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The Director

of the United States Patent and Trademark Office has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

Therefore, this United States

Patent

grants to the person(s) having title to this patent the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States of America or importing the invention into the United States of America, and if the invention is a process, of the right to exclude others from using, offering for sale or selling throughout the United States of America, products made by that process, for the term set forth in 35 U.S.C. 154(a)(2) or (c)(1), subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b). See the Maintenance Fee Notice on the inside of the cover.

Katherine Kelly Vidal

Director of the United States Patent and Trademark Office

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If the application for this patent was filed on or after December 12, 1980, maintenance fees are due three years and six months, seven years and six months, and eleven years and six months after the date of this grant, or within a grace period of six months thereafter upon payment of a surcharge as provided by law. The amount, number and timing of the maintenance fees required may be changed by law or regulation. Unless payment of the applicable maintenance fee is received in the United States Patent and Trademark Office on or before the date the fee is due or within a grace period of six months thereafter, the patent will expire as of the end of such grace period.

Patent Term Notice

If the application for this patent was filed on or after June 8, 1995, the term of this patent begins on the date on which this patent issues and ends twenty years from the filing date of the application or, if the application contains a specific reference to an earlier filed application or applications under 35 U.S.C. 120, 121, 365(c), or 386(c), twenty years from the filing date of the earliest such application ("the twenty-year term"), subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b), and any extension as provided by 35 U.S.C. 154(b) or 156 or any disclaimer under 35 U.S.C. 253.

If this application was filed prior to June 8, 1995, the term of this patent begins on the date on which this patent issues and ends on the later of seventeen years from the date of the grant of this patent or the twenty-year term set forth above for patents resulting from applications filed on or after June 8, 1995, subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b) and any extension as provided by 35 U.S.C. 156 or any disclaimer under 35 U.S.C. 253.

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(12) **United States Patent**
Hui et al.

(10) **Patent No.: US 11,768,522 B2**
(45) **Date of Patent: Sep. 26, 2023**

(54) **METHOD AND SYSTEM FOR DETECTING THE PRESENCE OR ABSENCE OF A PROTECTIVE CASE ON AN ELECTRONIC DEVICE**

(71) Applicant: **World Wide Warranty Life Services Inc.**, Port Moody (CA)

(72) Inventors: **Richard Hui**, Port Moody (CA); **Anthony Daws**, Vancouver (CA); **Ebrahim Bagheri**, Toronto (CA); **Fattane Zarrinkalam**, Toronto (CA); **Hossein Fani**, Toronto (CA); **Samad Paydar**, Toronto (CA)

(73) Assignee: **World Wide Warranty Life Services Inc.**, Port Moody (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/769,895**

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(86) PCT No.: **PCT/CA2020/051401**
§ 371 (c)(1),
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PCT Pub. Date: **Apr. 22, 2021**

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(51) **Int. Cl.**
G06F 1/16 (2006.01)
G06F 3/16 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 1/1656*** (2013.01); ***G06F 1/1694*** (2013.01); ***G06F 3/167*** (2013.01); *G06F 2200/1633* (2013.01)

(58) **Field of Classification Search**
CPC G06F 1/1656; G06F 1/1684; G06F 1/1694; G06F 2200/1633
See application file for complete search history.

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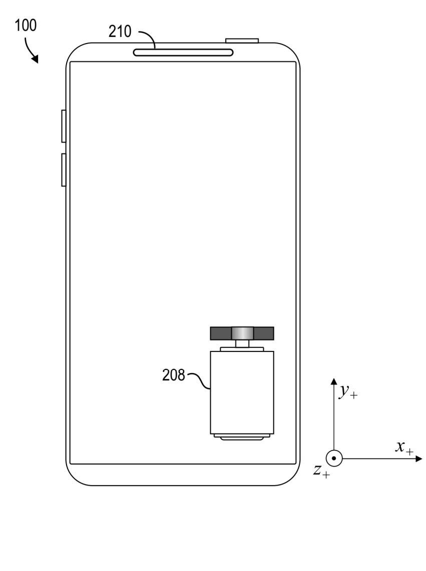
Primary Examiner — Adrian S Wilson
(74) *Attorney, Agent, or Firm* — BERESKIN & PARR LLP/S.E.N.C.R.L. s.r.l; Tonino Rosario Orsi

(57) **ABSTRACT**

Various embodiments for the automatic detection of the presence of a protective case on an electronic device are provided herein. Generally, the electronic device includes one or more sensors; a device memory storing an application; a device processor, which upon execution of the application, is configured to: monitor, via at least one first sensor, a trigger condition for detecting the presence of the protective case; detect the trigger condition; in response to detecting the trigger condition, cause the electronic device to

(Continued)



vibrate for a pre-determined period of time; collect, via at least one second sensor, sensor data during the pre-determined time; extract at least one feature from the sensor data; based on the extracted at least one feature, determine whether the protective case is applied to the electronic device; and generate an output indicating whether the protective case is applied to the electronic device.

20 Claims, 19 Drawing Sheets

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2009/0031803 A1	2/2009	Noda et al.	
2009/0316327 A1	12/2009	Mcnulty, Jr.	
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2014/0200054 A1	7/2014	Fraden	
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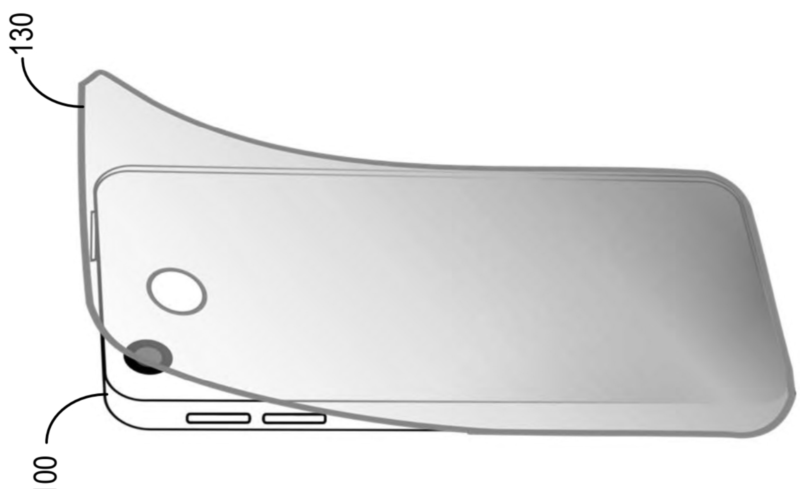


FIG. 1

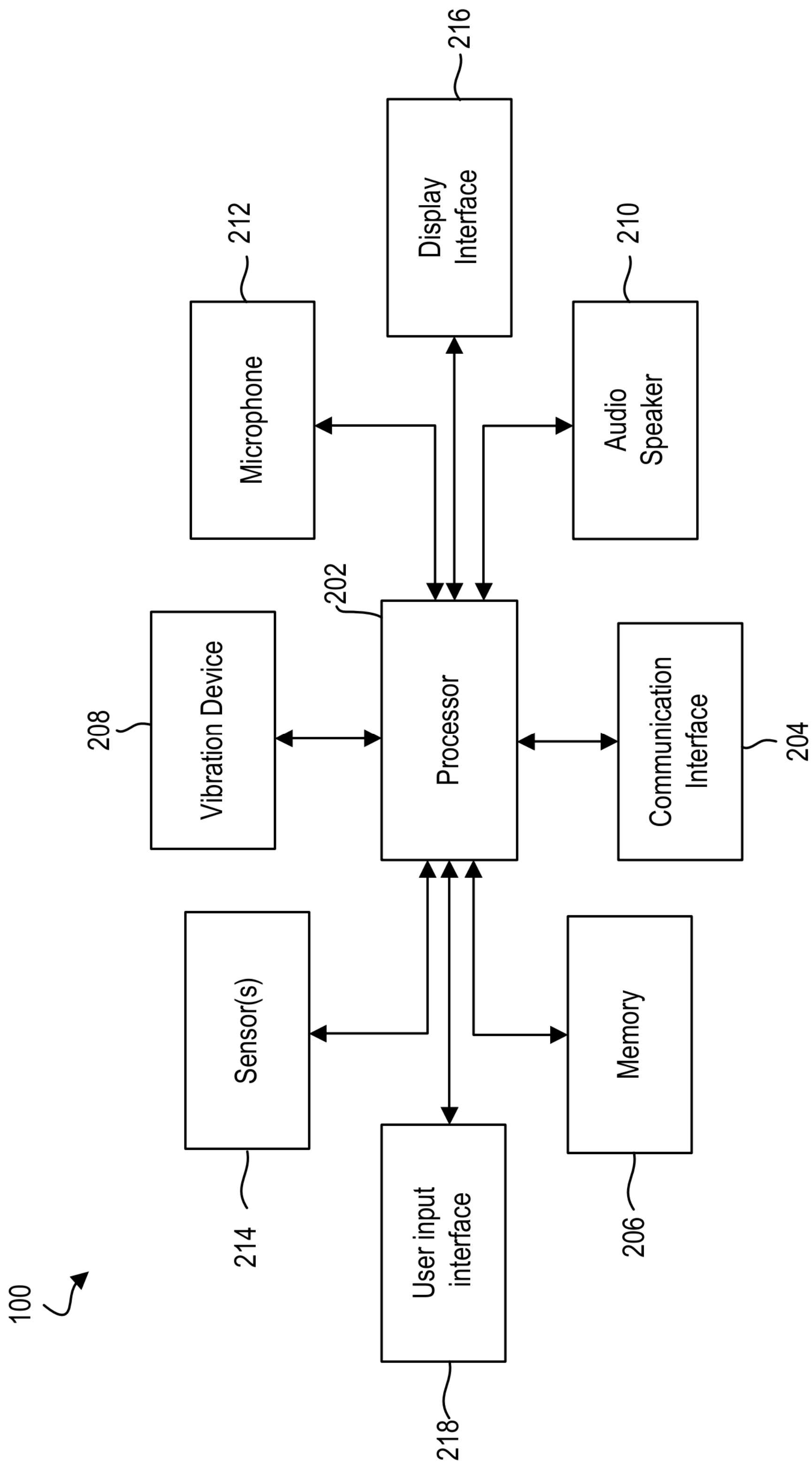

216
Display Interface
212
Microphone
210
Audio Speaker
202
Processor
208
Vibration Device
204
Communication Interface
Sensor(s)
214
Memory
206
User input interface
218
100

FIG. 2

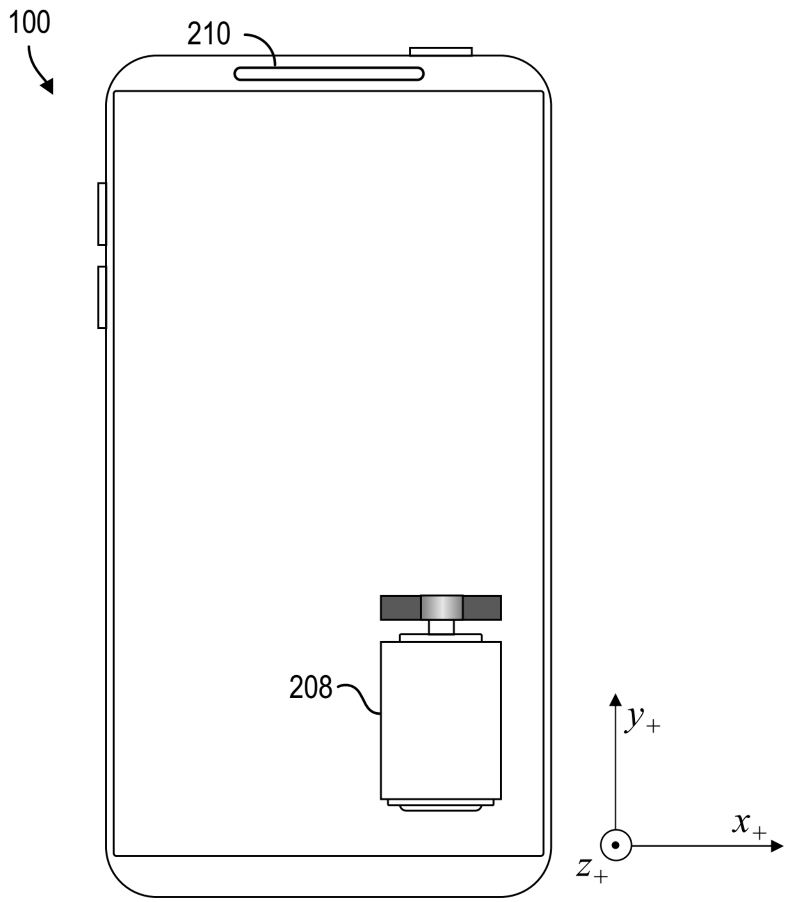


FIG. 3A

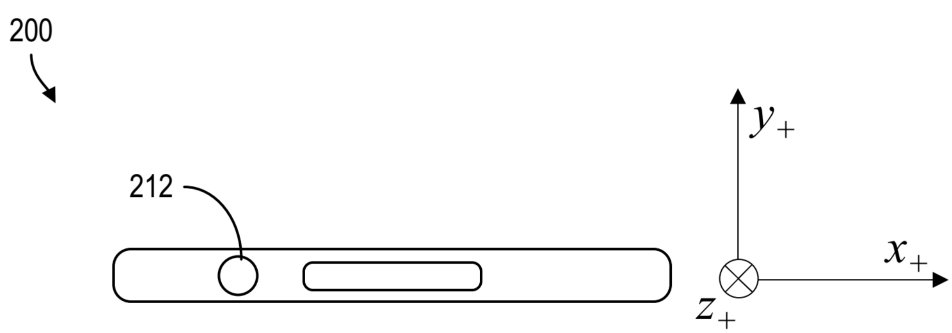


FIG. 3B

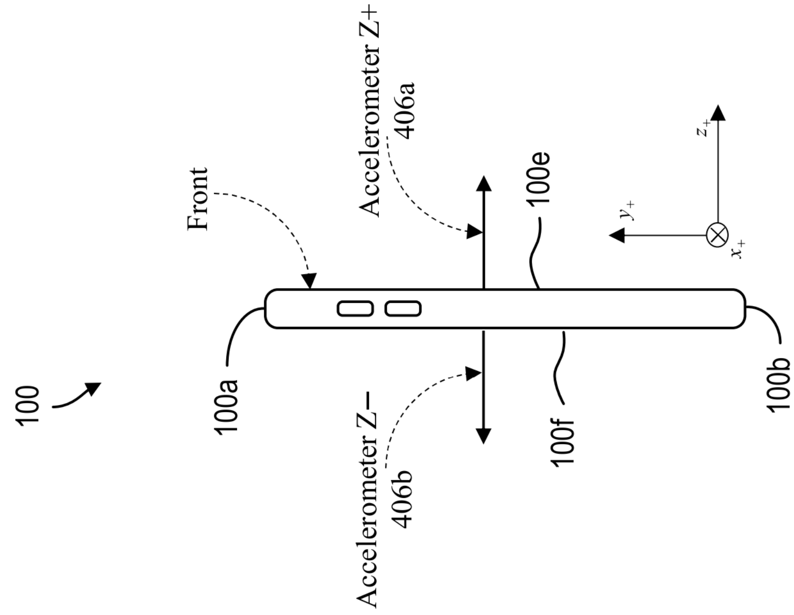

100
Front
Accelerometer Z+
406a
100e
100a
Accelerometer Z−
406b
100f
100b
z_+
y_+
x_+

FIG. 4B

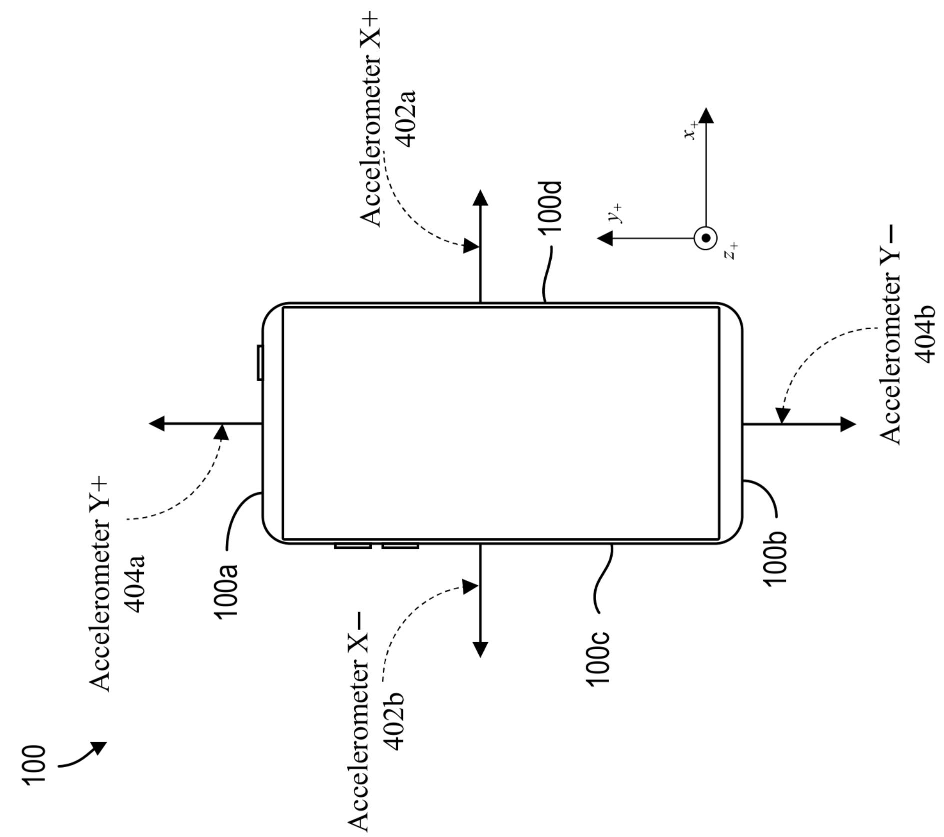

100
Accelerometer Y+
404a
100a
Accelerometer X−
402b
100c
Accelerometer X+
402a
100d
x_+
y_+
z_+
Accelerometer Y−
404b
100b

