface underneath the patient be changed. Such a threshold may be correlated to the amount of work that a rescuer would have to exert to achieve chest compressions that fall within a desired range. For example, to alleviate the rescuer of excess effort, a threshold may be set such that if the displacement arising from the compressible surface is greater than 10% (e.g., between 10-100%), greater than 25% (e.g., between 25-100%), greater than 50% (e.g., between 50-100%), greater than 75%, or greater than 100% of the recommended compression depth or another metric (e.g., comparison to the total displacement of the anterior sensor), then the user may be provided with a suggestion or instruction that the underlying surface on which the patient resides be changed. Such an instruction may be for a backboard to be placed underneath the patient, or for the patient to be moved from the existing relatively soft surface to a harder surface. The output device of the defibrillator 2202 may provide feedback instructions to a user for a surface upon which the patient 2 is positioned to be changed if it is determined that the patient 2 is provided on a compressible surface that meets the set threshold. This feedback can be real-time feedback in the form of an audible, visual or tactile indication requesting that the rescuer position a backboard beneath the patient or move the patient to a more rigid surface. Alternatively, the feedback may be issued at the end of the rescue sequence advising the rescuer to use a backboard in future CPR situations. In situations where displacement arising from a surface upon which the patient is placed is less than the predetermined threshold, the system assumes the patient is positioned on a rigid surface and the defibrillator 2202 provides feedback to the rescuer regarding the quality of compressions as discussed hereinabove.

[00260] As noted herein, it can be appreciated that other configurations of resuscitation assemblies may be employed. In some embodiments, an electrode assembly including an

electrode pad and a motion sensor might not require the motion sensor to be directly attached to the electrode pad. For example, the motion sensor may be coupled to the electrode pad via a cable or some other extension that allows for an electrical connection to the overall system. Alternatively, the motion sensor may be completely free of mechanical attachment to the electrode pad. For instance, the motion sensor may be in wireless communication with the defibrillator or another computing device and be configured to be coupled to the body in any suitable manner (e.g., adhesively attached). In addition, the motion sensors described herein may be provided with a memory that stores data from time of activation. For example, the motion sensors may be provided with a removable tab to activate the sensor to begin storing data in the memory. In addition, the motion sensors may be provided with an audible/visual output system to provide a light to indicate that the system is active or a chest compression metronome to guide the rescuer in providing chest compressions. Once the motion sensor is paired to a device (for example a defibrillator, a desktop top computer, a table computer, a mobile phone, a patient monitor, etc.), the data stored in the memory of the motion sensor is transmitted to the device and integrated in a case record for post-case review. In certain examples, the motion sensors may be wireless with an option for wired communication with a device for real-time feedback. Alternatively, communication between the motion sensors and the device may be exclusively wireless.

[00261] The described systems and methods can be assisted by the use of a computer-implemented medical device, such as a defibrillator that comprises computing capability, or another type of computing device. Such a defibrillator or other computing device is shown in FIG. 24, and can communicate with and/or incorporate a computer system 2400 in performing the operations discussed above, including operations for computing the quality of one or more components of CPR provided to a patient and generating feedback to rescuers, including feedback to change rescuers who are performing some components of the CPR. The system 2400 can be implemented in various forms of digital computers, including computerized defibrillators laptops, personal digital assistants, tablets, and other appropriate computers. Additionally, the system can comprise portable storage media, such as, Universal Serial Bus (USB) flash drives. For example, the USB flash drives can store operating systems and other applications. The USB flash drives can comprise input/output components, such as a wireless transmitter or USB connector that can be inserted into a USB port of another computing device.

[00262] The system 2400 comprises a processor 2410, a memory 2420, a storage device 2430, and an input/output device 2440. Each of the components 1110, 1120, 1130, and 1140

are interconnected using a system bus 2450. The processor 2410 is capable of processing instructions for execution within the system 2400. The processor can be designed using any of a number of architectures. For example, the processor 2410 can be a CISC (Complex Instruction Set Computers) processor, a RISC (Reduced Instruction Set Computer) processor, or a MISC (Minimal Instruction Set Computer) processor.

[00263] In one implementation, the processor 2410 is a single-threaded processor. In another implementation, the processor 2410 is a multi-threaded processor. The processor 2410 is capable of processing instructions stored in the memory 2420 or on the storage device 2430 to display graphical information for a user interface on the input/output device 2440.

[00264] The memory 2420 stores information within the system 2400. In one implementation, the memory 2420 is a computer-readable medium. In one implementation, the memory 2420 is a volatile memory unit. In another implementation, the memory 2420 is a non-volatile memory unit.

[00265] The storage device 2430 is capable of providing mass storage for the system 2400. In one implementation, the storage device 2430 is a computer-readable medium. In various different implementations, the storage device 2430 can be a floppy disk device, a hard disk device, an optical disk device, or a tape device.

[00266] The input/output device 2440 provides input/output operations for the system 2400. In one implementation, the input/output device 2440 comprises a keyboard and/or pointing device. In another implementation, the input/output device 2440 comprises a display unit for displaying graphical user interfaces. In another implementation, the input/output device 2440 comprises a touchscreen user interface.

[00267] The features described can be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations of them. The system can be implemented in a computer program product tangibly embodied in an information carrier, e.g., in a machine-readable storage device for execution by a programmable processor; and method steps can be performed by a programmable processor executing a program of instructions to perform functions of the described implementations by operating on input data and generating output. The described features can be implemented advantageously in one or more computer programs that are executable on a programmable system comprising at least one programmable processor coupled to receive data and instructions from, and to transmit data and instructions to, a data storage system, at least one input device, and at least one output device. A computer program is a set of instructions that can be used, directly or indirectly, in a computer to perform some activity or bring about some result. A computer

program can be written in any form of programming language, including compiled or interpreted languages, and it can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment.

[00268] Suitable processors for the execution of a program of instructions comprise, by way of example, both general and special purpose microprocessors, and the sole processor or one of multiple processors of any kind of computer. Generally, a processor will receive instructions and data from a read-only memory or a random access memory or both. The essential elements of a computer are a processor for executing instructions and one or more memories for storing instructions and data. Generally, a computer will also comprise, or be operatively coupled to communicate with, one or more mass storage devices for storing data files; such devices comprise magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; and optical disks. Storage devices suitable for tangibly embodying computer program instructions and data comprise all forms of non-volatile memory, including by way of example semiconductor memory devices, such as EPROM, EEPROM, and flash memory devices; magnetic disks such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks. The processor and the memory can be supplemented by, or incorporated in, ASICs (application-specific integrated circuits).

[00269] To provide for interaction with a user, the features can be implemented on a computer having an LCD (liquid crystal display) or LED display for displaying information to the user and a keyboard and a pointing device such as a mouse or a trackball by which the user can provide input to the computer.

[00270] The features can be implemented in a computer system that comprises a back-end component, such as a data server, or that comprises a middleware component, such as an application server or an Internet server, or that comprises a front-end component, such as a client computer having a graphical user interface or an Internet browser, or any combination of them. The components of the system can be connected by any form or medium of digital data communication such as a communication network. Examples of communication networks comprise a local area network ("LAN"), a wide area network ("WAN"), peer-to-peer networks (having ad-hoc or static members), grid computing infrastructures, and the Internet.

[00271] The computer system can comprise clients and servers. A client and server are generally remote from each other and typically interact through a network, such as the

described one. The relationship of client and server arises by virtue of computer programs running on the respective computers and having a client-server relationship to each other.

[00272] Although a medical system for determining placement of a resuscitation assembly and providing appropriate chest compression feedback has been described in detail for the purpose of illustration based on what is currently considered to be the most practical examples, it is to be understood that such detail is solely for that purpose and that the subject matter provided herein is not limited to the disclosed examples, but, on the contrary, is intended to cover modifications and equivalent arrangements. For example, it is to be understood that this disclosure contemplates that, to the extent possible, one or more features of any example can be combined with one or more features of any other example.

[00273] As used herein, the singular form of “a”, “an”, and “the” include plural referents unless the context clearly dictates otherwise.

[00274] As used herein, the terms “right”, “left”, “top”, and derivatives thereof shall relate to the subject matter provided herein as it is oriented in the drawing figures. However, it is to be understood that the subject matter provided herein can assume various alternative orientations and, accordingly, such terms are not to be considered as limiting. Also, it is to be understood that the subject matter provided herein can assume various alternative variations and stage sequences, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification, are examples. Hence, specific dimensions and other physical characteristics related to the embodiments disclosed herein are not to be considered as limiting.

What is claimed is:

1. A medical system for assisting a user in providing resuscitation care for a patient, comprising:

a first motion sensor;

a second motion sensor;

an output device; and

at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to:

receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the second motion sensor,

determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range,

determine whether the second motion sensor is positioned at a second orientation having an angle that falls within a second acceptable orientation range,

in response to a determination that the angle of the first orientation falls within the first acceptable orientation range and the angle of the second orientation falls within the second acceptable orientation range, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor, and

in response to a determination that either the angle of the first orientation falls outside of the first acceptable orientation range or the angle of the second orientation falls outside of the second acceptable orientation range, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

2. The medical system of claim 1, wherein the first motion sensor is positioned in a non-inverted orientation if the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range and the second motion sensor is positioned at a non-inverted orientation if the second motion sensor is positioned at a second orientation having an angle that falls within the second acceptable orientation range.

3. The medical system of claim 1, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 60 degrees.

4. The medical system of claim 1, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 45 degrees.

5. The medical system of claim 1, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 30 degrees.

6. The medical system of claim 1, wherein the first motion sensor is positioned in an inverted orientation if the first motion sensor is positioned at a first orientation having an angle that falls outside of the first acceptable orientation range and the second motion sensor is positioned at an inverted orientation if the second motion sensor is positioned at a second orientation having an angle that falls outside of the second acceptable orientation range.

7. The medical system of claim 1, wherein, in response to a determination that either the angle of the first orientation falls outside of the first acceptable orientation range or the angle of the second orientation falls outside of the second acceptable orientation range, causing the output device to provide a prompt to the user to check a placement of the first motion sensor and the second motion sensor.

8. The medical system of claim 1, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

9. The medical system of claim 1, wherein the signals from the first motion sensor and the second motion sensor comprise a first component and a second component.

10. The medical system of claim 9, wherein the first component of the signals corresponds to a positional motion of the first motion sensor and the second motion sensor and the second component of the signal corresponds to an oscillatory motion of the first motion sensor and the second motion sensor.

11. The medical system of claim 10, wherein the first component of the signals is used to determine whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range and the second motion sensor is positioned at a second orientation having an angle that falls within the second acceptable orientation range.

12. The medical system of claim 10, wherein the at least one processor is further configured to:

determine whether the oscillatory motion of the second motion sensor is greater than a threshold sufficient to initiate chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

13. The medical system of claim 1, wherein the at least one processor is further configured to:

invert the signal received from the first motion sensor in response to a determination that the angle of the first orientation falls outside of the first acceptable orientation range, and

cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

14. The medical system of claim 13, wherein the chest compression feedback comprises guidance for prompting a user to check or adjust the angle of the first orientation to fall within the first acceptable orientation range.

15. The medical system of claim 1, wherein the at least one processor is further configured to:

determine whether the motion in a first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor, and

determine whether the motion in the first direction of the first motion sensor is greater than the motion in a second direction and a third direction of the first motion sensor, the motion in the second direction and the third direction being different than the motion in the first direction.

16. The medical system of claim 15, wherein the at least one processor is further configured to:

in response to a determination that the motion in the first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor and the motion in the first direction of the first motion sensor is greater than the motion in the second direction and the third direction of the first motion sensor, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor, and

in response to a determination that either the motion in the first direction of the first motion sensor is less than the motion in the first direction of the second motion sensor or the motion in the first direction of the first motion sensor is less than the motion in the second direction and the third direction of the first motion sensor, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

17. The medical system of claim 1, wherein the at least one processor is further configured to:

determine an angle of the second motion sensor with respect to gravity,
compare the angle of the second motion sensor with a threshold angle,
and

in response to a determination that the angle of the second motion sensor is less than a threshold angle, cause the output device to provide chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

18. The medical system of claim 1, wherein the at least one processor is further configured to:

receive a signal representative of electrical impedance in a chest of the patient;

determine whether the signal is greater than a threshold value; and

in response to a determination that the signal is greater than the threshold value, determining whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range and determining

whether the second motion sensor is positioned at a second orientation having an angle that falls within the second acceptable orientation range.

19. The medical system of claim 1, wherein the at least one processor is further configured to:

process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and

cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

20. The medical system of claim 19, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

21. The medical system of claim 19, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

22. The medical system of claim 19, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

23. The medical system of claim 19, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

24. The medical system of claim 1, further comprising:
a first electrode assembly configured to provide electrotherapy for the patient,
and

a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly,

wherein the first motion sensor is provided with the first electrode assembly, and the second motion sensor is provided with the second electrode assembly.

25. The medical system of claim 24, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

26. The medical system of claim 24, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

27. The medical system of claim 24, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

28. The medical system of claim 1, wherein the at least one processor and the output device are provided in an external defibrillator.

29. A medical system for assisting a user in providing resuscitation care for a patient, comprising:

- a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy;

- a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy;

- an output device; and

- at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to:

- receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and the motion of the second motion sensor,

- determine whether oscillatory motion of the second motion sensor is greater than a threshold sufficient to initiate anterior-posterior chest compression feedback, and

- cause the output device to provide the anterior-posterior chest compression feedback based on the motion of the first motion sensor and the motion of the second motion sensor based at least in part on the determination that the oscillatory motion of

the second motion sensor is greater than the threshold sufficient to initiate the anterior-posterior chest compression feedback.

30. The medical system of claim 29, wherein the oscillatory motion signals are representative of movement of the second motion sensor over a given time period.

31. The medical system of claim 29, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

32. The medical system of claim 29, wherein the at least one processor is further configured to:

determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range,

determine whether the second motion sensor is positioned at a second orientation having an angle that falls within a second acceptable orientation range, and

in response to a determination that the angle of the first orientation falls within the first acceptable orientation range and the angle of the second orientation falls within the second acceptable orientation range, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

33. The medical system of claim 32, wherein the at least one processor is further configured to:

in response to a determination that either the angle of the first orientation falls outside of the first acceptable orientation range or the angle of the second orientation falls outside of the second acceptable orientation range, cause the output device to provide anterior-anterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

34. The medical system of claim 32, wherein the at least one processor is further configured to:

receive a signal representative of electrical impedance in a chest of the patient;

determine whether the signal is greater than a threshold value; and

in response to a determination that the signal is greater than the threshold value, determining whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range and the second motion sensor is positioned at a second orientation having an angle that falls within the second acceptable orientation range.

