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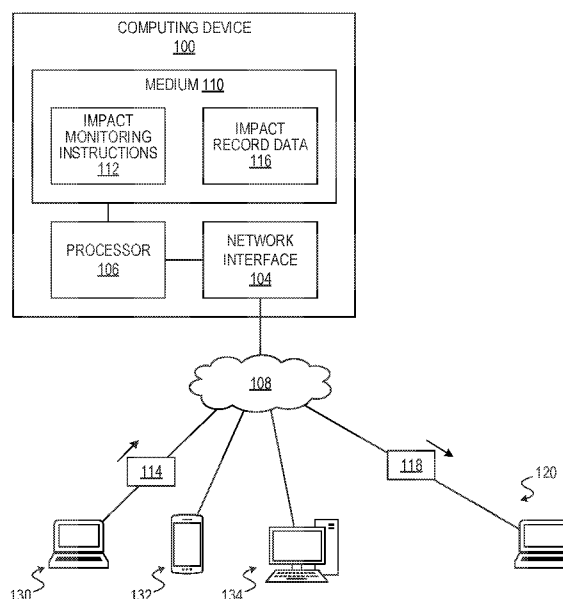


FIG. 1

(57) **Abstract:** An example computing device includes a network interface and a processor connected to the network interface. The processor is to receive new data from a user electronic device via the network interface. The new data is indicative of a new impact event experienced by the user electronic device. The processor is further to add the new data to impact record data that includes any past impact events experienced by the user electronic device, analyze the impact record data to determine if an intervention for the user electronic device is to be initiated, and, if an intervention is to be initiated, transmit via the network interface an intervention instruction to an intervening electronic device that is different from the user electronic device.



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IMPACT EVENTS MONITORING

BACKGROUND

[0001] Computing devices are used for a wide variety of tasks in a wide variety of environments. Computing devices may be purchased by an organization and assigned to employees, contractors, or others associated with the organization. Computing devices may be leased or rented from a provider, such as a Device as a Service (DaaS) provider, who may be responsible for the repair and replacement of computing devices as they become obsolete, endure normal wear-and-tear, and suffer damage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. 1 is a block diagram of an example computing device to monitor impact events experienced by user electronic devices.

[0003] FIG. 2 is a schematic diagram of an example relational database structure to track impact events experienced by user electronic devices.

[0004] FIG. 3 is a schematic block diagram of an example user electronic device with a hinge sensor to monitor impact events.

[0005] FIG. 4 is a flowchart of an example method of monitoring impact events experienced by user electronic devices.

[0006] FIG. 5 is a flowchart of an example method of detecting impact events at a user electronic device.

DETAILED DESCRIPTION

[0007] A computing device may suffer an impact due to being dropped, being hit by an object, or being subject to another form of external force. Detecting

impact events and responding with appropriate interventions may increase the useable life of computing devices and may increase the productivity of users of such devices.

[0008] An intervention directed to a device that suffers an impact may be disregarded if the device is severely damaged by an impact event or if the user does not take the impact event seriously. Accordingly, as discussed herein, intervention instructions and related information are provided to another device, such as a device operated by a service organization, technician, or other party. Moreover, intervention instructions may be provided to emergency services if the user is sick or elderly and the impact is considered to be the result of a fall or other unusual event experienced by the user.

[0009] Impact severity may be higher for devices that have moveable parts, such as notebook computers, and severity may depend on the relative positions of such parts. Accordingly, a hinge sensor may be referenced to determine that an impact has occurred and the severity of the impact. A trained machine-learning model may be provided with a hinge sensor signal, as well as signals from other sensors, to determine that an impact has occurred and the severity of same.

[0010] FIG. 1 shows an example computing device 100 to monitor impact events experienced by user electronic devices 130, 132, 134. The computing device 100 may be a server or similar computer. The plurality of user electronic devices 130, 132, 134 may include notebook computers, smartphones, tablet computers, all-in-one (AIO) computers, desktop computers, or similar. The user electronic devices 130, 132, 134 may be DaaS devices. It is noted that specific examples discussed herein with respect to the electronic device 130 also apply to the electronic devices 132, 134.

[0011] The computing device 100 includes a network interface 104 and a processor 106 connected to the network interface 104.

[0012] The network interface 104 includes hardware, such as a network adaptor card, network interface controller, or network-capable chipset, and may further include instructions, such as a driver and/or firmware. The network interface 104 allows data to be communicated with a computer network 108, such as a local-area network (LAN), wide-area network (WAN), virtual private network (VPN), the internet, or similar networks that may include wired and/or wireless pathways.

[0013] Communication between the user electronic devices 130, 132, 134 and the computing device 100 may be made via the computer network 108 and respective network interfaces of such devices.

[0014] The processor 106 may include a central processing unit (CPU), a microcontroller, a microprocessor, a processing core, a field-programmable gate array (FPGA), an application-specific integrated circuit (ASIC), or a similar device capable of executing instructions. The processor may cooperate with a non-transitory machine-readable medium 110, which may include an electronic, magnetic, optical, or other physical storage device that encodes instructions. The machine-readable medium 110 may include, for example, random access memory (RAM), read-only memory (ROM), electrically-erasable programmable read-only memory (EEPROM), flash memory, a storage drive, an optical device, or similar.

[0015] The computing device 100 further includes impact monitoring instructions 112 that are executable by the processor 106. The impact monitoring instructions 112 may be directly executed, such as a binary file, and/or may include interpretable code, bytecode, source code, or similar instructions that may undergo additional processing to be executed.

[0016] The impact monitoring instructions 112 monitor and track physical impact events (*e.g.*, drops) at the user electronic devices 130, 132, 134 and, when appropriate, initiate interventions that may include preventative maintenance, replacing a device, and similar actions.

[0017] To achieve this, the impact monitoring instructions 112 receive new data 114 from the user electronic devices 130, 132, 134 if and when such devices experience impact events. The new data 114 is indicative of a new impact event experienced by a user electronic device 130. That is, if the user of the electronic device 130 drops the device or the device experiences another kind of impact event, the electronic device 130 may transmit the data 114 indicative of the impact event to the computing device 100.