FIG. 4A

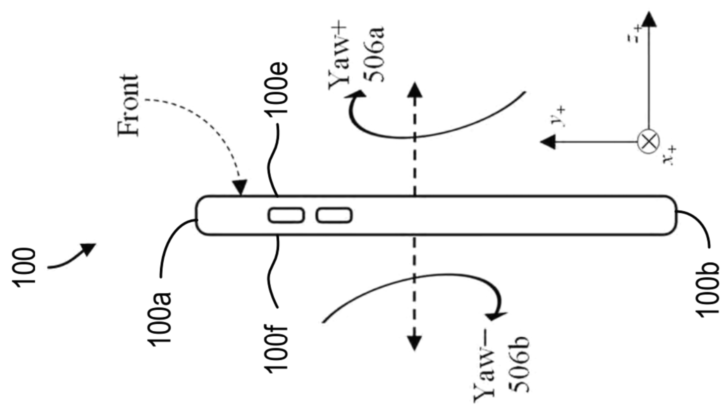

100
Front
100e
100a
100f
Yaw+
506a
Yaw−
506b
100b
y_+
z_+
x_+

FIG. 5B

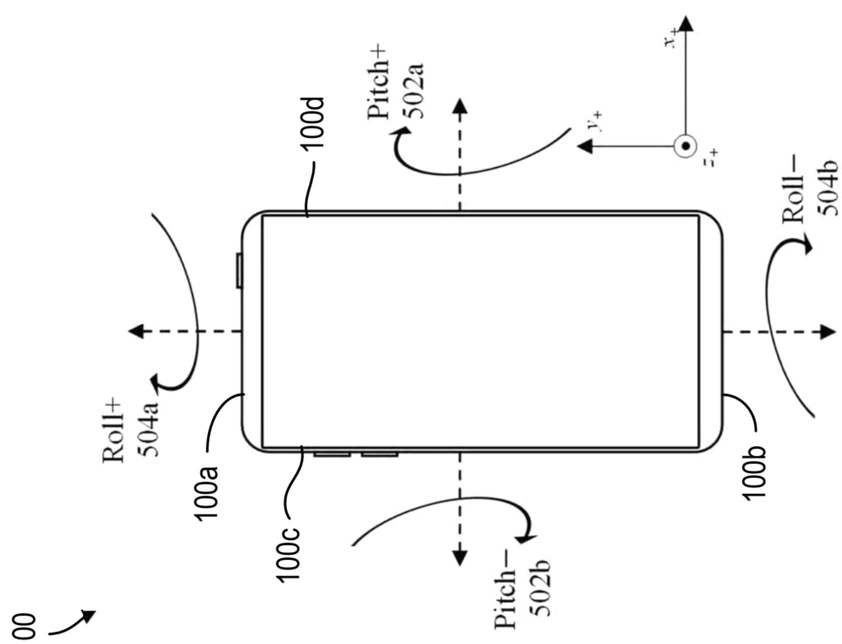

100
100d
Pitch+
502a
Roll+
504a
100a
100c
Pitch−
502b
Roll−
504b
100b
y_+
x_+
z_+

FIG. 5A

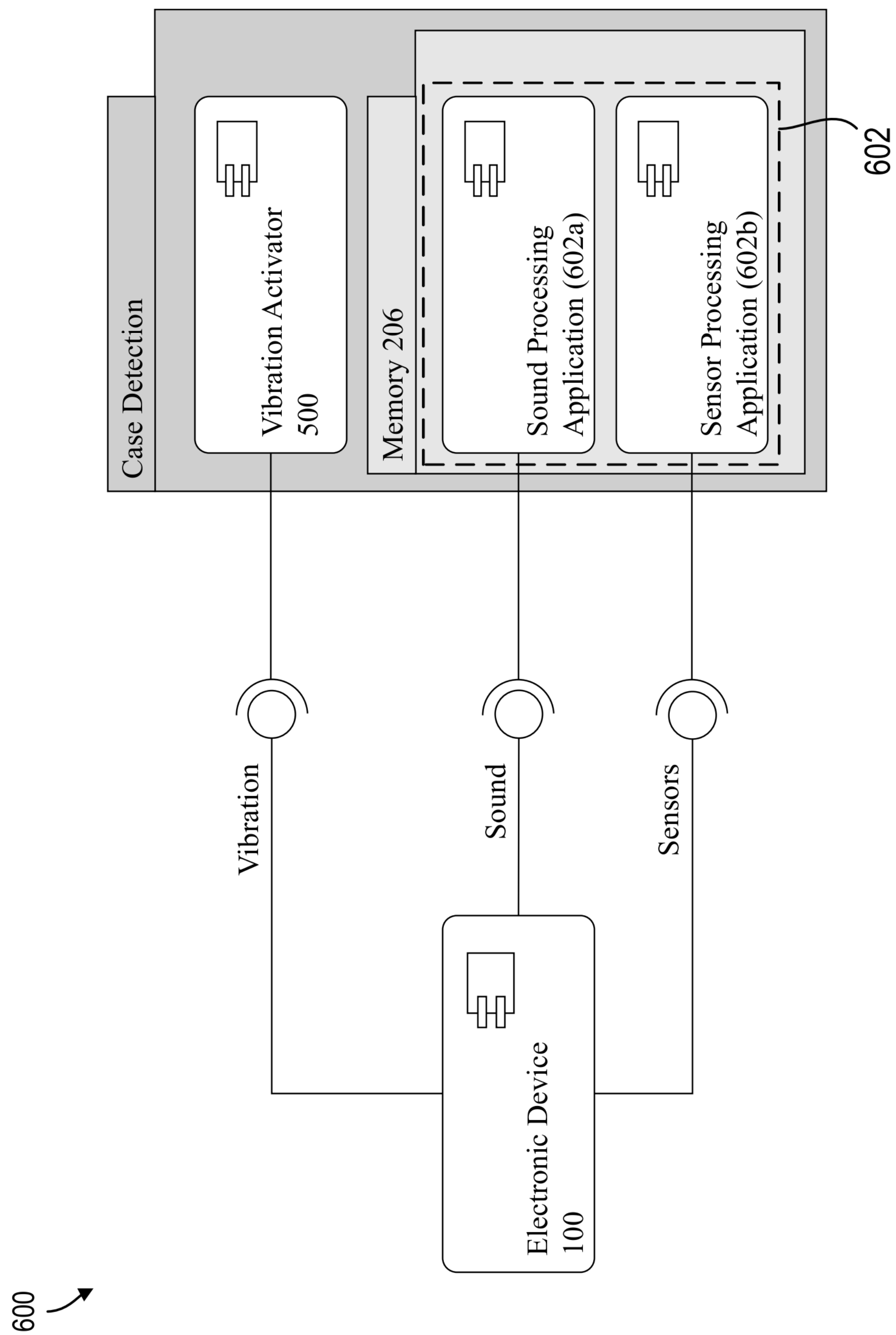

Case Detection
Vibration Activator
500
Memory 206
Sound Processing
Application (602a)
Sensor Processing
Application (602b)
602
Vibration
Sound
Sensors
Electronic Device
100
600

FIG. 6

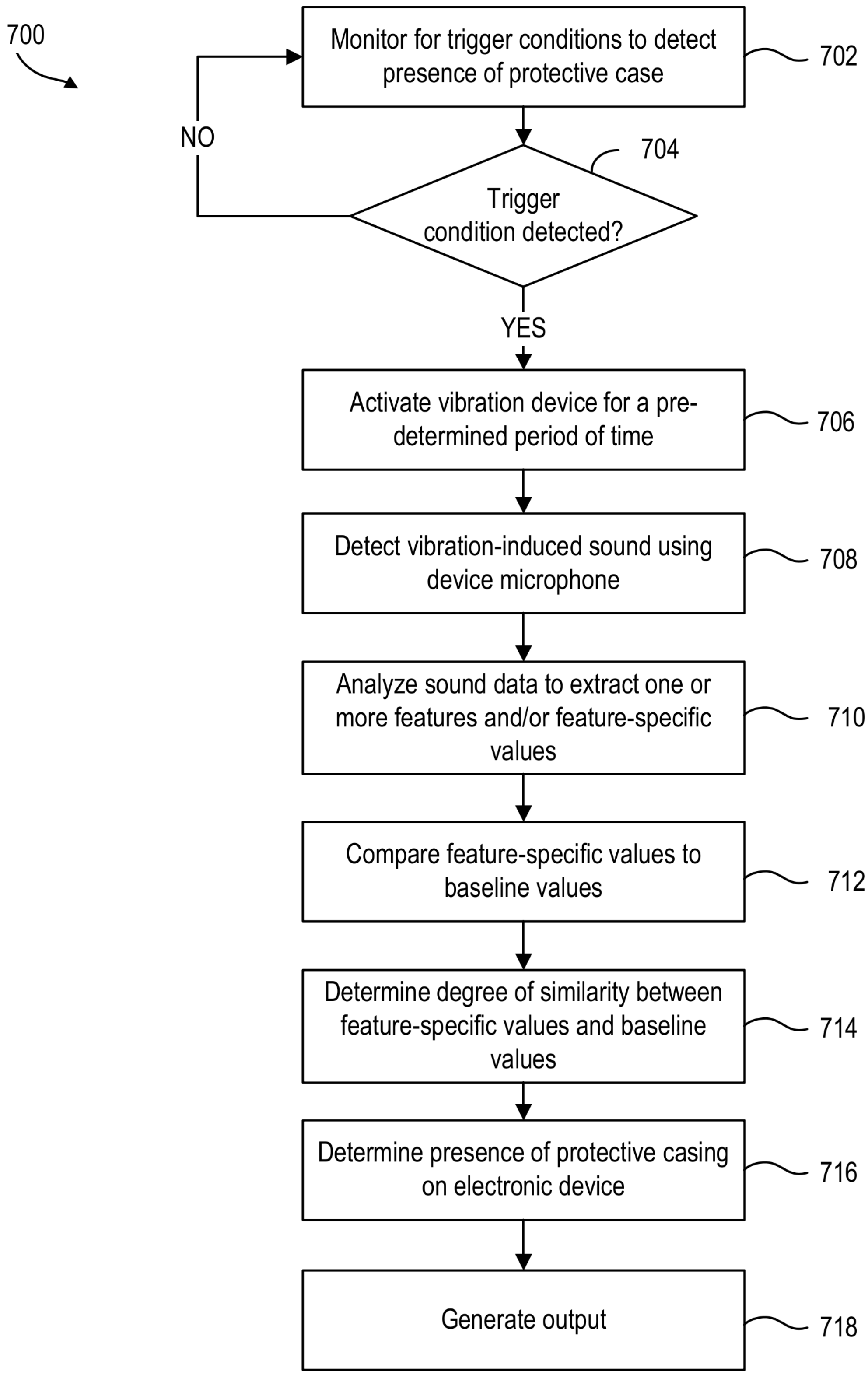
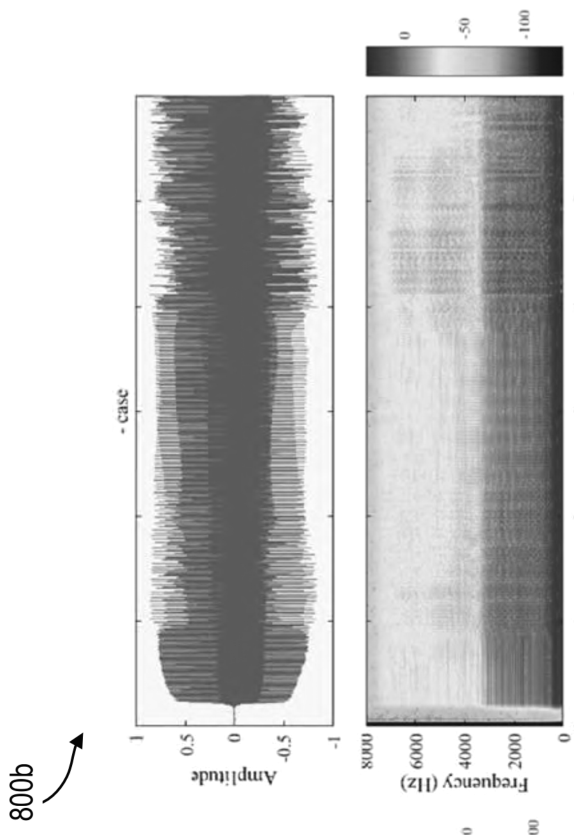
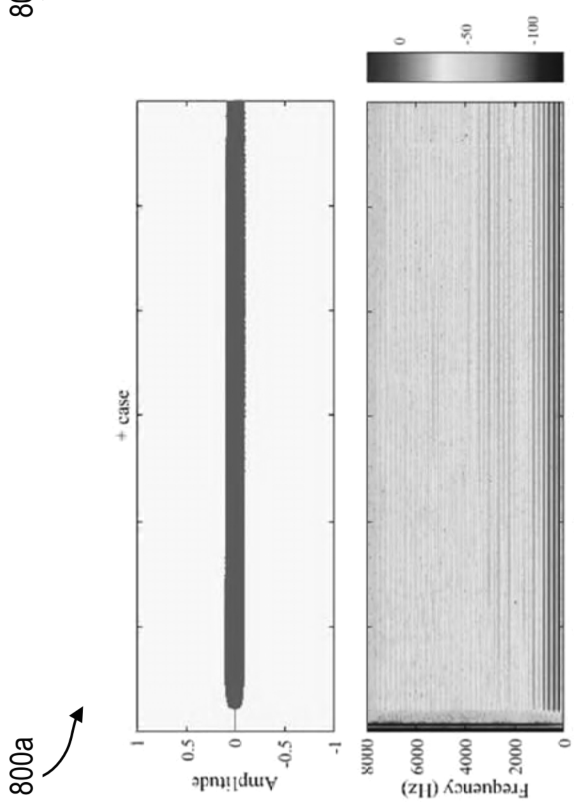