35. The medical system of claim 29, wherein the at least one processor is further configured to:

determine whether the motion in a first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor, and

determine whether the motion in the first direction of the first motion sensor is greater than the motion in a second direction and a third direction of the first motion sensor, the motion in the second direction and the third direction being different than the motion in the first direction.

36. The medical system of claim 35, wherein the at least one processor is further configured to:

in response to a determination that the motion in the first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor and the motion in the first direction of the first motion sensor is greater than the motion in the second direction and the third direction of the first motion sensor, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor, and

in response to a determination that either the motion in the first direction of the first motion sensor is less than the motion in the first direction of the second motion sensor or the motion in the first direction of the first motion sensor is less than the motion in the second direction and the third direction of the first motion sensor, cause the output device to provide anterior-anterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

37. The medical system of claim 29, wherein the at least one processor is further configured to:

determine an angle of the second motion sensor with respect to gravity,

compare the angle of the second motion sensor with a threshold angle,
and

in response to a determination that the angle of the second motion sensor is less than a threshold angle, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

38. The medical system of claim 29, wherein the at least one processor is further configured to:

process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and

cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

39. The medical system of claim 38, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

40. The medical system of claim 38, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

41. The medical system of claim 38, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

42. The medical system of claim 38, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

43. The medical system of claim 29, further comprising:
a first electrode assembly configured to provide electrotherapy for the patient,
and

a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly,

wherein the first motion sensor is provided with the first electrode assembly, and the second motion sensor is provided with the second electrode assembly.

44. The medical system of claim 43, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

45. The medical system of claim 43, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

46. The medical system of claim 43, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

47. The medical system of claim 29, wherein the at least one processor and the output device are provided in an external defibrillator.

48. A medical system for assisting a user in providing resuscitation care for a patient, comprising:

a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy;

a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy;

an output device; and

at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to:

receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the second motion sensor,

determine whether the motion in a first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor,

determine whether the motion in the first direction of the first motion sensor is greater than the motion in a second direction and a third direction of the first motion sensor, the motion in the second direction and the third direction being different than the motion in the first direction, and

cause the output device to provide anterior-posterior chest compression feedback based on the motion of the first motion sensor and the motion of the second motion sensor based at least in part on the determination that the motion in the first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor and further based at least in part on the determination that the motion in the first direction of the first motion sensor is greater than the motion in the second direction and the third direction of the first motion sensor.

49. The medical system of claim 48, wherein the at least one processor is further configured to:

cause the output device to provide anterior-anterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor in response to a determination that either the motion in the first direction of the first motion sensor is less than the motion in the first direction of the second motion sensor or the motion in the first direction of the first motion sensor is less than the motion in the second direction and the third direction of the first motion sensor.

50. The medical system of claim 48, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

51. The medical system of claim 48, wherein the at least one processor is further configured to:

determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range,

determine whether the second motion sensor is positioned at a second orientation having an angle that falls within a second acceptable orientation range, and

in response to a determination that the angle of the first orientation falls within the first acceptable orientation range and the angle of the second orientation falls within the second acceptable orientation range, cause the output device to provide the

anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

52. The medical system of claim 51, wherein the at least one processor is further configured to:

in response to a determination that either the angle of the first orientation falls outside of the first acceptable orientation range or the angle of the second orientation falls outside of the second acceptable orientation range, cause the output device to provide anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

53. The medical system of claim 51, wherein the at least one processor is further configured to:

receive a signal representative of electrical impedance in a chest of the patient;

determine whether the signal is greater than a threshold value; and

in response to a determination that the signal is greater than threshold value, determining whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range and the second motion sensor is positioned at a second orientation having an angle that falls within the second acceptable orientation range.

54. The medical system of claim 48, wherein the at least one processor is further configured to:

determine an angle of the second motion sensor with respect to gravity,

compare the angle of the second motion sensor with a threshold angle,

and

in response to a determination that the angle of the second motion sensor is less than a threshold angle, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

55. The medical system of claim 48, wherein the first direction corresponds to a height of the patient when lying in a supine position, the second direction

corresponds to a width of the patient when lying in the supine position, and the third direction corresponds to a length of the patient when lying in the supine position.

56. The medical system of claim 48, wherein the first direction, the second direction, and the third direction are orthogonal to each other.

57. The medical system of claim 48, wherein the at least one processor is further configured to:

process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and

cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

58. The medical system of claim 57, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

59. The medical system of claim 57, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

60. The medical system of claim 57, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

61. The medical system of claim 57, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

62. The medical system of claim 48, further comprising:
a first electrode assembly configured to provide electrotherapy for the patient,
and

a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly,

wherein the first motion sensor is provided with the first electrode assembly, and the second motion sensor is provided with the second electrode assembly.

63. The medical system of claim 62, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

64. The medical system of claim 62, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

65. The medical system of claim 62, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

66. The medical system of claim 48, wherein the at least one processor and the output device are provided in an external defibrillator.

67. A medical system for assisting a user in providing resuscitation care for a patient, comprising:

a first motion sensor;

a second motion sensor;

an output device; and

at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to:

identify a resuscitation mode of the system as one of a pediatric or adult resuscitation mode,

receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the second motion sensor,

determine whether the first motion sensor and the second motion sensor are correctly positioned to provide anterior-posterior chest compression feedback,

cause the output device to provide the anterior-posterior chest compression feedback based on the determination that the first motion sensor and the second motion sensor are correctly positioned to provide the anterior-posterior chest compression feedback,

when the resuscitation mode is identified as adult, cause the output device to provide anterior-anterior chest compression feedback based on a determination that at least one of the first motion sensor or the second motion sensor are incorrectly positioned, and

when the resuscitation mode is identified as pediatric, cause the output device to provide the anterior-posterior chest compression feedback based on a determination that the first motion sensor and the second motion are correctly positioned following an initial determination that the first motion sensor and the second motion are incorrectly positioned.

68. The medical system of claim 67, wherein the resuscitation mode of the system is determined based on an identification signal produced by an identification component associated with the resuscitation assembly.

69. The medical system of claim 68, wherein the identification component comprises at least one of a memory and a resistor from which the identification signal is based.

70. The medical system of claim 67, wherein the resuscitation mode of the system is determined based on a selection by the user.

71. The medical system of claim 67, wherein the anterior-posterior chest compression feedback is based from the motion of the first motion sensor and the motion of the second motion sensor.

72. The medical system of claim 67, wherein the anterior-anterior chest compression feedback is based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

73. The medical system of claim 67, wherein, when the resuscitation mode is identified as adult, the output device is configured to continue providing the anterior-

anterior chest compression feedback based on the determination that at least one of the first motion sensor or the second motion sensor are incorrectly positioned until a signal representative of electrical impedance in a chest of the patient is determined to be greater than a threshold value.

74. The medical system of claim 73, wherein the at least one processor is further configured to:

when the resuscitation mode is identified as pediatric, cause the output device to provide the anterior-anterior chest compression feedback based on a determination that the first motion sensor and the second motion are incorrectly positioned,

determine whether the first motion sensor and the second motion sensor are correctly positioned to provide anterior-posterior chest compression feedback without determining whether a signal representative of electrical impedance in a chest of the patient is greater than a threshold value, and

cause the output device to provide the anterior-posterior chest compression feedback based on a determination that the first motion sensor and the second motion are correctly positioned.

75. The medical system of claim 67, wherein determining whether the first motion sensor and second motion sensor are correctly positioned comprises at least one of: determining whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range; determining whether the second motion sensor is positioned at a second orientation having an angle that falls within a second acceptable orientation range; determining whether oscillatory motion of the second motion sensor is greater than a threshold; determining whether motion in a first direction of the first motion sensor is greater than motion in the first direction of the second motion sensor; determining whether the motion in the first direction of the first motion sensor is greater than motion in a second direction and a third direction of the first motion sensor; determining an orientation of the first motion sensor to ensure that the first motion sensor is positioned on an anterior portion of the patient's anatomy within substantially 45 degrees with respect to gravity; and determining an orientation of the second motion sensor to ensure that the second motion sensor is positioned on the posterior portion of the patient's anatomy within substantially 30 degrees with respect to gravity.

76. The medical system of claim 67, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

77. The medical system of claim 67, wherein the at least one processor is further configured to:

process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and

cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

78. The medical system of claim 77, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

79. The medical system of claim 77, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

80. The medical system of claim 77, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

81. The medical system of claim 77, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

82. The medical system of claim 67, further comprising:
a first electrode assembly configured to provide electrotherapy for the patient,
and

a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly,

wherein the first motion sensor is provided with the first electrode assembly, and the second motion sensor is provided with the second electrode assembly.

83. The medical system of claim 82, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

84. The medical system of claim 82, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

85. The medical system of claim 82, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

86. The medical system of claim 67, wherein the at least one processor and the output device are provided in an external defibrillator.

87. A medical system for assisting a user in providing resuscitation care for a patient, comprising:

- a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy;

- a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy;

- an output device; and

- at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to:

- receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and motion of the second motion sensor,

- determine whether chest compressions have been initiated based on the motion from at least one of the first motion sensor or the second motion sensor,

- determine whether the first motion sensor is positioned at a first orientation having an angle that falls within a first acceptable orientation range in response to a determination the chest compressions have been initiated,

determine whether oscillatory motion of the second motion sensor is greater than a threshold sufficient to initiate anterior-posterior chest compression feedback in response to a determination that the angle of the first orientation falls within the first acceptable orientation range, and

cause the output device to provide the anterior-posterior chest compression feedback based on the motion of the first motion sensor and the motion of the second motion sensor based at least in part on the determination that the oscillatory motion of the second motion sensor is greater than the threshold sufficient to initiate the anterior-posterior chest compression feedback.

88. The medical system of claim 87, wherein the first motion sensor is positioned in a non-inverted orientation if the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range.

89. The medical system of claim 87, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 60 degrees.

90. The medical system of claim 87, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 45 degrees.

91. The medical system of claim 87, wherein the first acceptable orientation range and the second acceptable orientation range are 0 to 30 degrees.

92. The medical system of claim 87, wherein the first motion sensor is positioned in an inverted orientation if the first motion sensor is positioned at a first orientation having an angle that falls outside of the first acceptable orientation range.

93. The medical system of claim 87, wherein, in response to a determination that the angle of the first orientation falls outside of the first acceptable orientation range, causing the output device to provide a prompt to the user to check a placement of the first motion sensor.

94. The medical system of claim 87, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

95. The medical system of claim 87, wherein the signals from the first motion sensor and the second motion sensor comprise a first component and a second component.

96. The medical system of claim 95, wherein the first component of the signals corresponds to a positional motion of the first motion sensor and the second motion sensor and the second component of the signal corresponds to the oscillatory motion of the first motion sensor and the second motion sensor.

97. The medical system of claim 96, wherein the first component of the signals is used to determine whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range.

98. The medical system of claim 96, wherein the second component of the signal is used to determine whether chest compressions have been initiated.

99. The medical system of claim 87, wherein the at least one processor is further configured to:

determine whether the second motion sensor is at a second orientation having an angle that falls within a second acceptable orientation range, and

in response to a determination that the angle of the first orientation falls within the first acceptable orientation range and the angle of the second orientation falls within the second acceptable orientation range, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

100. The medical system of claim 99, wherein the at least one processor is further configured to:

in response to a determination that either the angle of the first orientation falls outside of the first acceptable orientation range or the angle of the second orientation falls outside of the second acceptable orientation range, cause the output device to provide anterior-anterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

101. The medical system of claim 87, wherein the at least one processor is further configured to:

determine whether the motion in a first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor, and

determine whether the motion in the first direction of the first motion sensor is greater than the motion in a second direction and a third direction of the first motion sensor, the motion in the second direction and the third direction being different than the motion in the first direction.

102. The medical system of claim 101, wherein the at least one processor is further configured to:

in response to a determination that the motion in the first direction of the first motion sensor is greater than the motion in the first direction of the second motion sensor and the motion in the first direction of the first motion sensor is greater than the motion in the second direction and the third direction of the first motion sensor, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor, and

in response to a determination that either the motion in the first direction of the first motion sensor is less than the motion in the first direction of the second motion sensor or the motion in the first direction of the first motion sensor is less than the motion in the second direction and the third direction of the first motion sensor, cause the output device to provide anterior-anterior chest compression feedback for the user based from the motion of the first motion sensor without contribution from the motion of the second motion sensor.

103. The medical system of claim 87, wherein the at least one processor is further configured to:

determine an angle of the second motion sensor with respect to gravity,
compare the angle of the second motion sensor with a threshold angle,
and

in response to a determination that the angle of the second motion sensor is less than a threshold angle, cause the output device to provide the anterior-posterior chest compression feedback for the user based from the motion of the first motion sensor and the motion of the second motion sensor.

104. The medical system of claim 87, wherein the at least one processor is further configured to:

receive a signal representative of electrical impedance in a chest of the patient;

determine whether the signal is greater than a threshold value; and

in response to a determination that the signal is greater than threshold value, determining whether the first motion sensor is positioned at a first orientation having an angle that falls within the first acceptable orientation range.

105. The medical system of claim 87, wherein the at least one processor is further configured to:

process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and

cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

106. The medical system of claim 105, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

107. The medical system of claim 105, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

108. The medical system of claim 105, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

109. The medical system of claim 105, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

110. The medical system of claim 87, further comprising:
a first electrode assembly configured to provide electrotherapy for the patient,
and
a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly,
wherein the first motion sensor is provided with the first electrode assembly,
and the second motion sensor is provided with the second electrode assembly.

111. The medical system of claim 110, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

112. The medical system of claim 110, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

113. The medical system of claim 110, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

114. The medical system of claim 87, wherein the at least one processor and the output device are provided in an external defibrillator.