[0018] Impact-event data 114 may take various forms and may provide information directly relevant to the impact, such as acceleration data, and/or information that provides context as to how the device was being used prior to or at the time of impact. For example, the data 114 may include a simple indication that an impact event has occurred, as may be detected by a sensor (*e.g.*, an accelerometer) at the user electronic device 130. The data 114 may include an indication of an intensity of an impact event, as measured by a sensor. For example, an acceleration signal may be used to classify an impact as low, medium, or high. In another example, the data 114 may include a measurement, such as a raw signal value, a maximum acceleration, a minimum acceleration, an average acceleration, a force, a force per unit time, or similar. In still other examples, the data 114 may include a relevant aspect of the electronic device 130, such as the distance traveled by the device to impact (*e.g.*, height of a drop), its orientation in space when the impact occurred, or its physical configuration at time of impact (*e.g.*, degree of open/close of a notebook computer, whether a peripheral was attached, *etc.*). The data 114 may include a state of the device during the impact, such as the device's power state (*e.g.*, hibernation mode, modern standby, S4, S5, *etc.*), resource usage (*e.g.*, RAM usage, CPU usage, *etc.*), application status (*e.g.*, which applications were active, which application had focus, *etc.*), and similar. The data may 114 describe the location of the device during the impact, as may be indicated by global-positioning system (GPS) data, a cellular tower identifier, a Wi-Fi™ network name, an identifier of a connected Bluetooth™ device, and similar. Such information may be provided alone or in various suitable combinations to provide context for the impact event by indicating if and how the device 130 was

being used when the impact occurred. For example, if a notebook computer was open and an application was in focus at the time of impact, the usage context is different from a device that suffered an impact in a sleep state.

[0019] The data 114 may indicate the severity of the impact. For example, impacts with higher force or resulting from drops from greater heights may be more severe than low force impacts or short drops. The data 114 may be provided with an explicit value to directly indicate impact severity, or the severity may be implicit from the sensor, state, configuration, and other data.

[0020] The severity of an impact event at a notebook computer that is open may be higher than a notebook computer that is closed. Data 114 describing an impact may thus describe impact severity with an indication of an angular position of the notebook computer's hinge. Hinge position may describe whether the notebook computer was open, and to what degree, during the impact. Further, orientation of the notebook computer during impact may add a further indication as to impact severity, as an open notebook computer that lands screen down may be a more severe impact than one that lands upright.

[0021] The impact monitoring instructions 112 add the new data 114 to a collection of impact record data 116 that may include any past impact events experienced by the user electronic device 130. The impact record data 116 may be stored in a database and the instructions 112 may insert new records into the database to track impact events. An impact event may be associated with a user of the electronic device 130, as shown in FIG. 2, which depicts an example relational database structure 200 that correlates a table of devices 202 to a table of impact events 204 and a table of users 206. The table of devices 202 may include a device identifier column 210, to store a device identifier such as a media access control (MAC) address, an internet protocol (IP) address, an International Mobile Equipment Identity (IMEI) number, a serial number, or similar. The table of impact events 204 may include an event identifier column 212, an impact data column 214 to specify the nature of the impact, as discussed above, and a time of impact column 216 to store a timestamp or other

absolute measure of when the impact occurred. The impact data column 214 may store sensor indications, sensor data, device state at time of impact, device configuration at time of impact, device location at time of impact, and similar, as discussed above. The table of users 206 may include a user identifier column 218 and an organization column 220, which may be used to indicate organization such as an employer. New data 114 describing an impact event may specify a device identifier column 210, an impact data column 214, and a time column 216. In FIG. 2, new data 114 is shown as creating (at arrow) a new row in the table of impact events 204. Further shown are many-to-one relationships (in crow's foot notation) between the table of impact events 204 (many), the table of users 206 (many), and the table of interventions 208 (many) to the table of devices 202 (one). That is, each row stored in the table of devices 202 may be associated with many rows in the table of impact events 204, many rows in the table of users 206, and many rows in the table of interventions 208 via a device identifier as key.

[0022] The impact monitoring instructions 112 thus collect and store information related to impact events that may affect the user electronic devices 130, 132, 134. Such information may provide an overall usage picture as to how the electronic devices 130, 132, 134 have been physically treated while in service, whether impact events are accidental or intentional. The impact monitoring instructions 112 may provide for the adding and removing of devices and users as well as the creation and modification of associations between users and devices to reflect who is assigned which device during at various times during the usage of the device (see FIG. 2). A history the impact events experienced by a collection of user electronic devices 130, 132, 134 may therefore be maintained.

[0023] The impact monitoring instructions 112 further analyze the impact record data to identify a damaged or potentially damaged user electronic device 130 to determine if an intervention for the electronic device is to be initiated. This may be done at any time during the collection and maintenance of the impact record data. For example, the receipt of new data 114 may trigger the

analysis. In another example, the analysis may be performed at intervals, such as periodically (*e.g.*, once per hour, once per day, *etc.*), to identify devices 130, 132, 134 that are to receive interventions.

[0024] The data 116 maintained by the computing device may indicate probable damage to user electronic devices, such by the number of impact events and the characteristics or severity of such events. A likelihood of damage may be expressed as a numeric probability (*e.g.*, 0.74), a Boolean value (*e.g.*, true = likely, false = unlikely), a descriptor, or similar. The impact monitoring instructions 112 may identify devices with that are likely damaged or that are at risk of damage and determine that an intervention is to be made.

[0025] Examples of useful service or support interventions include performing preventative maintenance, maintaining data integrity, replacing a device, upgrading a user to a more robust device, downgrading the user to a less expensive device, providing a peripheral component to the device, or similar. For example, the analysis for a given device 130 may show that other devices with similar impact event histories required maintenance or replacement. As such, the device 130 may be flagged for preemptive maintenance or replacement prior to the user of the device experiencing a problem. As such, the user is less likely to experience a significant reduction in productivity. In another example, the analysis for a given device may show that other devices with similar impact event histories experienced data loss. A hard disk drive (HDD) or solid-state drive (SSD) may be damaged by impact and data loss may occur. An early intervention may preempt data loss. In other examples, the user's apparent treatment of the device 130 may warrant replacing the device for one that is less expensive, and thus less costly to the DaaS operator, or replacing the device with a more robust device, such as a ruggedized device. A device may be used in a factory or field setting that results in a high number of impact events. As such, the user may be assigned a ruggedized replacement device. Likewise, a user may be assigned a low-cost device in such environments or if the user is suspected of misusing the device 130. In still other examples, the impacts experienced by the device 130 may suggest that a

peripheral component should be assigned to the device. Examples of useful peripheral components include a dock that may secure a notebook computer to a table or other work surface, an attachable case that may absorb impact from a drop, a screen protector that may reduce the chance of screen damage during a drop, and so on.

[0026] Other examples of useful interventions include an emergency services intervention to check on the wellness of the user of a device 130 that experiences an impact event. For example, the user may be sick or elderly and an impact event at the device 130 may indicate that the user has fallen or suffered from some other injury or medical event that caused them to drop the device 130.

[0027] The analysis may be predictive. The instructions 112 may analyze the impact record data 116 for a specific device 130 with reference to the impact record data 116 for other electronic devices 132, 134. This may help preempt a future service request for the specific device 130.