700
Monitor for trigger conditions to detect presence of protective case
702
NO
704
Trigger condition detected?
YES
Activate vibration device for a pre-determined period of time
706
Detect vibration-induced sound using device microphone
708
Analyze sound data to extract one or more features and/or feature-specific values
710
Compare feature-specific values to baseline values
712
Determine degree of similarity between feature-specific values and baseline values
714
Determine presence of protective casing on electronic device
716
Generate output
718

FIG. 7



800b
- case
Amplitude
Frequency (Hz)
Time (s)
802b

FIG. 8B



800a
+ case
Amplitude
Frequency (Hz)
Time (s)
802a

FIG. 8A

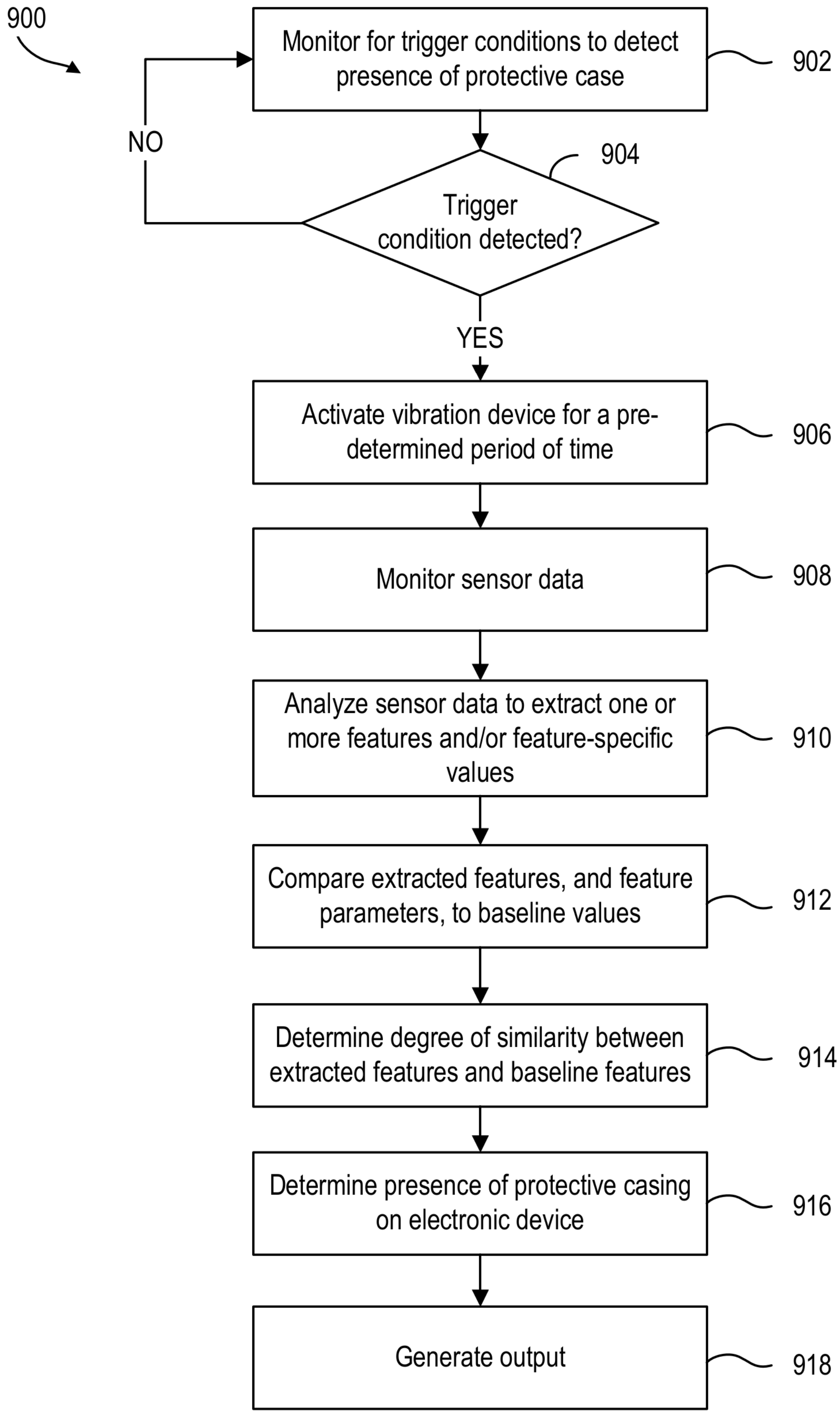

900
Monitor for trigger conditions to detect presence of protective case
902
NO
904
Trigger condition detected?
YES
Activate vibration device for a pre-determined period of time
906
Monitor sensor data
908
Analyze sensor data to extract one or more features and/or feature-specific values
910
Compare extracted features, and feature parameters, to baseline values
912
Determine degree of similarity between extracted features and baseline features
914
Determine presence of protective casing on electronic device
916
Generate output
918

FIG. 9

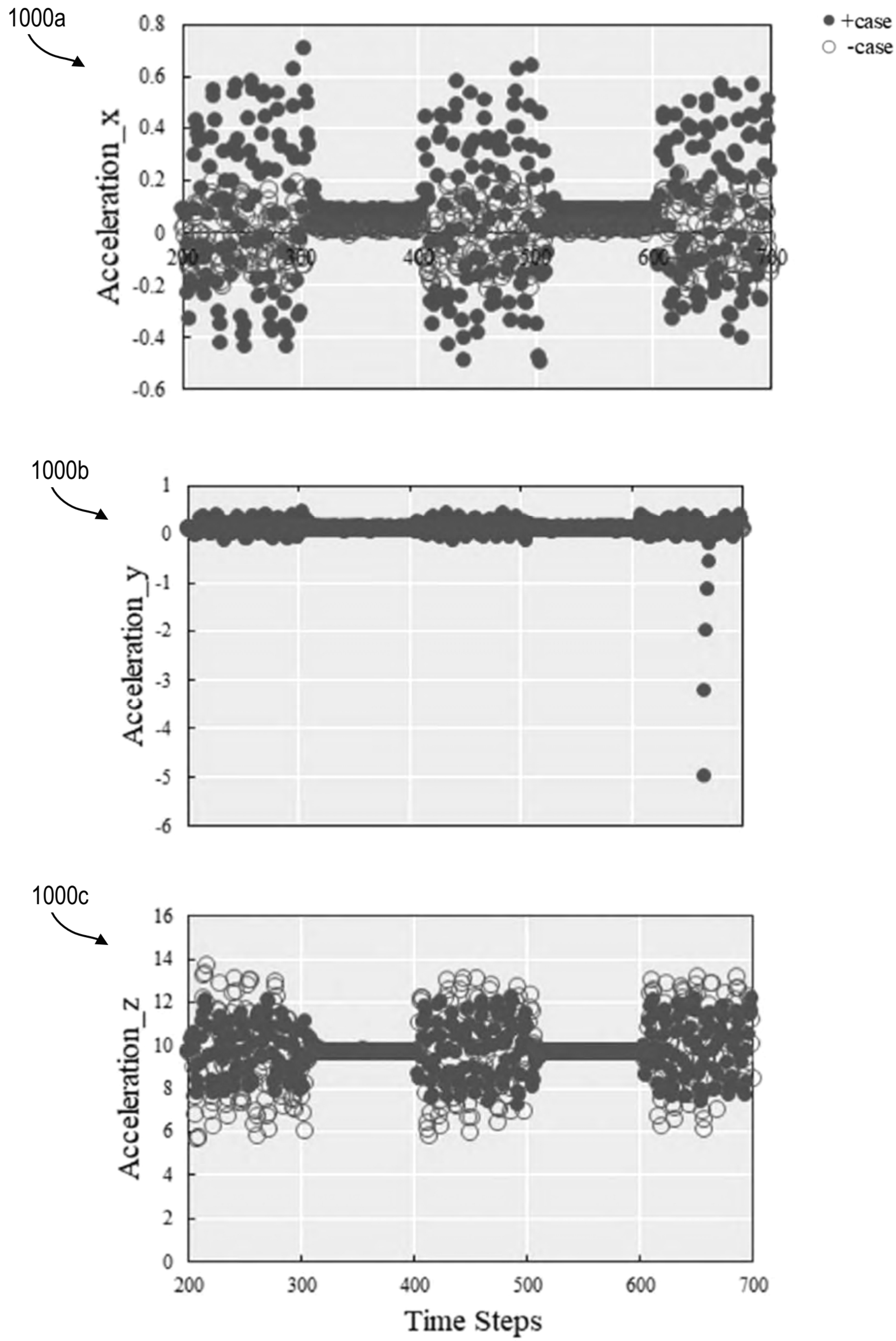

1000a
+case
-case
Acceleration_x
1000b
Acceleration_y
1000c
Acceleration_z
Time Steps

FIG. 10

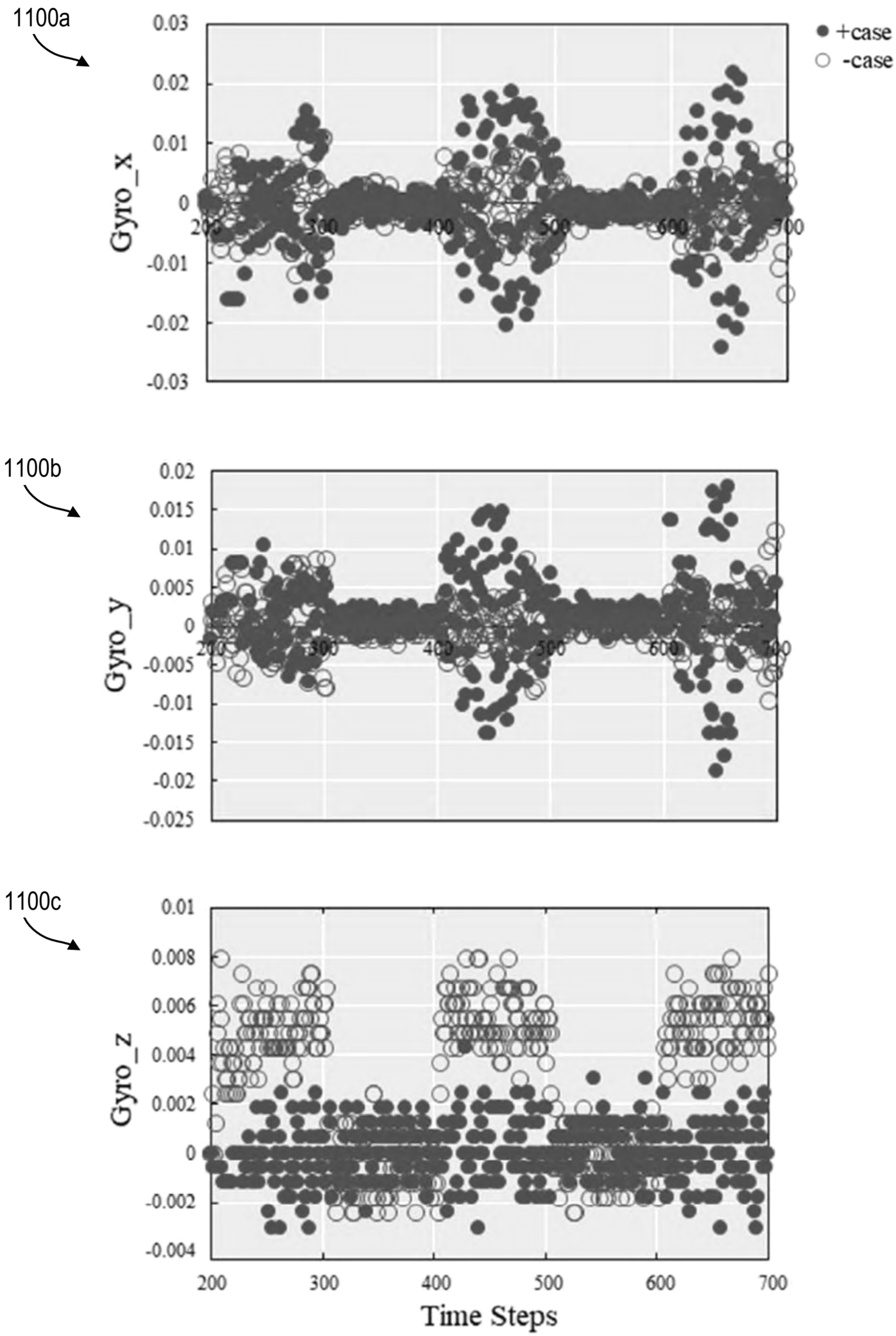

1100a
+case
-case
Gyro_x
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
200
300
400
500
600
700
1100b
Gyro_y
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
1100c
Gyro_z
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.004
Time Steps

FIG. 11

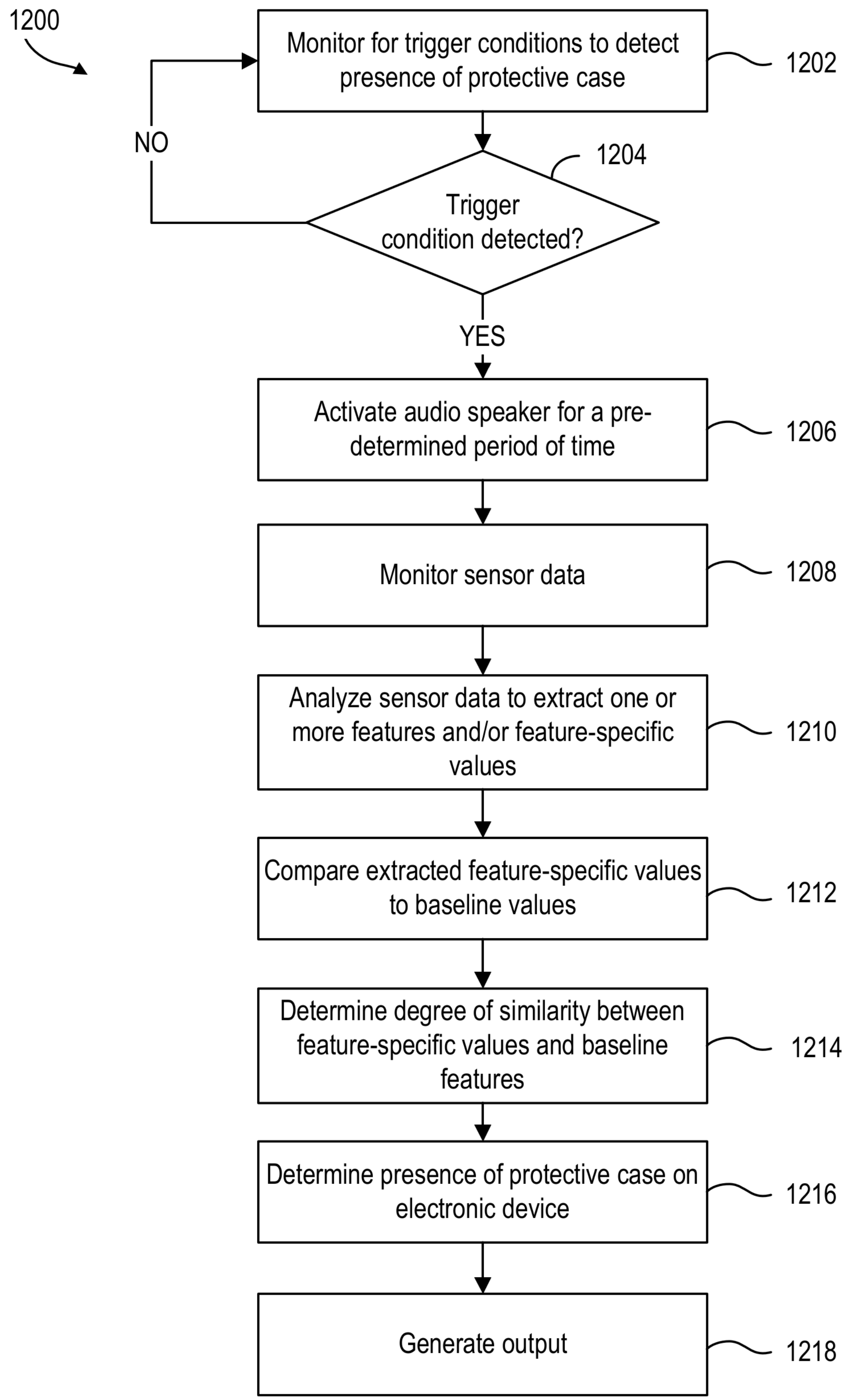

1200
Monitor for trigger conditions to detect presence of protective case
1202
Trigger condition detected?
1204
NO
YES
Activate audio speaker for a pre-determined period of time
1206
Monitor sensor data
1208
Analyze sensor data to extract one or more features and/or feature-specific values
1210
Compare extracted feature-specific values to baseline values
1212
Determine degree of similarity between feature-specific values and baseline features
1214
Determine presence of protective case on electronic device
1216
Generate output
1218

