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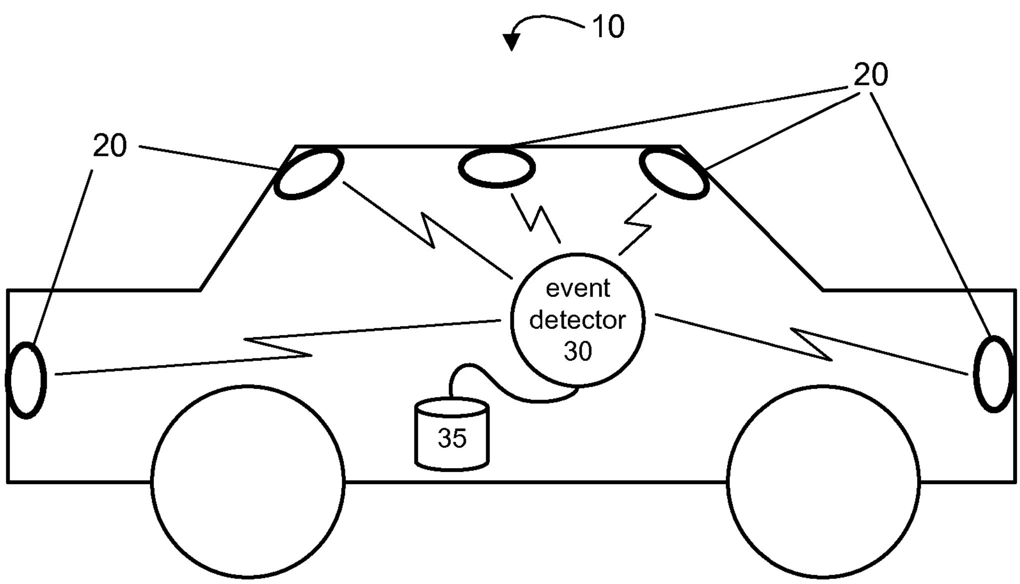
(54) Title: SYSTEM AND METHOD FOR REDUCING DRIVING RISK WITH HINDSIGHT



(57) Abstract: A system and method for computer assisted event based reconstruction and forensic analysis of vehicle accidents is provided. The system comprises an event capture device that records audio, video, and other information that collectively comprise one or more events related to a vehicle accident. The event data, including the audio, video, and other related information, is provided to an evaluation server where it is stored in a database for forensic analysis of the events comprising the vehicle accident. Event data for a specific automobile accident event is analyzed and compared to similar types of automobile accident event data in order to forensically analyze the specific event and correlate causal relationships with key elements of the event data to determine the likely cause of the accident or the factors contributing to the accident. Correlation information is also stored at the evaluation server to provide historical data points about causal relationships and key elements.

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SYSTEM AND METHOD FOR REDUCING DRIVING RISK WITH HINDSIGHT

Background

1. Field of the Invention

[01] The present invention generally relates to computer assisted forensic analysis of vehicle accidents and more specifically relates to event based reconstruction and review of vehicle accidents to facilitate forensic analysis.

2. Related Art

[02] Conventional systems for conducting forensic analysis of vehicle accidents are necessarily after the fact reconstructions based on informed guesswork after a costly and detailed review of an accident scene. Additionally, analysis of the data produced by these reconstructions is extremely time consuming and expensive, requires a specific skill set developed over significant time, and in the end results in conclusions based on circumstantial evidence gathered after the accident took place. Accordingly, what is needed is an efficient system and method for capturing environmental data leading up, during, and after a vehicle accident to facilitate the forensic analysis of the vehicle accident with relevant real time information.

Summary

[03] The present invention provides a system and method for computer assisted event based reconstruction and forensic analysis of vehicle accidents. The system comprises an event capture device that records audio, video, and other information that collectively comprise an event. The event data, including the audio, video, and other related information, is provided to an evaluation server where it is stored in a database for storage and later forensic analysis of the events comprising the vehicle accident.

[04] In one embodiment, data for a specific automobile accident event can be analyzed and compared to similar type of automobile accident event data in order to forensically analyze the specific event and determine the cause of the accident. Advantageously, information about the circumstances surrounding the event is captured during the event to provide an analyst with objective information about the event as it took place. For example, specific information may include (but are not limited to) the GPS location of the vehicle, the G-forces acting on the vehicle, the speed and direction of the vehicle, operation or status of vehicle systems such as lights or brakes or engine, and audio and video data from the vehicle during the automobile accident.

[05] Other features and advantages of the present invention will become more readily apparent to those of ordinary skill in the art after reviewing the following detailed description and accompanying drawings.

Brief Description of the Drawings

[06] The details of the present invention, both as to its structure and operation, may be gleaned in part by study of the accompanying drawings, in which like reference numerals refer to like parts, and in which:

[07] **Figure 1** is a block diagram illustrating an example event detector in control of a plurality of event capture devices deployed in a vehicle according to an embodiment of the present invention;

[08] **Figure 2** is a block diagram illustrating an example event detector according to an embodiment of the present invention;

[09] **Figure 3** is a block diagram illustrating an example event according to an embodiment of the present invention;

[10] **Figure 4A** is a block diagram illustrating an example event traveling from an event detector to an evaluation server according to an embodiment of the present invention;

[11] **Figures 4B – 4D** are network diagrams illustrating example routes for an event traveling from an event detector to an evaluation server according to various embodiments of the present invention;

[12] **Figure 5** is a network diagram illustrating an example system for reducing driving risk according to an embodiment of the present invention;

[13] **Figure 6** is a network diagram illustrating an example route for a group of events traveling from an evaluation server to an analysis station according to an embodiment of the present invention;

[14] **Figure 7** is a network diagram illustrating an example route for a coaching session and an event report traveling from an analysis station to an evaluation sever according to an embodiment of the present invention;

[15] **Figure 8** is a network diagram illustrating an example route for a coaching session and an event report traveling from an evaluation sever to a coaching station and a supervisor station according to an embodiment of the present invention;

[16] **Figure 9** is a block diagram illustrating an example evaluation server according to an embodiment of the present invention;

[17] **Figure 10** is a block diagram illustrating an example hindsight module according to an embodiment of the present invention;

[18] **Figure 11** is a block diagram illustrating an example administrative module according to an embodiment of the present invention;

[19] **Figure 12** is a flow diagram illustrating an example process for forensic analysis of a vehicle accident according to an embodiment of the present invention;

[20] **Figure 13** is a block diagram illustrating an example wireless communication device that may be used in connection with various embodiments described herein; and

[21] **Figure 14** is a block diagram illustrating an example computer system that may be used in connection with various embodiments described herein.

Detailed Description

[22] Certain embodiments as disclosed herein provide for systems and methods for reducing driving risk that capture driving events and provide those events to an evaluation server where the events are analyzed and reported to management and also compiled into coaching sessions for individuals or groups of drivers to receive in order to demonstrate to them how to avoid risky behaviors while driving. For example, one method as disclosed herein allows for an event capture device to capture an event and send the event via a communication network to an evaluation server. The evaluation server allows an analyst to review the raw event data and create a coaching session directed toward future avoidance of the risky behavior that caused the event. Additionally, the evaluation server compiles reports regarding the events for particular drivers or groups of drivers. The reports are then provided to management by the evaluation server and the coaching sessions are provided to the

individual drivers or groups of drivers to improve their future avoidance of risky driving behaviors.

[23] After reading this description it will become apparent to one skilled in the art how to implement the invention in various alternative embodiments and alternative applications. However, although various embodiments of the present invention will be described herein, it is understood that these embodiments are presented by way of example only, and not limitation. As such, this detailed description of various alternative embodiments should not be construed to limit the scope or breadth of the present invention as set forth in the appended claims.

[24] Fig. 1 is a block diagram illustrating an example event detector 30 in control of a plurality of event capture devices 20 deployed in a vehicle 10 according to an embodiment of the present invention. In the illustrated embodiment, the event detector 30 is integrated with the vehicle 10 and is communicatively coupled with the event capture devices 20. The event detector 30 is also configured with data storage 35.

[25] The event detector 30 can be any of a variety of types of computing devices with the ability to execute programmed instructions, receive input from various sensors, and communicate with one or more internal or external event capture devices 20 and other external devices (not shown). An example general purpose computing device that may be employed as all or a portion of an event detector 30 is later described with respect to Fig. 17. An example general purpose wireless communication device that may be employed as all or a portion of an event detector 30 is later described with respect to Fig. 16.

[26] When the event detector 30 identifies an event, the event detector 30 instructs the one or more event capture devices 20 to record pre-event data, during the event data, and post-event data that is then provided to the event detector 30 and stored in the data storage area 35. Events may comprise a variety of situations, including automobile accidents, reckless driving, rough driving, or any other type of stationary or moving occurrence that the owner of a vehicle 10 may desire to know about.

[27] The vehicle 10 may have a plurality of event capture devices placed in various locations around the vehicle 10. An event capture device 20 may comprise a video camera, still camera, microphone, and other types of data capture devices. For example, an event capture device 20 may include an accelerometer that senses changes in speed or direction.

