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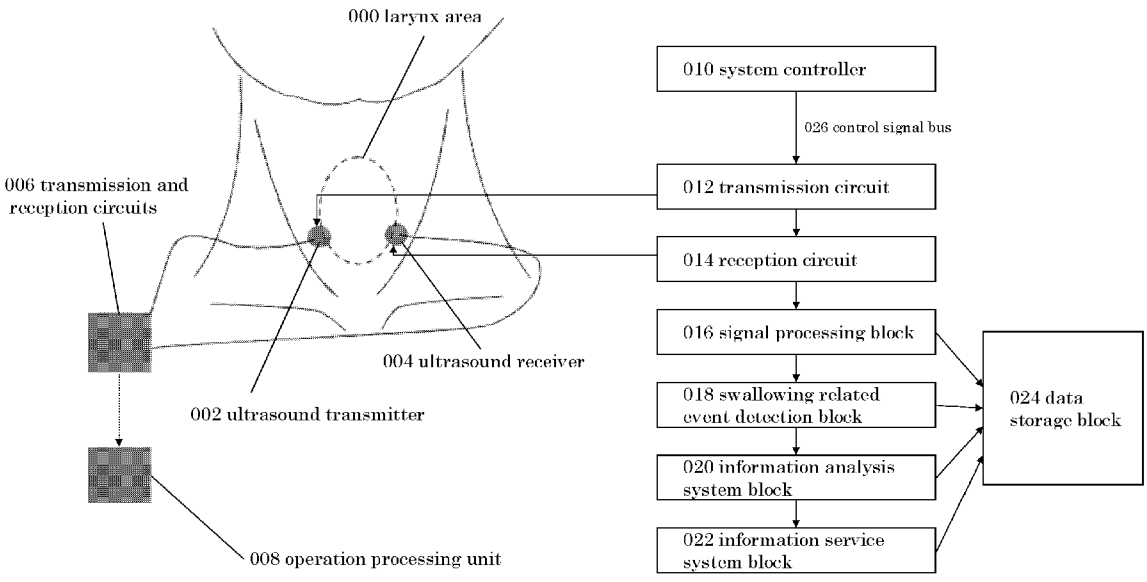
(54) Title: SWALLOWING-RELATED INFORMATION ACQUISITION APPARATUS, INFORMATION ANALYSIS METHOD, AND PROGRAM

[Fig. 1]



(57) Abstract: An apparatus for acquiring swallowing-related information includes an ultrasound transmitting device that transmits ultrasound waves to a larynx and/or trachea area of a subject, an ultrasound receiving device that converts the ultrasound waves transmitted through the larynx and/or trachea area of the subject to received signals, an attachment device that holds the ultrasound transmitting device and the receiving device on the neck of the subject such that the ultrasound waves pass through the larynx and/or trachea area of the subject, a processing device including circuitry that coverts the received signals into swallowing-related information, detects at least one swallowing-related event and biological information based on the swallowing-related information, analyzes at least one swallowing-related event and the biological information to generate swallowing-related information analysis, and generates information for safety and dysphagia rehabilitation based on the swallowing-related information analysis including an alert system activation

[Continued on next page]

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that activates alert system to inform aspiration of the subject. The swallowing-related event includes at least one selected from the group consisting of dysphasia, abnormal swallowing, and cough, and the biological information includes at least one selected from the group consisting of body temperature, pulse rate, respiration rate, blood pressure, mastication-related information, vocalization, and movement of the neck.

Description

Title of Invention: SWALLOWING-RELATED INFORMATION ACQUISITION APPARATUS, INFORMATION ANALYSIS METHOD, AND PROGRAM

Technical Field

[0001] The present invention is directed to an apparatus for acquiring swallowing-related information, a swallowing-related information investigation method, and a program that causes the computer to execute the method.

Background Art

[0002] Dysphagia is a disorder in the sequence of action that patients recognize, masticate, and swallow a food. That is mainly caused by a cerebrovascular accident, neurological diseases, head and neck tumor, disuse, etc.

[0003] Aspiration is a state caused by dysphagia, in which liquid or solid food accidentally pass through the vocal codes of the larynx. When aspiration occurred, it induces a cough reflex mechanism to expel food on a normal subject. A dysphagia patient lacks a cough reflex mechanism because of decreased laryngeal perception. Liquid or solid food that passes through the trachea and reaches to the lung increases the risk of aspiration pneumonia.

[0004] In present clinical situation, physicians have two test methods to evaluate the risk of dysphagia including aspiration: videofluoroscopic examinations and videoendoscopic examinations of swallowing.

Citation List

Patent Literature

[0005] PTL 1: WO 201301969 A2.

Non Patent Literature

[0006] NPL 1: Yuka Miura, et al., "Method for detection of aspiration based on B-mode video ultrasonography," Radiol Phys Technol (2014) 7:290-295.

[0007] NPL 2: Samah Jafari, et al., "Sensory regulation of swallowing and airway protection: a role for the internal superior laryngeal nerve in humans," J Physiol (2003) 550.1: 287-304.

[0008] NPL 3: Rachel A. Cassiani, et al., "Oral and pharyngeal bolus transit in patients with chronic obstructive pulmonary disease," Int J of COPD (2015) 10: 489-496.

Summary of Invention

Technical Problem

[0009] The present invention aims at producing new solution that can acquire swallowing-

related information such as aspiration in daily meal setting.

Solution to Problem

[0010] According to one aspect of the present invention, an apparatus for acquiring swallowing-related information includes an ultrasound transmitting device that transmits ultrasound waves to a larynx and/or trachea area of a subject, an ultrasound receiving device that converts the ultrasound waves transmitted through the larynx and/or trachea area of the subject to received signals, an attachment device that holds the ultrasound transmitting device and the receiving device on the neck of the subject such that the ultrasound waves pass through the larynx and/or trachea area of the subject, a processing device including circuitry that coverts the received signals into swallowing-related information, detects at least one swallowing-related event and biological information based on the swallowing-related information, analyzes at least one swallowing-related event and the biological information to generate swallowing-related information analysis, and generates information for safety and dysphagia rehabilitation based on the swallowing-related information analysis including an alert system activation that activates alert system to inform aspiration of the subject. The swallowing-related event includes at least one selected from the group consisting of dysphasia, abnormal swallowing, and cough, and the biological information includes at least one selected from the group consisting of body temperature, pulse rate, respiration rate, blood pressure, mastication-related information, vocalization, and movement of the neck.