[0028] With reference to FIG. 2, the table of interventions 208 may track interventions for the electronic devices 130, 132, 134 using the example relational database structure 200. Tracked interventions may include interventions initiated by the user of a device and interventions initiated by the impact monitoring instructions. Each row of the table of interventions 208 may be assigned an intervention identifier stored in an intervention identifier column 222. The table of interventions 208 may also include a device identifier column 210, a failure mode column 224 to store a mode of failure of the device, a type of intervention column 226 to store the type of intervention undertaken, and a time of intervention column 228. As such, a comparison of a given device to other devices, as tracked by the table of devices 202, that experienced similar impacts may be performed to determine if it is time to initiate an intervention for the device. This may be achieved by executing a query against a table of impact events 204 and joining other information, such data stored in the table of users 206 and/or the table of devices 202. A query may include a computation, such

as a count, average, *etc.* Any number of suitable queries and computations may be combined in an analysis. For example, if the average number of impact events for a set of similar devices was five before an intervention was made, and a particular device 130 has just experienced its fourth impact event, then a preemptive intervention may be initiated. This is merely an example, and various statistical methodologies may be used to increase or maximize the usefulness of preemptive interventions. The analysis may consider various factors, such as an intervention that is too early may waste resources while an intervention that is too late may damage the reputation of the device or DaaS operator.

[0029] If an intervention is determined to be useful, the impact monitoring instructions transmit information 118 concerning the intervention to an intervening electronic device 120. The intervening electronic device 120 is different from the user electronic device 130 for which the intervention is being made. It is useful to transmit the intervention information 118 to a different device rather than the device that suffered the impact because, in some circumstances, the device suffering the impact may no longer be completely operational or the user of the device may have fallen down or experienced a medical event and may not be able to respond. In other circumstances, the user of the device 130 that suffered the impact may not take such information seriously, may not act soon enough, or may believe that the impact was harmless. As such, dispatching the intervention information 118 to a different device 120 may be more reliable and safer.

[0030] Examples of intervening electronic devices 120 are the same as those given above for the user electronic devices. An intervening electronic device 120 may be user device of a person who will undertake or initiate an intervention. An intervening electronic device 120 may be a server or similar device that is accessible to multiple user devices of multiple people capable of undertaking or initiating interventions. For example, an intervening electronic device 120 may be a service technician's smartphone. In another example, an

intervening electronic device 120 may be a server that operates a technical-support helpdesk ticket system.

[0031] Intervention information 118 transmitted to an intervening device 120 may include an intervention instruction, an identity of the electronic device 130 requiring intervention, or both. Example electronic device identifiers are given above.

[0032] In various examples, the intervening electronic device 120 to which the intervention information 118 is sent is a service technician's electronic device. An intervention instruction may include an instruction to perform service on the electronic device 130 that is the subject to the intervention. The identity of the electronic device requiring intervention may also form a useful part of this information. Accordingly, a service technician may service the device 130 by, for example, attending to the location of the device 130 or by contacting the user of the device 130 to initiate service. A service technician may visit the user and swap out the device 130 or take other action. Alternatively, a service technician may contact the user via a messaging application, phone call, or other communications pathway to arrange for the user to bring or send the device 130 to a service location.

[0033] In various examples, the intervening electronic device 120 to which the intervention instruction is sent is an emergency services electronic device. The intervention instruction may include an instruction to assess the wellness of the user of the user electronic device 130 that is the subject to the intervention. For example, the intervention instruction may be communicated in an electronic message to a medical service provider, a caregiver, a family member, or similar. A user who subscribes to this service may provide contact information for such a person.

[0034] Examples of intervention instructions include text and/or images transmitted as an electronic message, an email, a new record in a service technician database, a short-message service (SMS) message, a social media post, an automated telephone call, and similar. Intervention instructions may

include human-intelligible instructions to direct a service technician or other person to undertake a service or emergency intervention. Intervention instructions may also include automation instructions that perform a function at the intervening electronic device 120. In the example of a server that operates a helpdesk ticket system, intervention instructions may include an instruction that creates a new ticket and a human-intelligible instruction that describes the type of service needed (e.g., "replace user's device," "device dropped, backup HDD," *etc.*). In an example where the intervening electronic device 120 is a service technician's smartphone, an intervention instruction may be an SMS message that describes the location of the device 130 requiring intervention, type of intervention needed, contact information of a user of the device 130 requiring intervention, or similar.

[0035] In addition, the identity of a device 130 requiring intervention may accompany intervention instructions, so as to help ensure that the proper intervention is made. For example, tools, hardware, software, and parts to perform specific interventions may vary and may depend on the specific type of device, which can be determined from its identity. For example, if a notebook computer's display panel is to be replaced, then the specific replacement display panel can be identified based on the notebook computer's serial number or MAC address or other identifier that can be used to lookup its serial number. Moreover, if the intervention is to replace the device, then a suitable replacement device can be determined from the damaged device's identity.

[0036] In addition to alerting an intervening device 120, the impact monitoring instructions 112 may transmit via the computer network a message to the electronic device 130 requiring intervention. Such a message may inform the user of the electronic device 130 requiring intervention that an intervention has been requested or scheduled. A message may instruct the user to initiate technical service, particularly if they believe there is damage to the device, so that both the user and a service technician may actively seek to address the damage. This may increase the overall effectiveness of technical support. Moreover, this may also allow for a service department to prepare for an

intervention by, for example, ordering a part based on the identity of a device 130 requiring intervention, while allowing the specific time of the intervention to be controlled by the user of the device 130. For example, if a device's display panel is to be replaced due to an undue number of impacts, the display panel may still be useable for a time. As such, the intervening device 120 may be alerted about this repair so that a service organization may order the replacement display panel. At the same time, the user of the damaged device 130 may be notified that they should visit the service department within a certain time range to have the replacement display panel installed. In the meantime, the user may continue to use the damaged or likely damaged device 130.

[0037] As such, the computing device 100 may be useful to initiate interventions for user electronic devices 130, 132, 134 on the basis of impact events. Interventions may be made by way of information 118, which may include instructions, sent to devices 120 not involved in the impact, such as devices 120 operated by service technicians. In other examples, intervention information 118 is sent to emergency services personnel, and such information 118 may include instructions for emergency services personnel to check on the user.

[0038] In addition, the impact monitoring instructions 112 may execute a query on the collection of impact record data to obtain a common mode of failure for the user electronic devices 130, 132, 134. This may be done as part of the analysis of the impact event data for a given device 130. Failure modes may be common to subsets of electronic devices, where such subsets may be based on device type (*e.g.*, smartphone or notebook computer), configuration (*e.g.*, computer with wired peripherals or computer with wireless peripherals), manufacturer, model, and so on. For example, screen cracking may be common in smartphones and uncommon in notebook computers, while hinge damage may be common in notebook computers and virtually nonexistent in smartphones. As shown in FIG. 2, the table of interventions 208 may track failure mode in a failure mode column 224, so that common mode of failure for a number of devices may be obtained via a query or data analysis. Failure mode

may be determined by a service technician and examples include cracked screen, damaged hinge, cracked case, and so on.