115. A medical system for assisting a user in providing resuscitation care for a patient, comprising:

a first motion sensor configured to be positioned on an anterior portion of a patient's anatomy;

a second motion sensor configured to be positioned on a posterior portion of the patient's anatomy;

an output device; and

at least one processor operatively connected to the first motion sensor, the second motion sensor, and the output device, the at least one processor configured to:

receive and process signals from the first motion sensor and the second motion sensor to measure motion of the first motion sensor and the motion of the second motion sensor,

determine an orientation of the first motion sensor to ensure that the first motion sensor is positioned on the anterior portion of the patient's anatomy within substantially 30 degrees to 60 degrees with respect to gravity,

determine an orientation of the second motion sensor to ensure that the second motion sensor is positioned on the posterior portion of the patient's anatomy with substantially 15 degrees to 45 degrees with respect to the first motion sensor, and

cause the output device to provide chest compression feedback for the user based on the motion from the first motion sensor and the second motion sensor in response to a determination that the first motion sensor is positioned on the anterior portion of the patient's anatomy within substantially 30 degrees to 60 degrees with respect to gravity and a determination that the second motion sensor is positioned on the posterior portion of the patient's anatomy with substantially 15 degrees to 45 degrees with respect to the first motion sensor.

116. The medical system of claim 115, wherein the at least one processor is further configured to:

cause the output device to provide chest compression feedback for the user based on the motion from the first motion sensor without contribution from the motion of the second motion sensor in response to the determination that the first motion sensor is positioned on the anterior portion of the patient's anatomy within substantially 30 degrees to 60 degrees with respect to gravity and a determination that the second motion sensor is not positioned on the posterior portion of the patient's anatomy with substantially 15 degrees to 45 degrees with respect to the first motion sensor.

117. The medical system of claim 115, wherein the at least one processor is further configured to:

cause the output device to withhold chest compression feedback in response to a determination that the first motion sensor not positioned on the anterior portion of the patient's anatomy within substantially 30 degrees to 60 degrees with respect to gravity and a determination that the second motion sensor is not positioned on the posterior portion of the

patient's anatomy with substantially 15 degrees to 45 degrees with respect to the first motion sensor.

118. The medical system of claim 115, wherein the first motion sensor and the second motion sensor are three-axis accelerometers.

119. The medical system of claim 115, wherein the at least one processor is further configured to:

process the signals from at least one of the first motion sensor and the second motion sensor to estimate at least one of a compression depth and a compression rate during administration of chest compressions, and

cause the output device to provide the chest compression feedback for the user including at least one of the compression depth and the compression rate.

120. The medical system of claim 119, wherein the chest compression feedback comprises at least one of audio prompts, visual prompts, or tactile prompts.

121. The medical system of claim 119, wherein the chest compression feedback comprises a display of an indication for estimated values of at least one of the chest compression depth and the chest compression rate.

122. The medical system of claim 119, wherein the chest compression depth is calculated by subtracting a distance traveled by the second motion sensor from a distance traveled by the first motion sensor.

123. The medical system of claim 119, wherein the first motion sensor is configured to produce a first signal representative of acceleration caused by compressions and the second motion sensor is configured to produce a second signal representative of acceleration due to movement on a compressible surface.

124. The medical system of claim 115, further comprising:
a first electrode assembly configured to provide electrotherapy for the patient,
and

a second electrode assembly configured to provide electrotherapy for the patient in cooperation with the first electrode assembly,

wherein the first motion sensor is provided with the first electrode assembly, and the second motion sensor is provided with the second electrode assembly.

125. The medical system of claim 124, wherein the first electrode assembly, the second electrode assembly, the first motion sensor, and the second motion sensor are provided as a resuscitation assembly.

126. The medical system of claim 124, wherein at least one of the first motion sensor and the second motion sensor is coupled to the respective first or second electrode assembly.

127. The medical system of claim 124, wherein at least one of the first motion sensor and the second motion sensor is removably coupled to the respective first or second electrode assembly.

128. The medical system of claim 115, wherein the at least one processor and the output device are provided in an external defibrillator.

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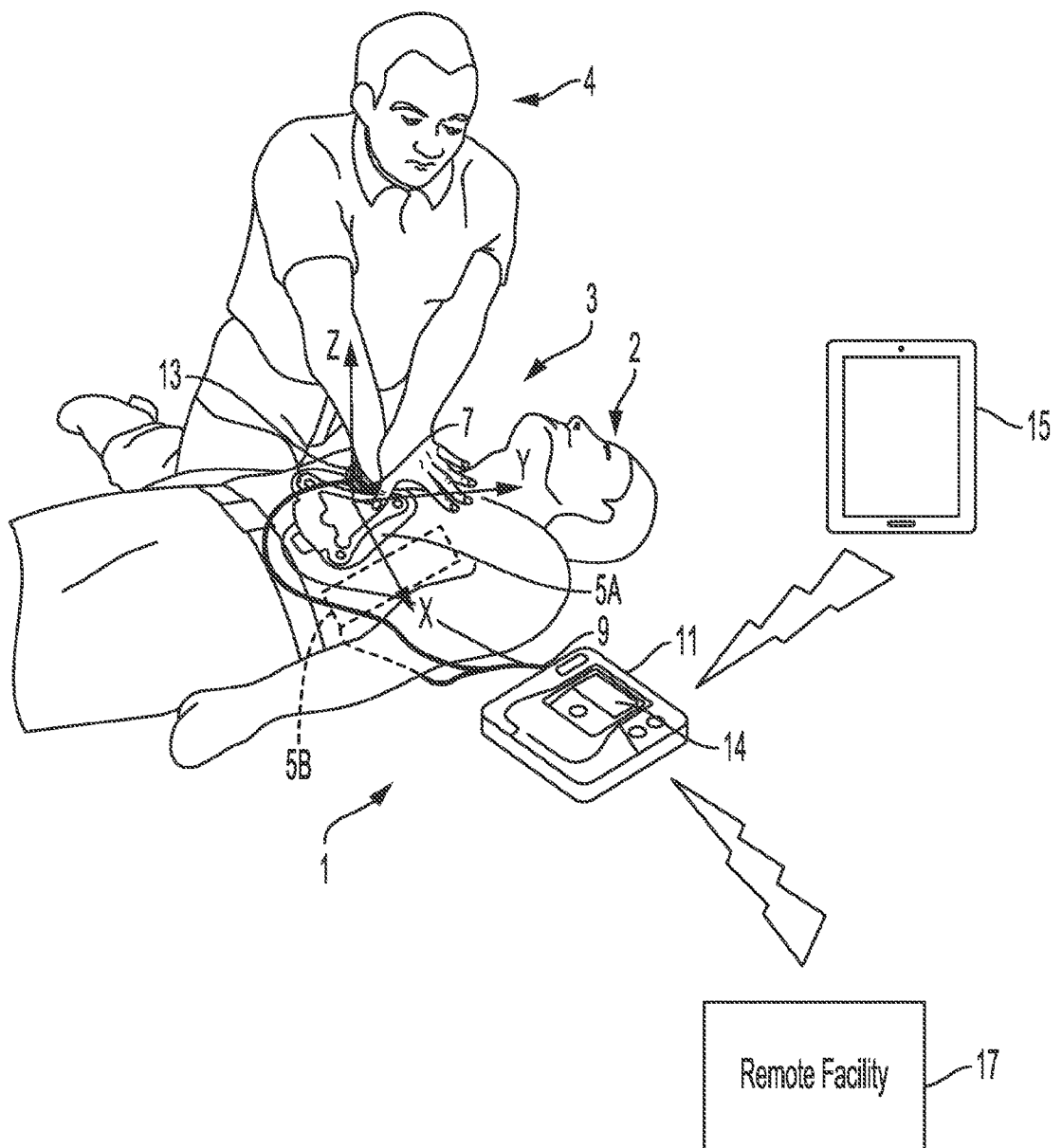


FIG. 1

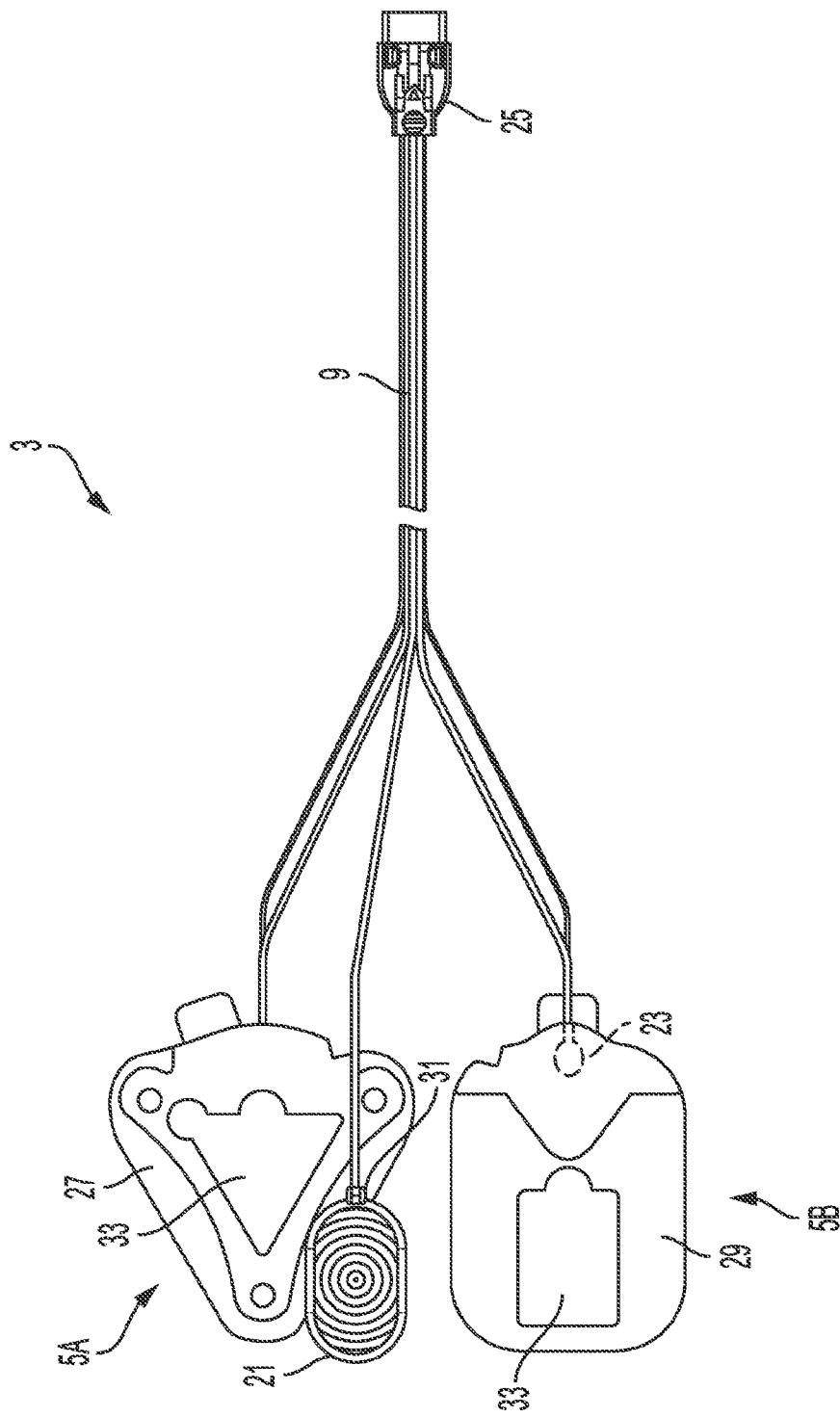


FIG. 2

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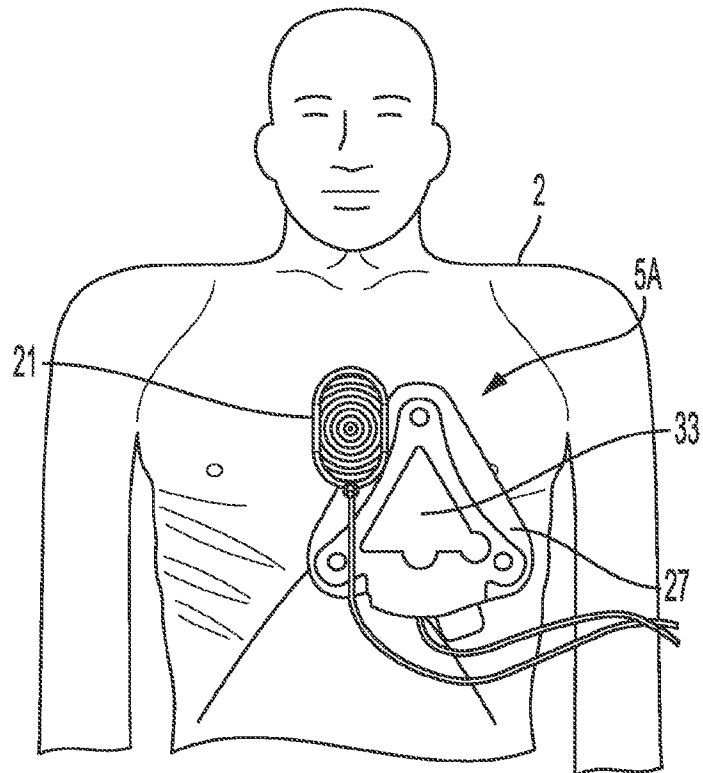