Additional sensors and / or data capture devices may also be incorporated into an event capture device 20 in order to provide a rich set of information about a detected event.

[28] The data storage area 35 can be any sort of internal or external, fixed or removable memory device and may include both persistent and volatile memories. The function of the data storage area 35 is to maintain data for long term storage and also to provide efficient and fast access to instructions for applications or modules that are executed by the event capture device 30.

[29] In one embodiment, event detector 30 in combination with the one or more event capture devices 20 identifies an event and stores certain audio and video data along with related information about the event. For example, related information may include the speed of the vehicle when the event occurred, the direction the vehicle was traveling, the location of the vehicle (e.g., from a global positioning system ("GPS") sensor), and other information from sensors located in and around the vehicle or from the vehicle itself (e.g., from a data bus integral to the vehicle such as an on board diagnostic ("OBD") vehicle bus). This combination of audio, video, and other data is compiled into an event that can be stored in data storage 35 onboard the vehicle for later delivery to an evaluation server.

[30] Fig. 2 is a block diagram illustrating an example event detector 30 according to an embodiment of the present invention. In the illustrated embodiment, the event detector 30 comprises an audio/video ("AV") module 100, a sensor module 110, a communication module 120, and a control module 130. Additional modules may also be employed to carry out the various functions of the event detector 30, as will be understood by those having skill in the art.

[31] The AV module 100 is configured to manage the audio and video input from one or more event capture devices and storage of the audio and video input. The sensor module 110 is configured to manage one or more sensors that can be integral to the event detector 20 or external from the event detector 20. For example, an accelerometer may be integral to the event detector 20 or it may be located elsewhere in the vehicle. The sensor module 110 may also manage other types of sensor devices such as a GPS sensor, temperature sensor, moisture sensor, or the like (all not shown).

[32] The communication module 120 is configured to manage communications between the event detector 20 and other devices and modules. For example, the communication module 120 may handle communications between the event detector 20 and the various event capture devices. The communication module 120 may also handle communications between the event detector 20 and a memory device, a docking station, or a server such as an evaluation server. The communication module 120 is configured to communicate with these various types of devices and other types of devices via a direct wire link (e.g., USB cable, firewire cable), a direct wireless link (e.g., infrared, Bluetooth, ZigBee), or a wired or any wireless network link such as a local area network ("LAN"), a wide area network ("WAN"), a wireless wide area network ("WWAN"), an IEEE 802 wireless network such as an IEEE 802.16 ("WiFi") network, a WiMAX network, satellite network, or a cellular network.

[33] The control module 130 is configured to control the actions or remote devices such as the one or more event capture devices. For example, the control module 130 may be configured to instruct the event capture devices to capture an event and return the data to the event detector when it is informed by the sensor module 110 that certain trigger criteria have been met that identify an event.

[34] Fig. 3 is a block diagram illustrating an example event 150 according to an embodiment of the present invention. In the illustrated embodiment, the event 150 comprises audio data 150, video data 160, and metadata 180. The audio data 150 can be collected from inside the vehicle, outside the vehicle, and may include information from an internal vehicle bus about the baseline noise level of the operating vehicle, if such information is available. Additional information about baseline noise level, radio noise level, conversation noise level, or external noise level may also be included in audio data 160.

[35] Video data 170 may include still images or moving video captured by one or more cameras in various locations in and around the vehicle. Video data 170 may include images or video from inside the vehicle, outside the vehicle, or both. In one particularly advantageous embodiment, still images and moving video that illustrate the entire area inside the vehicle and the entire 360 degree area surrounding the vehicle are captured by a plurality of image capture devices and included in video data 170.

[36] Metadata 180 may include a variety of additional information that is available to the event detector 30 at the time of an event. Such additional data may include, but is not limited to, the velocity and direction of the vehicle, the GPS location of the vehicle, elevation, time, temperature, and vehicle engine and electrical component information, status of vehicle lights and signals, brake operation and position, throttle position, etc. captured from an internal vehicle bus, just to name a few. Additional information may also be included such as the number of occupants in the vehicle, whether seatbelts were fastened, whether airbags deployed, whether evasive maneuvering was attempted as determined by the route of the vehicle prior to the event. The specific identification of the driver may also be included, for example as read by the event detector from a radio frequency identification ("RFID") badge worn by the driver or integrated with a vehicle key assigned to the driver. As will be understood by those skilled in the art, metadata 180 may include an extremely rich variety of information limited only by the scope and type of information obtained prior to, during, and after an event.

[37] Fig. 4A is a block diagram illustrating an example event 150 traveling from an event detector 30 to an evaluation server 50 according to an embodiment of the present invention. In one embodiment, events such as event 150 are captured by an event detector 30 and stored locally until they are provided to the evaluation server 50. The means by which an event 150 can be provided to the evaluation server 50 can vary. In various embodiments (or in a single embodiment), an event 150 may be provided from event detector 30 to evaluation server 50 by way of a portable media device, a direct wire link, a direct wireless link, an indirect wire link, an indirect wireless link, or any combination of these. Event 150 may be secured by encryption of the event 150 data structure and/or a secure channel between the event detector 30 and the evaluation server 50.

[38] For example, a portable media device may include a USB drive, compact disc, thumb drive, media card, or other similar type of device. A direct wire link may include a USB cable, a firewire cable, an RS-232 cable, or the like. A direct wireless link may include an infrared link, a Bluetooth link, ZigBee link, or an IEEE 802.11 point-to-point link, a WiMAX link, or a cellular link, just to name a few. An indirect wired link may include a packet switched or circuit switched network connection configured for conveyance of data traffic. An Ethernet network connection is an example of a packet switched indirect wired link and a dial up modem connection is an example of a circuit switched indirect wired link, both of which may be configured for conveyance of data traffic.

[39] The following figures 4B – 4D illustrate various embodiments for providing events to an evaluation server.

[40] Fig. 4B is a network diagram illustrating an example route for an event 150 traveling from an event detector 30 to an evaluation server 50 according to an embodiment of the present invention. In the illustrated embodiment, the event 150 travels over a network 70 from the event detector 30 to the evaluation server 50. The network 70 may comprise any of a variety of network types and topologies and any combination of such types and topologies. For example, the network 70 may comprise a plurality of networks including private, public, circuit switched, packet switched, personal area networks ("PAN"), local area networks ("LAN"), wide area networks ("WAN"), metropolitan area networks ("MAN"), satellite network, or any combination of the these. Network 70 may also include that particular combination of networks ubiquitously known as the Internet.

[41] Fig. 4C is a network diagram illustrating an example route for an event 150 traveling from an event detector 30 to an evaluation server 50 according to an embodiment of the present invention. In the illustrated embodiment, the event 150 travels to a wireless network 72 by way of an access point 210 and then on to the evaluation server 50 via the wireless network 72. The access point 210 may provide access via many different wireless network protocols as will be well understood by those having skill in the art. The wireless network 72 may be a WWAN or a WiFi network. The link between the event detector 30 and the access point 210 may be a short range direct link or a wide range direct link. The access point 210 may be a large radio tower device or a small in-home wireless appliance. The wireless network 72 may include over the air segments and also wired segments. For example, the last mile segments of wireless network 72 may be over the air while internal and back end segments may be wired segments. In one embodiment, the wireless network 72 may provide a wireless interface to the event detector 30 and then have a wired interface on the back end to the Internet, which in turn connects the evaluation server 50.

[42] Fig. 4D is a network diagram illustrating an example route for an event 150 traveling from an event detector 30 to an evaluation server 50 according to an embodiment of the present invention. In the illustrated embodiment, a docking station 200 is disposed between the event detector and the network 74. In such an embodiment, an event 150 may be provided from the event detector 30 to the docking station 200 via a variety of means as described above, including portable media, direct wired or wireless link, and indirect wired or wireless link. The event detector 30 may also be physically coupled with the docking station 200 to

convey the event 150 from the event detector 30 to the docking station 200. Once the event 150 is received by the docking station 200, the event is then sent over the network 74 to the evaluation server 50. In the illustrated embodiment, the network 74 may be a wired or wireless network or a combination of the two. The network 74 may also be private or public in whole or in part and may also include the Internet.

[43] Fig. 5 is a network diagram illustrating an example system for driver improvement according to an embodiment of the present invention. In the illustrated embodiment, the system includes an event detector 30, a coaching station 40, a supervisor station 42, an evaluation server 50, and an analysis station 60, each coupled with a data storage area 35, 45, 47, 55, and 65, respectively. Additional event detectors 30, coaching stations 40, supervisor stations 42, evaluation servers 50, and analysis stations 60 may also be included.

[44] The function of the event detector 30 is to identify and capture a plurality of events and send a data structure representing the audio, video, and other data related to the event to the evaluation server 50. The evaluation server maintains the captured events and provides them to the analysis station 60 where the events are reviewed. The analysis station 60 may be configured with certain hardware and software modules that allow an operator to review event data (e.g., audio, video, and metadata) in order to make an analysis related to the event and create summary reports and the like.