FIG. 12

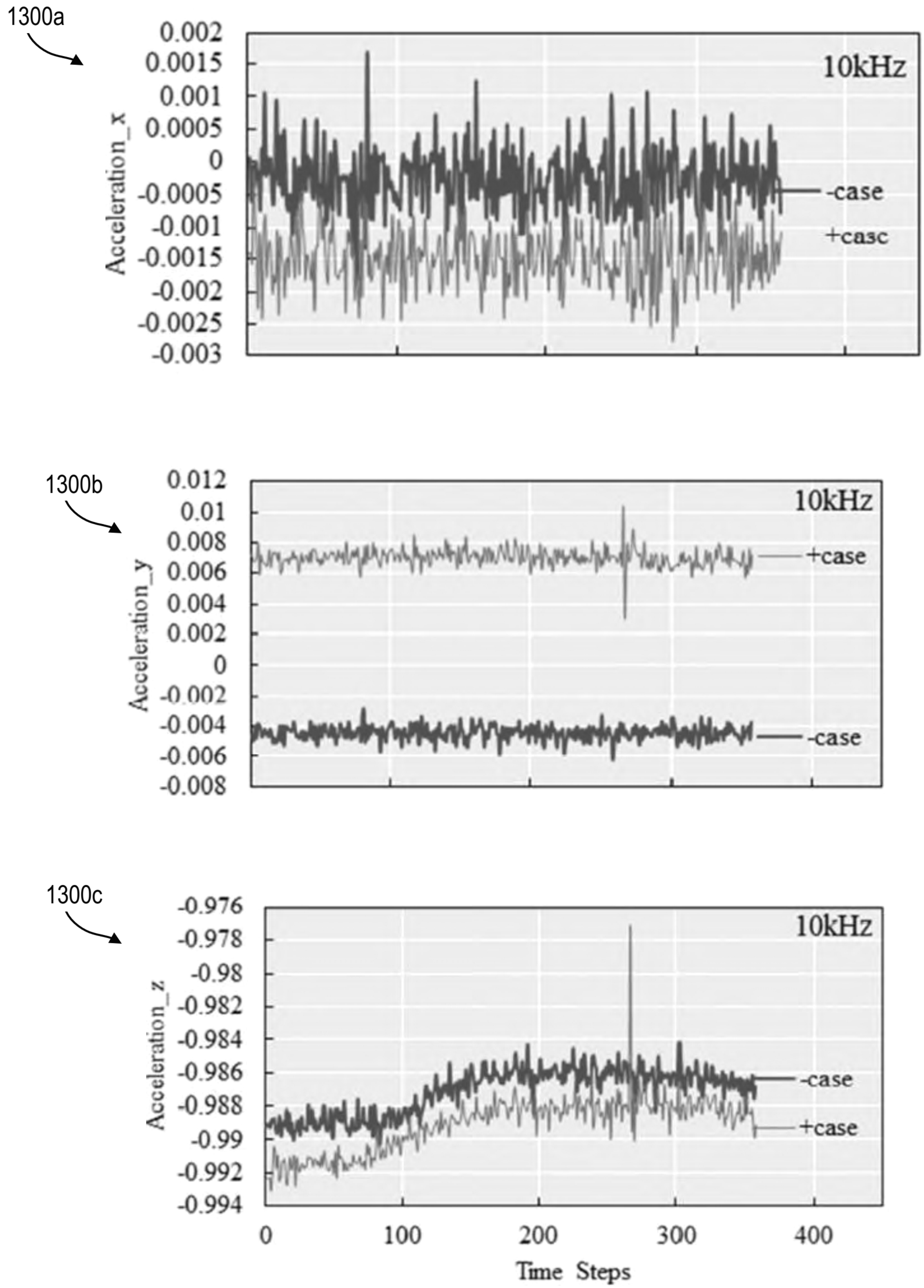

1300a
0.002
0.0015
0.001
0.0005
0
-0.0005
-0.001
-0.0015
-0.002
-0.0025
-0.003
Acceleration_x
10kHz
-case
+casc
1300b
0.012
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
Acceleration_y
10kHz
+case
-case
1300c
-0.976
-0.978
-0.98
-0.982
-0.984
-0.986
-0.988
-0.99
-0.992
-0.994
Acceleration_z
10kHz
-case
+case
0
100
200
300
400
Time Steps

FIG. 13

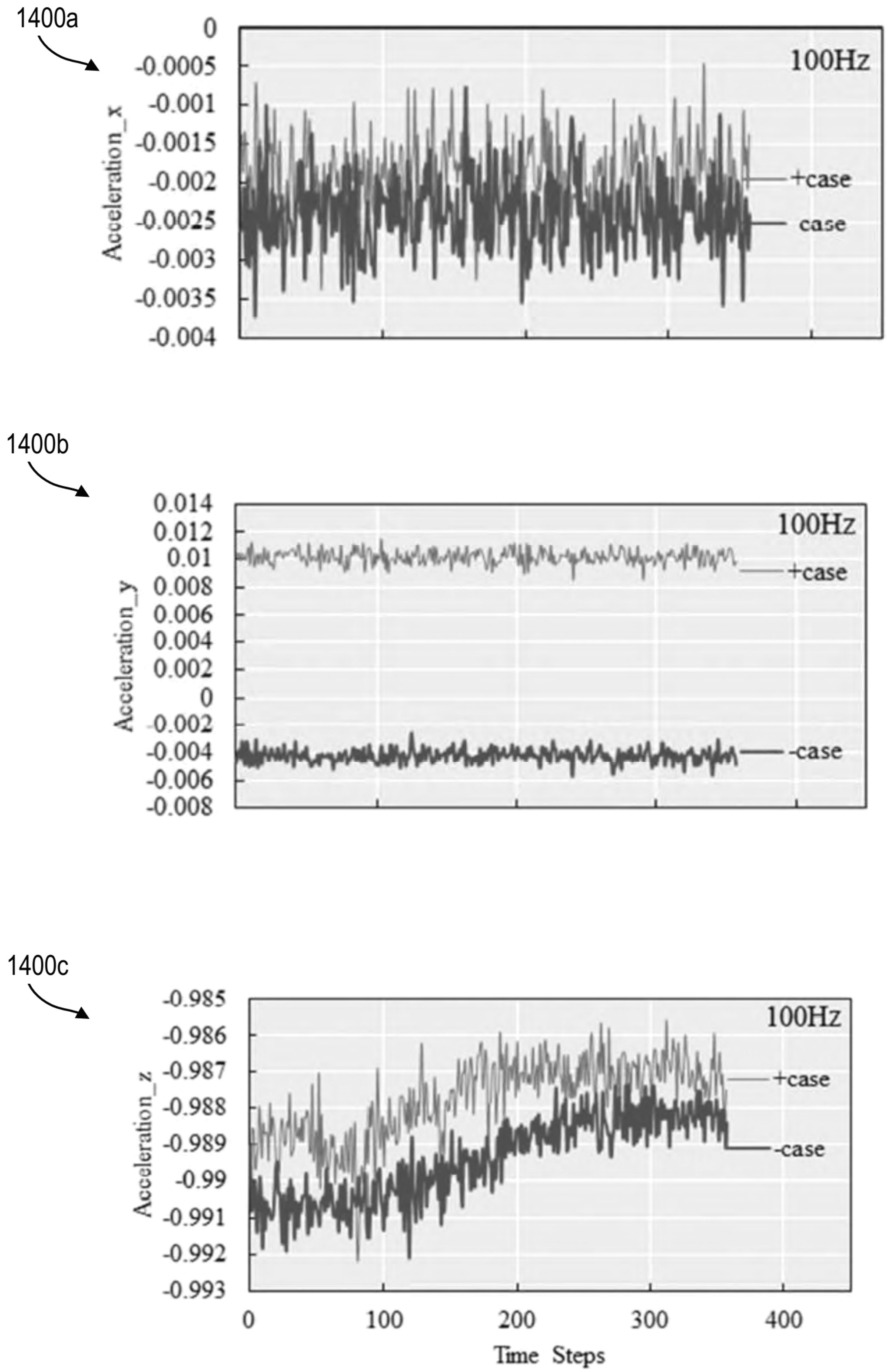

1400a
0
-0.0005
-0.001
-0.0015
-0.002
-0.0025
-0.003
-0.0035
-0.004
Acceleration_x
100Hz
+case
case
1400b
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
Acceleration_y
100Hz
+case
-case
1400c
-0.985
-0.986
-0.987
-0.988
-0.989
-0.99
-0.991
-0.992
-0.993
Acceleration_z
100Hz
+case
-case
0
100
200
300
400
Time Steps

FIG. 14

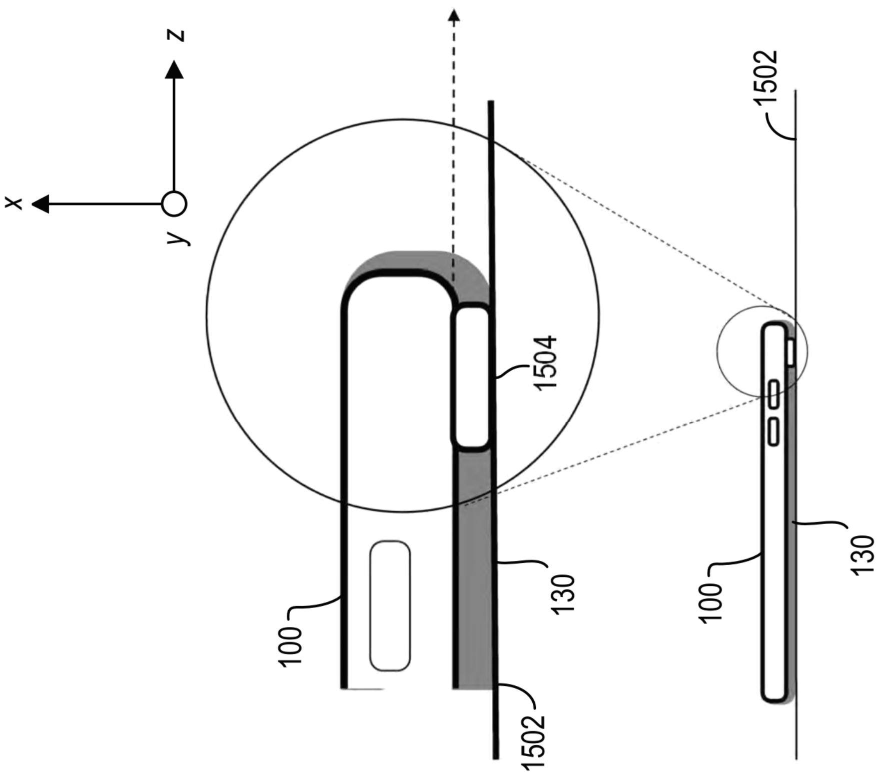


FIG. 15B

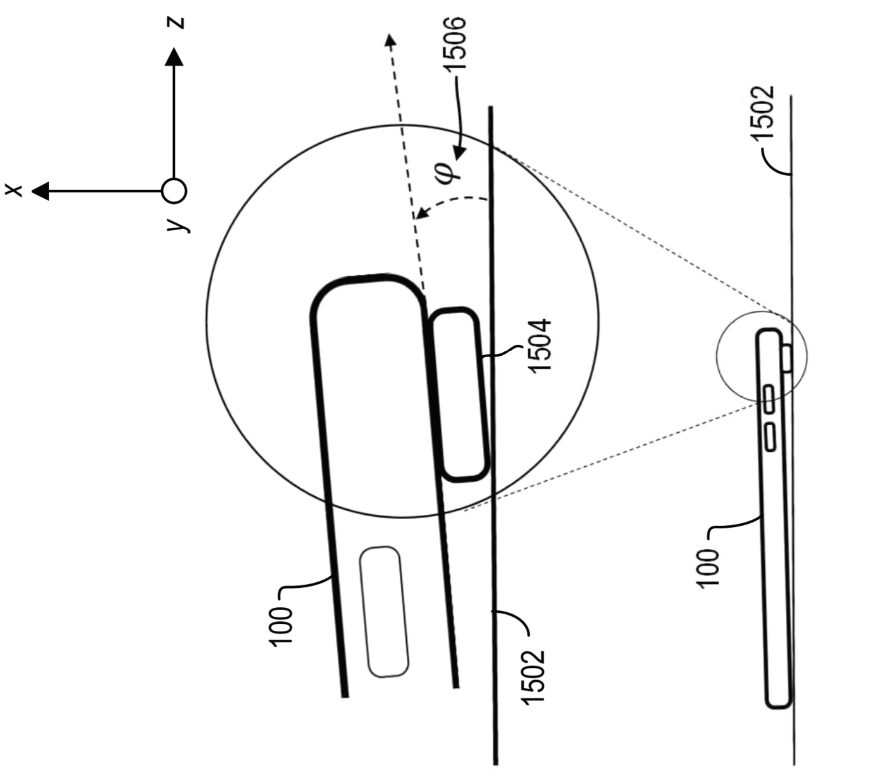


FIG. 15A

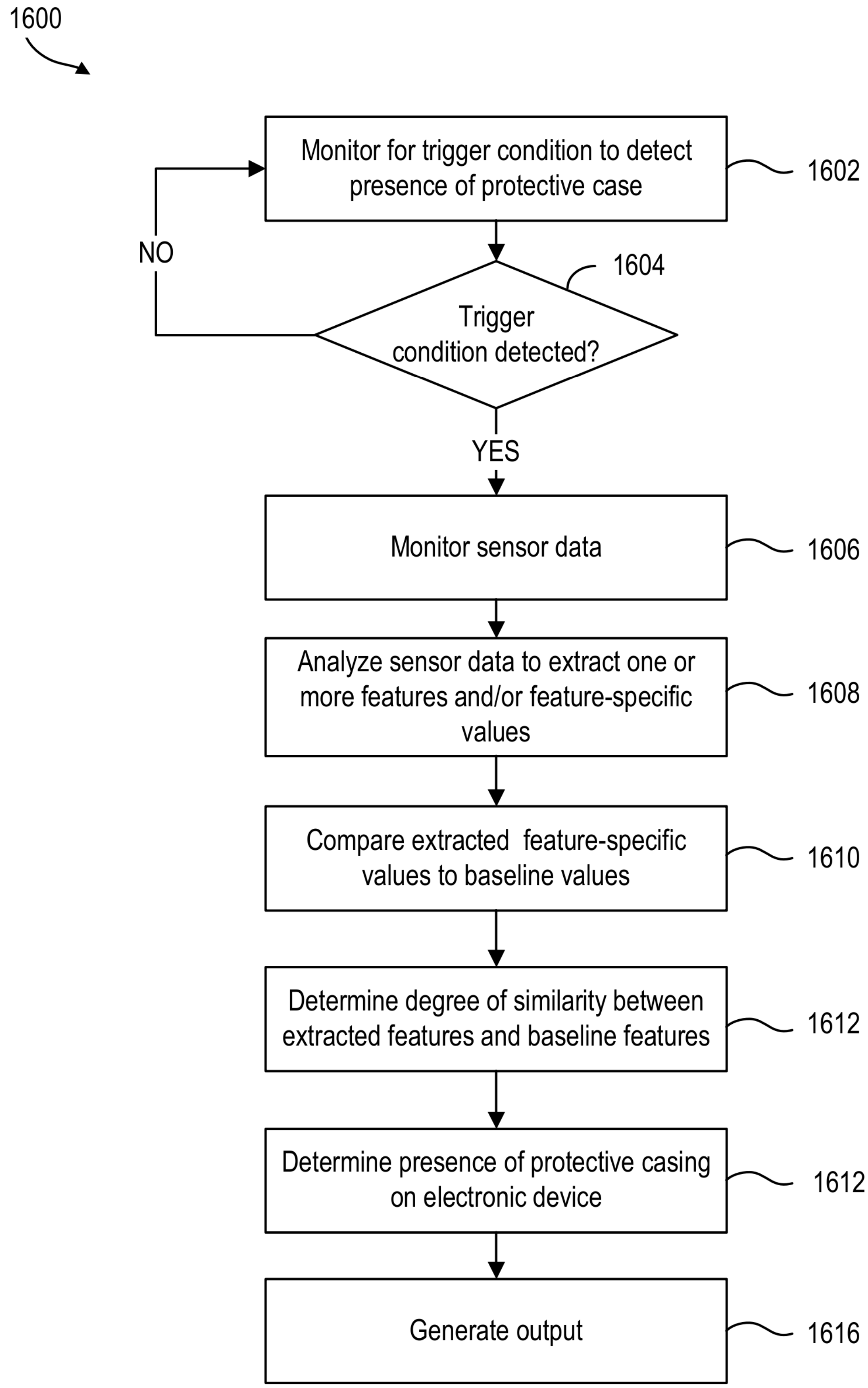

1600
Monitor for trigger condition to detect presence of protective case
1602
NO
1604
Trigger condition detected?
YES
Monitor sensor data
1606
Analyze sensor data to extract one or more features and/or feature-specific values
1608
Compare extracted feature-specific values to baseline values
1610
Determine degree of similarity between extracted features and baseline features
1612
Determine presence of protective casing on electronic device
1612
Generate output
1616