[0011] According to another aspect of the present invention, a method of acquiring swallowing-related information includes transmitting ultrasound waves to a larynx and/or trachea area of a subject, converting the ultrasound waves transmitted through the larynx and/or trachea area of the subject to received signals, converting the received signals into swallowing-related information, detecting at least one swallowing-related event and biological information has based on the swallowing-related information, and analyzing the at least swallowing-related event and the biological information to generate swallowing-related information analysis, and generate information for safety and food training based on the swallowing-related information analysis including an alert system activation that activates alert system to inform aspiration of the subject. The swallowing-related event includes at least one selected from the group consisting of dysphasia, abnormal swallowing, and cough, and the biological information includes at least one selected from the group consisting of body temperature, pulse rate, respiration rate, blood pressure, mastication-related information, vocalization, and movement of the neck.

[0012] According to yet another aspect of the present invention, a non-transitory computer

readable medium having stored thereon a program that when executed by a computer, causes the computer to execute a method of acquiring swallowing-related information. The method includes transmitting ultrasound waves to a larynx and/or trachea area of a subject, converting the ultrasound waves transmitted through the larynx and/or trachea area of the subject to received signals, converting the received signals into swallowing-related information, detecting at least one swallowing-related event and biological information has based on the swallowing-related information, and analyzing the at least swallowing-related event and the biological information to generate swallowing-related information analysis, and generate information for safety and food training based on the swallowing-related information analysis including an alert system activation that activates alert system to inform aspiration of the subject. The swallowing-related event includes at least one selected from the group consisting of dysphasia, abnormal swallowing, and cough, and the biological information includes at least one selected from the group consisting of body temperature, pulse rate, respiration rate, blood pressure, mastication-related information, vocalization, and movement of the neck.

Advantageous Effects of Invention

[0013] The present invention produces new solution that can acquire swallowing-related information such as aspiration in daily meal setting.

Brief Description of Drawings

[0014] [fig.1]FIG. 1 is a schematic diagram of a dysphagia information acquisition apparatus of the present invention using through-transmission ultrasound.

[fig.2]FIG. 2 is an exemplary embodiment of an apparatus for acquiring swallowing-related information of the present invention using through-transmission ultrasound, where one or more ultrasound transmitters and one or more ultrasound receivers are located at one or several levels of the neck of a subject, or surrounding the neck of a subject.

[fig.3]FIG. 3 is schematic diagrams of an ultrasound transmitter and receiver element of the present invention using through-transmission ultrasound.

[fig.4]FIG. 4 is schematic diagrams of a holder of the present invention using through-transmission ultrasound to hold one or more ultrasound transmitters and receivers appropriately to the neck of a subject.

[fig.5]FIG. 5 is a schematic illustration of the proposed method in a longitudinal section of the larynx area.

[fig.6]FIG. 6 is an algorithm of a dysphagia information acquisition apparatus of the present invention using through-transmission ultrasound.

Description of Embodiments

[0015] An apparatus for acquiring swallowing-related information according to an embodiment of the present invention includes an apparatus that transmits ultrasound waves to the larynx area of a subject 000 and receives ultrasound waves passed through the larynx area of a subject 000. FIG. 1 shows a schematic diagram of an apparatus for acquiring swallowing-related information employing an embodiment of the present invention. The apparatus is provided with one or more ultrasound transmitters 002, one or more ultrasound receivers 004, one or more transmission and reception circuits 006, one or more operation processing unit 008, one or more transmission circuits 012, one or more reception circuit 014, a signal processing block 016, a swallowing-related event detection block 018, an information analysis system block 020, an information service system block 022, and a system controller 010. An operation processing unit 008 includes one or more central processing units (CPU), one or more graphics processing units (GPU), one or more field-programmable gate arrays (FPGA), one or more random-access memories (RAM), and/or one or more read only memories (ROM). The data acquired by each block are stored to the data storage block 024 and can be communicated with other electrical devices. A system controller 010 and each block are connected to the control signal bus 026.

[0016] An ultrasound transmitter 002 includes a piezoelectric element 300 and a case 302. An ultrasound receiver 004 has the same structure to an ultrasound transmitter 002. The transmit frequency available for the apparatus using through-transmission ultrasound ranges from 0.5 mega-hertz (MHz) to 12 MHz. The transmit frequency optimum for the apparatus using through-transmission ultrasound ranges from 0.5 MHz to 2 MHz. The suitable pulse width ranges from 10 to 50 times the wavelength. Shorter pulse width causes worse signal-noise ratio and longer pulse width could cause unnecessary thermal affects to the tissue.

[0017] An ultrasound transmitter 002 and an ultrasound receiver 004 locate at both side of the larynx area of a subject 000 in order to receive through-transmission ultrasound waves that transmit through the neck of a subject. An ultrasound transmitter 002 transmits ultrasound waves during a subject takes liquid or solid food. Through-transmission ultrasound measurement is performed continuously during and after a meal. When the aspiration occurs, an aspirated object 500 changes ultrasound propagation characteristics passing through the larynx area 000, resulting in the waveform change in the received signal (FIG. 5).

[0018] A signal processing block 016 converts received signals into swallowing-related information like aspiration or abnormal swallowing movement. In aspiration, liquid or solid food goes into the airway of a subject slowly compared with it goes through the esophagus of a subject. For example, a few studies also have mentioned pharyngeal transit times (NPL 2, NPL 3). Therefore, a signal processing block 016 applies a digital

or analog filter to received signals in order to convert received signals into swallowing-related information effectively. Typically, the path-length that passes through an aspirated object depends on the location of the object in trachea, that is, the variation of received signal caused by aspiration occurs at the region that corresponds to the path-length in the time domain. Therefore, the employment of a time window that extracts the region corresponding to the path-length is suitable to detect aspirated objects.

[0019] A swallowing-related event detection block 018 detects at least one swallowing-related event and biological information based on the swallowing-related information converted by a signal processing block 016. Because the time-of-flight of an ultrasound wave between an ultrasound transmitter 002 and an ultrasound receiver 004 is much less than 0.1 millisecond (ms), a swallowing-related event detection block 018 uses swallowing-related event and biological information converted by a signal processing block 016 in order to improve the sensitivity and the specificity of an aspiration detection block 018. A swallowing-related event detection block 018 also detects abnormal swallowing movement, for example, by detecting muscular movement of the neck is not synchronized with respiratory rhythm or movement of the food in the esophagus.