[45] After an event is reviewed, it may be discarded, incorporated into a coaching session, flagged for follow up, flagged for inclusion in one or more reports, or otherwise maintained for later coaching, reporting, or analysis. In one embodiment, certain portions of one or more events may be incorporated into a report or a coaching session and then sent back to the evaluation server 50 for storage.

[46] The coaching station 40 is configured to play coaching sessions to a particular driver in order to educate the driver about his or her risky driving behavior and suggest alternative driving techniques that the driver may employ to reduce such risky behavior. The coaching station 40 can access coaching sessions from the evaluation server 50 via the network 76 to view the coaching session. The supervisor station 42 is configured to allow executives, managers, and supervisors to access reports on the evaluation server over network 76 and view coaching sessions and reports regarding driver behavior. In one embodiment, a conventional web browser utility can be used at either the coaching station 40 or the supervisor station 42 to view both reports and coaching stations, thereby making either device a coaching station or a supervisor station based on the type of information that is accessed from the evaluation server.

[47] Fig. 6 is a network diagram illustrating an example route for a group of events 152 traveling from an evaluation server to an analysis station according to an embodiment of the present invention. In the illustrated embodiment, the group of events 152 is provided by the evaluation server 50 to the analysis station 60 via the network 76. On the evaluation server, the group of events 152 may be identified by searching for all events that pertain to a particular driver. This may be accomplished by associating each event at the time it is captured with a particular driver. For example, the driver of a vehicle may have a unique identifier and that unique identifier may be included as part of the metadata for each event that is captured while that driver is operating the vehicle. In one embodiment, the driver identifier may be obtained by the event detector by reading an infrared identification device, perhaps incorporated into the driver's identification badge or by receiving the identifier as input when the driver begins the shift, or by reading the identifier from a media card or other wired or wireless device associated with the driver.

[48] Groups of events 152 may also be identified by all events associated with a particular company, a particular shift, a particular supervisor, or other reporting structure or working structure combinations. Such a group of events 152, once provided to the analysis station 60 can then be analyzed by an operator that reviews each event to identify those events that need to be reported or shown to the driver, for example as part of a coaching station.

[49] Fig. 7 is a network diagram illustrating an example route for a coaching session 200 and an event report 210 traveling from an analysis station 60 to an evaluation sever 50 according to an embodiment of the present invention. In the illustrated embodiment, an operator at the analysis station 60 may create a coaching session 200 that is made up of all or a portion of a plurality of events (audio, video, and metadata). The coaching session 200 may also include notes/comments from an operator who analyzed the event data or notes/comments from a supervisor or manager or executive. Such a coaching session 200 may be directed to an individual driver, a shift of drivers, or other classes of drivers for which the session may be beneficial (e.g., night time drivers, truck drivers, drivers of vehicles with trailers, etc.). The coaching session may also be directed to supervisors or managers or executives.

[50] Additionally, the operator may also create a report 210 that is made up of summary information about all notable events. A notable event may be characterized as any event that the vehicle owner wants to know about. In one embodiment, there can be certain variable criteria that each vehicle owner can set in order to determine the risk level for events that are compiled into a report 210. Additionally, a report 210 may be created that includes information about all captured events, whether the event reflects a pothole or an automobile accident.

[51] As shown in the illustrated embodiment, one or more coaching sessions 200 and reports 210 can be provided from the analysis station 60 to the evaluation server 50. These coaching sessions and reports can then be maintained at the evaluation server 50 for later viewing by executives, managers, supervisors, drivers, and the like. Such reports 210 and coaching sessions 200 can also be compiled onto a portable media such as a CD for viewing by new employees during orientation sessions.

[52] Fig. 8 is a network diagram illustrating an example route for a coaching session 200 and an event report 210 traveling from an evaluation sever 50 to a coaching station 40 and a supervisor station 42 according to an embodiment of the present invention. In the illustrated embodiment, the coaching session 200 and report 210 travel to one or more coaching stations 40 and supervisor stations 42 over network 76. Although as shown the report 210 goes to the supervisor station 42 and the coaching session 200 goes to the coaching station 40, reports and coaching sessions can be sent to any remote device for review. In one embodiment, a conventional web browser utility can be used at a remote station to view both reports and coaching stations, thereby making the device both a coaching station and a supervisor station based on the type of information that is accessed from the evaluation server.

[53] Fig. 9 is a block diagram illustrating an example evaluation server 50 according to an embodiment of the present invention. In the illustrated embodiment, the evaluation server 50 comprises a foresight module 250, a hindsight module 260, an insight module 270, and an administrative module 280.

[54] The foresight module 250 is configured to monitor individual driver behavior and objectively score that behavior. The driver score is provided to executives and managers who can use that information to make informed decisions about behavior modification to eliminate or reduce risky behavior of an individual driver. Advantageously, reducing or eliminating risky behavior of a fleet of drivers may have a significant effect on the cost of insurance for the owner of the fleet of vehicles being driven.

[55] The hindsight module 260 is configured to capture and store event data related to accidents, crashes, and other serious driving events in order to document for use by law enforcement in forensic analysis and insurance companies in coverage disputes. Advantageously, the captured event information provides a purely objective reconstruction of what happened prior to, during, and after an event.

[56] The insight module 270 is configured to aggregate event data into a database of driving events and correlate information in the database to identify trends in driving behavior that relate to risk factors. For example, information about the vehicle and its various components, the driver and occupants, the driving conditions, the driving environment, and other useful data can be employed. The insight module 270 is additionally configured to correlate cause and effect relationships between data points and determine the effect of those relationships upon driver safety. The insight module 270 additionally compares these correlations and driver safety trends with historical event information for individual drivers to provide a driver rating or driver score for an individual driver. The driver score can be used by insurance companies to establish individualized insurance rates.

[57] Fig. 10 is a block diagram illustrating an example hindsight module according to an embodiment of the present invention. In the illustrated embodiment, the hindsight module 260 comprises a key element module 350, a correlation module 360, a factor module 370, a reporting module 380, and an other module 390.

[58] The element module 350 is configured to identify particular elements in one or more events that comprise a vehicle accident. For example, an element may include the temperature or other weather related conditions (e.g., if it was raining), the number of vehicle occupants, road conditions (icy, wet, unpaved), traffic conditions (heavy, light), driving conditions (traffic light, stop sign, yield sign, one way street, divided highway, merging traffic, etc.), vehicle status (speed, accelerating, decelerating), interior noise level, and the like. Advantageously, discrete data points related to one or more events comprising a vehicle accident can each be an element.

[59] The element module is configured to identify such elements from the one or more events that comprise a vehicle accident. This can be accomplished by reviewing metadata, the audio playback, and the video playback for the one or more events. The review can be conducted by an operator or by automated computer analysis. For example, the decibel level on the audio track can be analyzed by computer to determine the sound level inside the vehicle at certain times during the one or more events. Similarly, computer analysis of metadata fields can provide temperature information, vehicle status information (e.g., speed), and other information collected from an OBD vehicle bus without operator intervention. Similarly, the video track can be analyzed for indicators that point to elements of the vehicle accident, for example, significant color changes from frame to frame over large portions of the frame may indicate a rapid change in direction of the vehicle. Advantageously, other computer facilitated analyses of the audio, video, and metadata information related to the one or more events can be performed without an operator. Additionally, elements can also be identified by an operator reviewing the one or more events that comprise a vehicle accident.

[60] The correlation module 360 is configured to manage a data storage area of historical correlations and identify causation and/or contributory correlations between elements and vehicle accidents. Advantageously, correlation module 360 is configured to automatically review vehicle accident event data and elements identified by the element module 350 on an ongoing basis to further identify and refine causal and contributory correlations between one or more elements or combinations of elements and accidents.

[61] For example, the correlation module 360 may receive a group of elements from the element module 350 and analyze those elements to determine that the ice on the road caused the vehicle to crash. In one embodiment, the correlation module 360 analyzes each of the elements identified from one or more events of a vehicle accident and compares those elements to causal and contributory correlations stored in a data storage area accessible to the correlation module, e.g., in the data storage area of the evaluation server. By making such comparisons and identifying the elements that are present, the correlation module 360 can categorize the elements related to the vehicle accident, for example, those elements that are possibly causal and those elements that are possible contributory.

[62] The factor module 370 is configured to receive information from the element module 350 and the correlation module 360 and identify those elements that are the likely factors that

caused or contributed to the cause of the vehicle accident. For example, the element module 350 may identify certain elements related to an accident such as icy road conditions and vehicle speed within the posted speed limit. The correlation module 360 may categorize the ice road conditions as possibly causal and categorize normal vehicle speed as unrelated. The factor module 370 may review the information from the element module 350 and the correlation module 360 and determine that the speed of the vehicle was the likely factor that caused the vehicle accident because the speed was too great under the specific conditions of the road.

[63] Advantageously, the factor module 370 may also maintain a data storage area of historical factors that are continuously refined and updated so that future factor comparisons and judgments made by computer analysis can be more accurate.