[0039] Identifying a common mode of failure may be useful in generating an appropriate intervention instruction. For example, if a common mode of failure is display cracking, then an intervention instruction may indicate that a screen may likely need to be replaced or that a screen protector may need to be provided. This may allow a service technician to prepare for the likely intervention prior to inspecting the device in question, which may allow for faster fixes to common problems and less downtime for the affected user and device.

[0040] In addition, the impact monitoring instructions 112 may execute a query and/or perform an analysis on the collection of impact record data for other purposes related to impact events. Examples include modifying a rental/service fee of a group of devices or a single device, identifying weaknesses in a design, and identifying a hazardous location.

[0041] Impact events may increase the cost to a DaaS provider, in the form of replacement devices and repairs. As such, fees charged by a DaaS provider may be decreased based on a low number of impact events, a low frequency, or a low severity of impact events. With reference to FIG. 2, an analysis for adjustment of fees may compare impact events from the table of impact events 204 and/or interventions from the table of interventions 208 for a specific user or organization in the table of users 206 to impact events stored in the table of impact events 204 and/or interventions stored in the table of interventions 208 of related devices irrespective of user or organization. Example organizations include a company, an office, and a user group. In a similar example, a cost of a replacement device or repair may be borne by the DaaS provider if the impact events and/or interventions show that the device to be replaced or repaired was treated well.

[0042] Impact events may also be useful in understanding design weaknesses. For example, if multiple designs of device are used, then one may be identified as the weaker design if it required more interventions for the same

number of impact events. A design flaw may also exist if a device has more impact events or more severe impact events than comparable devices.

[0043] In addition, if location information is collected for impact events, then a hazardous location may be identified based on impact events that tend to occur at such location. For example, a location in a manufacturing facility may be frequented by users of electronic devices who carry out a task, such as controlling a machine, assembling parts, taking a measurement, or similar. A cluster of impact events at a specific location may indicate that the location contains a latent hazard.

[0044] FIG. 3 shows an example computing device 300 useable as any of the user electronic devices 130, 132, 134, discussed above.

[0045] The computing device 300 includes a main housing 302, a display housing 304, and a hinge 306 that connects the display housing 304 to the main housing 302. The hinge 306 allows the housings 302, 304 to be opened and closed. The computing device 300 may be termed a notebook or laptop computer.

[0046] The computing device 300 further includes a hinge sensor 308. The hinge sensor 308 is to output a signal 310 indicative of a position of the hinge 306. In this example, the hinge sensor 308 includes a three-axis accelerometer located at the display housing 304. The position of the hinge 306 may be computed based on a sensed acceleration. For example, detected acceleration may indicate movement of the display housing 304 with respect to the main housing 302, and a measured acceleration may be integrated to obtain a velocity or position. The hinge sensor 308 may be a virtual sensor based on a hardware accelerometer. In other examples, a hinge sensor 308 may include an inclinometer, a rotational potentiometer, a contact switch, a rotary encoder, or similar.

[0047] The computing device 300 further includes a processor 312, a non-transitory machine-readable medium 314 connected to the processor 312, and

a network interface 316 connected to the processor to communicate data with a computer network. Examples of processors, non-transitory machine-readable media, network interfaces, and computer networks are given above.

[0048] The computing device 300 may further include an input/output (I/O) circuit 318 that connects the hinge sensor 308 to the processor 312 to communicate the sensor signal 310 to the processor 312.

[0049] Impact determination instructions 320 may be stored in the non-transitory machine-readable medium 314 to be executed by the processor. The impact determination instructions 320 determine when an impact to the computing device 300 has occurred, such as by the computing device 300 being dropped, and may further determine a severity, orientation, or other characteristics of the impact.

[0050] The impact determination instructions 320 may be executed at a low level, such that impact events are detected and communicated when the computing device 300 is in a hibernation state, sleep state, standby state, or other low-power state, in addition to a regular working state. As such, the instructions 320 may be executed by a processor 312 that is operable during the desired states, such as embedded controller.

[0051] The impact determination instructions 320 capture the signal 310 outputted by the hinge sensor 308. The impact determination instructions 320 may capture the signal 310 in real time or near real time.

[0052] The impact determination instructions 320 may apply the signal 310 outputted by the hinge sensor 308 to a trained machine-learning model 322 to determine that the impact has occurred. As discussed above, the hinge sensor 308 may include an accelerometer that may provide information sufficient to detect an impact. A machine-learning model, such as a neural network, may be trained to detect impacts based on sensor input. The trained machine-learning model 322 may be provided to the computing device 300, such as at the

medium 314, to take the sensor signal 310 as input and output an indication, classification, or confidence level of an impact event having occurred.

[0053] In other examples, the impact determination instructions 320 determine that an impact has occurred at the computing device 300 based on the captured signal 310. The instructions 320 may process a raw signal 310 to obtain a processed signal that may be evaluated with a mathematical model. When an accelerometer is used, an example mathematical model may determine magnitude of acceleration, a , as:

$$[0054] \quad a = \sqrt{a_x^2 + a_y^2 + a_z^2}$$

[0055] where a_x , a_y , a_z are three-axis component acceleration values. The model may consider an acceleration, a , of zero or close to zero to indicate freefall. The model may detect an impact by detection of freefall followed by a high acceleration that indicates collision with the floor or other body.

[0056] In response to determining that the impact has occurred, the impact determination instructions 320 transmit data 114 to a remote computing device, such as the computing device 100 discussed above. The data 144 may include an indication that an impact has occurred, as well as additional data concerning the state or configuration of the computing device 300 during the impact. In this example, the data 114 includes an indication of an angular position of the hinge 306 based on the hinge sensor signal 310. The data 114 may further include an orientation of the computing device 300 as may be measured by the hinge sensor 308 or another sensor. As discussed above, the hinge sensor 308 may include an accelerometer that enables a virtual hinge sensor while also providing acceleration measurements that may indicate the orientation of the computing device 300 in three-dimensional space, in addition to detecting impacts. Speed of impact and distance traveled to impact (*i.e.*, height of drop) may also be obtained from an accelerometer used as the hinge sensor 308.

[0057] A hinge position indication may include an angle, a Boolean value (*e.g.*, true = open, false = closed), or similar. Hinge position may provide

information as to the severity of an impact. For example, an open notebook computer may suffer greater damage than a closed notebook computer dropped from the same height.

[0058] In addition to detecting impact events, the machine-learning model 322 may be trained to further determine impact severity.