FIG. 3A

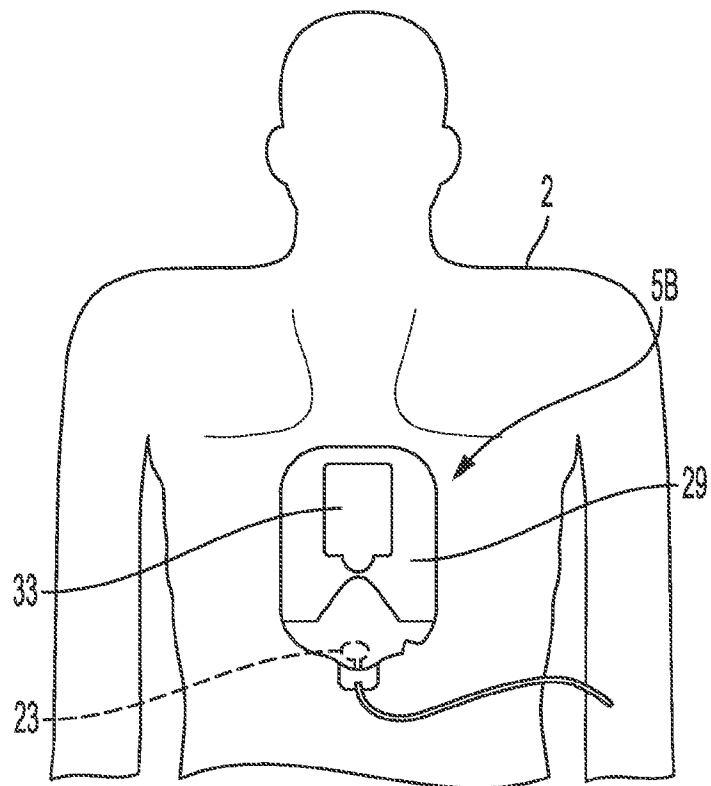


FIG. 3B

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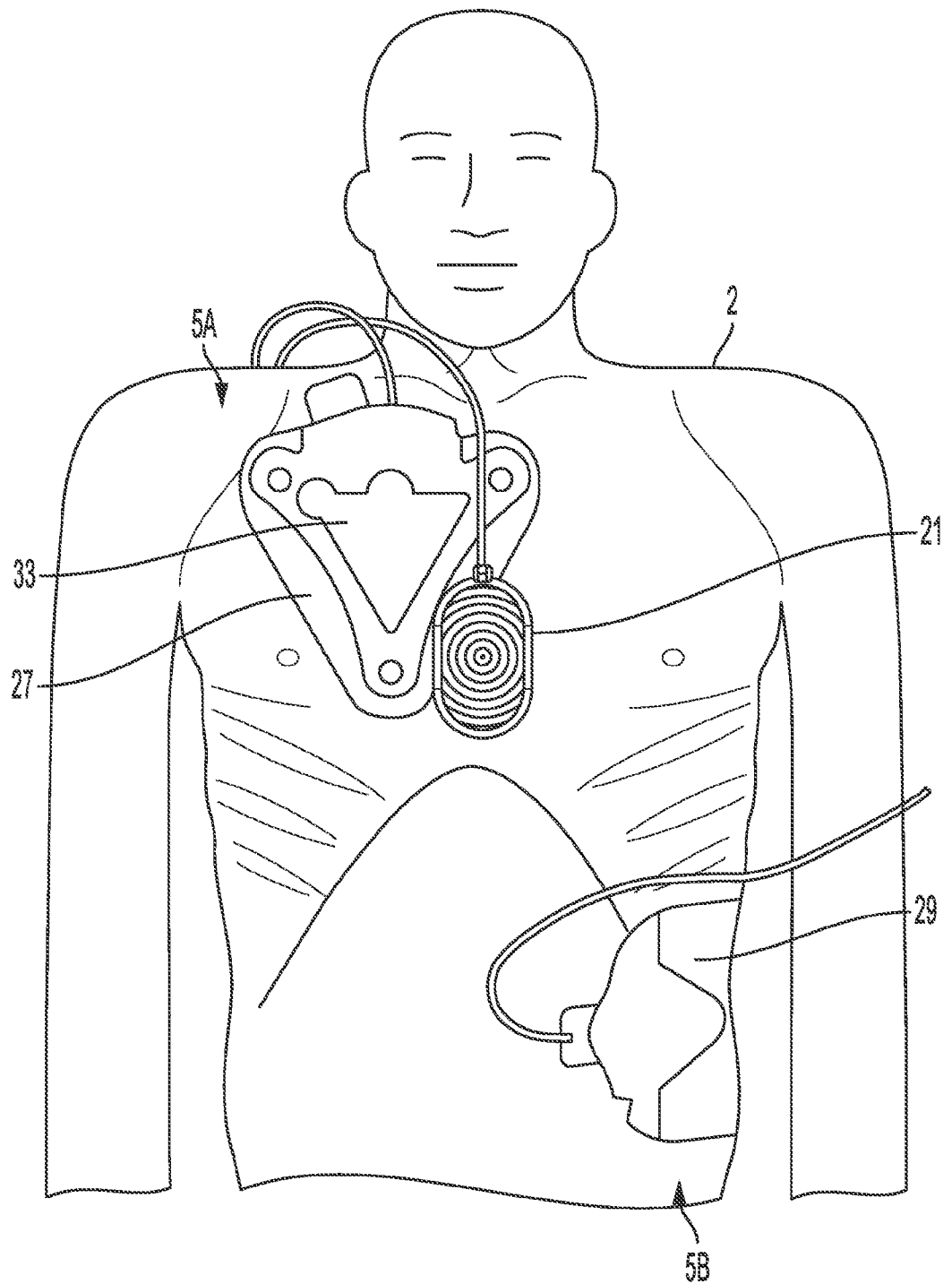


FIG. 4

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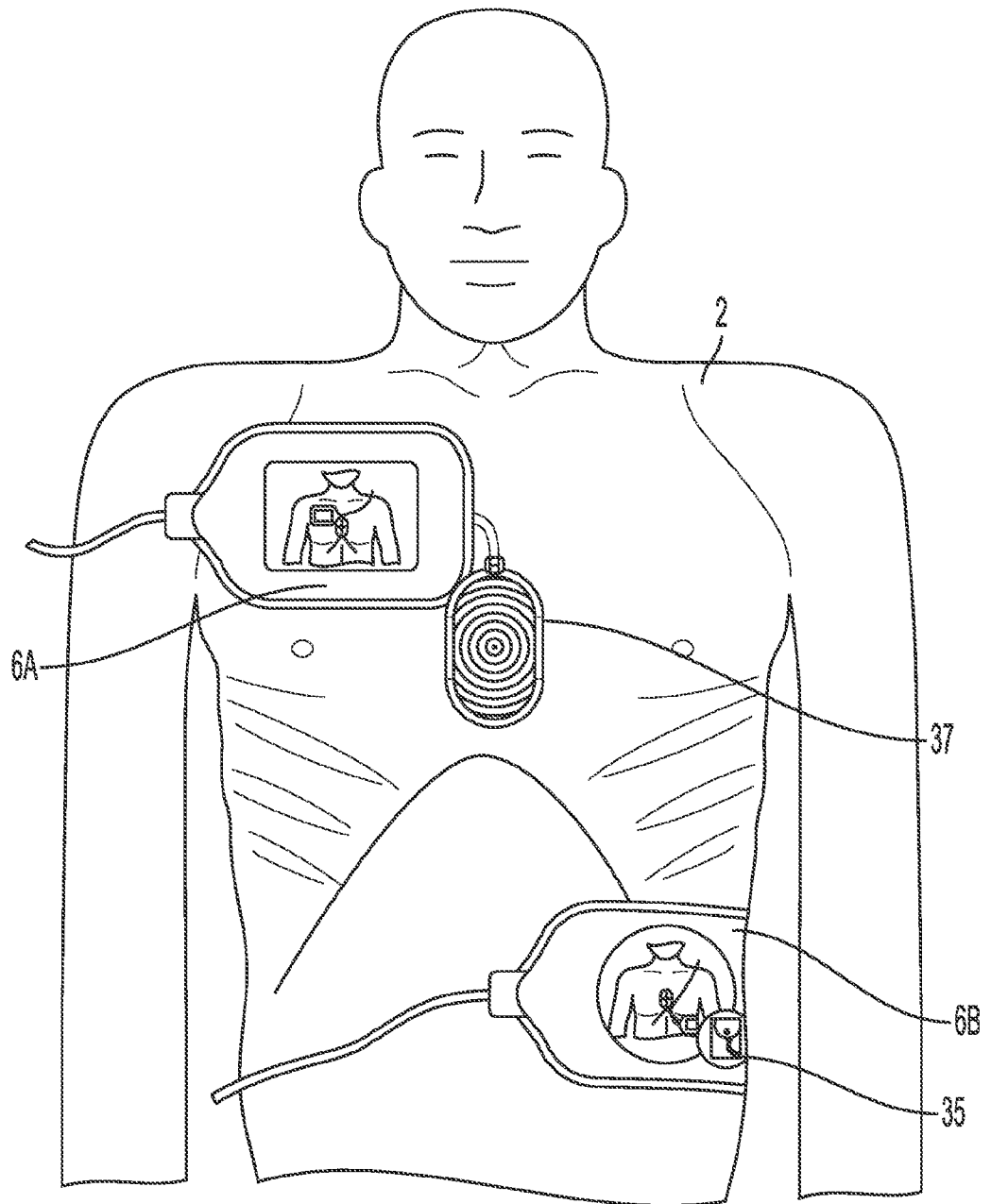


FIG. 5

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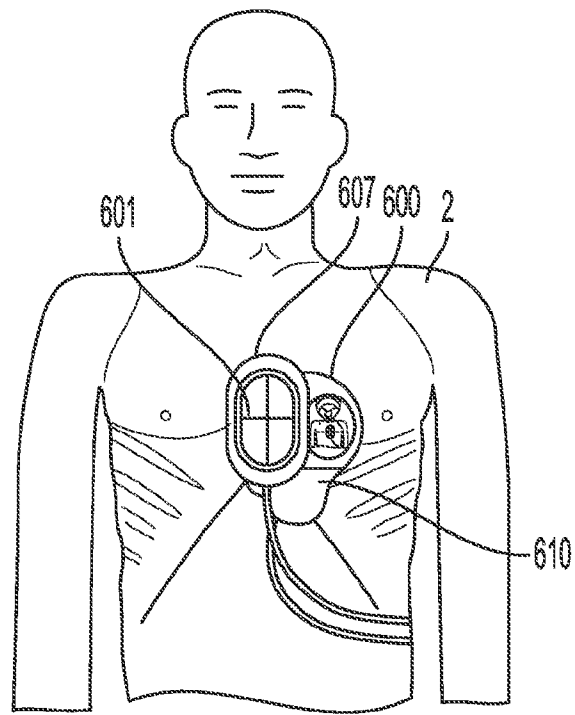


FIG. 6A

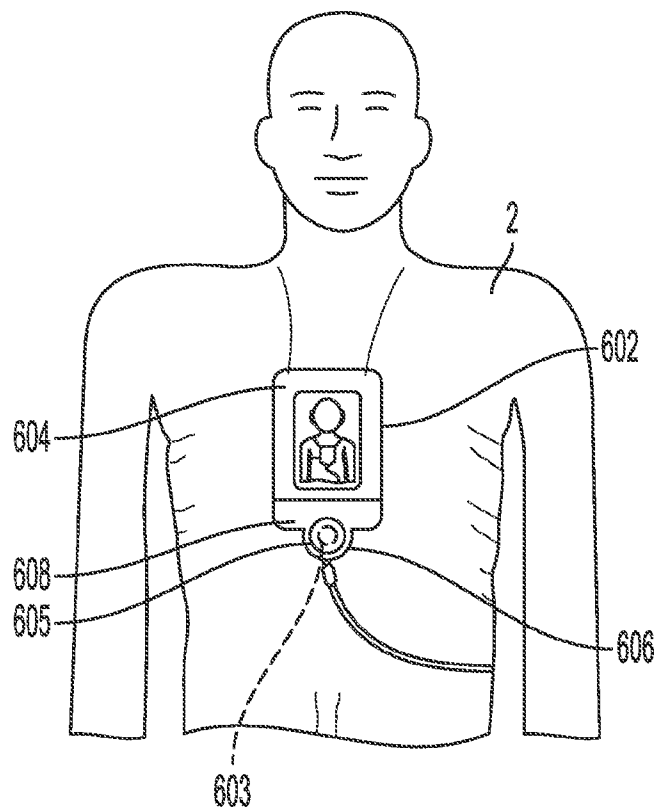


FIG. 6B

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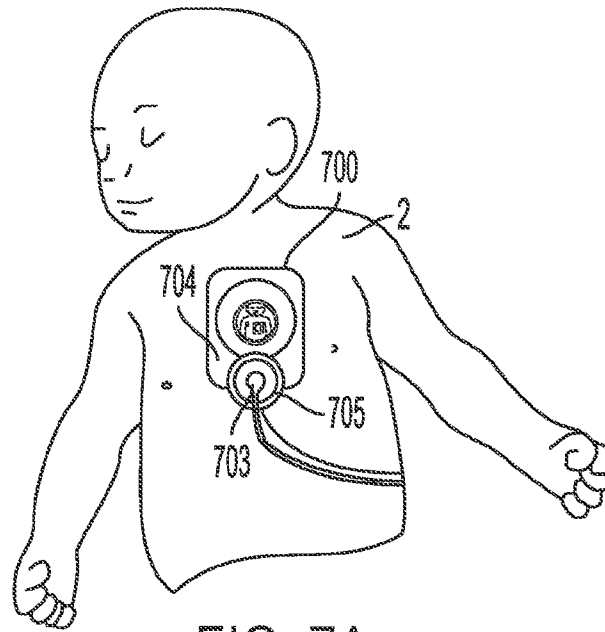


FIG. 7A

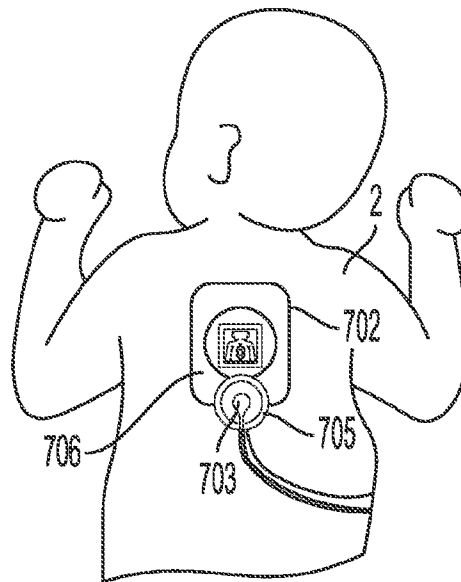


FIG. 7B

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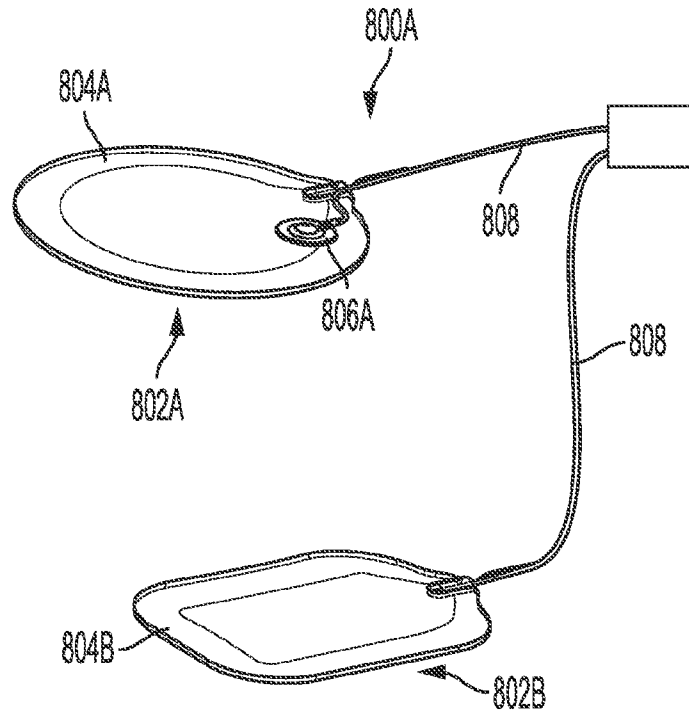