[64] Reporting module 330 is configured to compile reports based on individual and aggregate event data. Reports may be compiled for an individual driver, a particular shift, all day time drivers, all night time drivers, all twilight drivers (morning and evening), all drivers of particular vehicle types, and other groupings. These reports can be provided to supervisors, managers, and executives. The reports may also be provided to the individual drivers, for example, a report of the individual driver's events for the previous month, a report of a particularly significant individual event, etc. Advantageously, reports can be included as part of a coaching session to provide the viewer with concise summary data about the events in the coaching session.

[65] In one embodiment, reports can be targeted for drivers, supervisors, managers, executives, public relations (e.g., reporters/press), insurance companies, government agencies, legal authorities, legal representatives and the like. The reports may be used for a variety of purposes, including supplemental coaching of drivers to emphasize the benefits of reducing risky driving behavior.

[66] Additional functionality may also be included in the hindsight module 260, as indicated by the other module 390. The other module 390 may be configured to perform a variety of tasks, including but not limited to: scoring driver behavior before during and after the accident, identifying the presence of additional passengers in the vehicle, integration and assimilation of accident event data into a common data storage area; and mining of accident event data from the data storage area, just to name a few.

[67] Fig. 11 is a block diagram illustrating an example administrative module 280 according to an embodiment of the present invention. In the illustrated embodiment, the administrative module 280 comprises a communication module 450, an event detector module 460, a database module 470, and an other module 480.

[68] In one embodiment, the communication module 450 is configured to manage communications between the evaluation server 50 and the various stations and event detectors that are part of the system for reducing driving risk. For example, the communication module 450 may manage communications with individual event detectors, analysis stations, coaching stations, supervisor stations, docking stations, and the like.

[69] Additionally, communication module 450 may also manage communications between the various modules of the evaluation server 50. For example, communications between the foresight, hindsight, and insight modules may be managed by communication module 450. The communication module 450 is configured to manage wireless and wired communications and send and receive communications over a wired or wireless network.

[70] The communication module 450 is configured to send and receive communications to and from an event detector device, either directly or indirectly. For example, communications with an event detector device may take place through a docking station or a server that aggregates event data from multiple event detector devices before sending the event data to the evaluation server.

[71] The event detector module 460 is configured to manage individual and groups of event detectors. In one embodiment, the event detector module 460 may manage software versions that are resident on individual event detector devices so that the overall system may be kept up to date with respect to the versions of software deployed in the field.

[72] Event detector module 460 may also track the individual event detectors that have provided event data or otherwise reported back to the evaluation server during a given time period. For example, event detector module 460 may track those event detectors that have reported in during each day and provide summary reports so that managers and supervisors can determine if event data from each vehicle in use is being sent to the evaluation server. In one embodiment, the event detector module 460 may attempt to contact an individual event detector in order to determine the status of the event detector. Advantageously, the evaluation server can determine the efficacy of the overall system by periodic confirmation of the status

of each event detector. If the event detector module 460 determines that a particular event detector is not working properly, then that event detector may be identified as needing service or replacement.

[73] Database module 470 is configured to manage a database of information related to reducing driving risk. For example, event data, coaching sessions, and reports can be maintained in a data storage area by database module 470. Additionally, related information from sources other than event detectors and analysis stations may also be managed by the database module 470. For example, weather information can be obtained from third party sources and stored to provide objective information about the weather conditions during a particular event. Additional information may also include traffic congestion information and smog/visibility information. Other beneficial information may also be included and managed by database module 470.

[74] Additional functionality may also be included in the administrative module 280, as indicated by the other module 480. The other module 480 may be configured to perform a variety of tasks, including but not limited to: obtaining related information (e.g., road conditions, traffic conditions, weather, etc.), providing reports about event detector status, and tracking overall system performance and facilitating system maintenance when appropriate.

[75] Fig. 12 is a flow diagram illustrating an example process for forensic analysis of a vehicle accident according to an embodiment of the present invention. The illustrated process may be carried out by a hindsight module on an evaluation server previously described with respect to Fig. 9 and included in a system such as that previously described with respect to Fig. 5. The forensic analysis may also be carried out on an analysis station such as that described in the system of Fig. 5.

[76] Initially, in step 500 the system obtains event data related to a vehicle accident. The event data may comprise one or more discrete events captured by an event detector in a vehicle, with each event comprising audio, video, and metadata from one or more event capture devices. The event data may be obtained from a data storage area or from a companion application residing on a remote server across a network. The event data may also be obtained directly from one or more event detectors. In one embodiment, the event data may include events from each vehicle involved in the accidents and other vehicles that were near the accident scene and captured information relevant to the event.

[77] Once the event data has been obtained, in step 510 the event data is reviewed. The review may include computerized analysis of audio data, video data, and metadata. The review may also include operator analysis of audio data, video data, and metadata. The review may also include a combination of computerized and operator analysis. In one embodiment, the computerized analysis proceeds automatically and an operator reviews the results of the computerized analysis. Alternatively, the operator may only review certain elements that are flagged by the computerized analysis as potentially benefiting from further operator analysis.

[78] Next, in step 520 event elements are identified. The elements may be from one or more events and may be identified by an operator review or by computerized review. In one embodiment, elements include individual data points that are included in the event data, for example, the weather conditions, speed of the vehicle, location of the vehicle, operational status of the vehicle, etc. Elements may also include audio and video elements. Advantageously, a plurality of elements can be identified by a combination of computerized analysis and operator analysis.

[79] Once the elements have been identified, in step 530 those elements are correlated with historical information about vehicle accidents. For example, the same or similar elements can be analyzed from a historical perspective to determine the likelihood that a particular element was a contributing factor to the vehicle accident or the cause of the vehicle accident. In one embodiment, a database of elements is maintained such that each element includes one or more relative weights that describe how often the particular element is the cause of an accident or a contributing factor to an accident. Relationships between elements may also be tracked historically so that, for example, the presence of a first element in combination with a second element may indicate a cause of a vehicle accident 90% of the time.

[80] Accordingly, in step 540 the particular factors that may have caused the vehicle accident and those that may have contributed to the vehicle accident are determined. In one embodiment, these factors are determined by ranking the relative correlations between identified elements singularly and also in the presence of others. After the factors have been determined, in step 550 the system advantageously updates the data storage area that contains historical element, correlation, and factor data. This allows later forensic analyses to benefit from the aggregate historical data about the various elements, correlations, and factors.

[81] Next, in step 560 the system can generate a forensic analysis report that details all of the information collected and analyzed and determined about the vehicle accident. In one embodiment, the report may be a multimedia document that includes audio, video, and other data that steps through (under computer control) the vehicle accident and plays audio and video data and displays critical information to provide an objective reconstruction of the vehicle accident and highlight the various factors that may be causal or contributory. Advantageously, such a report may be later used by an insurance company, a legal team or the like to convey information about the accident.

[82] Fig. 13 is a block diagram illustrating an exemplary wireless communication device 650 that may be used in connection with the various embodiments described herein. For example, the wireless communication device 650 may be used in conjunction with an event detector previously described with respect to Fig. 1, or an evaluation server, analysis station, coaching station, or supervisor station previously described with respect to Fig. 2. However, other wireless communication devices and/or architectures may also be used, as will be clear to those skilled in the art.

[83] In the illustrated embodiment, wireless communication device 650 comprises an antenna 652, a multiplexor 654, a low noise amplifier ("LNA") 656, a power amplifier ("PA") 658, a modulation circuit 660, a baseband processor 662, a speaker 664, a microphone 666, a central processing unit ("CPU") 668, a data storage area 670, and a hardware interface 672. In the wireless communication device 650, radio frequency ("RF") signals are transmitted and received by antenna 652. Multiplexor 654 acts as a switch, coupling antenna 652 between the transmit and receive signal paths. In the receive path, received RF signals are coupled from a multiplexor 654 to LNA 656. LNA 656 amplifies the received RF signal and couples the amplified signal to a demodulation portion of the modulation circuit 660.

[84] Typically modulation circuit 660 will combine a demodulator and modulator in one integrated circuit ("IC"). The demodulator and modulator can also be separate components. The demodulator strips away the RF carrier signal leaving a base-band receive audio signal, which is sent from the demodulator output to the base-band processor 662.

[85] If the base-band receive audio signal contains audio information, then base-band processor 662 decodes the signal and converts it to an analog signal. Then the signal is amplified and sent to the speaker 664. The base-band processor 662 also receives analog audio signals from the microphone 666. These analog audio signals are converted to digital signals and encoded by the base-band processor 662. The base-band processor 662 also codes the digital signals for transmission and generates a base-band transmit audio signal that is routed to the modulator portion of modulation circuit 660. The modulator mixes the base-band transmit audio signal with an RF carrier signal generating an RF transmit signal that is routed to the power amplifier 658. The power amplifier 658 amplifies the RF transmit signal and routes it to the multiplexor 654 where the signal is switched to the antenna port for transmission by antenna 652.

[86] The baseband processor 662 is also communicatively coupled with the central processing unit 668. The central processing unit 668 has access to a data storage area 670. The central processing unit 668 is preferably configured to execute instructions (i.e., computer programs or software) that can be stored in the data storage area 670. Computer programs can also be received from the baseband processor 662 and stored in the data storage area 670 or executed upon receipt. Such computer programs, when executed, enable the wireless communication device 650 to perform the various functions of the present invention as previously described.