[0059] The computing device 300 may include an additional sensor 324 that may be connected to the processor 312 via the I/O circuit 318. The sensor 324 may include an accelerometer, gyroscope sensor, location subsystem, or similar. The additional sensor 324 may be used in conjunction with the hinge sensor 308 to determine hinge position. For example, the additional sensor 324 may be provided at the main body 302 and provide a reference for a virtual hinge sensor enabled by the sensor 308.

[0060] The impact determination instructions 320 may use a signal 326 outputted by the sensor 324 to determine an impact at the computing device 300. The signal 326 may also be used to provide data 114, such as orientation of the computing device 300 during impact, speed of impact, and distance traveled to impact. Any suitable number and type of additional sensors 324 may be used, with examples of different types of sensors given above.

[0061] FIG. 4 shows an example method 400 of monitoring impact events experienced by user electronic devices. The method 400 may be implemented by a computing device, such as a server computing device 100 discussed above. The method 400 may be implemented with processor executed instructions.

[0062] At block 402, new data is received from a user electronic device. The new data is indicative of a new impact event experienced by the user electronic device. The new data may contain information as to the severity and other characteristics of the impact. For example, if the electronic device is a notebook computer, the new data may indicate whether or not the notebook computer is

closed or open and to what degree. Notebook computer hinge position may be indicative of impact severity.

[0063] At block 404, the new data is added to impact record data that includes any past impact events experienced by the user electronic devices. The information pertaining to the impact may be stored indefinitely.

[0064] At block 406, the impact record data is analyzed to determine if an intervention for the user electronic device is to be initiated. Analysis may be triggered by block 402, that is, receiving new impact event data may cause the analysis to be performed. In other examples, analysis is performed asynchronously at time intervals, irrespective of when impact events are received. The analysis may consider the number and severity (or other characteristic) of the new impact event in addition to past impact events. The analysis may also use impact event data for similar or identical electronic devices as context, such as, the number and severity (or other characteristic) of impact events before a failure occurred or for which past interventions were made. The analysis may be directed to preempting a future possible request for technical service.

[0065] If an intervention is to be initiated, at block 408, then an intervention instruction is, at block 410, communicated to an intervening electronic device that is different from the user electronic device that suffered the impact. A user with access to the intervening device may then carry out the intervention by, for example, scheduling or undertaking maintenance or replacement of the device. Alternatively, an intervention instruction may be directed to emergency services to check on the wellness of the user of the device as the impact may be due to a medical condition, fall, or other health-related incident.

[0066] FIG. 5 shows an example method 500 of detecting impact events at a user electronic device. The method 500 may be implemented by a computing device, such as a user computing device 300 discussed above. The method 500 may be implemented with processor executed instructions.

[0067] At block 502, a signal outputted by a hinge sensor is captured by a user electronic device. The electronic device may be a notebook computer or similar device with a moveable part and the sensor may be the hinge sensor.

[0068] At block 504, the captured sensor signal is processed to determine whether an impact has occurred at the user electronic device. The sensor signal may be provided to a trained machine-learning model to determine whether an impact has occurred. Other signals from other sensors may be provided to the trained machine-learning model to contribute to the determination of impact. In other examples, the sensor signal may be provided to a mathematical model. Block 504 may also determine a severity or other characteristic of the impact as indicated by the sensor signal.

[0069] In response to determining that an impact has occurred, at block 506, data indicative of the position of the hinge is transmitted, at block 508, via a computer network to a remote computing device that may collect impact data and determine whether an intervention is to be made.

[0070] In view of the above, it should be apparent that an impact event at an electronic device may trigger an intervention via another electronic device. This may increase the reliability and efficiency of interventions. Further, a hinge sensor may be used to determine an impact event or severity of such, which may increase the accuracy of determining to the type and timing of interventions.

[0071] It should be recognized that features and aspects of the various examples provided above can be combined into further examples that also fall within the scope of the present disclosure. In addition, the figures are not to scale and may have size and shape exaggerated for illustrative purposes.

CLAIMS

1. A computing device comprising:

a network interface; and

a processor connected to the network interface, the processor to:

receive new data from a user electronic device via the network interface, the new data indicative of a new impact event experienced by the user electronic device;

add the new data to impact record data that includes any past impact events experienced by the user electronic device;

analyze the impact record data to determine if an intervention for the user electronic device is to be initiated; and

if an intervention is to be initiated, transmit via the network interface an intervention instruction to an intervening electronic device that is different from the user electronic device.

2. The computing device of claim 1, wherein the processor is to analyze the impact record data with reference to a collection of impact record data of a plurality of user electronic devices to determine that the intervention is to be initiated to preempt a future service request for the user electronic device.

3. The computing device of claim 1, wherein:

the intervening electronic device is a service technician electronic device;
and

the intervention instruction is an instruction to perform service on the user electronic device.

4. The computing device of claim 1, wherein:

the intervening electronic device is an emergency services electronic device; and

the intervention instruction is an instruction to assess a wellness of a user of the user electronic device.

5. The computing device of claim 1, wherein the processor is to analyze the impact record data to determine if the intervention for the user electronic device is to be initiated in response to receiving the new data.

6. The computing device of claim 1, wherein the processor is further to execute a query on a collection of impact record data of a plurality of user electronic devices to obtain a common mode of failure of the plurality of user electronic devices.

7. A non-transitory machine-readable medium including instructions, when executed, cause a processor of a computing device to:

maintain a collection of impact record data for a plurality of user electronic devices;

add to the collection new data received from a user electronic device of the plurality of user electronic devices via a computer network, the new data indicative of a new impact event experienced by the user electronic device;

analyze the collection of impact record data to identify from the plurality of user electronic devices a damaged electronic device to receive technical service; and

transmit via the computer network an identity of the damaged electronic device to a service technician electronic device.

8. The non-transitory machine-readable medium of claim 7, wherein the instructions are further to modify a rental fee of the damaged electronic device.

9. The non-transitory machine-readable medium of claim 7, wherein the instructions are further to analyze the collection of impact record data to identify a weakness of a design of the plurality of user electronic devices.

10. The non-transitory machine-readable medium of claim 7, wherein the instructions are further to analyze the collection of impact record data to identify a hazardous location.

11. The non-transitory machine-readable medium of claim 7, wherein the instructions are further to transmit via the computer network a message to the damaged electronic device to instruct a user of the damaged electronic device to initiate the technical service.