FIG. 8A

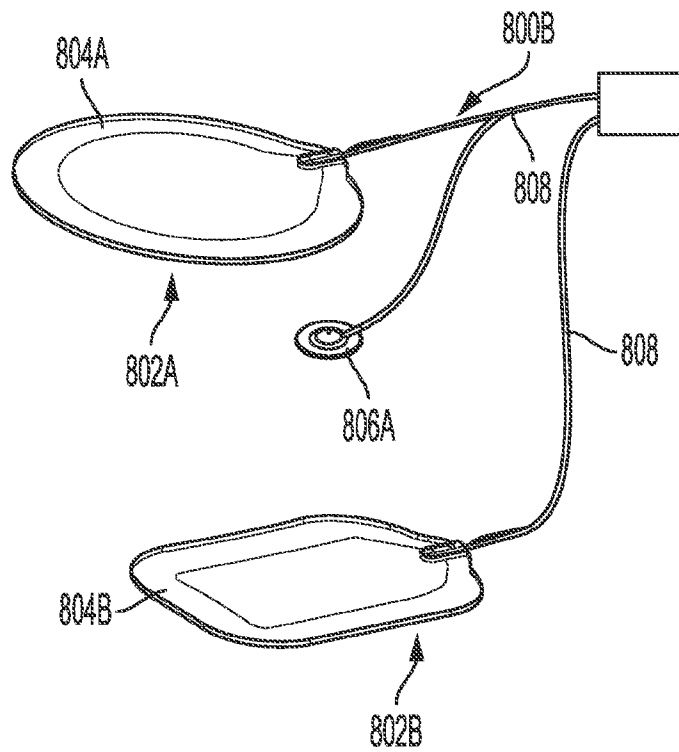


FIG. 8B

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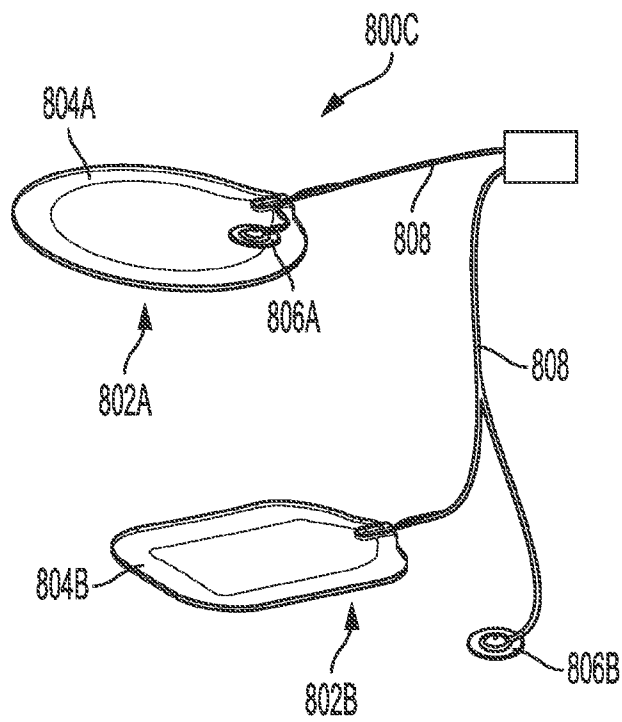


FIG. 8C

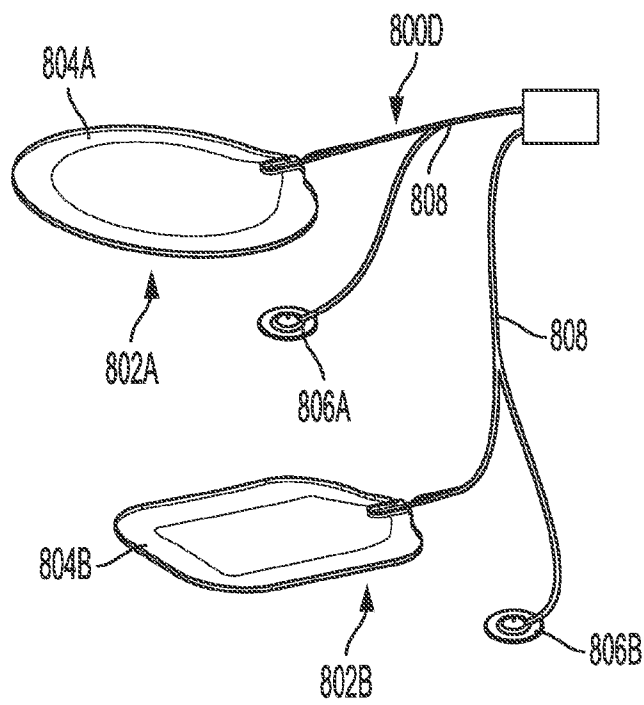


FIG. 8D

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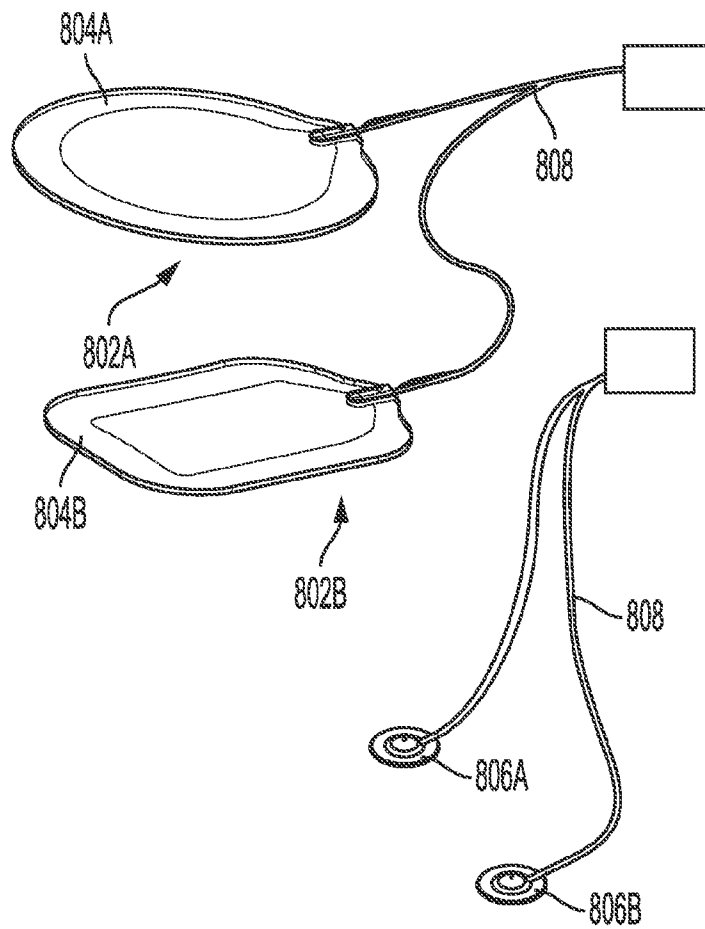


FIG. 8E

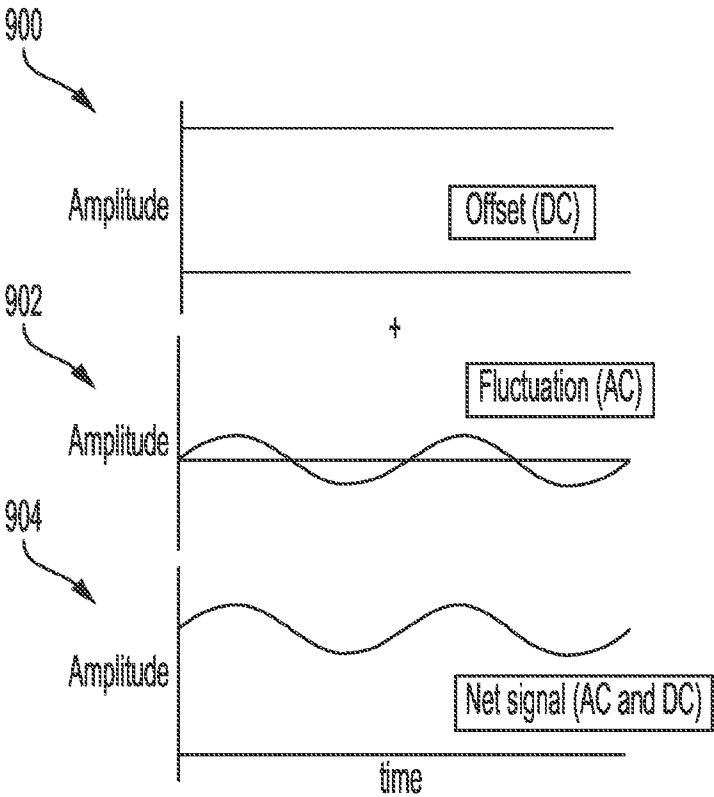


FIG. 9

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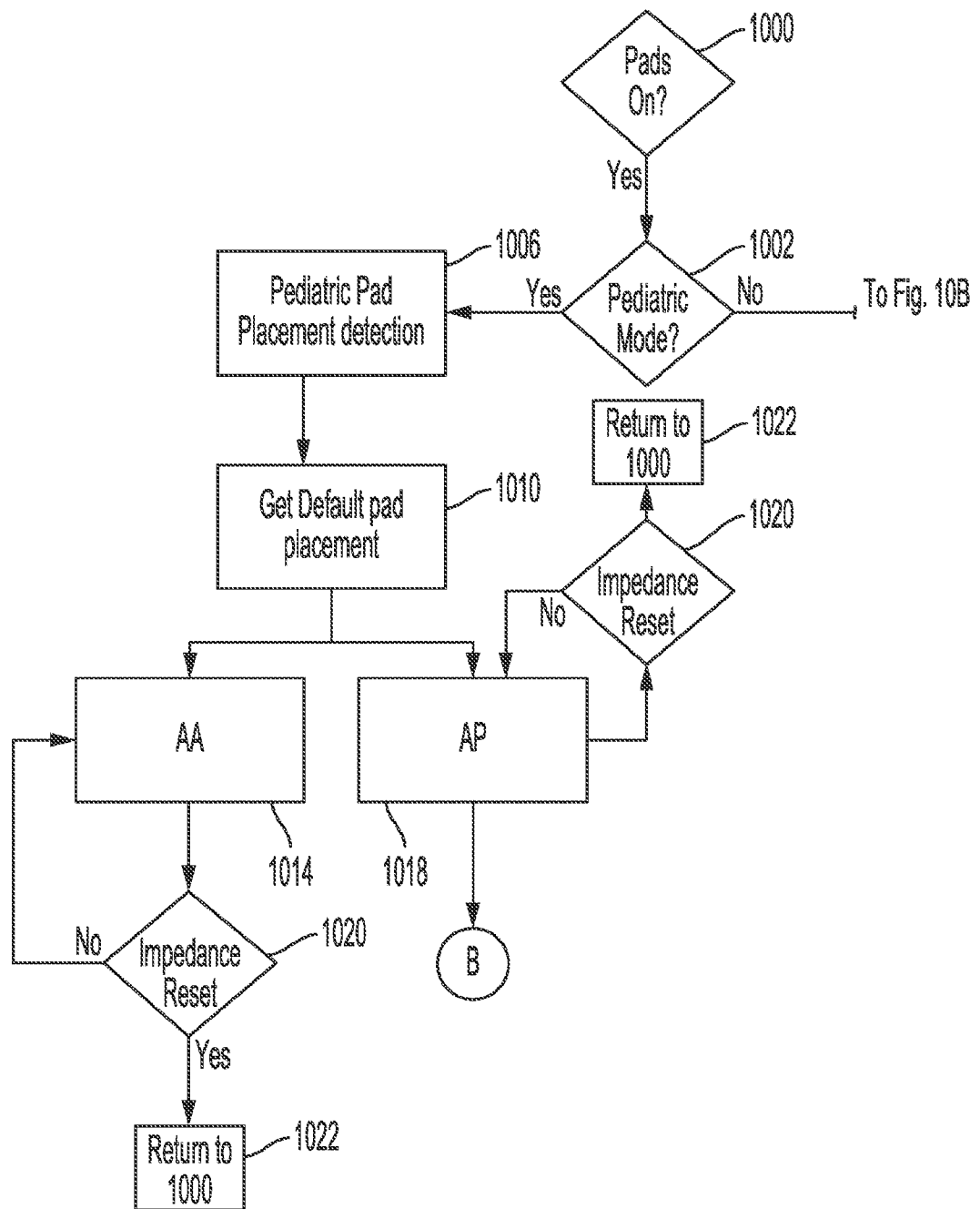


FIG. 10A

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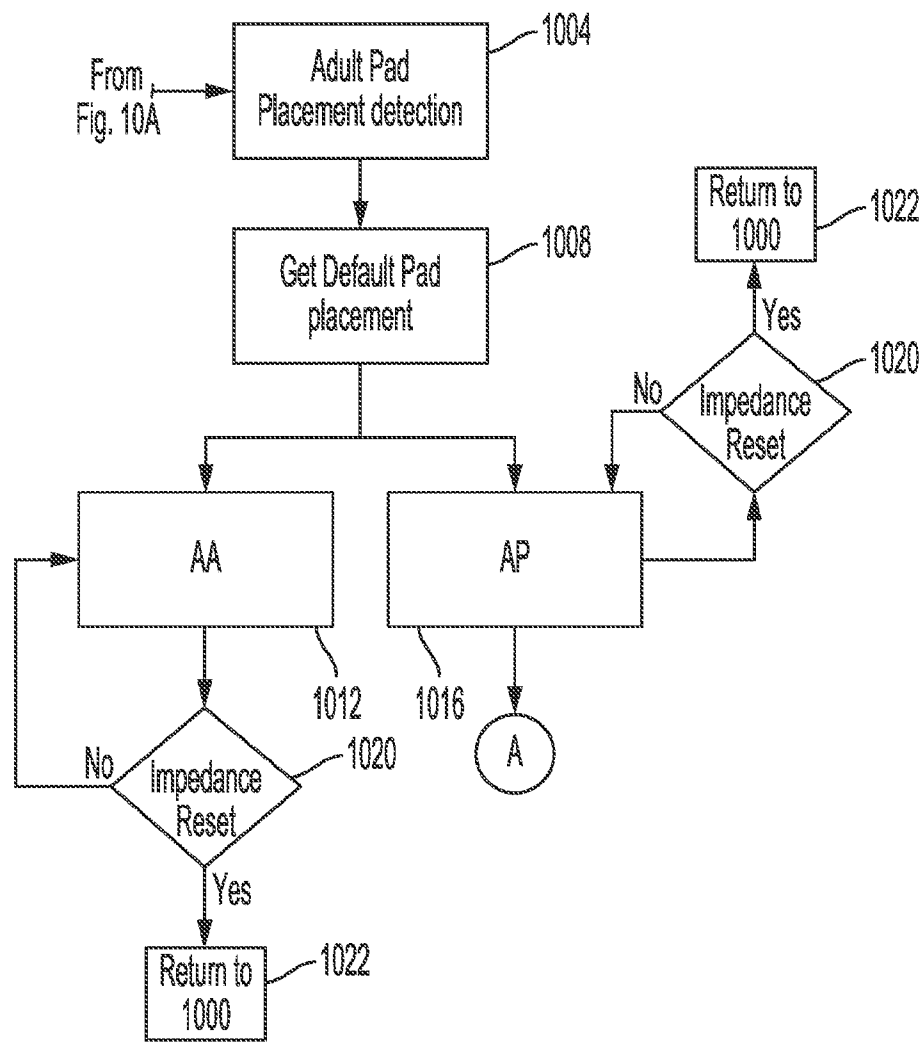