[87] In this description, the term "computer readable medium" is used to refer to any media used to provide executable instructions (e.g., software and computer programs) to the wireless communication device 650 for execution by the central processing unit 668. Examples of these media include the data storage area 670, microphone 666 (via the baseband processor 662), antenna 652 (also via the baseband processor 662), and hardware interface 672. These computer readable mediums are means for providing executable code, programming instructions, and software to the wireless communication device 650. The executable code, programming instructions, and software, when executed by the central processing unit 668, preferably cause the central processing unit 668 to perform the inventive features and functions previously described herein.

[88] The central processing unit is also preferably configured to receive notifications from the hardware interface 672 when new devices are detected by the hardware interface. Hardware interface 672 can be a combination electromechanical detector with controlling software that communicates with the CPU 668 and interacts with new devices.

[89] Fig. 14 is a block diagram illustrating an exemplary computer system 750 that may be used in connection with the various embodiments described herein. For example, the computer system 750 may be used in conjunction with an event detector previously described with respect to Fig. 1, or an evaluation server, analysis station, coaching station, or supervisor station previously described with respect to Fig. 2. However, other computer systems and/or architectures may be used, as will be clear to those skilled in the art.

[90] The computer system 750 preferably includes one or more processors, such as processor 752. Additional processors may be provided, such as an auxiliary processor to manage input/output, an auxiliary processor to perform floating point mathematical operations, a special-purpose microprocessor having an architecture suitable for fast execution of signal processing algorithms (e.g., digital signal processor), a slave processor subordinate to the main processing system (e.g., back-end processor), an additional microprocessor or controller for dual or multiple processor systems, or a coprocessor. Such auxiliary processors may be discrete processors or may be integrated with the processor 752.

[91] The processor 752 is preferably connected to a communication bus 754. The communication bus 754 may include a data channel for facilitating information transfer between storage and other peripheral components of the computer system 750. The communication bus 754 further may provide a set of signals used for communication with the processor 752, including a data bus, address bus, and control bus (not shown). The communication bus 754 may comprise any standard or non-standard bus architecture such as, for example, bus architectures compliant with industry standard architecture ("ISA"), extended industry standard architecture ("EISA"), Micro Channel Architecture ("MCA"), peripheral component interconnect ("PCI") local bus, mini PCI express, or standards promulgated by the Institute of Electrical and Electronics Engineers ("IEEE") including IEEE 488 general-purpose interface bus ("GPIB"), IEEE 696/S-100, and the like.

[92] Computer system 750 preferably includes a main memory 756 and may also include a secondary memory 758. The main memory 756 provides storage of instructions and data for programs executing on the processor 752. The main memory 756 is typically semiconductor-based memory such as dynamic random access memory ("DRAM") and/or static random access memory ("SRAM"). Other semiconductor-based memory types include, for example, synchronous dynamic random access memory ("SDRAM"), Rambus dynamic random access memory ("RDRAM"), ferroelectric random access memory ("FRAM"), and the like, including read only memory ("ROM").

[93] The secondary memory 758 may optionally include a hard disk drive 760 and/or a removable storage drive 762, for example a floppy disk drive, a magnetic tape drive, a compact disc ("CD") drive, a digital versatile disc ("DVD") drive, etc. The removable storage drive 762 reads from and/or writes to a removable storage medium 764 in a well-known manner. Removable storage medium 764 may be, for example, a floppy disk, magnetic tape, CD, DVD, memory stick, USB memory device, etc.

[94] The removable storage medium 764 is preferably a computer readable medium having stored thereon computer executable code (i.e., software) and/or data. The computer software or data stored on the removable storage medium 764 is read into the computer system 750 as electrical communication signals 778.

[95] In alternative embodiments, secondary memory 758 may include other similar means for allowing computer programs or other data or instructions to be loaded into the computer system 750. Such means may include, for example, an external storage medium 772 and an interface 770. Examples of external storage medium 772 may include an external hard disk drive or an external optical drive, or and external magneto-optical drive.

[96] Other examples of secondary memory 758 may include semiconductor-based memory such as programmable read-only memory ("PROM"), erasable programmable read-only memory ("EPROM"), electrically erasable read-only memory ("EEPROM"), or flash memory. Also included are any other removable storage units 772 and interfaces 770, which allow software and data to be transferred from the removable storage unit 772 to the computer system 750.

[97] Computer system 750 may also include a communication interface 774. The communication interface 774 allows software and data to be transferred between computer system 750 and external devices (e.g. printers), networks, or information sources. For example, computer software or executable code may be transferred to computer system 750 from a network server via communication interface 774. Examples of communication interface 774 include a modem, a network interface card ("NIC"), a communications port, a PCMCIA slot and card, an infrared interface, and an IEEE 1394 fire-wire, just to name a few.

[98] Communication interface 774 preferably implements industry promulgated protocol standards, such as Ethernet IEEE 802 standards, Fiber Channel, digital subscriber line ("DSL"), asynchronous digital subscriber line ("ADSL"), frame relay, asynchronous transfer mode ("ATM"), integrated digital services network ("ISDN"), personal communications services ("PCS"), transmission control protocol/Internet protocol ("TCP/IP"), serial line Internet protocol/point to point protocol ("SLIP/PPP"), and so on, but may also implement customized or non-standard interface protocols as well.

[99] Software and data transferred via communication interface 774 are generally in the form of electrical communication signals 778. These signals 778 are preferably provided to communication interface 774 via a communication channel 776. Communication channel 776 carries signals 778 and can be implemented using a variety of wired or wireless communication means including wire or cable, fiber optics, conventional phone line, cellular phone link, wireless data communication link, radio frequency (RF) link, or infrared link, just to name a few.

[100] Computer executable code (i.e., computer programs or software) is stored in the main memory 756 and/or the secondary memory 758. Computer programs can also be received via communication interface 774 and stored in the main memory 756 and/or the secondary memory 758. Such computer programs, when executed, enable the computer system 750 to perform the various functions of the present invention as previously described.

[101] In this description, the term "computer readable medium" is used to refer to any media used to provide computer executable code (e.g., software and computer programs) to the computer system 750. Examples of these media include main memory 756, secondary memory 758 (including hard disk drive 760, removable storage medium 764, and external storage medium 772), and any peripheral device communicatively coupled with communication interface 774 (including a network information server or other network device). These computer readable mediums are means for providing executable code, programming instructions, and software to the computer system 750.

[102] In an embodiment that is implemented using software, the software may be stored on a computer readable medium and loaded into computer system 750 by way of removable storage drive 762, interface 770, or communication interface 774. In such an embodiment, the software is loaded into the computer system 750 in the form of electrical communication

signals 778. The software, when executed by the processor 752, preferably causes the processor 752 to perform the inventive features and functions previously described herein.

[103] Various embodiments may also be implemented primarily in hardware using, for example, components such as application specific integrated circuits ("ASICs"), or field programmable gate arrays ("FPGAs"). Implementation of a hardware state machine capable of performing the functions described herein will also be apparent to those skilled in the relevant art. Various embodiments may also be implemented using a combination of both hardware and software.

[104] Furthermore, those of skill in the art will appreciate that the various illustrative logical blocks, modules, circuits, and method steps described in connection with the above described figures and the embodiments disclosed herein can often be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled persons can implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the invention. In addition, the grouping of functions within a module, block, circuit or step is for ease of description. Specific functions or steps can be moved from one module, block or circuit to another without departing from the invention.

[105] Moreover, the various illustrative logical blocks, modules, and methods described in connection with the embodiments disclosed herein can be implemented or performed with a general purpose processor, a digital signal processor ("DSP"), an ASIC, FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor can be a microprocessor, but in the alternative, the processor can be any processor, controller, microcontroller, or state machine. A processor can also be implemented as a combination of computing devices, for example, a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[106] Additionally, the steps of a method or algorithm described in connection with the embodiments disclosed herein can be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module can reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium including a network storage medium. An exemplary storage medium can be coupled to the processor such the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium can be integral to the processor. The processor and the storage medium can also reside in an ASIC.

[107] The above description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the invention. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles described herein can be applied to other embodiments without departing from the spirit or scope of the invention. Thus, it is to be understood that the description and drawings presented herein represent a presently preferred embodiment of the invention and are therefore representative of the subject matter which is broadly contemplated by the present invention. It is further understood that the scope of the present invention fully encompasses other embodiments that may become obvious to those skilled in the art and that the scope of the present invention is accordingly limited by nothing other than the appended claims.

Claims

1. A method for forensic analysis of a vehicle accident, comprising:

capturing a driving event at an event capture device coupled with a vehicle, the driving event associated with a vehicle accident and comprising video data from before and during the vehicle accident;

providing the driving event to an evaluation server;

analyzing the driving event to determine one or more key elements related to the vehicle accident;

determining one or more factors that contributed to the cause of the vehicle accident;

providing the one or more factors to the evaluation server; and

generating a report identifying the one or more factors that contributed to the cause of the vehicle accident.