[0020] A swallowing-related event detection block 018 can apply sound data acquired by one or pleural portable microphones to record the swallowing sounds additionally for the improvement of the sensitivity in aspiration detection. A swallowing-related event detection block 018 can also apply a speech coding technique to sound data in order to detect swallowing-related events effectively.

[0021] A swallowing-related event detection block 018 can calculate correlation ratio between ultrasound data and vital data including a respiratory rate, respiratory patterns, a pulse rate, and a peripheral blood oxygen saturation rate acquired by one or more portable biosensors in order to improve the performance in aspiration detection.

[0022] An information analysis system block 020 analyzes at least one swallowing-related event and the biological information which are detected in swallowing-related event detection block 018, and to generate swallowing-related information analysis including occurrence of aspiration, inadequate installation of a holder, system errors, and abnormal vital signs. An information analysis system block 020 can also be synchronized with an external analysis device via a data storage block and analyze information in order to increase the accuracy of analysis.

[0023] An information service system block 022 generates information for safety and dysphagia rehabilitation based on the swallowing-related information analysis including an alert system activation that activates alert system to inform aspiration of the subject, inadequate installation of a holder, system errors, and abnormal vital signs.

[0024] A real-time alert system may inform an alarm to a patient and/or healthcare provider

using a beep sound, recorded voice and sound, an image display apparatus, light emitting diode (LED) indicators, and vibration of the device. A real-time alert system may employ a wireless communication system in order to inform an alarm to a computer, a tablet computer, and a cellular phone of a healthcare provider. An information service system block 022 may employ a cough induction system activated by an information analysis system block 020 in exchange for a real-time alert system.

[0025] A dysphagia rehabilitation information service system informs information valid for dysphagia rehabilitation based on information analyzed in an information analysis system block 020 in real time and/or after rehabilitation. A dysphagia rehabilitation information service system can offer information using an external device by communicating with a data storage block 024.

[0026] An operation processing unit 008 has functions including a signal processing block 016, a swallowing-related event detection block 018, an information analysis system block 020, an information service system block 022, and a data storage block 024. The received signals acquired from one or more transmission and reception circuits 006 by wireless communication can be processed in an operation processing unit 008. As an operation processing unit 008, laptop computers, personal digital assistants (PDA), tablet computers and smartphones may be used.

[0027] A system controller 010 transmits and receives information which regulates transmission and reception circuits and each block. A system controller 010 has one or more touch sensors, one or more liquid crystal displays, one or more vibratory equipment, one or more speakers and microphones, one or more buttons and knobs for operation.

[0028] FIG. 3 is schematic diagrams of an ultrasound transmitter and receiver element of the present invention using through-transmission ultrasound. FIG. 3A is a longitudinal section of an ultrasound transmitter and receiver element. FIG. 3B is a horizontal projection of an ultrasound transmitter and receiver element. A piezoelectric element 300 is covered with a case 302. Adequate diameter (R in FIG. 3B) of an ultrasound transmitter and receiver element ranges from 5 to 15 millimeter (mm) because a larger element can converge the ultrasound beam, while a larger element tends not to adhere to the neck skin which has an irregular surface. FIG. 3C and FIG.3D are longitudinal sections of ultrasound transmitter and receiver elements which have convex curved couplers 304. To increase a signal intensity by adhering an ultrasound transmitter and receiver element to the neck skin which has an irregular surface effectively, a coupler 304 in FIG. 3C applies a convex shape in the center of an element. To increase a signal intensity by adjusting the direction of an ultrasound beam toward the tracheal wall adequately, a coupler 304 in FIG. 3D has a slope in an edge of an element.

[0029] FIG. 4 are schematic diagrams of a holder of the present invention using through-

transmission ultrasound to hold one or more ultrasound transmitters and receivers appropriately to the neck of a subject. FIG. 4A to FIG. 4C are schematic diagrams of horizontal projections of holder bases 400, and FIG. 4D and FIG. 4E are schematic diagrams of longitudinal sections of holder bases 400.

In FIG. 4A, a rectangular holder base 400 of which the edges are rounded has elemental trenches 402 and band attaching holes. In FIG. 4B, a holder base 400 has a narrow part in the center in order not to oppress the neck skin when a subject bends the neck forward. A center to center distance of a pair of ultrasound elements (D in FIG. 4B) which are suitable to put on the neck skin with an irregular surface ranges from 25 mm to 35 mm. This can be adjusted based on the distance between the anterior margins of the sternocleidmastoid muscles of both sides, the largest muscles in the human neck. In FIG. 4C, a holder base 400 has an integrated transmission and reception circuit 006 with cables 406, which improves the portability of the device. In FIG. 4D, a holder base 400 has element trenches 402 for piezoelectric elements 300. Piezoelectric elements 300 are covered with a hydrogel sheet 408 before a holder base 400 are attached to the neck skin of a subject. A hydrogel jelly can be applied instead of a hydrogel sheet 408. In FIG. 4E, a holder base 400 has processes in the other side of element trenches 410 for containing larger piezoelectric elements 300 and ratchets for element fixation 412 to prevent dropping out.

Example

[0030] First Exemplary Embodiment

An ultrasound transmitter 002 and an ultrasound receiver 004 locate at one side or both sides of the neck of a subject 000 in order to receive through-transmission ultrasound waves that transmit through the larynx area of a subject 000. An ultrasound transmitter 002 transmits ultrasound waves during a subject takes liquid or solid food. When aspiration occurs, food or liquid goes into the larynx area of a subject. The contact of liquid or solid food with the larynx changes the path between an ultrasound transmitter 002 and an ultrasound receiver 004 through the larynx, resulting in the waveform changes in received signals.

[0031] Second Exemplary Embodiment

Ultrasound transmitters 200 and/or ultrasound receivers 202 located at one side or both sides of the neck as in FIG. 2A or surrounding the neck 204 as in FIG. 2B at one or several levels in order to improve the received ultrasound waves that transmit through the larynx area of a subject 000. An ultrasound transmitter may be used as an ultrasound receiver. When ultrasound transmitters 200 and ultrasound receivers 202 located at several levels as in FIG. 2A, a dysphagia information acquisition apparatus can detect liquid or solid food passing through the trachea at several levels, resulting in high sensitivity aspiration detection of the apparatus.