FIG. 16

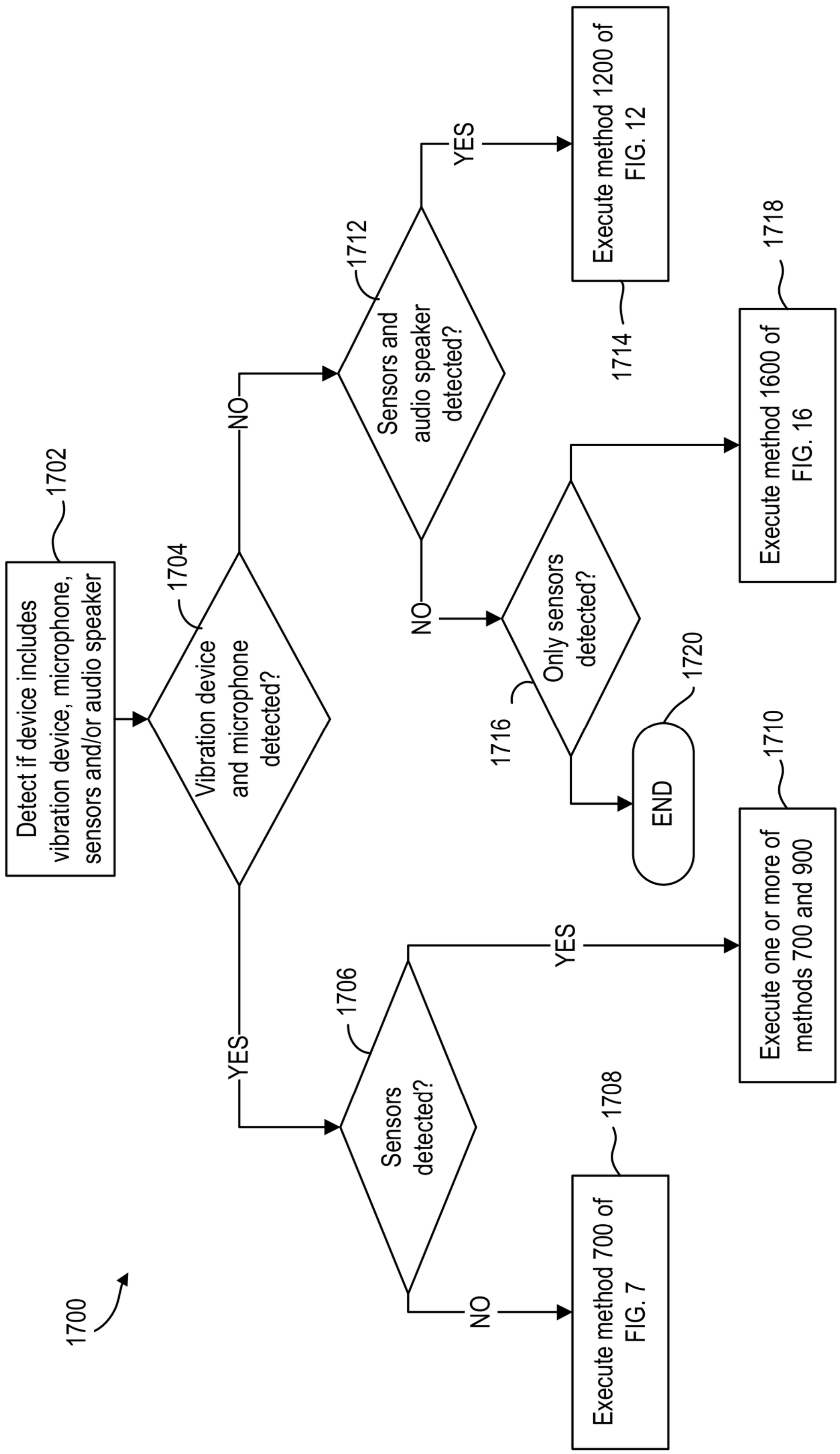

1700
1702
Detect if device includes vibration device, microphone, sensors and/or audio speaker
1704
Vibration device and microphone detected?
YES
NO
1706
Sensors detected?
YES
NO
1708
Execute method 700 of FIG. 7
1710
Execute one or more of methods 700 and 900
1712
Sensors and audio speaker detected?
YES
NO
1714
Execute method 1200 of FIG. 12
1716
Only sensors detected?
1718
Execute method 1600 of FIG. 16
1720
END

FIG. 17

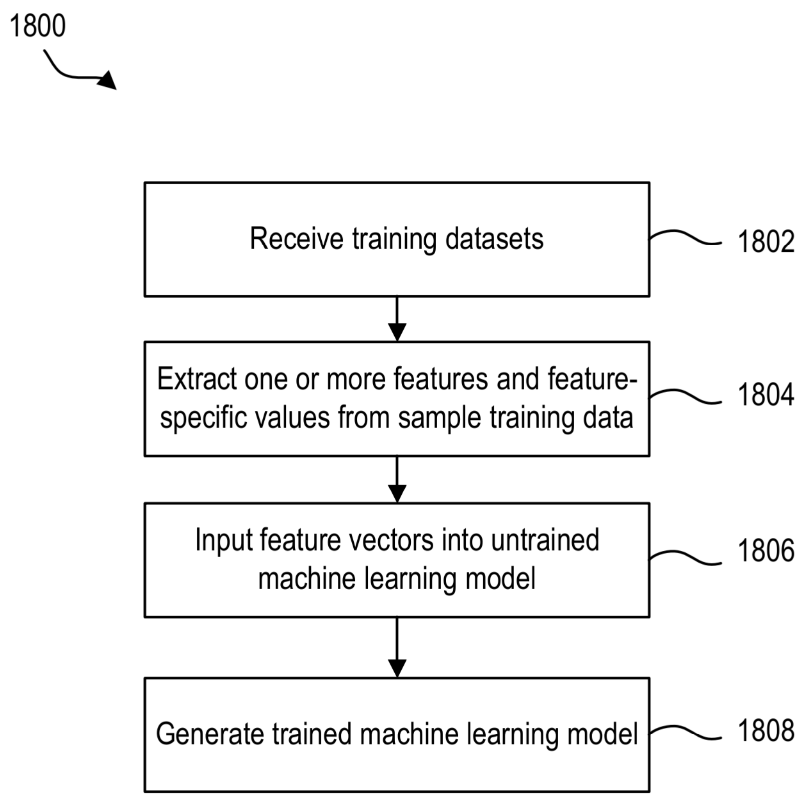

1800
Receive training datasets
1802
Extract one or more features and feature-specific values from sample training data
1804
Input feature vectors into untrained machine learning model
1806
Generate trained machine learning model
1808

FIG. 18

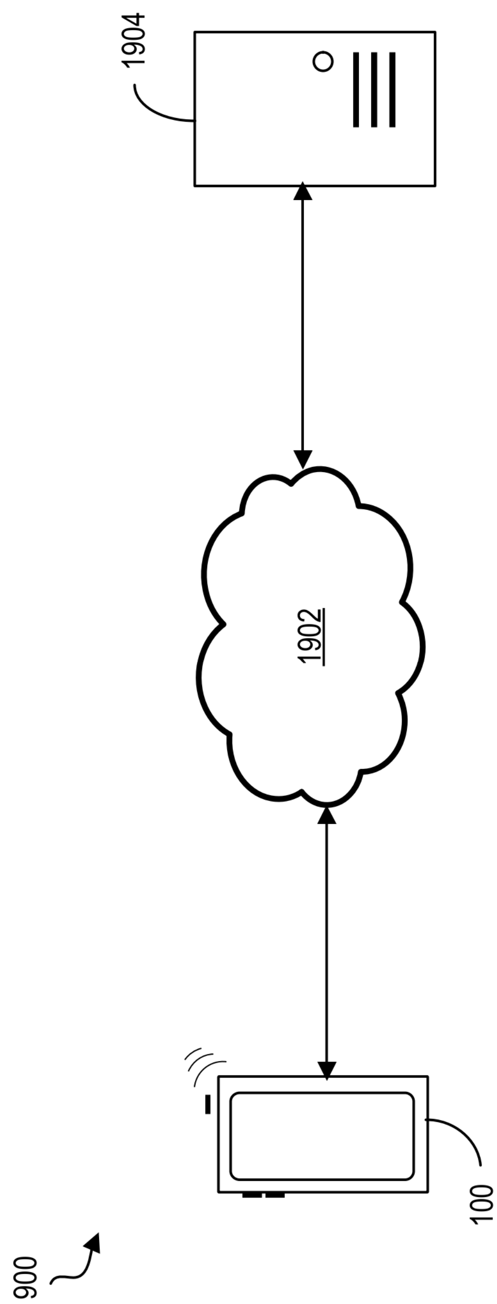


FIG. 19

METHOD AND SYSTEM FOR DETECTING THE PRESENCE OR ABSENCE OF A PROTECTIVE CASE ON AN ELECTRONIC DEVICE

FIELD

Various embodiments are described herein that generally relate to protective casings for electronic devices, and in particular, to a method and system for detecting the presence or absence of a protective case on an electronic device.

INTRODUCTION

Portable electronic devices such as cellular phones, smart phones, a variety of portable personal computing devices (e.g., personal digital assistants (PDA), electronic book readers, video game consoles, and the like) have become ubiquitous globally. Due to their portability, apparatuses to provide them with protection against physical damage (e.g., hits, scratches, drops, etc.) have become prevalent as well. A widely available, yet inexpensive, solution to protect such portable electronic devices against damage is to use a protective cover, also commonly referred to as a protective case. A protective case may be manufactured in different sizes and with a variety of materials (e.g., silicone, leather, plastics, gels, etc.) which may be substantially rigid or at least partially deformable (flexible and/or stretchable). A prominent feature of protective cases is that they are not a permanent addition to the electronic device and can be detached.

SUMMARY OF THE VARIOUS EMBODIMENTS

In accordance with a broad aspect of the teachings herein, there is provided at least one embodiment of an electronic device for detecting the presence of a protective case on the electronic device, the electronic device comprising: one or more sensors; a device memory storing an application including programs instructions for performing a method for detecting the presence of the protective case; a device processor coupled to the device memory and the one or more sensors, the device processor, upon execution of the application, being configured to: monitor, via at least one first sensor of the one or more sensors, a trigger condition for detecting the presence of the protective case; detect the trigger condition; in response to detecting the trigger condition, cause the electronic device to vibrate for a pre-determined period of time; collect, via at least one second sensor of the one or more sensors, sensor data during the pre-determined time; extract at least one feature from the sensor data; based on the extracted at least one feature, determine whether the protective case is applied to the electronic device; and generate an output indicating whether the protective case is applied to the electronic device.

In some embodiments, the trigger condition comprises detecting a sensor value, generated by the at least one first sensor, that is greater than a pre-determined sensor value threshold.

In some embodiments, the electronic device further comprises a vibrating device, and causing the device to vibrate comprises activating the vibrating device.

In some embodiments, the electronic device further comprises an audio speaker, and when the electronic device is caused to vibrate the device processor further activates the audio speaker to emit an audio tone.

In some embodiments, the first and second sensors comprise each comprise at least one of an accelerometer or a gyroscope.

In some embodiments, the at least one second sensor comprises a microphone.

In some embodiments, the extracted feature comprises at least one of amplitude, frequency, energy and a Fast Fourier Transform (FFT) of the sensor data.

In some embodiments, the device processor is further configured to determine, for each extracted feature, one or more feature-specific values.

In some embodiments, the one or more feature-specific values comprise at least one of a minimum value, a maximum value, an average value, a standard deviation or a variation (x) value.

In some embodiments, determining whether the protective case is applied to the electronic device comprises comparing the one or more feature-specific values to at least one of baseline feature-specific values corresponding to a positive case indicating a presence of a protective case, and baseline feature-specific values corresponding to a negative case indicating an absence of a protective case.

In some embodiments, the comparing comprises determining a similarity measure between the one or more feature-specific values to at least one of the positive case and negative case baseline feature-specific values.

In some embodiments, determining whether the protective case is applied to the electronic device comprises inputting the one or more feature-specific values into a trained machine learning model.

In accordance with another broad aspect of the teachings herein, there is provided a method for detecting the presence of a protective case on an electronic device, the method comprising: monitor, via at least one first sensor of the one or more sensors of the electronic device, a trigger condition for detecting the presence of the protective case; detect, via a device processor of the electronic device, the trigger condition; in response to detecting the trigger condition, cause the electronic device to vibrate for a pre-determined period of time; collect, via at least one second sensor of the one or more sensors of the electronic device, sensor data during the pre-determined time; extract, using the device processor, at least one feature from the sensor data; based on the extracted at least one feature, determine, using the device processor, whether the protective case is applied to the electronic device; and generate, using the device processor, an output indicating whether the protective case is applied to the electronic device.

In some embodiments, the trigger condition comprises detecting a sensor value, generated by the at least one first sensor, that is greater than a pre-determined sensor value threshold.

In some embodiments, causing the electronic device to vibrate for a pre-determined period of time comprises activating a vibration device of the electronic device.

In some embodiments, causing the electronic device to vibrate for a pre-determined period of time comprises activating an audio speaker of the electronic device to emit an audio tone.

In some embodiments, the first and second sensors comprise each comprise at least one of an accelerometer or a gyroscope.

In some embodiments, the at least one second sensor comprises a microphone.

In some embodiments, the extracted feature comprises at least one of amplitude, frequency, energy and a Fast Fourier Transform (FFT) of the sensor data.

In some embodiments, the method further comprises determining, using the device processor, for each extracted feature, one or more feature-specific values.

In some embodiments, the one or more feature-specific values comprise at least one of a minimum value, a maximum value, an average value, a standard deviation or a variation(x) value.

In some embodiments, determining whether the protective case is applied to the electronic device comprises comparing, using the device processor, the one or more feature-specific values to at least one of baseline feature-specific values corresponding to a positive case indicating a presence of a protective case, and baseline feature-specific values corresponding to a negative case indicating an absence of a protective case.

In some embodiments, the comparing comprises determining, using the device processor, a similarity measure between the one or more feature-specific values to at least one of the positive case and negative case baseline feature-specific values.

In some embodiments, determining whether the protective case is applied to the electronic device comprises inputting the one or more feature-specific values into a trained machine learning model stored on a device memory of the electronic device.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the various embodiments described herein, reference will be made, to the accompanying drawings. The drawings are not intended to limit the scope of the teachings described herein.