2. The method of claim 1, wherein the determining step further comprises:

correlating the one or more key elements with causation data stored at the evaluation server; and

identifying key elements with the highest correlation for causing the vehicle accident.

3. The method of claim 1, wherein the determining step further comprises:

correlating the one or more factors with causation data stored at the evaluation server; and

identifying factors with the highest correlation for causing the vehicle accident.

4. The method of claim 1, wherein the providing step further comprises updating causation data in a data storage area to reflect the one or more key elements.

5. The method of claim 1, wherein the providing step further comprises updating causation data in a data storage area to reflect the one or more factors.

6. A system for forensic analysis of a vehicle accident, comprising:

an event detector coupled with a vehicle, the event detector configured to capture a driving event associated with a vehicle accident, the driving event captured in response to a trigger and comprising audio, video, and metadata information;

a communication link configured to convey the driving event from the event detector to an evaluation server; and

an evaluation server comprising an element module, a correlation module, and a factor module, said modules configured to analyze the audio, vide, and metadata information to identify a cause of the vehicle accident.

7. The system of claim 6, wherein the communication link is a wired network.

8. The system of claim 7, wherein the wired network comprises a private network.

9. The system of claim 7, wherein the wired network comprises a public network.

10. The system of claim 6, wherein the communication link is a wireless network.

11. The system of claim 10, wherein the wireless network comprises a ZigBee link.

12. The system of claim 10, wherein the wireless network comprises a Bluetooth link.

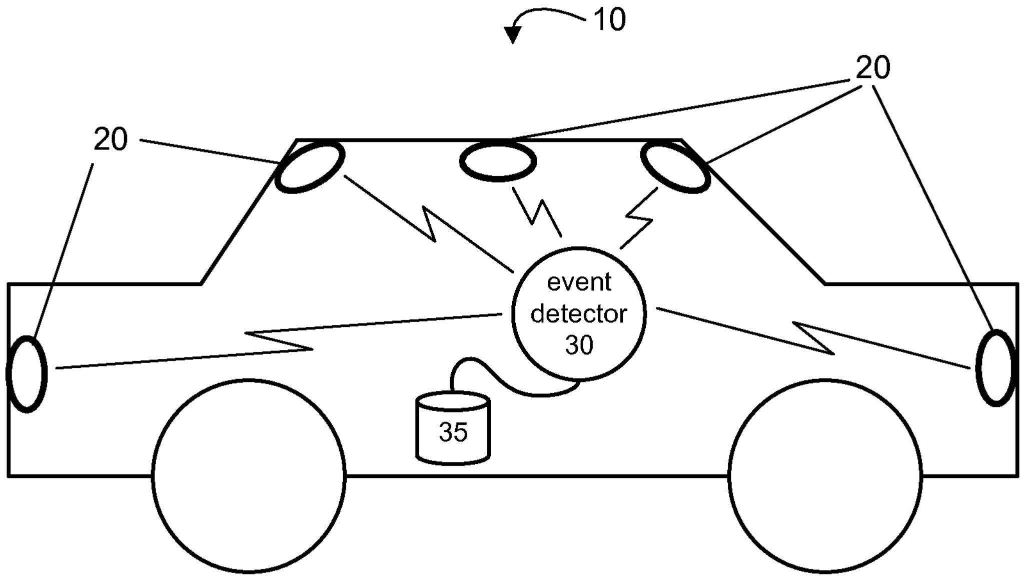

FIG. 1

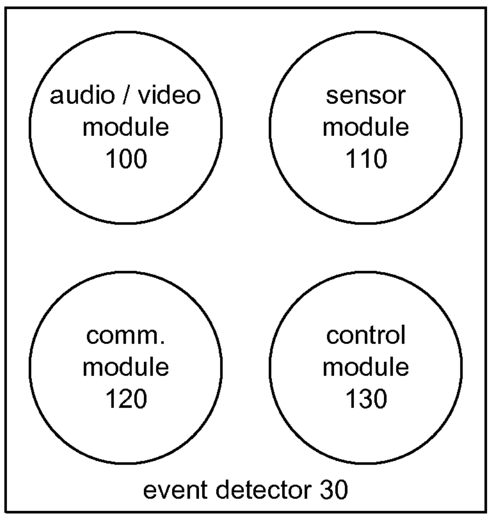

FIG. 2

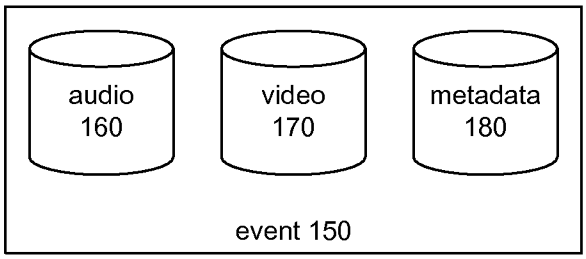

FIG. 3