12. A computing device comprising:

a main housing;

a display housing;

a hinge connecting the display housing to the main housing;

a hinge sensor to output a signal indicative of a position of the hinge;

a network interface; and

a processor connected to the hinge sensor and the network interface, the processor to:

capture the signal outputted by the hinge sensor;

determine that an impact has occurred at the computing device based on the signal outputted by the hinge sensor; and

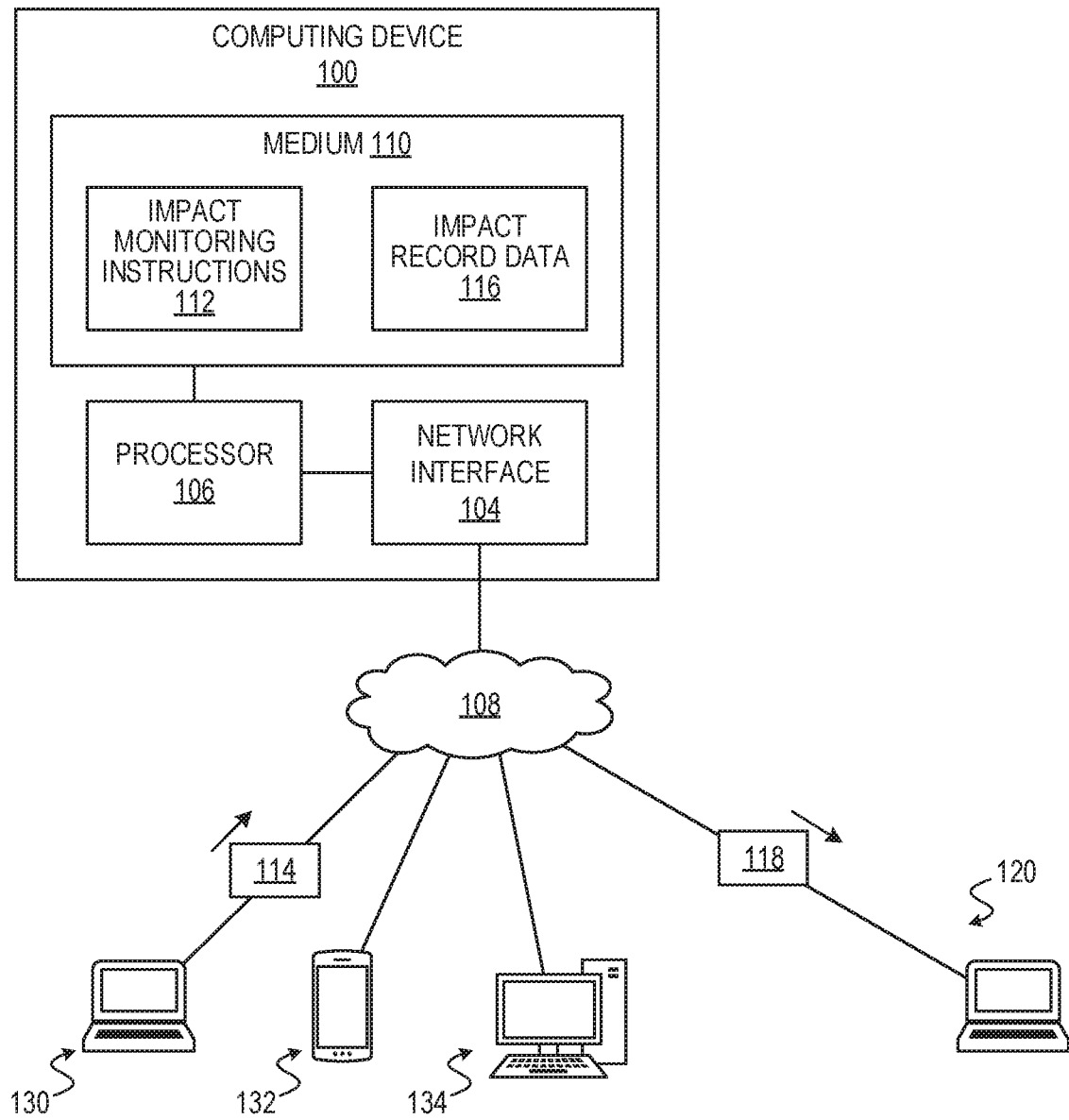
in response to determining that the impact has occurred, transmit, via the network interface, data indicative of the position of the hinge to a remote computing device.

13. The computing device of claim 12, wherein the processor is further to apply the signal outputted by the hinge sensor to a trained machine-learning model to determine that the impact has occurred.

14. The computing device of claim 12, wherein the hinge sensor comprises an accelerometer.

15. The computing device of claim 12, further comprising an additional sensor, wherein the processor is to determine that the impact has occurred based an additional signal outputted by the additional sensor.