FIG. 10B

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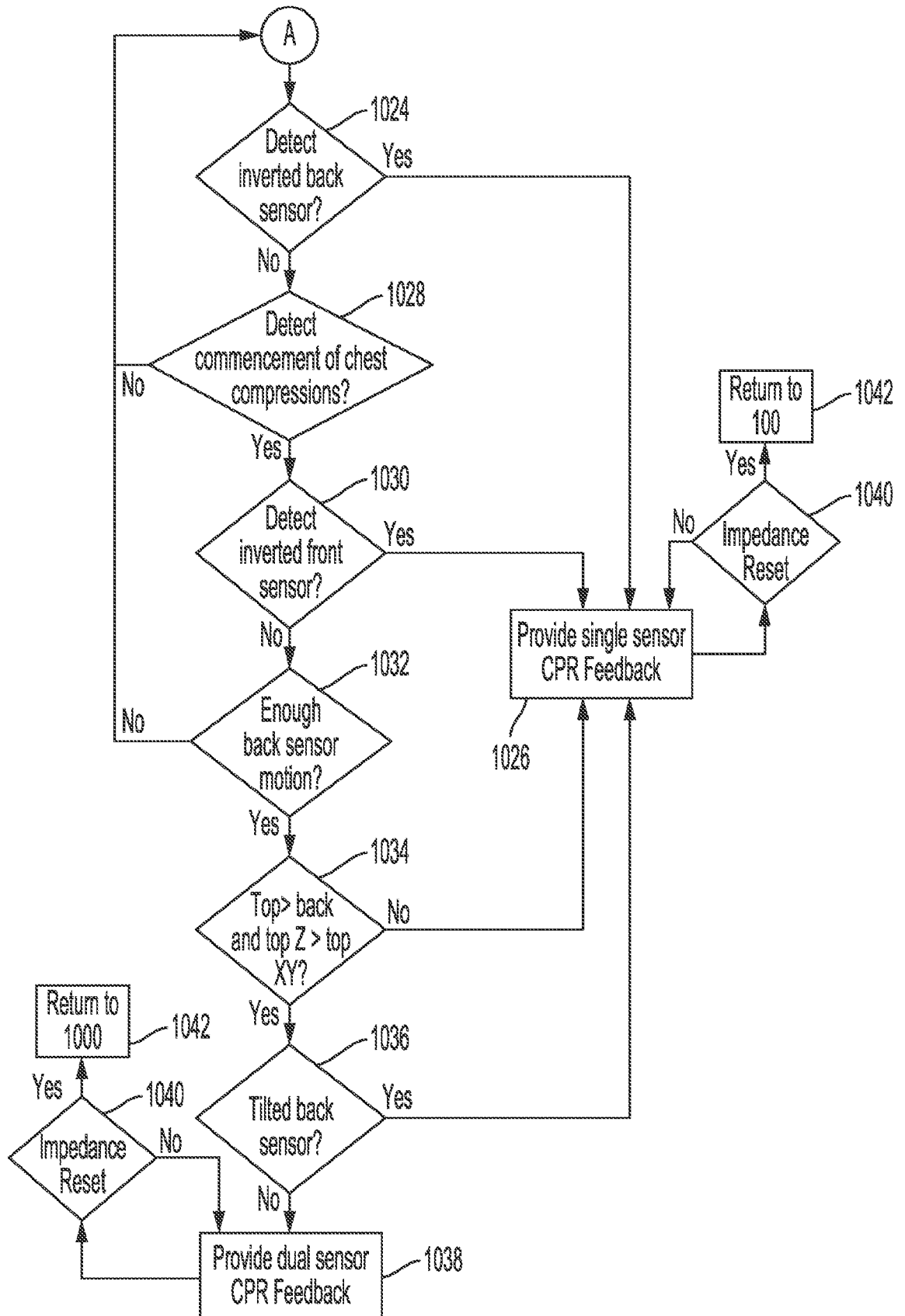


FIG. 11

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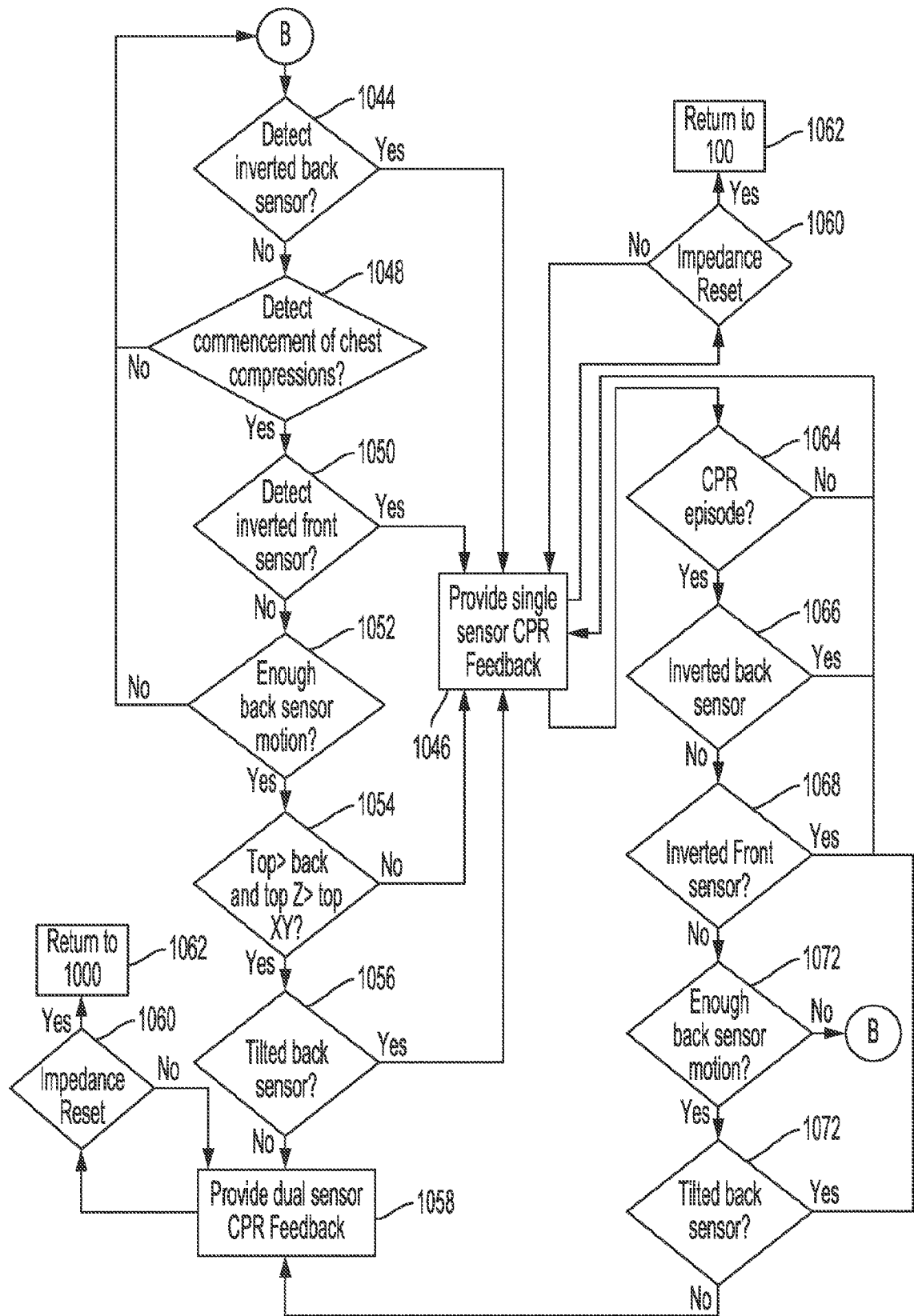


FIG. 12

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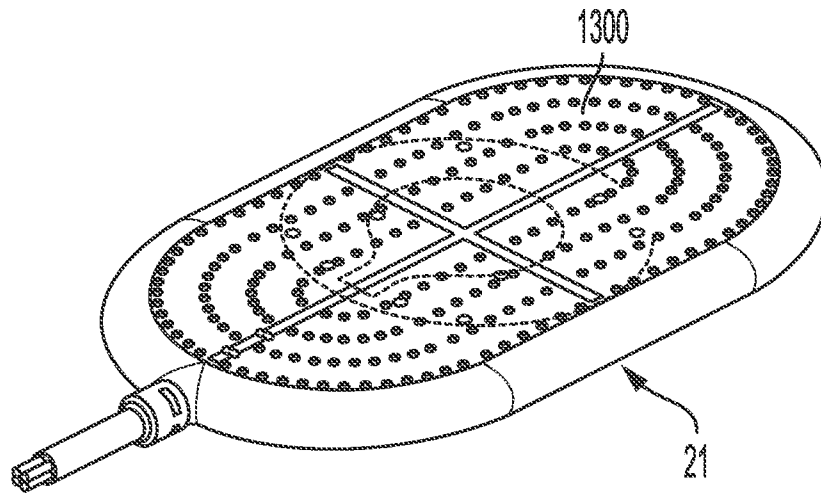


FIG. 13A

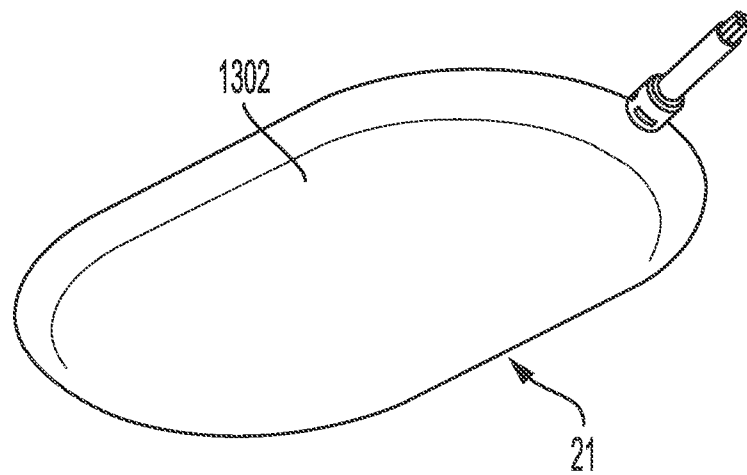


FIG. 13B

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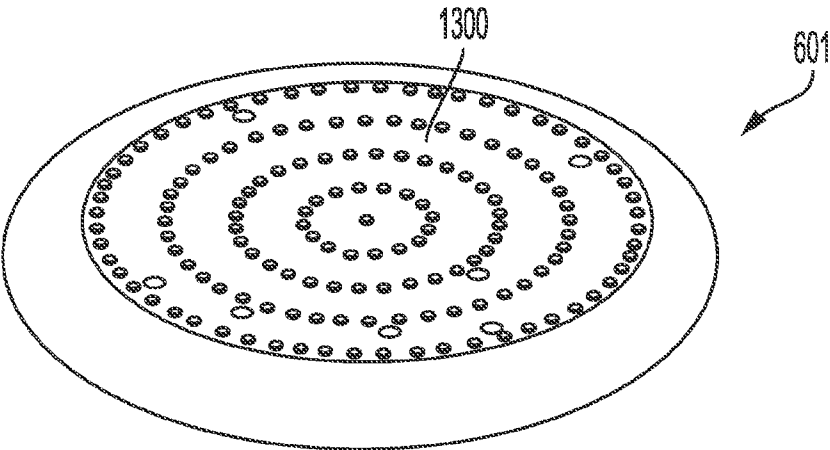