When analyzing ultrasound receivers 202, ultrasound transmitters 200 can apply a method to transmit frequencies which differ by small amounts in order to avoid resonance of received waves of each ultrasound receiver 004.

[0032] Third Exemplary Embodiment

An operation processing unit 008 determines aspiration events using functions including a filter for aspiration detection or a filter for noise detection based on a plurality of received signals, as in FIG. 6. An operation processing unit may be programed to change the order of functions and/or add more functions.

[0033] As a result, an information service system block 022 provides a real-time alert system in order to inform inadequate installation of a holder, system errors, aspiration, and abnormal vital signs as an application software of one or more tablet computers and smartphones.

[0034] A holder is placed at a level of cricoid cartilage of the neck of a subject 000 because the distance from the neck surface to a posterior wall of the larynx is minimum at this level, which leads to enough sensitivity of the received signal of through-transmission method of ultrasound. A device body employs one or more transmission and reception circuits 006, a battery, and one or more wireless communication modules for communicating with terminals of nurses like tablet computers and smartphones.

[0035] When aspiration has occurred during food training with this device in a hospital, a real-time alert system informs an alarm by a beep sound, recorded voice and sound, an image display apparatus, LED indicators, and vibration of a device. A recorded voice includes an instruction for a patient to induce cough to expel food after aspiration. This instruction encourages a patient to cough and a nurse to confirm a clear lung sound by stethoscope. Otherwise, this instruction encourages a nurse to expel food by a suction catheter. It is important to expel liquid or solid food before it reaches to the lung by spontaneous or reflective cough. After confirmation of safety, a patient is allowed to restart food training. As a result of this procedure, a real-time alert system can manage safe food training by detecting aspiration just after occurrence. Compared with videofluoroscopic examinations and videoendoscopic examinations of swallowing, this apparatus can also be implemented in the situations of daily meal settings, repetitive tests, and absence of a seasoned physician.

[0036] Fourth Exemplary Embodiment

An information analysis system block 020 analyzes at least one swallowing-related event and the biological information valid for dysphagia rehabilitation including existence of aspiration, frequency of aspiration, and supportive information like a time relation between aspiration and muscular movement of the neck, a food transit time, and mastication frequency.

[0037] By using a result of the analysis, an information service system block 022 provides a

dysphagia rehabilitation information service system as an application software of one or more tablet computers and smartphones in order to inform information valid for dysphagia rehabilitation including recommendation of an optimized rehabilitation program and types of training food, an offer of summarized information to a medical care team, an advice of an expert physician and/or an expert speech-language-hearing therapist, useful information for families of a patient, and information contents for a patient to keep motivation of rehabilitation.

[0038] Some methods use ultrasound to evaluate dysphagia (for example, PL 1, NPL 1). They detect abnormal swallowing movement and preventing aspiration, but do not detect aspiration and to promote to expel food by cough. Moreover, because the larynx and the trachea have a lumen structure and contain air, it is difficult to radiate ultrasound wave to liquid or solid food in trachea, causing low sensitivity of detecting aspiration.

[0039] A dysphagia patient lacks a cough reflex mechanism because of decreased laryngeal perception. Liquid or solid food that passes through the trachea and reaches to the lung increases the risk of aspiration pneumonia. Therefore, it is important to expel liquid or solid food before it reaches to the lung by spontaneous or reflective cough.

[0040] To detect aspiration caused by dysphagia is very important to suppress the occurrence of aspiration pneumonia. In addition, it is also effective for offering safe rehabilitation maneuver by combining with detection of normal and abnormal swallowing movement. However, there is no existing solution that detects aspiration in daily meal setting.

[0041] To solve the above-mentioned problem, the present invention aims at detecting dysphagia using through-transmission ultrasound. According to one aspect of the present invention, an apparatus for acquiring swallowing-related information uses through-transmission ultrasound and includes: an ultrasound transmitting device that transmits ultrasound waves to a larynx and/or trachea area of a subject; an ultrasound receiving device that converts the ultrasound waves transmitted through the larynx and/or trachea area of the subject to received signals; an attachment device that holds the ultrasound transmitting device and the receiving device on the neck of the subject such that the ultrasound waves pass through the larynx and/or trachea area of the subject; a processing device including circuitry that converts the received signals into swallowing-related information, detects at least one swallowing-related event and biological information based on the swallowing-related information, analyzes at least one swallowing-related event and the biological information to generate swallowing-related information analysis, and generates information for safety and food training based on the swallowing-related information analysis including an alert system activation that activates alert system to inform aspiration of the subject.

[0042] According to another aspect of the present solution, a method for acquiring swallowing-related information uses through-transmission ultrasound and includes: an ultrasound transmitter that transmits ultrasound waves to a larynx and/or trachea area of a subject; an ultrasound receiver that converts the ultrasound waves transmitted through the larynx and/or trachea area of the subject to received signals; an attachment that holds the ultrasound transmitting device and the receiving device on the neck of the subject such that the ultrasound waves pass through the larynx and/or trachea area of the subject; a processer comprising circuitry configured to convert the received signals into swallowing-related information, detect at least one swallowing-related event and biological information based on the swallowing-related information, analyze at least one swallowing-related event and the biological information to generate swallowing-related information analysis, and generate information for safety and food training based on the swallowing-related information analysis including an alert system activation that activates alert system to inform aspiration of the subject.