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**FIG. 1**

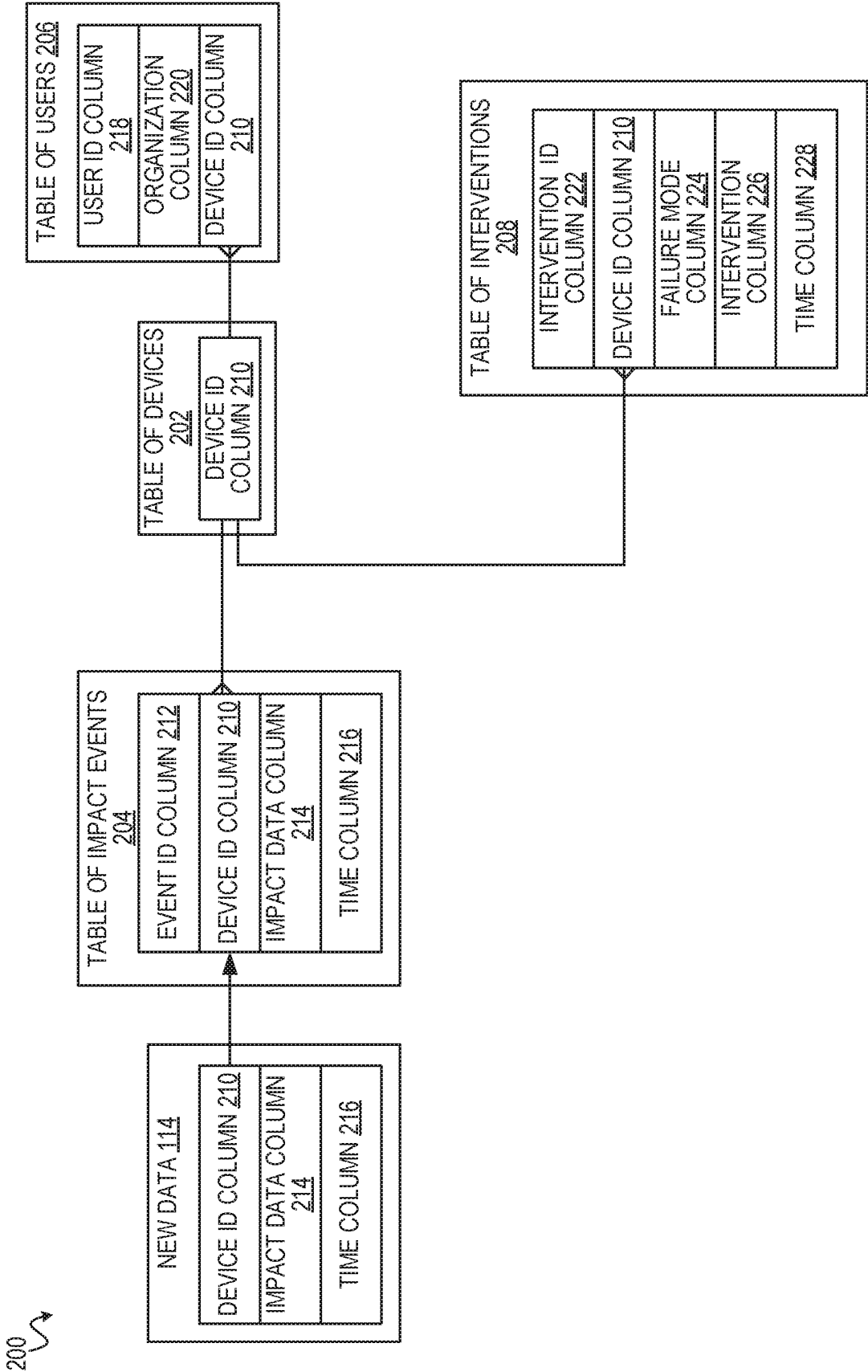


FIG. 2

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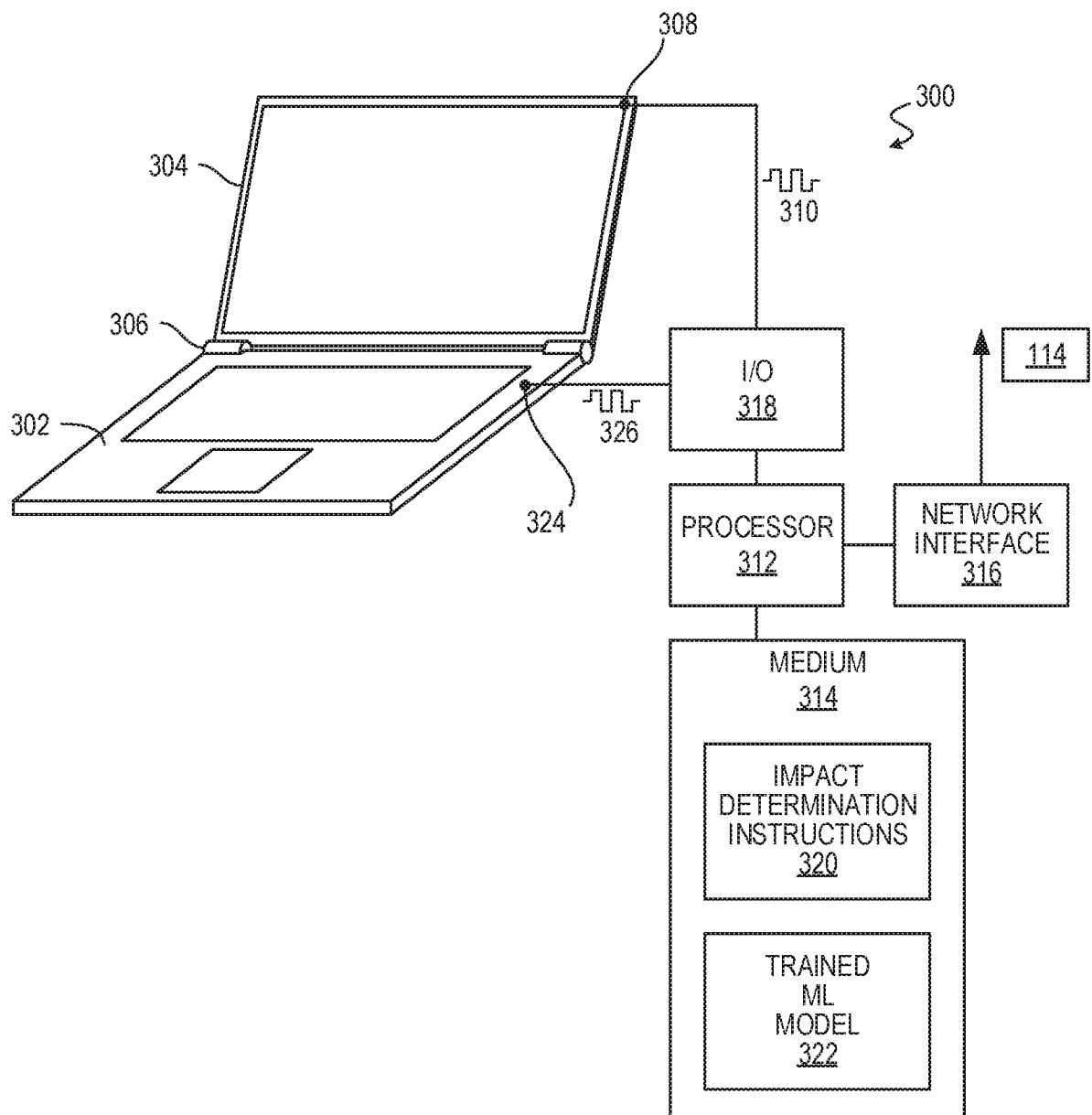