FIG. **1** is a schematic illustration of an example electronic device with a removable protective case.

FIG. **2** is a simplified block diagram showing an example embodiment of electronic hardware located inside of an electronic device.

FIG. **3**A is a front-side, partial-internal view of an example embodiment of an electronic device with a built-in vibration device.

FIG. **3**B is a bottom view of an example embodiment of an electronic device with a built-in audio recording device.

FIG. **4**A is a front view of an example embodiment of an electronic device with a built-in three-axis accelerometer.

FIG. **4**B is a side view of the example electronic device of FIG. **4**A.

FIG. **5**A is a front view of an example electronic device with a built-in three-axis rotation sensor.

FIG. **5**B is a side view of the example electronic device of FIG. **5**A.

FIG. **6** is a simplified software/hardware block diagram for an example electronic device, in accordance with the teachings provided herein.

FIG. **7** is an example embodiment of a process flow for a method for automatic detection of the presence of a protective case on an electronic device based on vibration-induced sound.

FIG. **8**A shows plots for amplitude over time, and frequency over time, for vibration-induced sound generated by an example vibrating electronic device with a protective case applied.

FIG. **8**B shows plots for amplitude over time, and frequency over time, for vibration-induced sound generated by an example vibrating electronic device with no protective case applied.

FIG. **9** is an example embodiment of a process flow for a method for automatically detecting the presence a protective case on an electronic device using sensor data generated during vibration of the electronic device.

FIG. **10** shows plots for linear acceleration values—along the X, Y, and Z axes—obtained from a built-in accelerometer of a vibrating electronic device for both cases where a protective case is applied to the electronic device, and where no protective case is applied to the electronic device.

FIG. **11** shows plots for rotational acceleration values—along the X, Y, and Z axes—obtained from a built-in gyroscope of a vibrating electronic device for both cases where a protective case is applied to the electronic device, and where no protective case is applied to the electronic device.

FIG. **12** is an example embodiment of a process flow for a method for automatically detecting the presence of a protective case on an electronic device where an audio tone is used to vibrate the electronic device.

FIG. **13** shows plots for linear acceleration values—along the X, Y, and Z axes—obtained from a built-in accelerometer of an electronic device vibrating due to a 10 KHz audio tone, for both cases where a protective case is applied to the electronic device, and where no protective case is applied to the electronic device.

FIG. **14** shows plots for linear acceleration values—along the X, Y, and Z axes—obtained from a built-in accelerometer of an electronic device vibrating due to a 100 Hz audio tone, for both cases where a protective case is applied to the electronic device, and where no protective case is applied to the electronic device.

FIG. **15**A schematically illustrates an example electronic device resting on a level surface, wherein the electronic device includes a protruding part, and no protective case is applied to the electronic device.

FIG. **15**B schematically illustrates an example electronic device resting on a level surface, wherein the electronic device includes a protruding part, and a protective case is applied to the electronic device.

FIG. **16** is an example embodiment of a process flow for a method for automatically detecting the presence of a protective case on an electronic device based on monitored sensor data.

FIG. **17** is an example embodiment of a process flow for a method for automatically detecting the presence of a protective case on an electronic device, in accordance with the teachings provided herein.

FIG. **18** is an example embodiment for a process flow for a method for training a machine learning model to automatically detect the presence of a protective case on an electronic device.

FIG. **19** is a simplified block diagram of an example system for detecting the presence of a protective case on an electronic device, in accordance with the teachings provided herein.

Further aspects and features of the example embodiments described herein will appear from the following description taken together with the accompanying drawings.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Various embodiments in accordance with the teachings herein will be described below to provide an example of at least one embodiment of the claimed subject matter. No embodiment described herein limits any claimed subject matter. The claimed subject matter is not limited to devices, systems or methods having all of the features of any one of the devices, systems or methods described below or to features common to multiple or all of the devices, systems or methods described herein. It is possible that there may be a device, system or method described herein that is not an embodiment of any claimed subject matter. Any subject matter that is described herein that is not claimed in this document may be the subject matter of another protective instrument, for example, a continuing patent application, and the applicants, inventors or owners do not intend to abandon, disclaim or dedicate to the public any such subject matter by its disclosure in this document.

It will be appreciated that for simplicity and clarity of illustration, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements or steps. In addition, numerous specific details are set forth in order to provide a thorough understanding of the example embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein may be practiced without these specific details. In other instances, well-known methods, procedures and components have not been described in detail so as not to obscure the embodiments described herein. Also, the description is not to be considered as limiting the scope of the example embodiments described herein.

Referencing the figures is meant only to provide an example of how the embodiments described herein are structured and intended to function, and in no way limits the scope of the embodiments of the claimed subject matter. For instance, although the figures show a particular electronic device, a smartphone, the scope of the claimed subject matter includes many other electronic devices.

It should also be noted that the terms "coupled" or "coupling" as used herein can have several different meanings depending in the context in which these terms are used. For example, the terms coupled or coupling can have a mechanical, fluidic or electrical connotation. For example, as used herein, the terms coupled or coupling can indicate that two elements or devices can be directly connected to one another or connected to one another through one or more intermediate elements or devices via an electrical or magnetic signal, electrical connection, an electrical element or a mechanical element depending on the particular context. Furthermore coupled electrical elements may send and/or receive data.

Unless the context requires otherwise, throughout the specification and claims which follow, the word "comprise" and variations thereof, such as, "comprises" and "comprising" are to be construed in an open, inclusive sense, that is, as "including, but not limited to".

It should also be noted that, as used herein, the wording "and/or" is intended to represent an inclusive-or. That is, "X and/or Y" is intended to mean X or Y or both, for example. As a further example, "X, Y, and/or Z" is intended to mean X or Y or Z or any combination thereof.

It should be noted that terms of degree such as "substantially", "about" and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed. These terms of degree may also be construed as including a deviation of the modified term, such as by 1%, 2%, 5% or 10%, for example, if this deviation does not negate the meaning of the term it modifies.

Furthermore, the recitation of numerical ranges by endpoints herein includes all numbers and fractions subsumed within that range (e.g. 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.90, 4, and 5). It is also to be understood that all numbers and fractions thereof are presumed to be modified by the term "about" which means a variation of up to a certain amount of the number to which reference is being made if the end result is not significantly changed, such as 1%, 2%, 5%, or 10%, for example.

Reference throughout this specification to "one embodiment", "an embodiment", "at least one embodiment" or "some embodiments" means that one or more particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments, unless otherwise specified to be not combinable or to be alternative options.

As used in this specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless the content clearly dictates otherwise. It should also be noted that the term "or" is generally employed in its broadest sense, that is, as meaning "and/or" unless the content clearly dictates otherwise.

The headings and Abstract of the Disclosure provided herein are for convenience only and do not interpret the scope or meaning of the embodiments.

Similarly, throughout this specification and the appended claims the term "communicative" as in "communicative pathway," "communicative coupling," and in variants such as "communicatively coupled," is generally used to refer to any engineered arrangement for transferring and/or exchanging information. Exemplary communicative pathways include, but are not limited to, electrically conductive pathways (e.g., electrically conductive wires, electrically conductive traces), magnetic pathways (e.g., magnetic media), optical pathways (e.g., optical fiber), electromagnetically radiative pathways (e.g., radio waves), or any combination thereof. Exemplary communicative couplings include, but are not limited to, electrical couplings, magnetic couplings, optical couplings, radio couplings, or any combination thereof.

Throughout this specification and the appended claims, infinitive verb forms are often used. Examples include, without limitation: "to detect," "to provide", "to transmit", "to communicate", "to process", "to route", and the like. Unless the specific context requires otherwise, such infinitive verb forms are used in an open, inclusive sense, that is as "to, at least, detect, to, at least, provide", "to, at least, transmit" and so on.

The example embodiments of the systems and methods described herein may be implemented as a combination of hardware or software. For example, a portion of the example embodiments described herein may be implemented, at least in part, by using one or more computer programs, executing on one or more programmable devices comprising at least one processing element, and a data storage element (including volatile memory, non-volatile memory, storage elements, or any combination thereof). These devices may also have at least one input device (e.g. a keyboard, mouse, touchscreen, or the like), and at least one output device (e.g. a display screen, a printer, or the like) and a communication interface including one or more ports and/or radios depending on the nature of the device.

It should also be noted that there may be some elements that are used to implement at least part of the embodiments described herein that may be implemented via software that is written in a combination of high-level procedural language such as object-oriented programming as well as assembly language, machine language, or firmware as needed. For example, the program code may be written in C, C++ or any other suitable programming language and may comprise modules or classes, as is known to those skilled in object-oriented programming.

At least some of the software programs used to implement at least one of the embodiments described herein may be stored on a storage media (e.g., a computer readable medium such as, but not limited to, ROM, magnetic disk, optical disc) or a device that is readable by a programmable device. The software program code, when read by the programmable device, configures the programmable device to operate in a new, specific and predefined manner in order to perform at least one of the methods described herein.

Furthermore, at least some of the programs associated with the devices, systems and methods of the embodiments described herein may be capable of being distributed in a computer program product comprising a computer readable medium that bears computer usable instructions, such as program code, for one or more processors. The program code may be preinstalled and embedded during manufacture and/or may be later installed as an update for an already deployed computing system. The medium may be provided in various forms, including non-transitory forms such as, but not limited to, one or more diskettes, compact disks, tapes, chips, and magnetic and electronic storage. In alternative embodiments, the medium may be transitory in nature such as, but not limited to, wire-line transmissions, satellite transmissions, internet transmissions (e.g. downloads), media, digital and analog signals, and the like. The computer useable instructions may also be in various formats, including compiled and non-compiled code.

The terms "cloud" is used to describe a network of computing equipment distributed over multiple physical locations and accessible over the Internet.

The term "AI-powered model" is a mathematical model of given sample data, known as training data, used to make predictions or decisions without being explicitly programmed to perform the task. The model is obtained from algorithms in Artificial Intelligence in Computer Science.

The terms "binary classifier" is an AI-powered model whose task is to classify the elements of a given set into two groups, namely positive and negative.

The terms "protective case" and "case" refer to an apparatus that covers an electronic device fully or partially in order to protect it from damage. It is manufactured with different sizes and variety of materials (e.g., silicone, leather, gels, etc.) and may be substantially rigid or at least partially deformable (flexible and/or stretchable). Protective cases are not a permanent addition to the device and can be detached.

As stated in the background, protective covers for electronic devices—also commonly referred to as protective cases—have become a widely available, yet inexpensive solutions to protect and minimize damage to electronic devices. FIG. **1**, for example, illustrates an example protective case **130** that can be removably applied to an electronic device **100** (e.g., a mobile phone).

As used herein, electronic devices can refer to any computing device, including portable electronic devices such as smartphones, tablet computers, laptops, wearable computing devices (e.g., smartwatches), personal digital assistants (PDA), electronic book readers, video game consoles, and the like.

In particular, it has been appreciated that users of electronic devices may benefit from receiving alerts (or notifications) when protective cases are not applied to their devices. For example, in many cases, users may not be aware that a protective case has inadvertently de-detached from their device. Otherwise, the protective case may have been removed, but the user may have inadvertently omitted to re-apply the case after removal. In these cases, alerting the user to the absence of the protective case can provide the user an opportunity to re-apply the case, and thereby reduce the risk of unforeseen damage to the device.

Similarly, it has also been appreciated that monitoring the presence of protective cases on electronic devices can also provide benefits to manufacturers—who in collaboration with warrantors, or individually—provide warranty coverage to damaged electronic devices. For example, in various cases, before validating a claim of warranty over a damaged device, manufacturers and/or warrantors will often require assurances that a protective case was applied to the electronic device at the point of damage. Accordingly, it may be desirable to automatically monitor and detect the presence of protective cases on devices at the time of damage.

In view of the foregoing, embodiments herein provide for a method and system for automatic detection of the presence of a protective case on an electronic device.

In accordance with the teachings provided herein, in some embodiments, the presence of a protective case is determined by activating a vibrating device located inside the electronic device (e.g., a built-in vibrating device). As the device is made to vibrate, vibration-induced sound is recorded and analyzed to determine whether or not a protective case is applied to the device. Alternatively, or in addition, data from built-in sensors (i.e., motion and orientation sensors) is also recorded during device vibration, and analyzed to determine the presence or absence of a protective case. In particular, it has been appreciated herein that vibration-induced sound, as well as certain sensor data captured during device vibration, may vary as between devices with a protective case, or devices without a protective case.

In accordance with other teachings provided herein, in at least some other embodiments, the presence of a protective case is determined by activating an audio speaker located inside the electronic device. The audio speaker can generate an audio tone which causes the electronic device to vibrate. Sensor data (i.e., motion and/or orientation sensors) is recorded during device vibration, and analyzed to determine the presence or absence of a protective case on the electronic device.

In accordance with still further teachings provided herein, the presence of a protective case is determined by monitoring and analyzing sensor data (e.g., motion, orientation and other environmental sensor data (e.g., light, pressure, and temperature)), while the device is resting on a surface, to determine the presence or absence of a protective case on the electronic device.

Referring now to FIG. **2**, there is shown an example simplified hardware block diagram for an example embodiment of an electronic device **100**.

As shown, the electronic device **100** generally includes a processor **202** coupled, via a data bus, to one or more of a communication interface **204**, a memory **206**, a vibration device **208**, an audio speaker **210**, a microphone **212** (or an audio recording unit), one or more sensors **214**, a display interface **216** and an input/output (I/O) interface **218**. In some embodiments, the electronic device **100** may not include all of components **204**—**218**, and may only include a subset of the illustrated components. For example, in some cases, the electronic device **100** may not include one or more of the vibration device **208**, audio speaker **210**, microphone **212** or one or more sensors **214**.

Processor **202** is a computer processor, such as a general purpose microprocessor. In some other cases, processor **202** may be a field programmable gate array (FPGA), application specific integrated circuit (ASIC), microcontroller, or other suitable computer processor.

Communication interface **204** is one or more data network interface, such as an IEEE 802.3 or IEEE 802.11 interface, for communication over a network.

Processor **202** is coupled, via a computer data bus, to memory **206**. Memory **206** may include both volatile and non-volatile memory. Non-volatile memory stores computer programs consisting of computer-executable instructions, which may be loaded into volatile memory for execution by processor **202** as needed. It will be understood by those of skill in the art that references herein to the electronic device **100** as carrying out a function, or acting in a particular way, imply that processor **202** is executing instructions (e.g., a software program) stored in memory **206** and possibly transmitting or receiving inputs and outputs via one or more interfaces. Memory **206** may also store data input to, or output from, processor **202** in the course of executing the computer-executable instructions.

As provided herein, with reference to FIG. **6**, the memory **206** may store one or more software programs which can be used for automatic detection of the presence or absence of a protective case **130** on an electronic device. In particular, the software programs may be configured—upon execution by the processor **202**—to perform one or more of the methods which are described in further detail herein (i.e., FIGS. **7**, **9**, **12**, **16**, **17** and/or **18**). In some cases, the software programs can be software applications deployed to and installed on the electronic device **100**. Depending on the nature of the operating system and/or platform of the electronic device **100**, the software applications may be deployed directly to the electronic device **100**, and/or the applications may be downloaded from an application marketplace. For example, a user of the electronic device **100** may download the applications through an app store such as the Apple App Store™ or Google™ Play™.

Memory **206** can also store data generated by one or more of the components of electronic device **100**. For example, as explained herein, memory **206** can store data captured by the microphone **212** and/or sensors **214**. The data captured by these components can be analyzed by one or more software programs, stored on memory **206** and executing on processor **202**, to determine the presence (or absence) of a protective case **130** on the electronic device **100**. Vibration device **208** may be any device which, upon activation, causes mechanical vibration of the electronic device **100**. In various cases, vibration device **208** is a mobile phone surface mount (SMD/SMT) vibration motor that comprises an eccentric rotating mass vibration motor (ERM) and/or a linear vibration motor. In many cases, electronic devices **100** (e.g., mobile phones) may already include built-in vibration devices to provide haptic effects for users of the electronic device **100**. For example, as shown in FIG. **3**, a vibration motor **208** may be pre-built inside (or otherwise installed inside) of the electronic device **100**. As provided herein, the vibration device **208** may be controlled to cause sufficient vibrational forces such that vibration-induced sound is generated and detected by the microphone **212**. In other cases, the vibration device **208** can cause sufficient vibrational forces to be detectable by one or more motion and/or orientation sensors **214**. In some embodiments, the vibration device **208** can effect vibration forces of up to 0.2 g to 0.8 g.