Reference Signs List

[0043] 000 the larynx area
002 ultrasound transmitter
004 ultrasound receiver
006 transmission and reception circuit
008 operation processing unit
010 system controller
012 transmission circuit
014 reception circuit
016 signal processing block
018 swallowing-related event detection block
020 information analysis system block
022 information service system block
024 data storage block
026 control signal bus
200 ultrasound transmitters
202 ultrasound receivers
204 transmitters and/or receivers surrounding the neck of a subject
206 a device holder surrounding the neck of a subject
300 piezoelectric element
302 case
304 coupler
400 holder base

402 element trench

404 band attaching hole

406 cable

408 hydrogel sheet

410 processes in the other side of element trench

412 a ratchet for element fixation

500 aspirated object

Claims

[Claim 1] An apparatus for acquiring swallowing-related information, comprising:
an ultrasound transmitting device that transmits a plurality of ultrasound waves to a larynx and/or trachea area of a subject;
an ultrasound receiving device that converts the plurality of ultrasound waves transmitted through the larynx and/or trachea area of the subject to a plurality of received signals;
an attachment device that holds the ultrasound transmitting device and the receiving device on the neck of the subject such that the ultrasound waves pass through the larynx and/or trachea area of the subject;
a processing device comprising circuitry configured to covert the plurality of received signals into swallowing-related information, detect at least one swallowing-related event and biological information based on the swallowing-related information, analyze at least one swallowing-related event and the biological information to generate swallowing-related information analysis, and generate information for safety and dysphagia rehabilitation based on the swallowing-related information analysis including an alert system activation that activates alert system to inform aspiration of the subject,
wherein the swallowing-related event includes at least one selected from the group consisting of dysphasia, abnormal swallowing, and cough, and the biological information includes at least one selected from the group consisting of body temperature, pulse rate, respiration rate, blood pressure, mastication-related information, vocalization, and movement of the neck.

[Claim 2] The apparatus for acquiring swallowing-related information according to claim 1, wherein the ultrasound transmitting device comprises a plurality of ultrasound transmitters, and the ultrasound receiving device comprises a plurality of ultrasound receivers.

[Claim 3] The apparatus for acquiring swallowing-related information according to claim 1, wherein the ultrasound transmitting device transmits narrow band ultrasound waves having the central frequency in a range of from 0.5 MHz to 12 MHz, and a pulse width that is longer than three times a wavelength of the narrow band ultrasound waves.

[Claim 4] The apparatus for acquiring swallowing-related information according to claim 1, wherein the circuitry is configured to acquire the

swallowing-related information including a plurality of through-transmission events and use the swallowing-related information including the plurality of through-transmission events to detect the swallowing-related event.

[Claim 5] The apparatus for acquiring swallowing-related information according to claim 1, further comprising:
a data storage device that holds raw data of the received signals and/or data of the received signals after signal processing.

[Claim 6] The apparatus for acquiring swallowing-related information according to claim 1, wherein the circuitry is configured to use the swallow information and aspiration information of the subject acquired previously such that a frequency and a pulse width of the ultrasound waves transmitted from the ultrasound transmitting device, signal processing and/or aspiration detection setting is optimized.

[Claim 7] The apparatus for acquiring swallowing-related information according to claim 1, wherein the circuitry is configured to send the plurality of received signals, aspiration information, and/or a number of aspiration phenomena via network such that setting of a dysphagia information acquisition apparatus connected to the circuitry through the network is optimized.

[Claim 8] The apparatus for acquiring swallowing-related information according to claim 1, wherein the alert system includes a cough induction device that is activated by the alert system activation from the circuitry.

[Claim 9] The apparatus for acquiring swallowing-related information according to claim 1, further comprising:
an ultrasound transmission and reception circuit that is connect to the circuity and the ultrasound transmitting and receiving devices; and
a neck attachment device that attaches the ultrasound transmission and reception circuit to the neck of the subject.

[Claim 10] The apparatus for acquiring swallowing-related information according to claim 5, wherein the circuitry is configured to transfer information held by the data storage device to an external device.

[Claim 11] The apparatus for acquiring swallowing-related information according to claim 1, wherein the circuitry is configured to record data combined with information from at least one of the microphones, an electrical cardiogram, and an oxygen monitor.

[Claim 12] The apparatus for acquiring swallowing-related information according to claim 1, wherein the circuitry is configured to convert the plurality of

received signals into the swallowing-related information in a time window corresponding to a time region during which the ultrasound receiving device receives the ultrasound waves passing through the larynx and/or trachea area of the subject.

[Claim 13] The apparatus for acquiring swallowing-related information according to claim 1, wherein the circuitry is configured to convert the plurality of received signals into the swallowing-related information using a band-pass filter.

[Claim 14] The apparatus for acquiring swallowing-related information according to claim 1, wherein the circuitry is configured to determine whether the at least one swallowing-related event has occurred from variation in the swallowing-related information in a measurement time.

[Claim 15] The apparatus for acquiring swallowing-related information according to claim 2, wherein the circuitry is configured to determine whether the at least one swallowing-related event has occurred from variation in the swallowing-related information in a measurement time.

[Claim 16] The apparatus for acquiring swallowing-related information according to claim 1, wherein the circuitry is configured to communicate with a data storage device that holds raw data of the received signals and/or data of the received signals after signal processing and covert the plurality of received signals into the swallowing-related information based on the raw data of the received signals and/or the data of the received signals after signal processing.

[Claim 17] A method of acquiring swallowing-related information, comprising:
transmitting a plurality of ultrasound waves to a larynx and/or trachea area of a subject;
converting the plurality of ultrasound waves transmitted through the larynx and/or trachea area of the subject to a plurality of received signals;
converting the plurality of received signals into swallowing-related information;
detecting at least one swallowing-related event and biological information has based on the swallowing-related information; and
analyzing the at least swallowing-related event and the biological information to generate swallowing-related information analysis, and generate information for safety and food training based on the swallowing-related information analysis including an alert system activation that activates alert system to inform aspiration of the subject,

wherein the swallowing-related event includes at least one selected from the group consisting of dysphasia, abnormal swallowing, and cough, and the biological information includes at least one selected from the group consisting of body temperature, pulse rate, respiration rate, blood pressure, mastication-related information, vocalization, and movement of the neck.