FIG. 13C

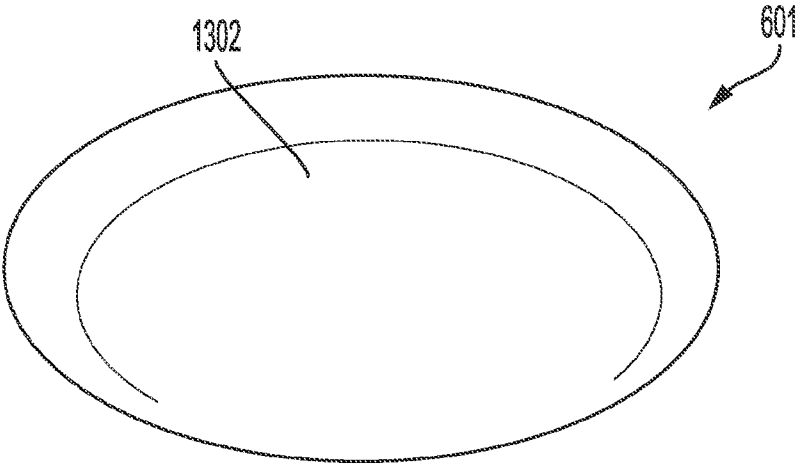


FIG. 13D

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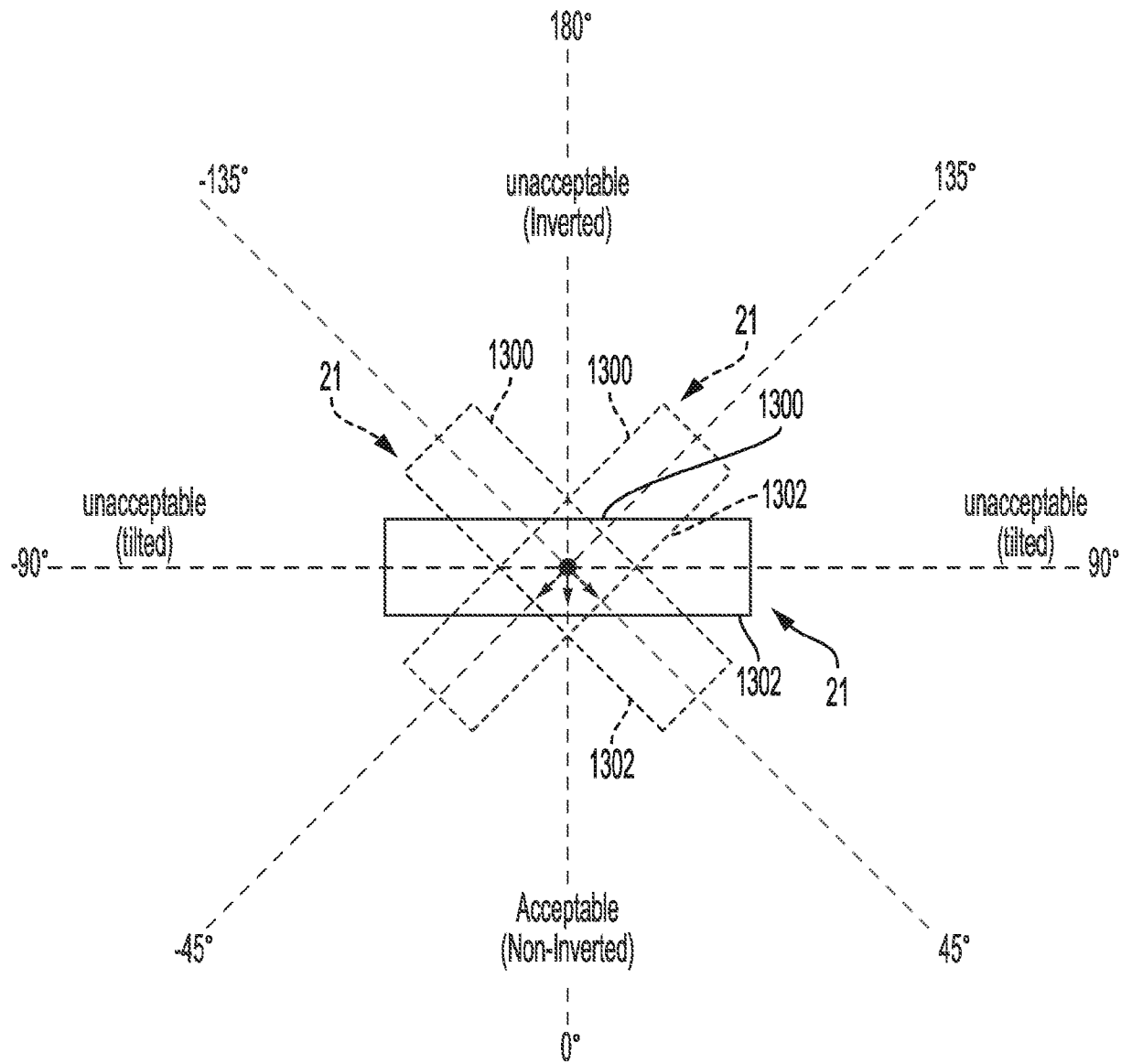


FIG. 13E

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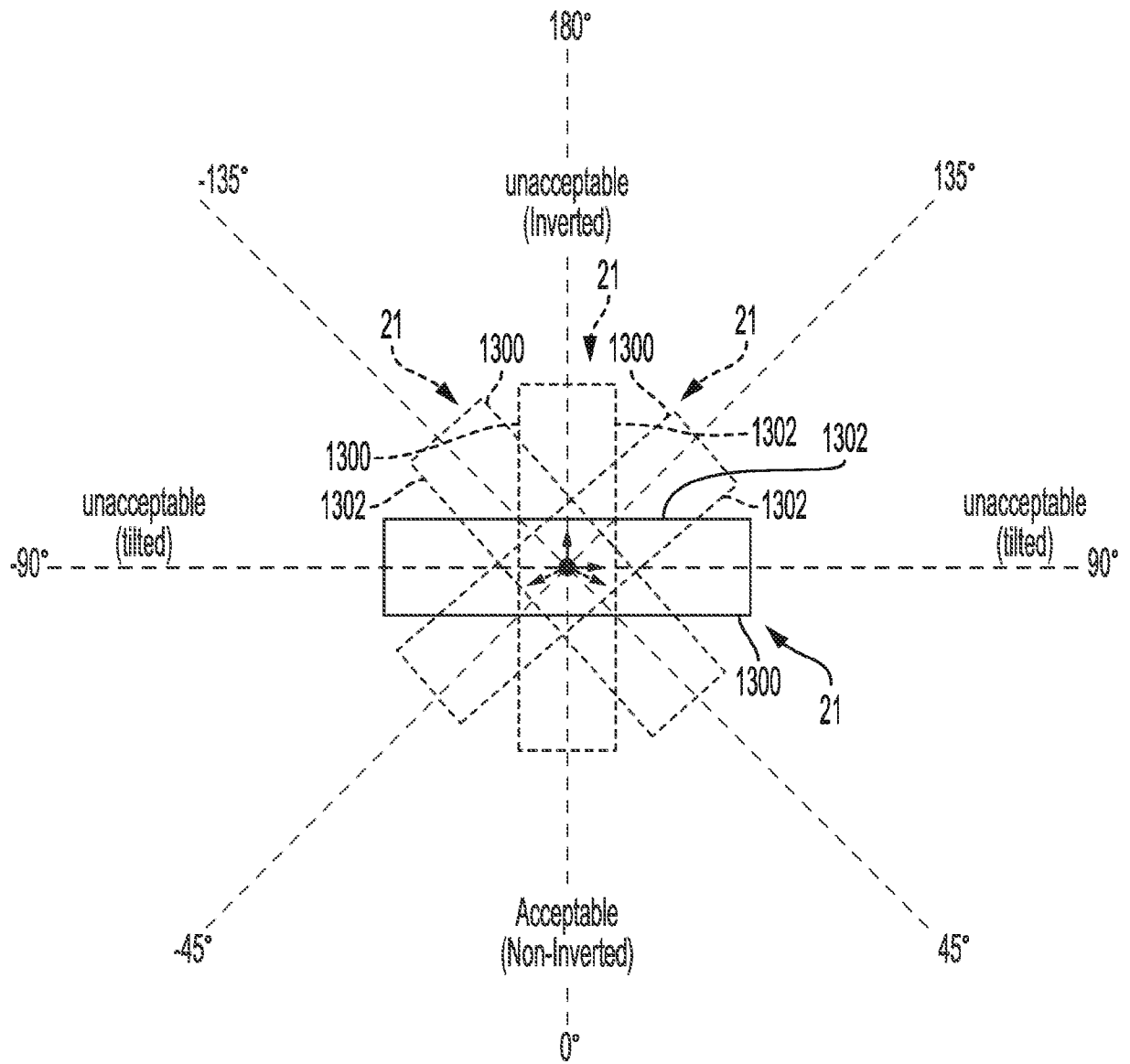


FIG. 13F

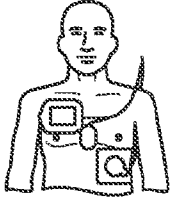
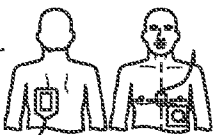
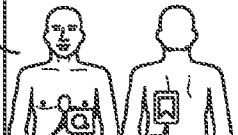
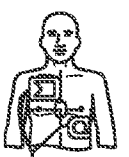
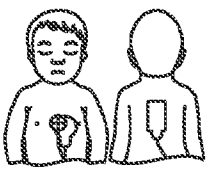
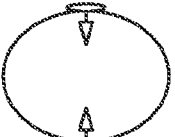
Correct Pad Placement			
Pad Placement	Sensor Orientation	Placement Detection	CPR Feedback
1400  Anterior/Anterior		AA	Single-sensor CPR Feedback
1402  Anterior/Posterior		AA	Single-sensor CPR Feedback
1404  Anterior/Posterior		AP	Dual-Sensor CPR Feedback
1406  Anterior/Anterior		AA	Single-sensor CPR Feedback
1408  Anterior/Posterior		AP	Dual-Sensor CPR Feedback

FIG. 14

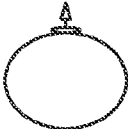
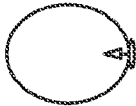
Incorrect Pad Placement - Single Motion Sensor Electrode Assembly			
Pad Placement	Sensor Orientation	Placement Detection	CPR Feedback
1500 Default pad placement (AA) with CPR sensor inverted		AA	Single-sensor CPR Feedback
1502 Alternate pad placement (AP) with CPR sensor inverted		AA	Single-sensor CPR Feedback
1504 Default (AA) or alternate (AP) pad placement with CPR sensor on patient side		Other	No CPR Feedback

FIG. 15

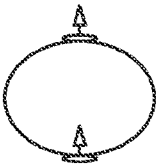
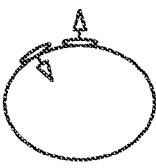
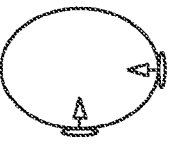
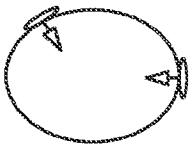
Incorrect Pad Placement - Dual Motion Sensor Electrode Assembly			
Pad Placement	Sensor Orientation	Placement Detection	CPR Feedback
1600 Default pad placement (AP) with Anterior sensor inverted		AP	Single-sensor CPR Feedback
1602 Alternate pad placement (AA) with Anterior sensor inverted		AA	Single-sensor CPR Feedback
1604 Default (AP) pad placement with Anterior sensor on patient side		Other	No CPR Feedback
1606 Alternate (AA) pad placement with Anterior sensor on patient side		Other	No CPR Feedback

FIG. 16

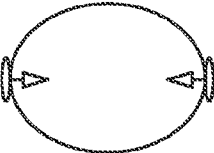
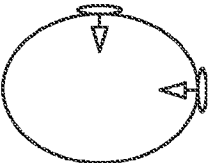
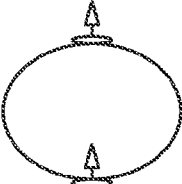
Incorrect Pad Placement - Dual Motion Sensor Pediatric Electrode Assembly			
Pad Placement	Sensor Orientation	Placement Detection	CPR Feedback
1700 Lateral-lateral pad placement		Other	No CPR Feedback
1702 Lateral-lateral pad placement with Anterior sensor attached to chest		AA	Single-sensor CPR Feedback
1704 Default pad placement (AP) with Anterior sensor inverted		AP	Single-sensor CPR Feedback

FIG. 17

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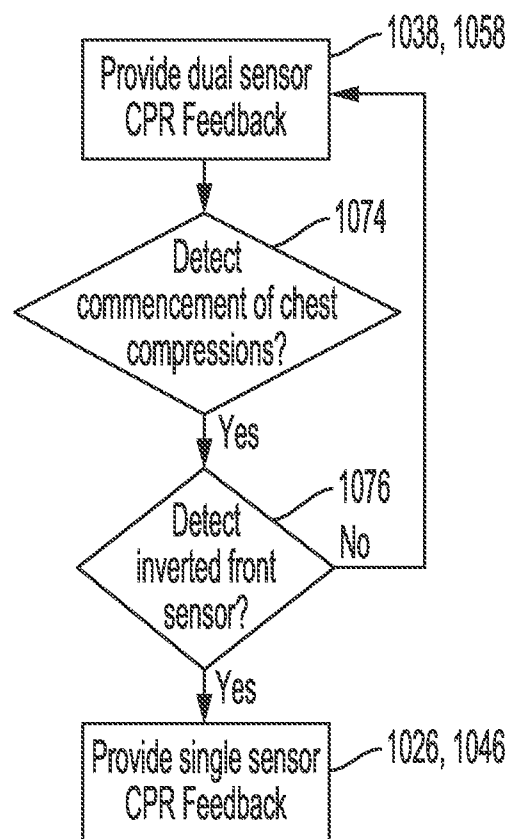