Audio speaker **210** is any device configurable to output an auditory signal. As shown in FIG. **3**A, the audio speaker **210** can be—for example—a front-facing speaker of a mobile device.

Microphone **212** is any sensor that is used along with hardware (e.g. an amplifier, a filter and an analog to digital convertor) and software to provide a device used to detect, monitor and record surrounding auditory noise. For example, referring briefly to FIG. **3**B, the microphone **212** may be an audio sensor that is located on a bottom edge of a mobile phone. While illustrated separately from sensors **214**, it will be appreciated that the microphone **212** may itself be regarded as a sound detection sensor. In other embodiments, any other audio recording unit may be provided inside of the electronic device **100**.

Sensors **214** can include various sensors for monitoring and measuring motion and rotation of the electronic device **100**, as well as surrounding environmental parameters. For example, sensors **214** can include one or more of a three-axis accelerometer, a three-axis gyroscope, an inertial measurement unit (IMU), as well as pressure sensors, optical (e.g. light) sensors, temperature sensors and/or humidity sensors.

Referring briefly to FIGS. **4**A and **4**B, there is shown an example electronic device **100** (e.g., a mobile phone), and illustrating accelerometer parameters measurable by a built-in three-axis accelerometer. As shown, the three-axis accelerometer can measure linear acceleration along the X-axis direction—i.e., extending between the lateral sides **100***c*, **100***d* of the device (e.g., positive X-axis direction **402***a*, and negative X-axis direction **402***b*), the Y-axis direction—extending between the top **100***a* and bottom **100***b* of the device (e.g., positive Y-axis direction **404***a*, and negative Y-axis direction **404***b*), and the Z-axis direction—i.e., extending between the front **100***e* and the rear **100***f* of the device. (e.g., positive Z-axis direction **406***a*, and negative Z-axis direction **406***b*).

Referring briefly to FIGS. **5**A and **5**B, there is shown an example electronic device **100** (e.g., a mobile phone), and illustrating gyroscope parameters measurable by a built-in three-axis gyroscope. As shown, the three-axis gyroscope can measure rotational acceleration along the X-axis (e.g., positive direction pitch **504***a*, and negative direction pitch **502***b*), Y-axis (e.g., positive direction roll **504***a*, and negative direction roll **502***b*), and the Z-axis (e.g., positive direction yaw **506***a*, and negative direction yaw **506***b*).

Referring back to FIG. **2**, display interface **216** is any suitable display (e.g., a screen) for outputting information and data as needed by various computer programs. In some cases, display **216** may display a graphical user interface (GUI) associated with one or more software programs stored on memory **206**.

User input interface **218** is any interface used for receiving user inputs (e.g., buttons). In some cases the display interface **216** can be a touch screen display, and accordingly may function as a user input interface **218**.

Referring now briefly to FIG. **6**, there is shown a simplified hardware/software block diagram **600** for the electronic device **100**, in accordance with some embodiments.

As stated previously, memory **206**—of electronic device **100**—can store one or more software programs **602** for use in automatic detection of the presence of a protective case **130**. For example, as shown, the memory **206** can store one or more of a sound processing application **602***a* and/or a sensor processing application **602***b*. As provided herein, the sound processing application **602***a* can receive sound data (e.g., captured by microphone **212**), and analyze the sound data to determine the presence of a protective case **130** on the device. Similarly, the sensor processing application **602***b* can receive sensor data (e.g., generated by sensors **214**), and analyze the sensor data to determine the presence of a protective case **130** on the device. While illustrated as separate applications, each of the sound and sensor processing applications **602***a*, **602***b* may comprise a single protective case detection application **602**.

Referring now to FIGS. **7** and **9**, which illustrate example embodiments of process flows of methods for automatically detecting the presence of a protective case **130**, on the electronic device **100**, by vibrating the electronic device **100** using the vibration device **208**.

Referring first to FIG. **7**, there is shown an example embodiment of a process flow for a method **700** for automatically detecting the presence of a protective case **130** on an electronic device **100**. In particular, the method **700** is based on detecting vibration-induced sound resulting from activating vibration device **208** inside the electronic device **100**. To this end, it has been appreciated that the presence or absence of a protective case **130** on the electronic device **100** can impact vibration-induced sound data generated by vibrating the electronic device **100**. The method **700** can be implemented, for example, using protection case detection application **602** (e.g., sound processing application **602***a*), executing on device processor **202**.

As shown, at act **702**, case detection application **602** can monitor for one or more trigger conditions indicating that the case detection application **602** should commence determining whether or not a protective case **130** is applied to the electronic device **100**.

In some embodiments, the trigger conditions monitored at act **702** can be user-induced. For example, a user—of electronic device **100**—may request case detection application **602** to execute the test for detecting the presence of a protective case **130** on the device. For instance, a graphical user interface (GUI)—associated with case detection application **602**—can display an option for the user (e.g., via display interface **612**) to execute the test to determine the presence of a protective case **130**. In various cases, this may be required as part of a warranty condition on the device, which requires the device user to run intermittent detection tests to confirm a protective case **130** is applied. At a subsequent time, if the electronic device **100** is damaged, the warranty provider may validate the warranty claim by accessing test results to ensure a protective case **130** has been generally applied to the electronic device **100**. For example, the warranty provider may access test results stored on the device memory **206**, or otherwise transmitted to a third-party computing device (e.g., associated with the warranty provider).

The trigger condition, at act **702**, may also be an automated trigger. More specifically—rather than being user-induced—case detection application **602** can automatically trigger the protective case detection test. For example, case detection application **602** can trigger the test at pre-determined time or frequency intervals.

In addition to validating warranty claims, automated triggers can also act as a safety feature for device users. For example, automated triggers—i.e., to detect the presence of a protective case **130** on an electronic device **100**—can be used to alert users when a protective case **130** is not detected. For example, a user may not be aware that the protective case **130** is detached from the electronic device **100**, or otherwise, that the case was not re-applied after being removed from the electronic device **100**. In this manner, automated monitoring for the presence of the protective case **130** can assist a user to take proactive measures to apply the case to a device when no case is detected, and in turn, minimize potential damage to the electronic device **100**.

In various cases, the periodicity (or frequency) of the automated test can be adjusted by the user (e.g., via the user input interface **218**). In other cases, the case detection application **602** may be pre-configured (e.g., by an application developer) to run the automated test at specific time or frequency intervals.

The trigger condition, at act **702**, may also correspond to a trigger event. The trigger event can include, for example, detecting that the device has been dropped, incidentally hit or otherwise damaged. The detected event can, in turn, prompt case detection application **602** to run the protective case detection test. In particular, warranty conditions can require a protective case **130** to be applied at the point of damage. Accordingly, in various cases, the results of the detection test—resulting from the trigger event—can be accessed by a warranty provider to confirm that a protective case **130** was applied to the device at the time of damage.

In some embodiments, trigger events can be detected by monitoring outputs from one or more sensors **214**. For example, a sudden increase in linear acceleration recorded by an accelerometer, or a sudden increase in rotational acceleration recorded by a gyroscope, can indicate a drop event. For instance, a drop event can correspond to recording linear acceleration above a pre-determined linear acceleration threshold (e.g., greater than 7.0-11.0 m/s^2) or rotational acceleration above a pre-determined rotational acceleration threshold (e.g., greater 0.5-10 rad/s^2). In other cases, a sudden increase in pressure values, recorded by a pressure sensor (e.g., a pressure value between 0.5-3.0 PSI]), can indicate an impact event (e.g., an incidental hit). In various cases, the case detection application **602** may monitor for detected trigger events over pre-defined time or frequency intervals (e.g., every 1-5 seconds).

At act **704**, the case detection application **602** can determine whether a trigger condition has been detected, i.e., based on monitoring sensor output values. In cases where the trigger condition is not detected, the method **700** can return to act **702** and iterate until the trigger condition is detected. Otherwise, if a trigger condition is detected, at act **706**, the case detection application **602** can activate the vibration device **208**. For example, an API or system call by the case detection application **602** to the device operating system can be used to activate the vibration device **208**.

In some embodiments—upon detecting the trigger condition—the application **602** may not immediately activate the vibration device **208**. For example, in some cases, where the trigger condition corresponds to a dropped device, the application **602** may wait a pre-determined period of time (e.g. **2**—5 seconds) before activating the vibration device **208**. The pre-determined time can ensure that the electronic device **100** has landed on the ground before activating the vibration device **208**. In other cases, the method can involve monitoring, by application **602**, and detecting a second trigger condition. For example, in a drop event, the second trigger condition can correspond to detecting that the electronic device **100** has landed on a surface. For example, the second trigger condition can involve detecting the linear acceleration measured by an accelerometer is within a pre-determined linear acceleration range (e.g., 0.003 to 0.004 m/s^2), or rotational acceleration measured by a gyroscope is within a pre-determined rotational acceleration range (e.g., 0.1 and 0.001 m/s^2). Once the second trigger condition is detected, the application **602** can activate the vibration device **208**.

In some cases, application **602** may automatically begin monitoring for the second trigger condition from the start of the method **700**. In other cases, the second trigger condition is monitored only once the first trigger condition has been detected (e.g., act **704**). In some cases, the application **602** may only monitor for the second trigger condition in respect of specific detected first trigger conditions. In other words, the second trigger condition is only monitored if the first trigger condition indicates a drop event (e.g., based on sensor values). That is, it may only be necessary to monitor for second trigger conditions when certain first trigger conditions are detected. In particular, it may not be necessary to monitor for a second trigger condition if the first trigger condition is in respect of an automated or user-induced device protection test, or otherwise an impact event. In these cases, the vibration device **208** may be automatically activated after detecting the first trigger condition, as no second event is necessary (e.g., a phone landing) before carrying out the device protection test.

At act **706**, the case detection application **602** can control parameters of the vibration device **208**. For example, the case detection application **602** can control the frequency and/or amplitude (e.g., strength) of the vibration device **208**. Case detection application **602** can also control the pattern of vibration of the vibration device **208** (e.g., vibrate 100 milliseconds and then sleep 1000 milliseconds, then vibrate 200 milliseconds and sleep 2000 milliseconds). In some embodiments, more complex patterns can result in higher detection rates of applied protective cases on electronic devices.

In some embodiments, the API—used to activate the vibration device **208**—may provide the case detection application **602** with limited, pre-defined activation parameters. Accordingly, in these cases, the activation parameters are limited to those supported by the specification of the corresponding system call.

In various cases, the case detection application **602** can activate the vibration device **208** for a pre-determined period of time (e.g., 1-5 seconds).

At act **708**—as the vibration device **208** is being activated—case detection application **602** can detect, via microphone **212**, vibration induced-sound generated by the vibrating device **208**. In some cases, the case detection application **602** may automatically activate the microphone **212** to begin streaming (e.g., collecting) vibration sound immediately, or shortly after, the trigger condition is detected at act **704**. The collected sound data may then be stored by case detection application **602** inside the memory **206**. In some cases, as discussed previously, where a first and second trigger condition are necessary before activating the vibration device **206**, the microphone **212** may be activated after the second trigger condition is detected.

At act **710**, the case detection application **602** can determine that the pre-determined vibration period has lapsed. In turn, the case detection application **602** can de-activate the vibration device **208**, and can retrieve the collected vibration-induced sound data from memory **206**. The sound data is then analyzed to determine whether a protective case **130** is applied to the electronic device **100**.

In particular, at act **710**, the sound data can be analyzed to extract one or more sound data features. The extracted features can include, by way of non-limiting examples, the amplitude of the sound data over the vibration period, the frequency of the sound data, and the calculated energy of the data. The extracted features can also include determining the Fast Fourier Transform (FFT) of the recorded sound data.

For each extracted features, at act **710**, one or more feature-specific values can also be determined. The feature-specific values can include—for each extracted feature—determining a minimum, maximum, average, standard deviation and variation(x) values. In particular, variation (x) values can correspond to the percentage of the values, in the sound signal, where a value increases or decreases by a pre-determined percent (i.e., x %), relative to its previous value over the duration of the sound signal. For example, determining the variation(x), may include determining a variation (50), or otherwise, determining when the signal values increase/decrease by at-least 50%, compared to their previous value. In other cases, the variation (x) may be determined for values of "x" equal to one or more of 25, 50, 75, 100, etc. The variation (x) can be computed over all signal values, or otherwise, over specific signal values. In the latter case, for example, variation (x) can be determined over the first or last twenty-five percent of the signal. In some cases, a variation (x,y) is determined, wherein the "y" variable represents the percentage of the signal analyzed.

At act **712**, the feature-specific values—extracted at act **710**—are compared to baseline values.

More specifically, memory **206** may store pre-determined sound "baselines". A sound baseline is sound data corresponding to the "true" vibration-induced sound with and/or without a protective case **130**.

In some cases, the sound baseline is pre-recorded in an experimental, clean environment wherein the electronic device is vibrated, and vibration-induced sound is recorded in two experimental scenarios: (a) a scenario where no protective case applied to the device (e.g., a negative test case), and (b) a scenario where a protective case is applied to the device (e.g., a positive case). In various cases, multiple experimental tests can be executed—for each of the two scenarios—under various testing conditions. For example, the various test conditions can include: (i) vibrating the electronic device on different surface types (e.g., varying levels of hardness (i.e., rugs, softwood, hard wood, asphalt, glass, etc)); (ii) vibrating electronic devices using different makes and models of protective cases (i.e., cases having varying levels of hardness and thickness); (iii) conducting the tests using different makes and models of electronic devices; and (iv) conducting tests with the varying levels of background noise.

In some cases, the experimental tests can be conducted, for example, by the application developer. Features, and feature-specific values, may then be extracted from the baseline sound data to form the baseline dataset.

In some cases, the sound "baseline" may not be pre-determined, but may be user-generated. For example, upon installing case detection application **602** on an electronic device **100** (or anytime thereafter), case detection application **602** may prompt the user (e.g., via the display interface **216**) to conduct an initialization baseline test. During the baseline test, the user may be requested to apply or remove the device protective case **130**. In each scenario, the case detection application **602** may conduct a vibration test to generate baseline sound data in a controlled manner. For example, case detection application **602** may include a GUI that prompts the user—e.g., via the user input interface **218**—to initiate one or more vibration tests with and/or without a protective case **130**, while the device is resting on a surface. Once initiated, the case detection application **602** activates the vibration device **208** for a pre-determined time period, and records the vibration-induced sound. The vibration induced-sound is then analyzed to extract features, and feature-specific values, which are recorded in memory **206** as "baseline" values for a positive test case (e.g., a protective case **130** is present), and a negative test case (e.g., no protective case **130** is present). In this manner, the case detection application **602** can guide the user to generate the baseline values that are unique to the user's device.

Referring now briefly concurrently to FIGS. **8**A and **8**B. FIG. **8**A shows example plots **800***a*, **802***a* corresponding to example baseline amplitude and frequency values, respectively, for recorded vibration-induced sound when a protective case **130** is applied (e.g., a positive test case). FIG. **8**B shows example plots **800***b*, **802***b* for example baseline amplitude and frequency values, respectively, for recorded vibration-induced sound when a protective case **130** is not applied (e.g., a negative test case).

As shown in FIGS. **8**A and **8**B, the presence of the protective case **130** (FIG. **8**A) generates a different frequency and amplitude sound response (e.g., lower amplitude and frequency) as compared to where no protective case **130** is applied (FIG. **8**B). In particular, this is owing to the fact that the protective case **130** dampens the effect of the vibration, and in turn, reduces the effect of the resulting vibration-induced sound.