[Claim 18] A non-transitory computer readable medium having stored thereon a program that when executed by a computer, causes the computer to execute a method of acquiring swallowing-related information, comprising:

transmitting a plurality of ultrasound waves to a larynx and/or trachea area of a subject;

converting the plurality of ultrasound waves transmitted through the larynx and/or trachea area of the subject to a plurality of received signals;

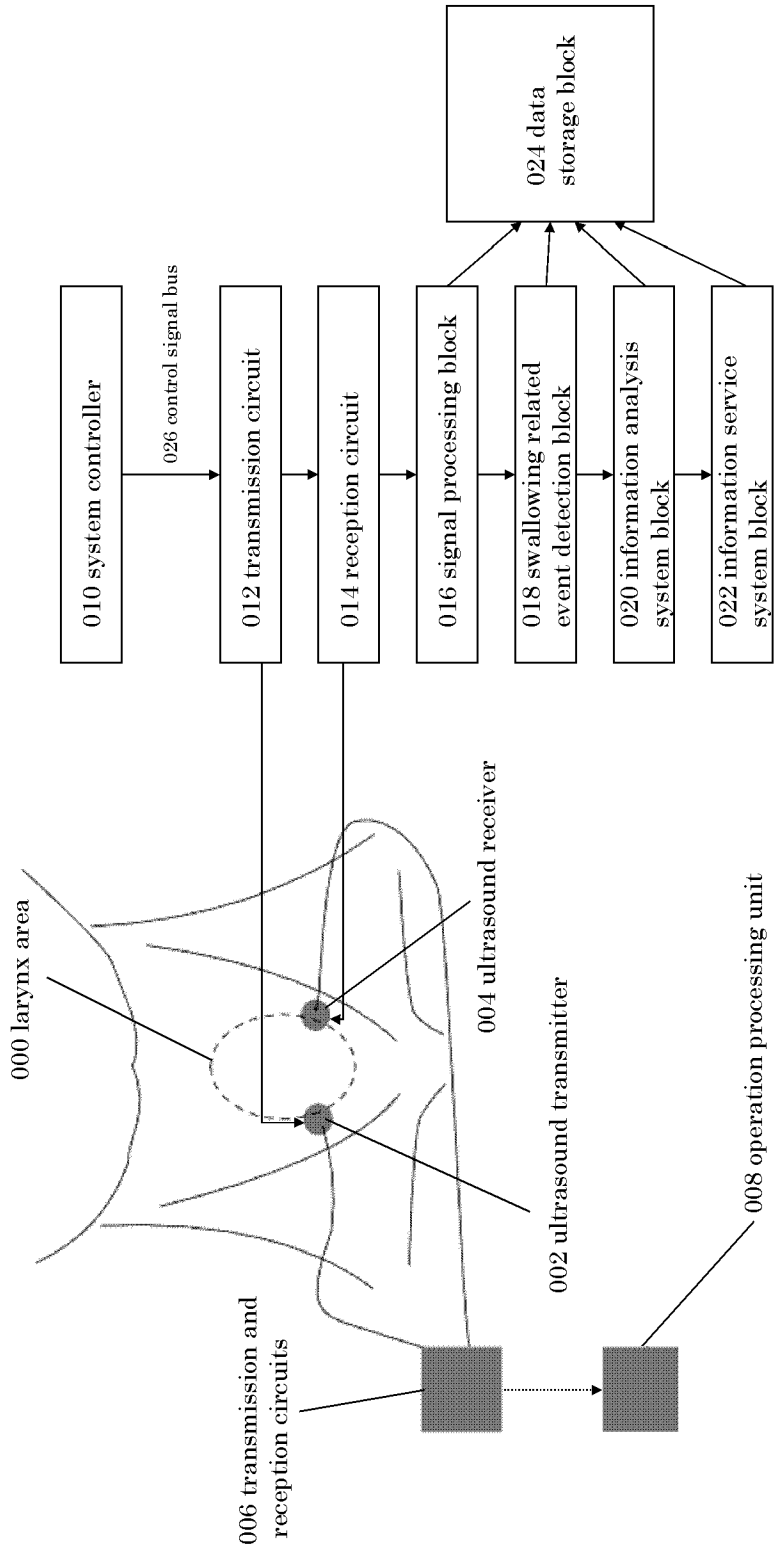
converting the plurality of received signals into swallowing-related information;

detecting at least one swallowing-related event and biological information has based on the swallowing-related information; and

analyzing the at least swallowing-related event and the biological information to generate swallowing-related information analysis, and generate information for safety and food training based on the swallowing-related information analysis including an alert system activation that activates alert system to inform aspiration of the subject,

wherein the swallowing-related event includes at least one selected from the group consisting of dysphasia, abnormal swallowing, and cough, and the biological information includes at least one selected from the group consisting of body temperature, pulse rate, respiration rate, blood pressure, mastication-related information, vocalization, and movement of the neck.

[Fig. 1]


024 data storage block
010 system controller
026 control signal bus
012 transmission circuit
014 reception circuit
016 signal processing block
018 swallowing related event detection block
020 information analysis system block
022 information service system block
000 larynx area
004 ultrasound receiver
002 ultrasound transmitter
006 transmission and reception circuits
008 operation processing unit

[Fig. 2]

FIG. 2B

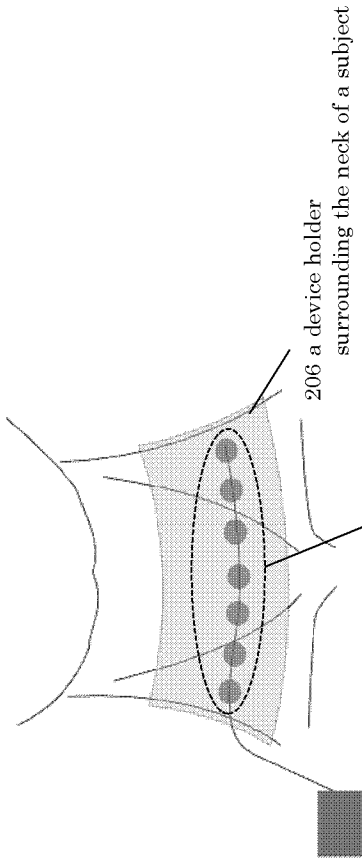
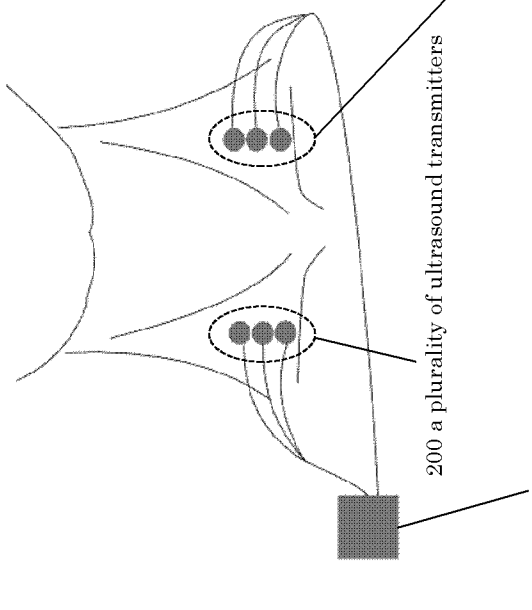