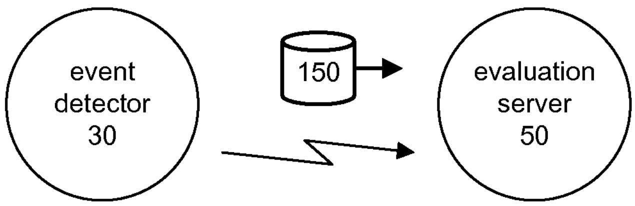

FIG. 4A

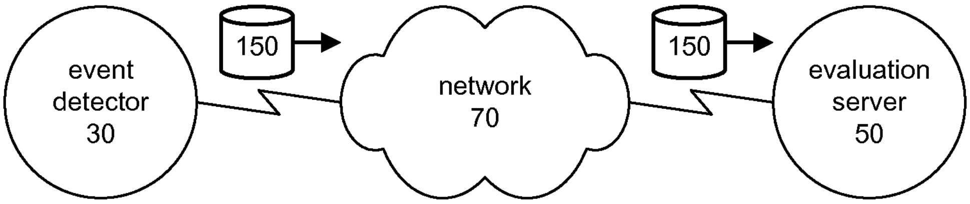

FIG. 4B

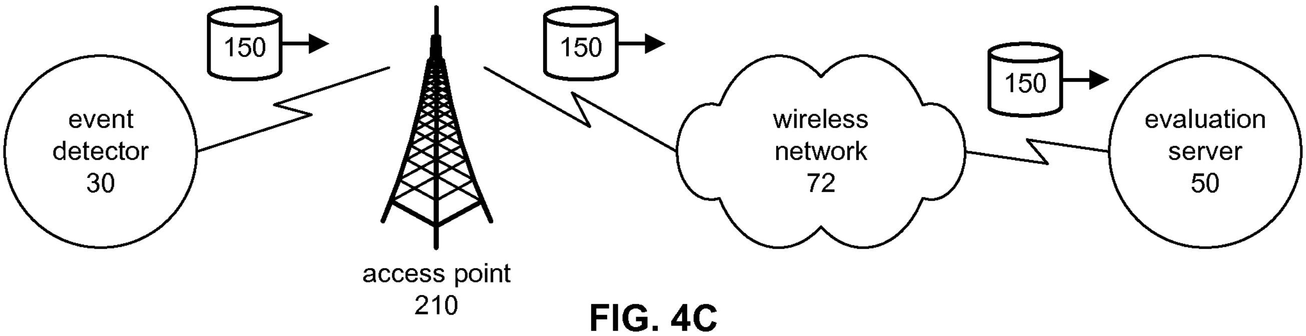

FIG. 4C

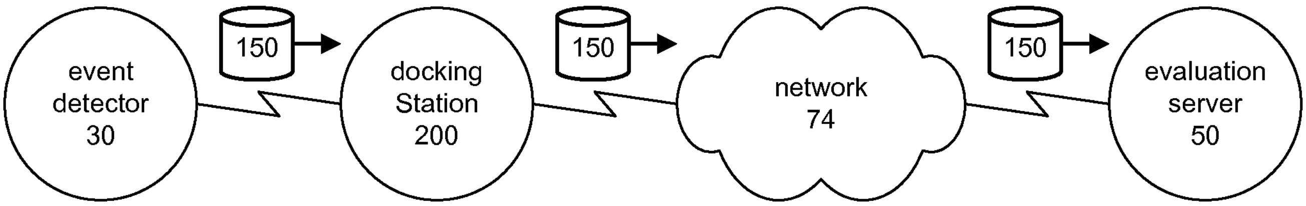

FIG. 4D

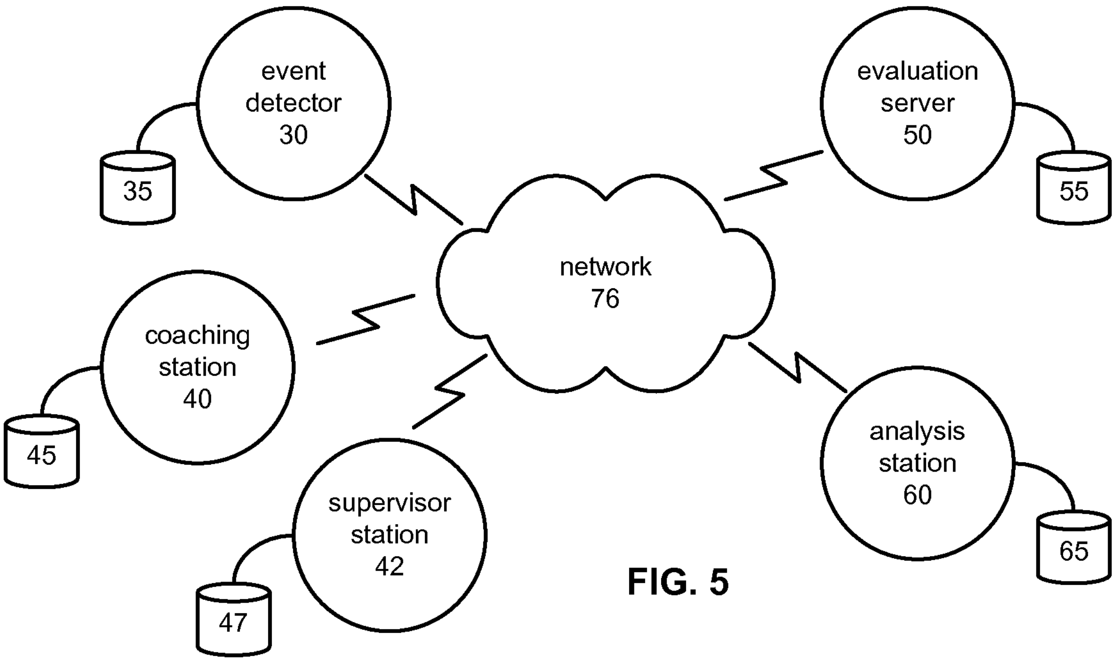

FIG. 5

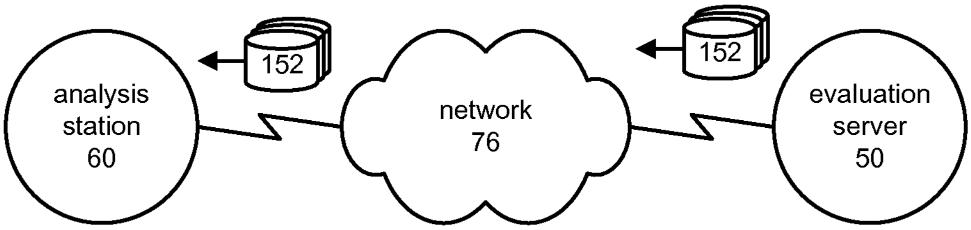

FIG. 6

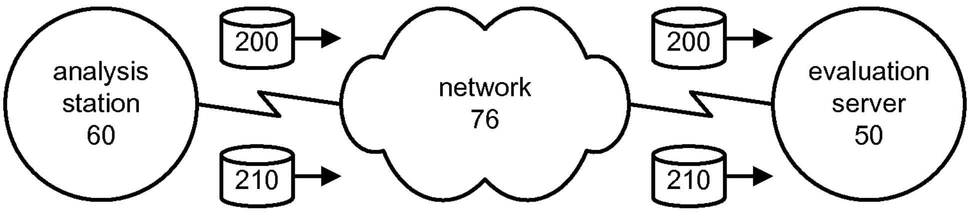

FIG. 7

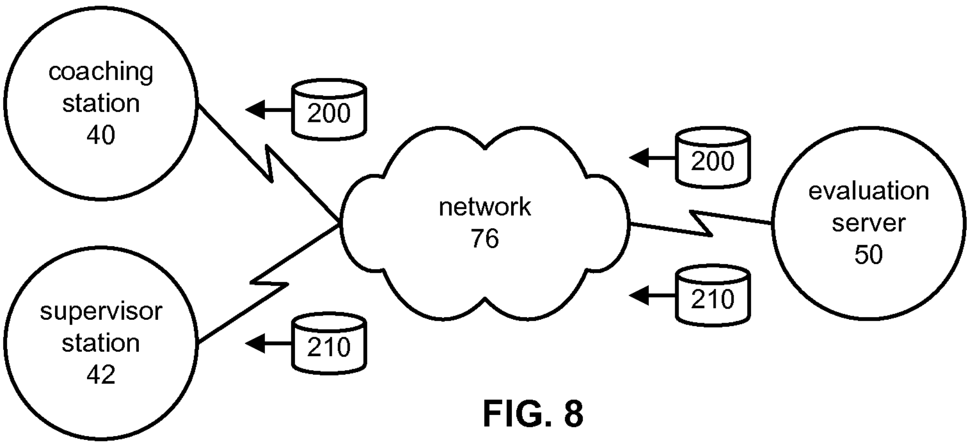

FIG. 8

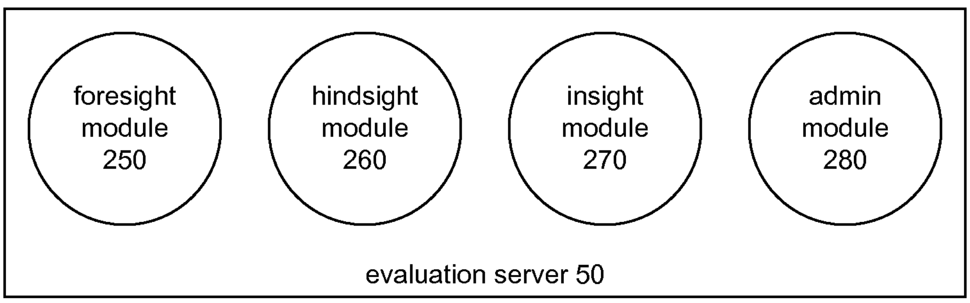

FIG. 9

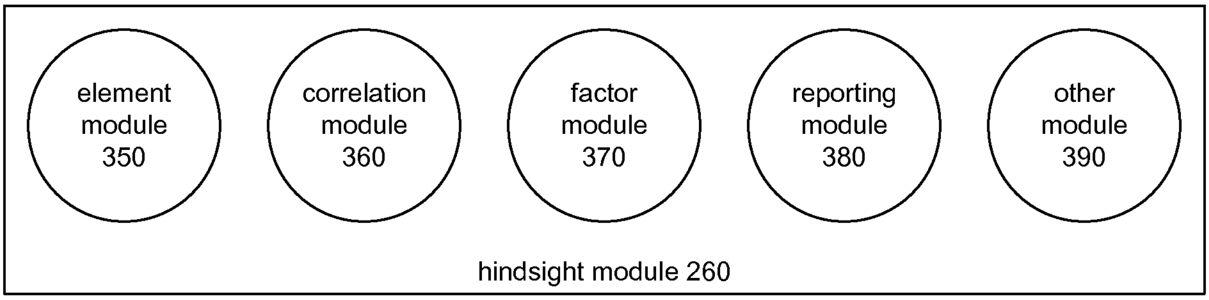

FIG. 10

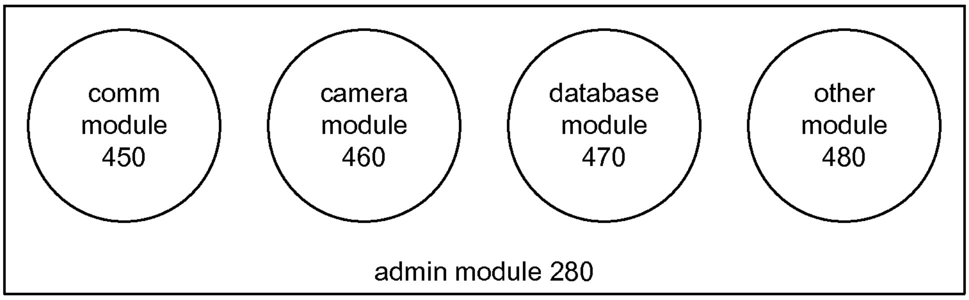

FIG. 11

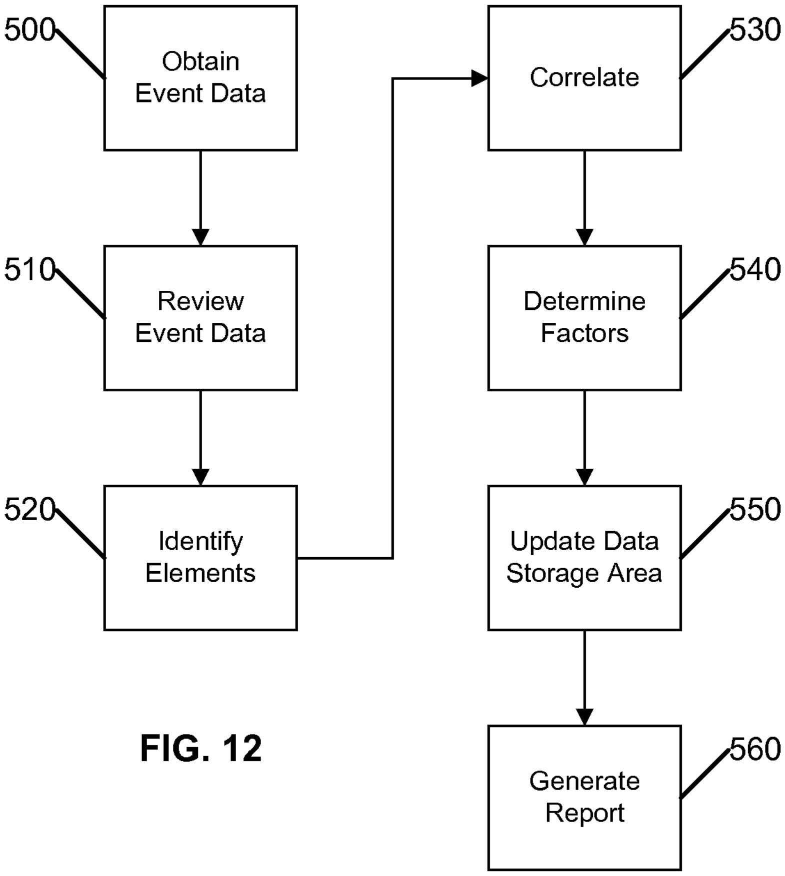

FIG. 12

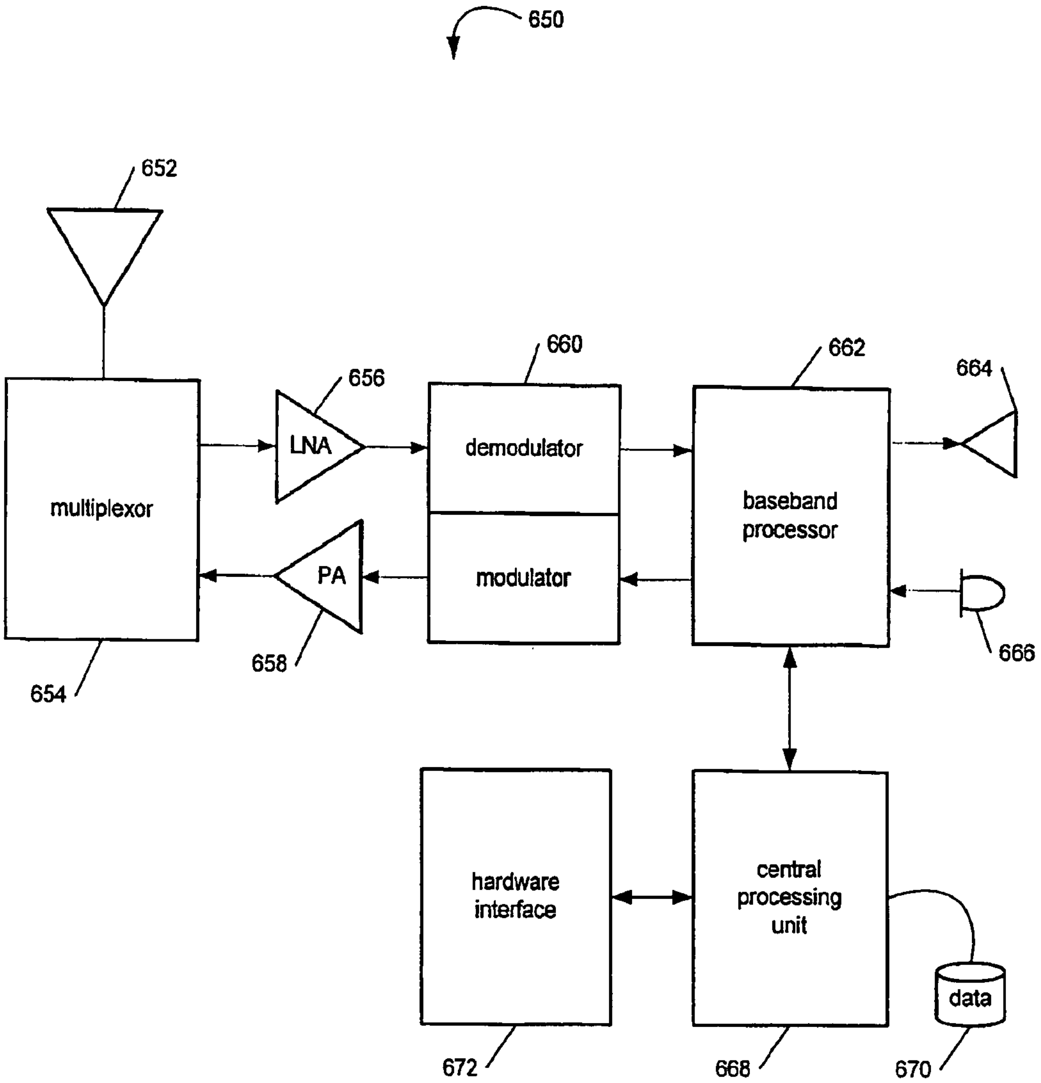
650
652
660
662
664
656
LNA
demodulator
baseband
processor
multiplexor
PA
modulator
666
658
654
hardware
interface
central
processing
unit
data
672
668
670

FIG. 13

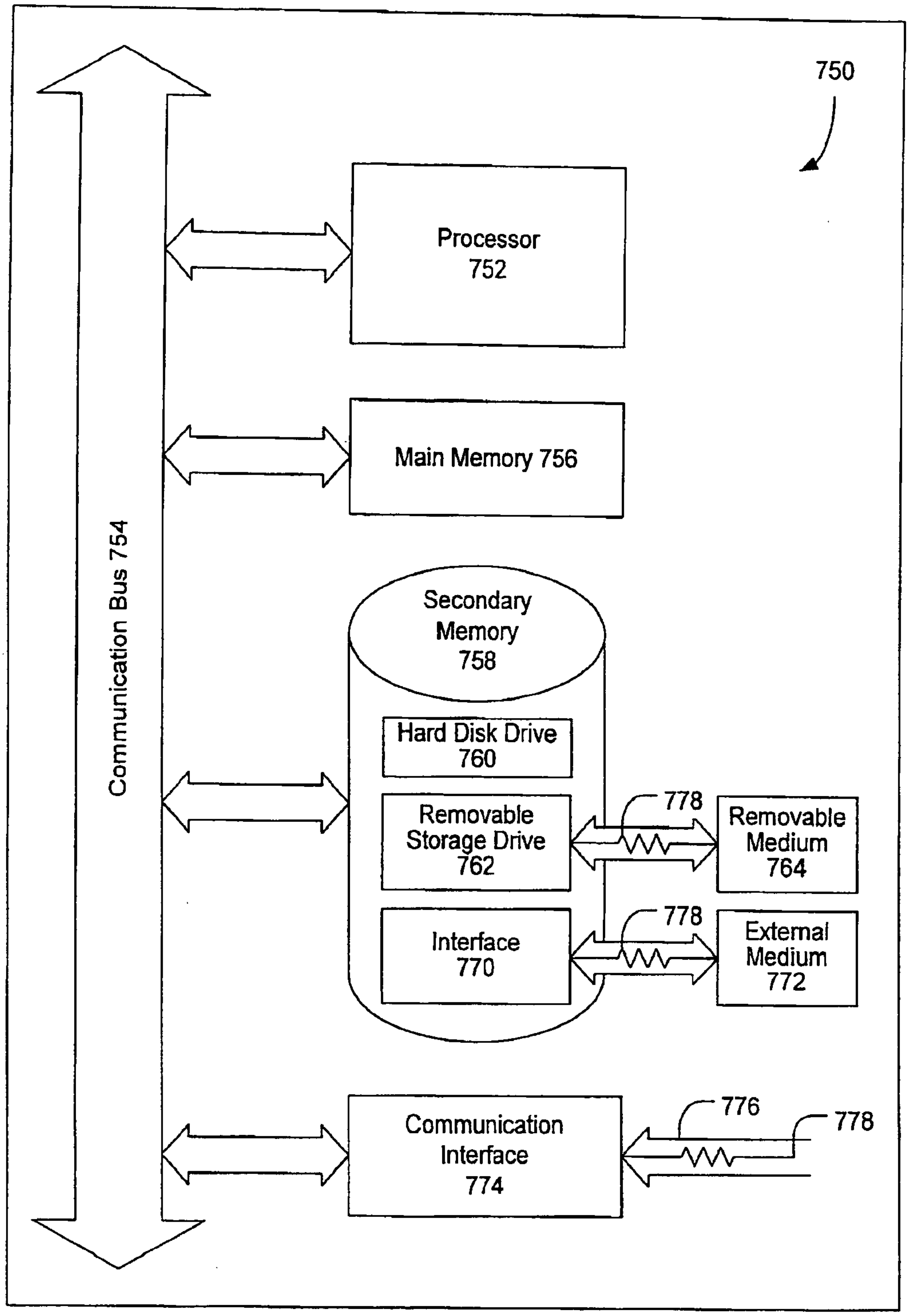
750
Processor
752
Main Memory 756
Communication Bus 754
Secondary
Memory
758
Hard Disk Drive
760
Removable
Storage Drive
762
778
Removable
Medium
764
Interface
770
778
External
Medium
772
Communication
Interface
774
776
778

FIG. 14