FIG. 3

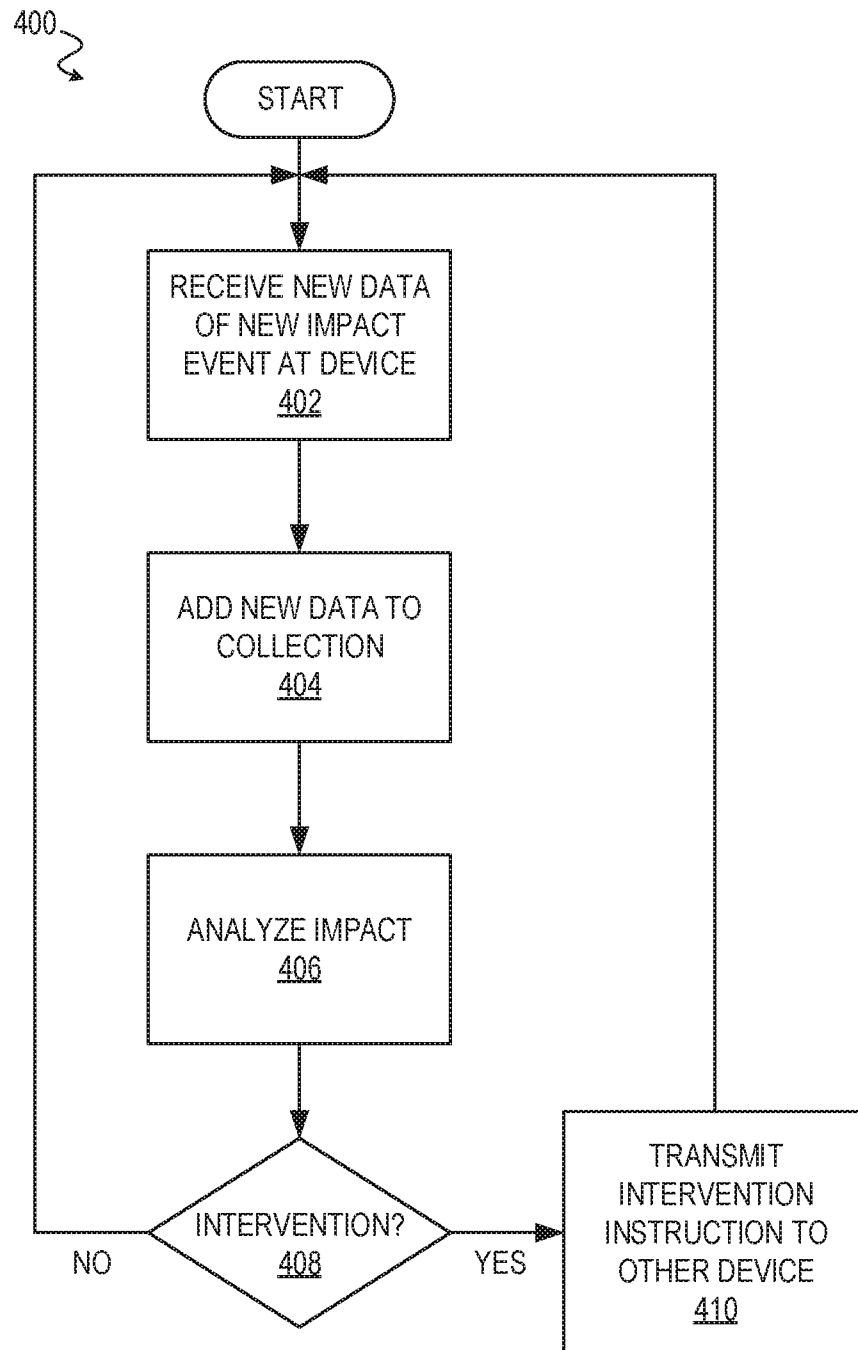


FIG. 4

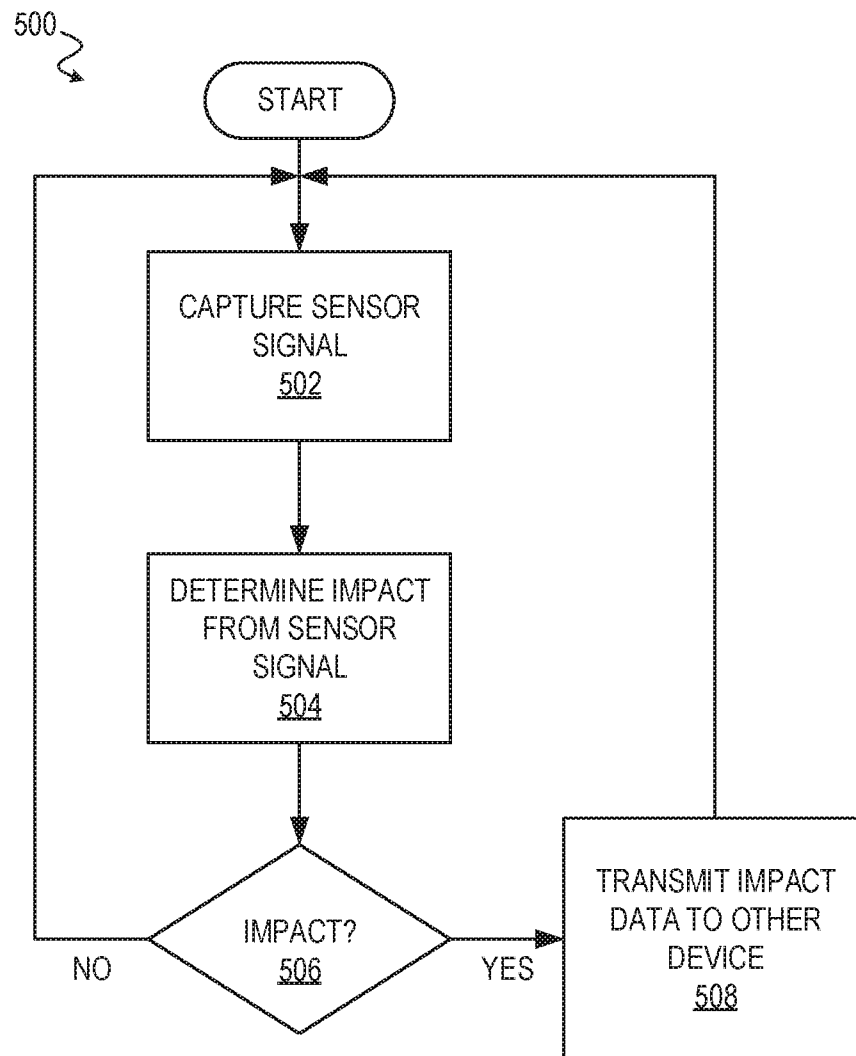


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2020/047199

A. CLASSIFICATION OF SUBJECT MATTER		
G06F 13/00 (2006.01) G16Y 40/50 (2020.01) 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)		
G06F 13/00, G16Y 40/50		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
EAPATIS, ESPACENET, PatSearch (RUPTO internal), USPTO, PATENTSCOPE, Google		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2020/0205733 A1 (I1 SENSORTTECH, INC.) 02.07.2020, abstract, paragraphs [0030], [0037], [0042], [0049], [0050], [0055], [0106], [0115], [0116], [0120], [0141], [0144], [0167], [0170], [0184], [0187], [0189]	1-3, 5-7
Y		4, 11
A		8-10, 12-15
Y	US 2007/0271686 A1 (RODGER H. RAST) 29.11.2007, abstract, paragraph [0016], claim 10	4, 11
A	US 2017/0071538 A1 (I1 SENSORTTECH, INC.) 16.03.2017	1-15
A	US 9451795 B2 (WESLEY W. O. KRUEGER) 27.09.2016	1-15
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents:	“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	
“A” document defining the general state of the art which is not considered to be of particular relevance	“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	
“D” document cited by the applicant in the international application	“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	
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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		
Date of the actual completion of the international search	Date of mailing of the international search report	
27 April 2021 (27.04.2021)	13 May 2021 (13.05.2021)	
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37	Authorized officer V. Zakharov Telephone No. +7 (495) 531-64-81	