FIG. 18

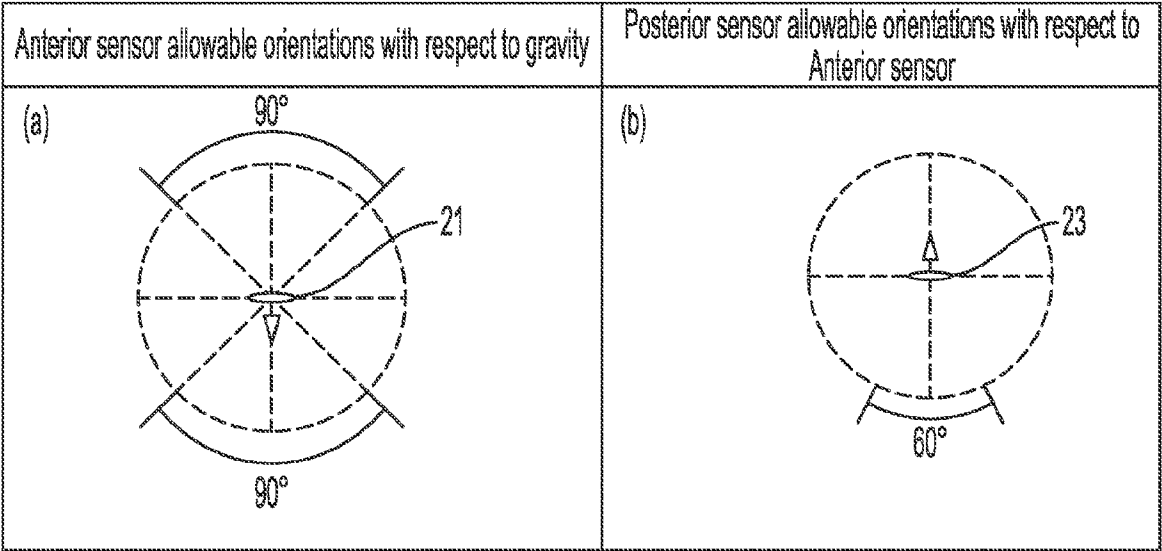


FIG. 19

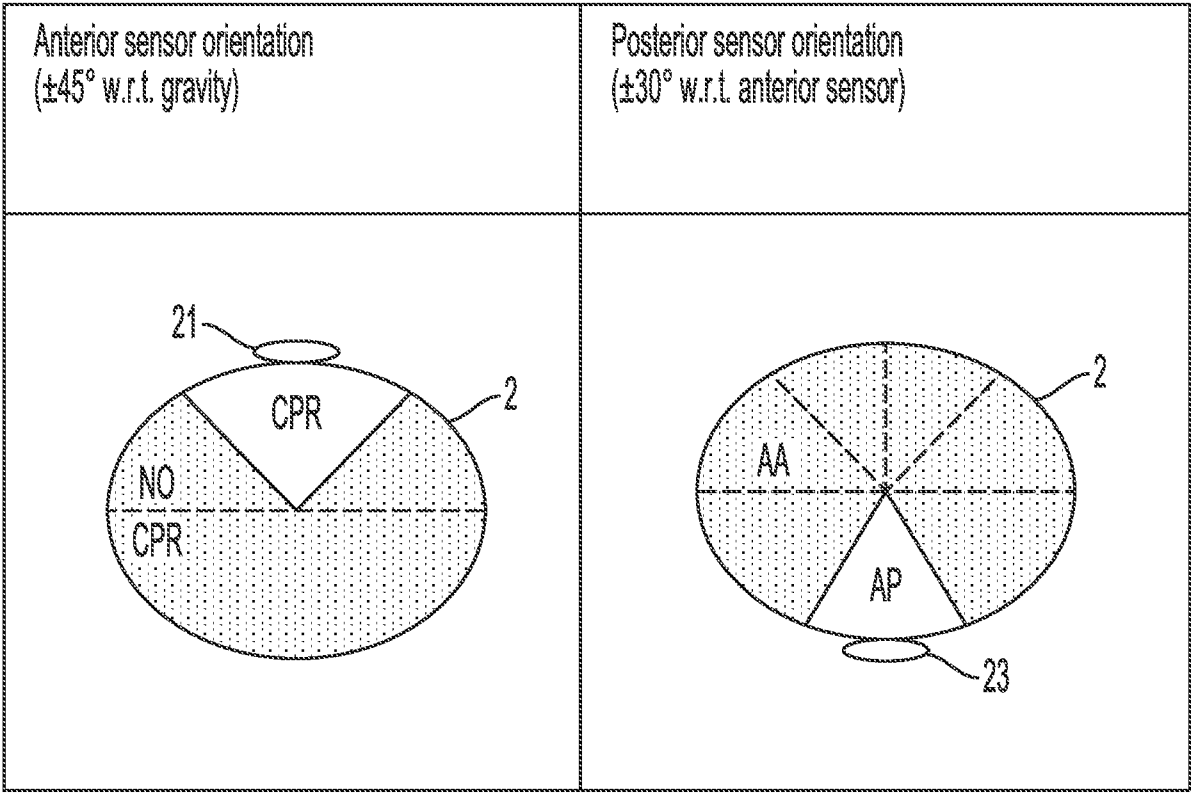


FIG. 20

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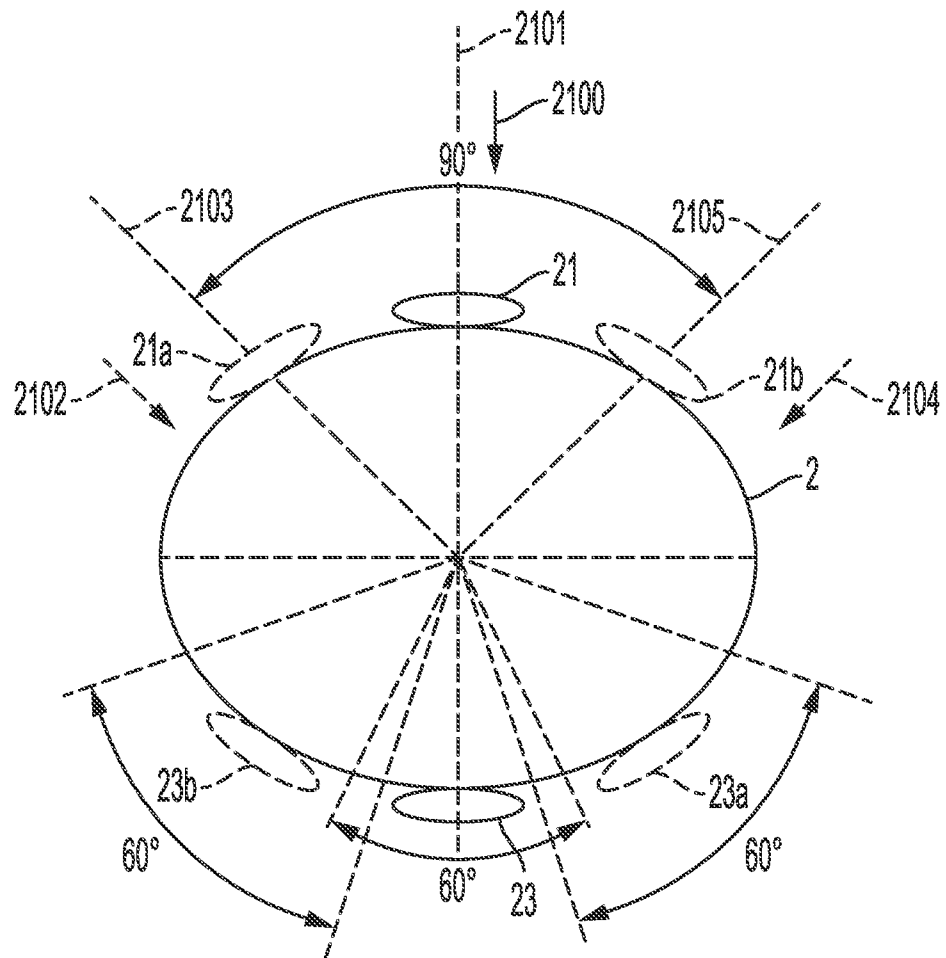


FIG. 21

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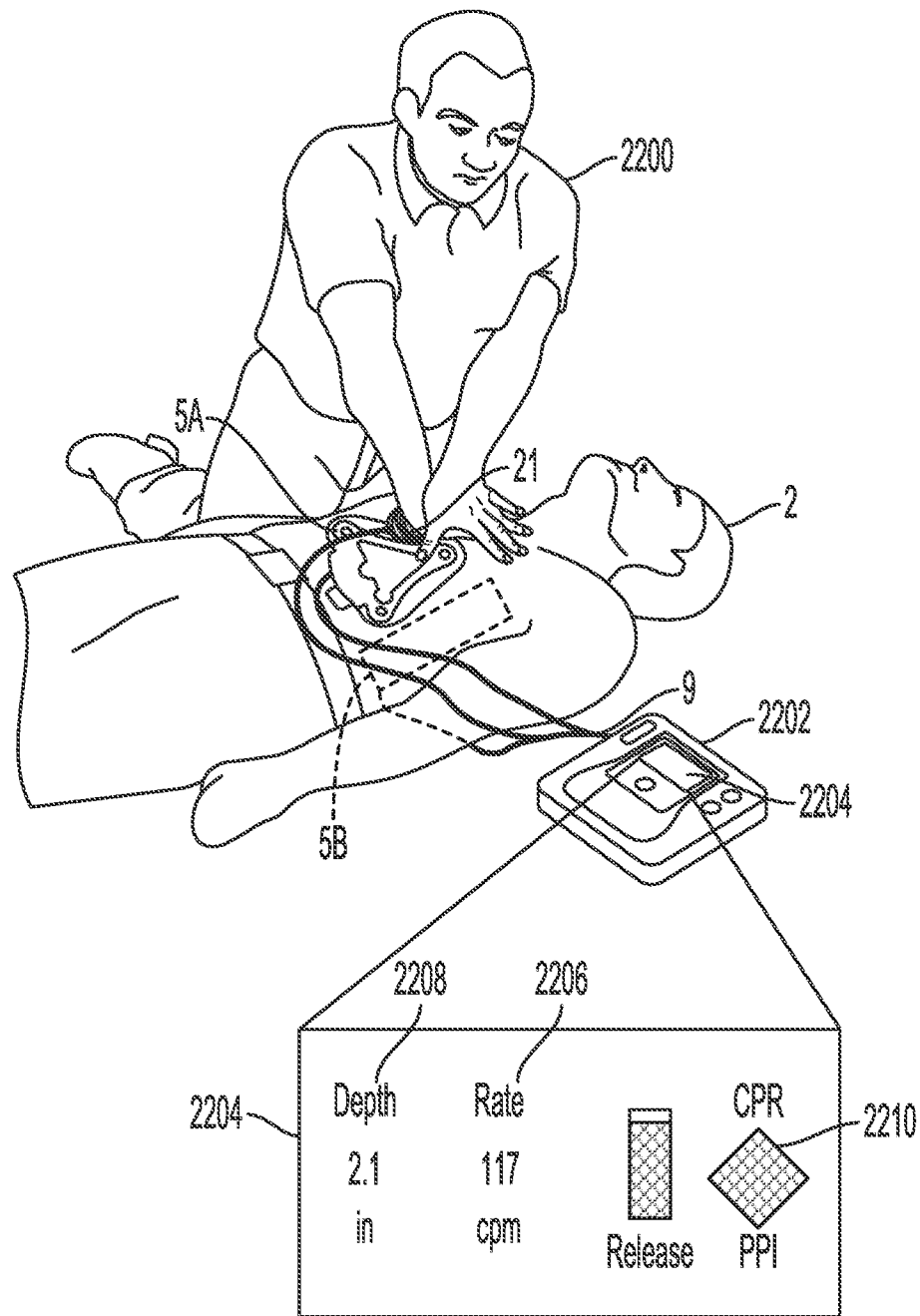


FIG. 22

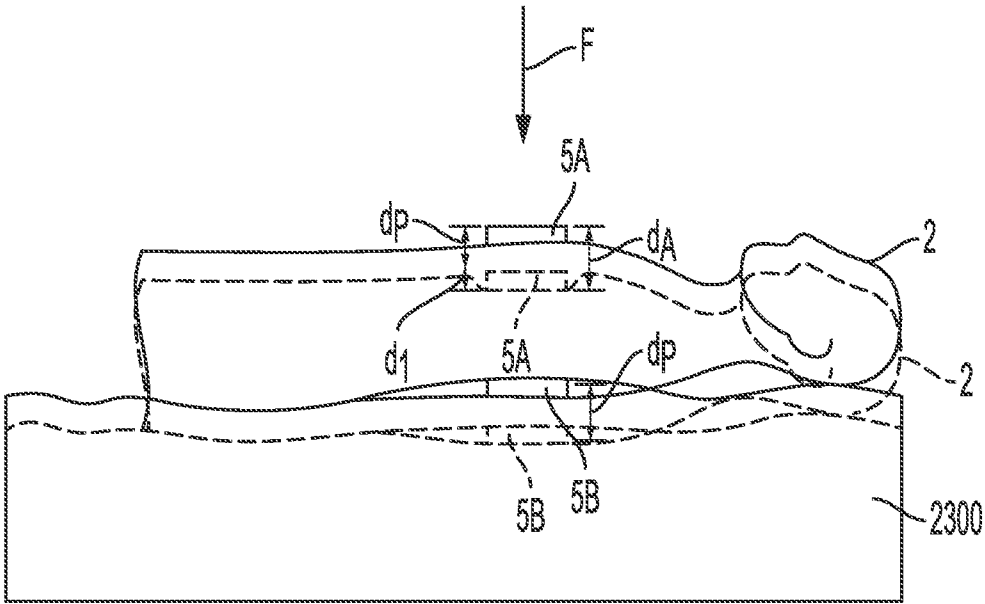


FIG. 23

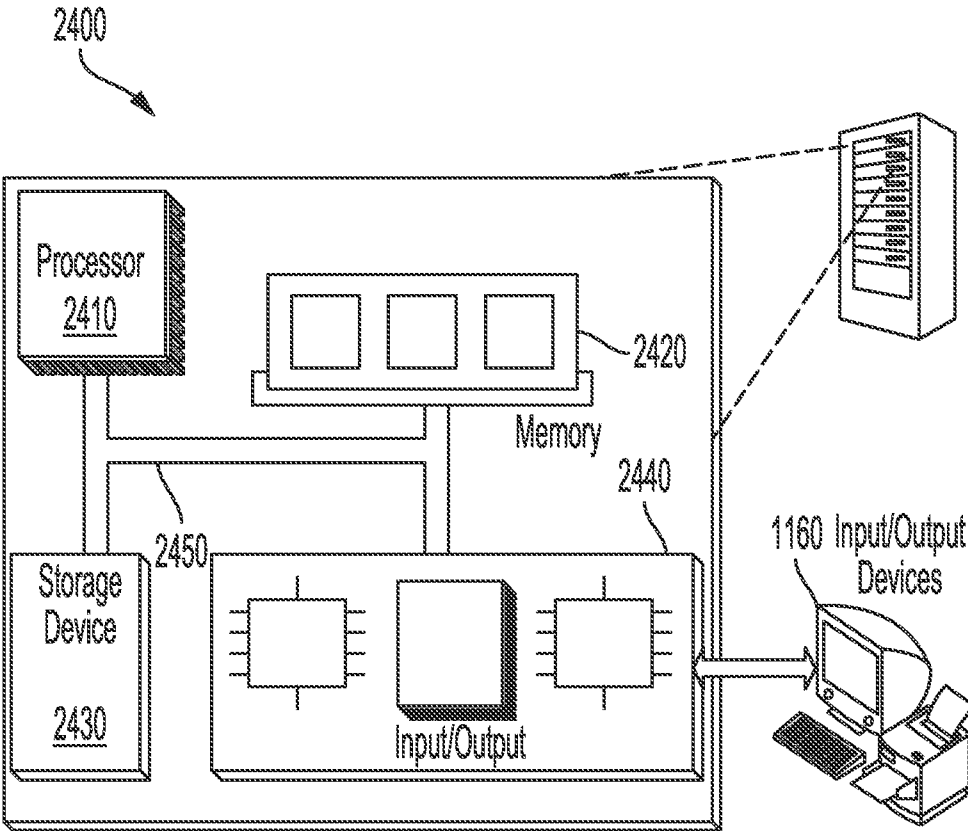


FIG. 24