FIG. 2A



[Fig. 3]

FIG. 3A

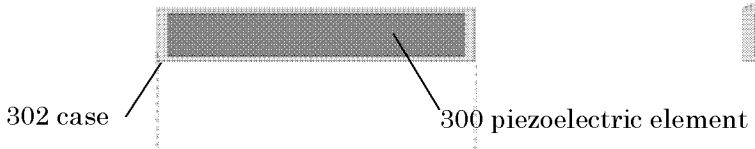


FIG. 3B

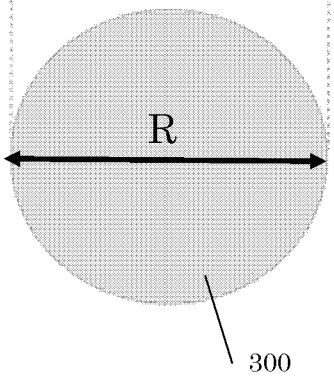


FIG. 3C

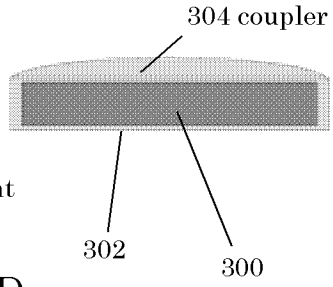
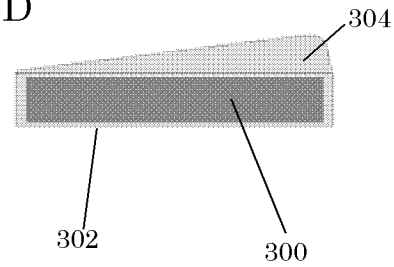


FIG. 3D



[Fig. 4]

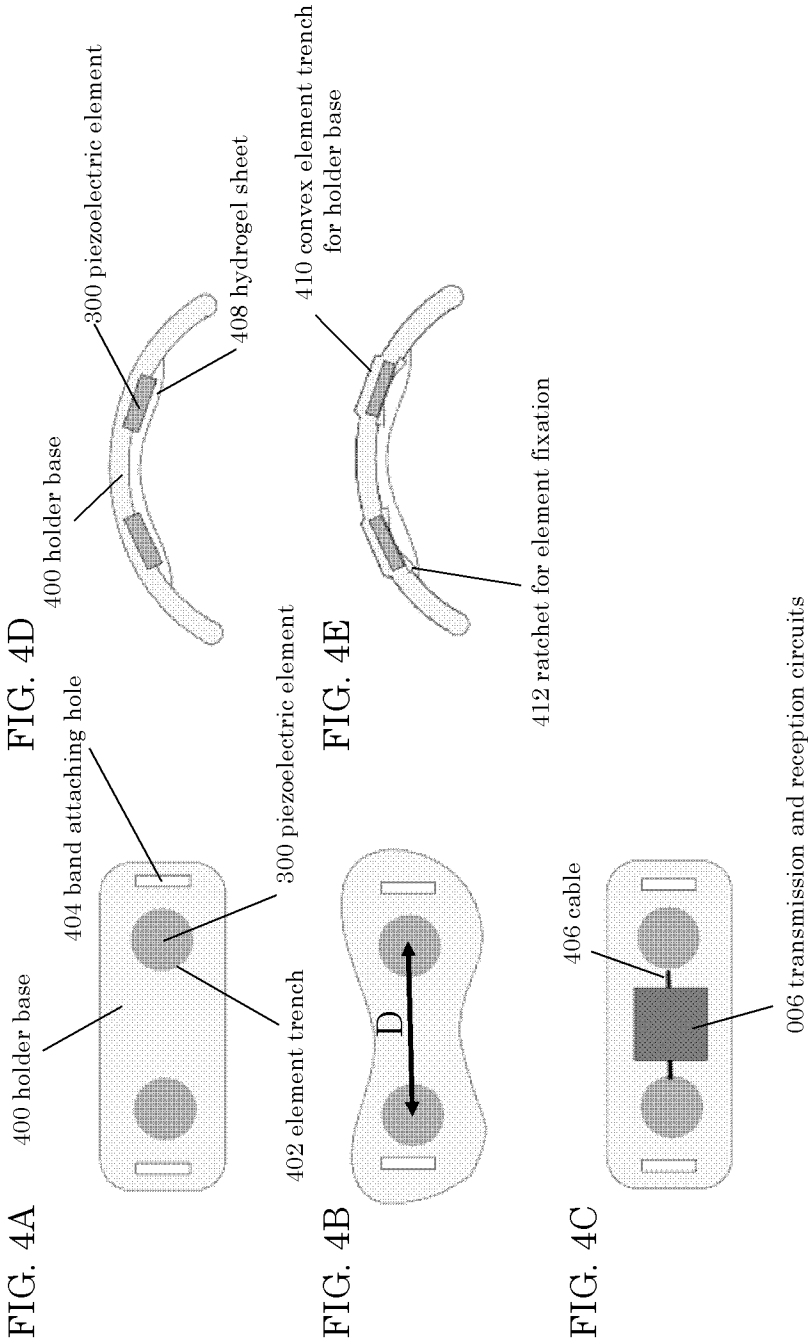
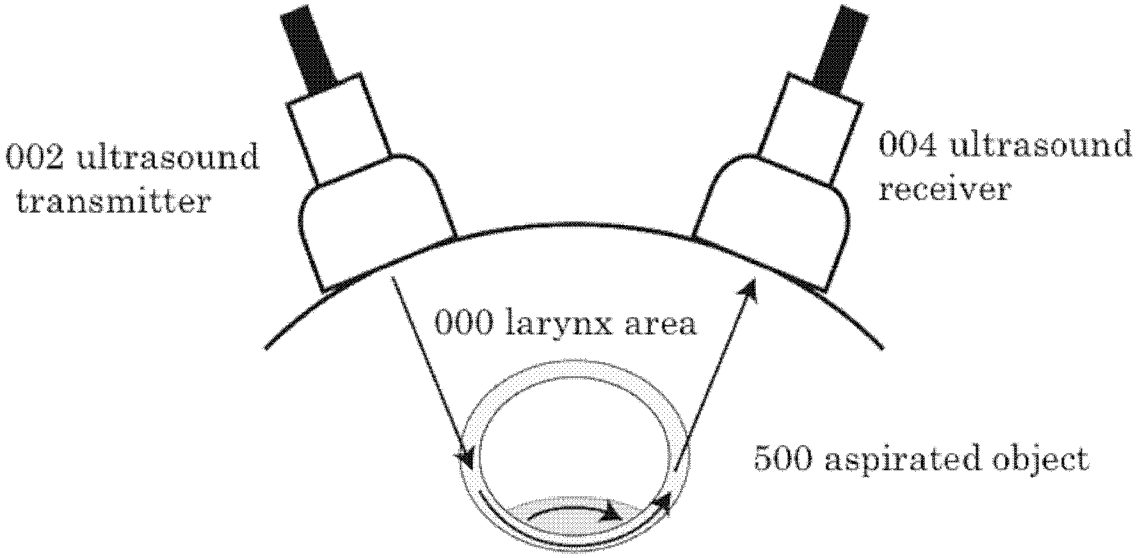
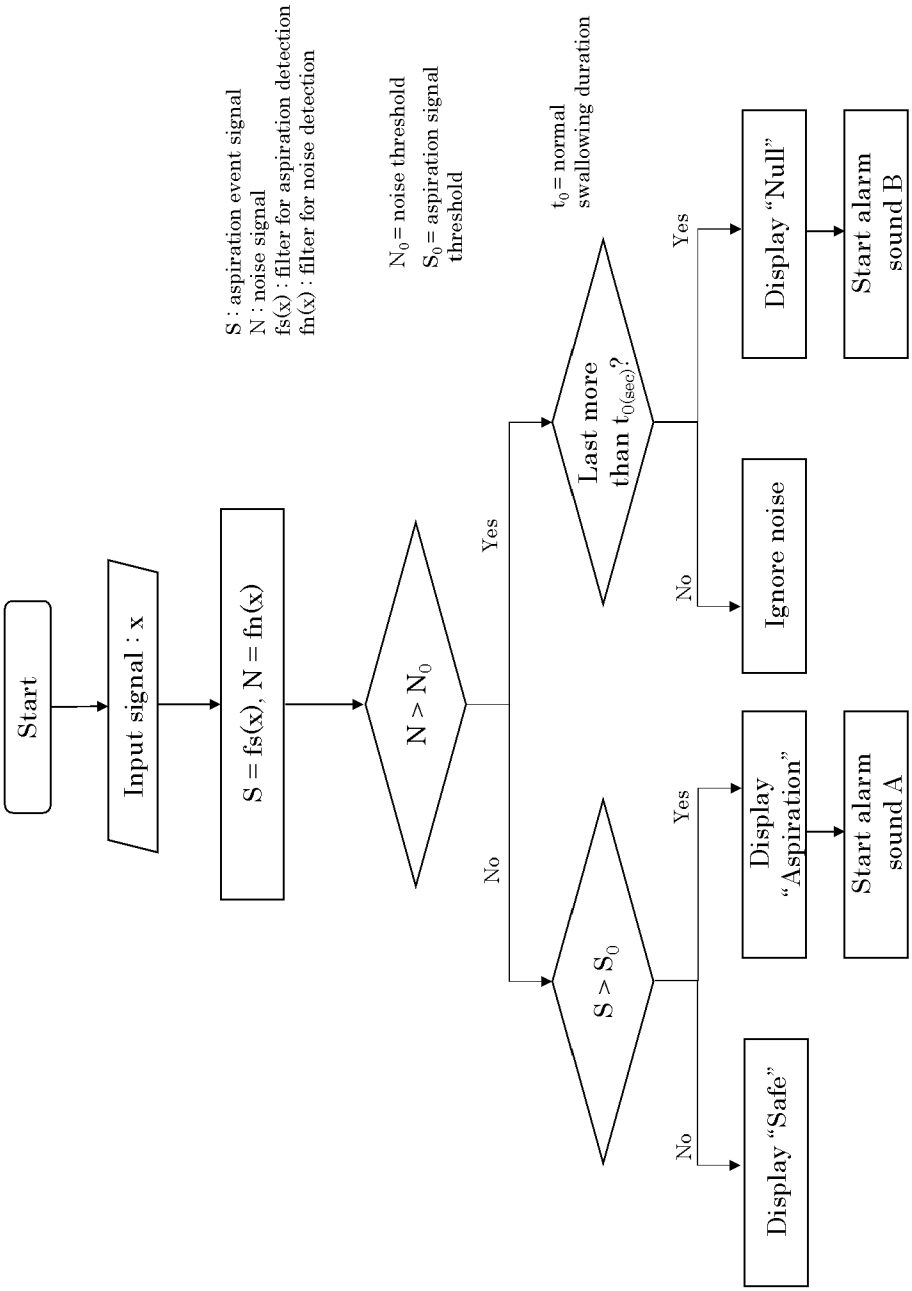


FIG. 4A FIG. 4B FIG. 4C FIG. 4D FIG. 4E

[Fig. 5]


002 ultrasound transmitter
004 ultrasound receiver
000 larynx area
500 aspirated object

[Fig. 6]


Start
Input signal : x
S = fs(x), N = fn(x)
S : aspiration event signal
N : noise signal
fs(x) : filter for aspiration detection
fn(x) : filter for noise detection
N > N0
N0 = noise threshold
S0 = aspiration signal threshold
Yes
No
Last more than t0(sec)?
t0 = normal swallowing duration
Yes
No
Display "Null"
Start alarm sound B
Ignore noise
S > S0
Yes
No
Display "Aspiration"
Start alarm sound A
Display "Safe"

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/018425

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. A61B8/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. A61B8/00, A61B5/11

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2018
Registered utility model specifications of Japan 1996-2018
Published registered utility model applications of Japan 1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

JSTPlus/JMEDPlus/JST7580 (JDreamIII)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013/0046181 A1 (BOARD OF REGENTS, THE UNIVERSITY OF TEXAS SYSTEM) 2013.02.21, Abstract, Figs.1-2 (No Family)	1-18
A	MIURA, Yuka et al., Method for detecting aspiration based on image processing-assisted B-mode video ultrasonography, Journal of Nursing Science and Engineering, 2014, Vol.1,No.1, pp.12-20	1-18

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09.07.2018	31.07.2018

Name and mailing address of the ISA/JP	Authorized officer
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