Referring back to FIG. **7**, at act **714**, the degree of similarity between baseline feature-specific values (act **712**) and recorded feature-specific values (act **710**) are compared to determine whether the recorded vibration-induced sound is more similar to the negative baseline dataset (e.g., no protective case **130** applied), or the positive baseline dataset (a protective case **130** is applied). Based on this determination, at act **716**, the recorded sound data is classified as either corresponding to a positive case scenario (e.g., a protective case **130** is present), or a negative case scenario (e.g., no protective case **130** is present).

In some cases, the similarity measure at act **714** is determined by comparing each extracted feature-specific value (act **710**) to a corresponding base-line feature-specific value (act **712**). For example, the comparison is performed using any suitable similarity measure, including determining a cosine distance, a Manhattan distance, a Euclidean distance, a Minkowski distance, or a Jaccard similarity. Based on the similarity value, it is then determined whether the similarity measure is smaller between the extracted feature-specific value and the negative baseline dataset (e.g., corresponding baseline feature-specific values for the negative dataset), or the positive baseline dataset (e.g., corresponding baseline feature-specific values for the negative dataset). In cases, where a plurality of extracted feature-specific values are compared to a plurality of baseline feature-specific values (e.g., positive and negative baselined datasets), a plurality of similarity values may be generated. In these cases, an averaging or combination (e.g., weighted or unweighted) of each of the similarity values can be used to determine whether the extracted feature-specific values more closely correspond to the positive or negative baseline dataset.

In some embodiments, only a single baseline dataset may be available for acts **712**-**714**. For example, in some cases, only a positive case baseline data set is available, and the similarity to this dataset can indicate a protective case **130** was applied, and a dissimilarity may imply that no protective case **130** was applied.

In various embodiments, the sound "baseline" datasets are generated using the same vibration parameters (e.g., frequency, amplitude, pattern and activation time) as used at act **706**. This, in turn, allows for a direct comparison between the recorded sound, and the baseline sound.

At act **718**, an output is generated based on the determination at act **716**. In particular, the output indicates whether or not a protective case **130** was applied at the instance the trigger condition was detected at act **704**.

In some cases, the output can be stored in memory **206**. For example, the output can be stored in memory **206** in association with a timestamp. Accordingly, when the user attempts to subsequently validate a warranty claim after damaging the device, the warranty provider may access the device memory **206** to retrieve a log of time-stamped test results. This, in turn, can be used to verify whether a protective case **130** was applied during a damage event (e.g., during a drop event). In some cases, in addition or in the alternative to a time-stamp, the output can be stored with an indication of the detected trigger (e.g., a drop or impact event, or specific sensor values instigated the protection case detection test) to provide more information to a warranty provider in regards to the context of the stored output. In other embodiments as provided herein, the output determination at act **718**—as well as any associated data (e.g., timestamps, etc.)—can also be transmitted to a third party computing device or server (e.g., a 3^{rd} party computer or server associated with a warranty provider). In some cases, as explained herein, the output can be transmitted in real-time, or near real-time.

In still other cases, a notification may be transmitted to the user (e.g., via display interface **216**, or audio speaker **210**). For example, if the trigger condition—at act **704**—corresponds to a routine test to check for the presence of a protective case **130** (e.g., automated or user-induced), the user may be immediately notified, or alerted, where no protective case **130** is detected. Accordingly, this can allow the user to take pre-emptive action to apply a protective case **130** before the device is damaged.

In various cases, the output may vary based on the trigger condition at act **704**. For example, where the trigger condition is a trigger event (e.g., a drop, or impact event), case detection application **602** may be configured to automatically transmit the output to a third-party computing device associated with a warranty provider, or otherwise, store the output (and associated data) in a portion of memory **206** that is inaccessible (or unalterable) by the device user. Otherwise, where the trigger condition is an automated trigger which is used to monitor for the presence of a protective case **130** for the benefit of the user, the output can be a visual or audio notification to the user where no protective case **130** is detected. In some cases, memory **206** can store a look-up table that includes trigger conditions, and corresponding forms of output at act **718**.

Referring now to FIG. **9**, there is shown an example process flow for a method **900** for detecting the presence a protective case **130** on the electronic device **100**, according to some other embodiments. The method **900** can be implemented, for example, by the processor **202** executing case detection application **602** (e.g., sensor processing application **602***b* in FIG. **6**)

In particular, the method **900** is generally analogues to the method **700**, with the exception that the presence—or absence—of a protective case **130** is determined by analyzing sensor data generated during device vibration, rather than analyzing vibration-induced sound data. To this end, it has been appreciated that the presence of a protective case **130** on the electronic device **100** can impact sensor data generated during device vibration. For example, motion and orientation sensor data (e.g., generated by an accelerometer or gyroscope) may vary between devices which have, or do not have, an applied protective case **130**.

As shown, acts **902**—**906** of method **900** are generally analogous to acts **702**-**706** of method **700**. At act **908**, however, rather than monitoring the microphone **212** for vibration-induced sound, case detection application **602** can monitor sensor data generated by one or more sensors **214**. For example, in some embodiments, case detection application **602** can monitor linear acceleration data generated by a three-axis accelerometer, or rotational acceleration data generate by a three-axis gyroscope.

At act **910**, the sensor data is analyzed to extract one or more features, and determine one or more feature-specific values. In particular, act **910** is analogous to act **710** of FIG. **7**, but with respect to sensor data rather than audio data.

At act **912**, the feature-specific values are compared to feature-specific values determined from baseline sensor datasets. In particular, the baseline sensor datasets can be generated in a similar manner as previously described in relation to act **712** of FIG. **7**. For example, baseline accelerometer and/or gyroscope data can be generated for a positive test case (e.g., a protective case **130** is applied), a negative test case (e.g., no protective case **130** is applied).

At acts **912** and **914**, based on the degree of similarity between the feature-specific values and the baseline datasets, the recorded sensor data is classified as corresponding to a device with, or without, a protective case **130**.

Referring now briefly to FIGS. **10** and FIG. **11**. FIG. **10** shows example plots for baseline amplitude values for linear acceleration data (e.g., accelerometer data) for example vibrating devices, with and without a protective case **130**, along the X-axis (plot **1000***a*), Y-axis (plot **1000***b*), and Z-axis (plot **1000***c*). FIG. **11** shows example plots for baseline values for rotational acceleration data (e.g., gyroscope data) for example vibrating devices, with and without a protective case **130**, in the X-axis (plot **1100***a*), Y-axis (plot **1100***b*), and Z-axis (plot **1100***c*). In particular, the axes in the plots shown in FIGS. **10** and **11** are defined as shown in FIGS. **4**A and **4**B.

As shown in each of the plots of FIGS. **10** and **11**, the acceleration and gyroscope data generated for the positive case (e.g., with a protective case **130**) is more pronounced in contrast to when a protective case **130** is not present (e.g., a negative case).

Referring now to FIG. **12**, there is shown an example embodiment of process flow for a method **1200** for automatically detecting the presence of a protective case **130** on the electronic device **100** by vibrating the device using an audio tone, rather than using the vibration device **208**. The method **1200** can be performed, for example, by the processor **202** executing an case detection application **602** (e.g., sensor processing application **602***b*).

In particular, the method **1200** is generally analogous to method **900**, with the exception that—at act **1206**—vibration is not induced by a vibration device **208**, but rather, is induced by generating an audio tone, i.e., via the audio speaker **210**.

More specifically, at act **1206**, the case detection application **602** can control the audio speaker **210** to generate an audio tone (e.g., a single frequency sine wave), having a pre-determined frequency (e.g., 100 Hz to 20 kHz), with the range of frequencies being limited only by the capabilities of the device's audio speaker **210**. The audio speaker **210** is controlled, for example, based on a system call or an API call to the operating system. In some cases, more than one audio frequency is played (e.g., 100 Hz, 250 Hz, 440 Hz, 1 KHz and 10 KHz) for a pre-determined period of time (e.g., 1-5 seconds per frequency tone), at the maximum allowed volume of audio speaker **210**. In some cases, generating more than one audio frequency may increase the accuracy of the system as relying on multiple frequencies allow for a wider array of possible extracted feature-specific values, and a greater ability to identify whether or not a protective case **130** is applied.

Similar to act **908** of FIG. **9**, at act **1208**, case detection application **602** can monitor sensor data generated by vibration of the device resulting from the one or more frequency audio tones. For example, the case detection application **602** can monitor three-axis linear acceleration data generated by an accelerometer, or three-axis rotational acceleration data generated by a gyroscope.

At act **1210**, the sensor data is analyzed to extract one or more features, and feature-specific values. The determined feature-specific values are then compared to a baseline sensor dataset, which may be generated in a similar manner as described previously at acts **712** of FIG. **7** and act **912** of FIG. **9**. Where more than one frequency audio tone is generated, features and feature-specific values can be extracted for each frequency tone, and compared to a corresponding baseline dataset for that specific frequency tone.

At acts **1212** and **1214**, the feature-specific values are compared to the baseline datasets to classify—at act **1216**—the sensor data as corresponding to a device with, or without, a protective casing. At act **1218**, an output may then be generated, based on the comparison.

Referring now briefly to FIGS. **13** and FIG. **14**. FIG. **13** shows example plots for baseline amplitude values—with and without a protective case **130**—for acceleration data in the X-axis (plot **1300***a*), Y-axis (plot **1300***b*), and Z-axis (plot **1300***c*) resulting from vibration induced by a 10 KHz audio tone. FIG. **14** shows example plots for baseline amplitude values—with and without a protective case **130**—for acceleration data in the X-axis (plot **1400***a*), Y-axis (plot **1400***b*), and Z-axis (plot **1400***c*) generated from vibration induced by a 100 Hz audio tone. As shown, in each case, the difference between the recorded acceleration values is most pronounced along the Y-axis. Further, the positive case (e.g., protective case **130**) has a generally greater acceleration amplitude than the negative case (e.g., no protective case **130**).

Referring now to FIGS. **15**A and **15**B. FIG. **15**A illustrates an example electronic device **100**, resting on a level surface **1502**, without a protective case **130**. FIG. **15**B illustrates an example electronic device **100**, resting on a level surface **1502**, with a protective case **130**.

As shown, electronic devices **100** often include one or more protruding parts—or otherwise—parts that extend beyond the enclosing body of the electronic device **100** (e.g., a protruding rear camera **1504**). When the device is placed on a level surface, the protruding parts can tilt the electronic device **100** at an angled inclination, relative to the level surface. For example, as shown in FIG. **15**A, an electronic device **100** without the protective case **130** sits at a tilt angle ((p) **1506** relative to the horizontal surface **1502**. However, in many cases, when a protective case **130** has been applied to the device, the case may cover over the protruding part. For example, as shown in FIG. **15**B, the protective case **130** can encapsulate the rear camera **1504**, such that the device **100** now rests almost parallel to the surface **1502**.

In view of the foregoing, it has been appreciated that determining whether or not a protective case **130** is applied to an electronic device **100** may be based on detecting the resting inclination or tilt of the device. Further, as provided herein, it has also been appreciated that various surrounding environmental parameters can also be monitored and measured, while the device is in a resting state, to determine the presence of a protective case **130**.

Referring now to FIG. **16**, there is shown an example embodiment of a process flow for a method **1600** for automatically determining the presence of a protective case **130** based on monitored sensor data. The method **1600** can be performed, for example, by the processor **202** executing case detection application **602** (e.g., sensor processing application **602***b*).

In particular, the method **1600** is generally analogous to the method **900** of FIG. **9** and/or method **1200** of FIG. **12**, with the exception that the method **1600** does not activate vibration device **208** or the audio speaker **210**. Rather, at act **1606**, responsive to detecting the trigger condition, the case detection application **602** automatically commences to monitor sensor data for a pre-determined time threshold (e.g., 1-5 seconds). For example, as shown in FIGS. **15**A and **15**B, the case detection application **602** can monitor accelerometer data to determine whether the device is tilted (i.e., inclined) on a level surface. In other cases, case detection application **602** can also monitor other sensor data, including temperature sensor data, light data, light sensor data, etc. For example, in various cases, optical (i.e., light) sensor data may be used to determine the presence of a protective case **130**. In particular, the presence of a case may increase the distance between the electronic device **100** (e.g., the camera and flash components), and the resting surface, thereby varying optical surface reflection from activating the flash between cases where protection is, or is not present. Acts **1608** to **1616** of method **1600** are then generally analogous to acts **910** to **918** of method **900**, or acts **1210** to **1218** of method **1200**.

Referring now to FIG. **17**, there is shown an example embodiment fora process flow for a method **1700** for automatically detecting the presence of a protective case **130** on an electronic device **100**. In particular, method **1700** provides for an integrated combination of method **700** of FIG. **7**, method **900** of FIG. **9**, method **1200** of FIG. **12** and method **1600** of FIG. **16**.

In particular, as shown, at act **1702**, the case detection application **602** can initially determine whether the electronic device **100** includes one or more of a vibration device **208**, a microphone **212**, an audio speaker **210** and/or sensors **214** (e.g., motion or orientation sensors). As provided herein, this determination can allow the case detection application **602** to determine which of methods **700**, **900**, **1200** or **1600** to use in detecting the presence of a protective case **130** on the electronic device **100**.

In various embodiments, the determination at act **1702** is made—by the case detection application **602**—via an API (Application Programming Interface) call, or system call, to the device. In particular, the API or system call can confirm that the electronic device **100** includes a vibration device **208**, a microphone **212**, an audio speaker **210** or one or more relevant sensors **214**. Responsive to the API/system call, the operating system may return a Boolean response (true/false) in respect of each query for each system device. In other cases, the API/system call may simply provide a list of all supported features on the device **100**. Accordingly, in these cases, the case detection application **602** can iterate over the returned list and compare each element of the list with the features of interest (e.g., a microphone, audio speaker and/or specific sensors), to determine if the features are supported. In this manner, the logic of the determination at act **1702** may vary based on the specification of the API provided by the corresponding device operating system.

Based on the sub-device component data received at act **1702**, at act **1704**, the case detection application **602** can initially determine whether the device includes at least a vibration device **208** and a microphone **212**.

If so, at act **1706**, the case detection application **602** can further determine—based on information received at act **1702**—whether the device also includes relevant sensors (e.g., accelerometers and gyroscopes).

If not, at act **1708**, the case detection application **602** can perform the method **700** of FIG. **7**, using only the detected vibration device **208** and microphone **212** to detect the presence of a protective case **130** on the electronic device **100**.

Otherwise, at act **1710**, if both sensors and a microphone are detected, the case detection application **602** can perform one or more of method **700** of FIG. **7** (e.g., using the microphone **212**), and method **900** of FIG. **9** (e.g., using the sensor data) to determine the presence of a protective case **130** through device vibration. In some cases, a combination of methods **700** and **900** can also be used to increase protective case detection accuracy. For example, a combination (e.g., weighted or unweighted) of the results of each method can be used to determine final output result.

At act **1704**, if a microphone and vibration device are not detected—then at act **1712**, the case detection application **602** can determine if sensors **212** and an audio speaker **210** are detected.

If so, at act **1714**, the case detection application **602** can perform method **900** of FIG. **9** using the audio speaker **210** to induce device vibration, and the sensors **212** to detect the vibration and the presence of a protective case **130**. Otherwise if no audio speaker is detected at act **1712**, at act **1716**, the case detection application **602** can further determine if the device includes at least one or more sensors **214**. If so, the case detection application **602** can execute act **1718**, wherein the method **1200** of FIG. **12** is performed using only position and/or environmental sensor data to detect a protective case **130**. Otherwise, if no microphone, audio speakers or sensors are detected, the method can end at act **1720**.

In the illustrated embodiment, the presence of the microphone, sensors and audio speaker is initially determined at act **1702**. However, in other cases, this check can also be performed at the relevant act in method **1700**. For example, the presence of the microphone may be confirmed at act **1704**, and the presence of sensors may be separately confirmed at act **1706** and/or act **1712**, as the case may be.

It will also be appreciated that the order of actions in method **1700** is only shown by way of example, and that the determinations at acts **1704**, **1706**, **1712** and **1716**, can be performed in any other order while accomplishing the same result. For example, the case detection application **602** can first determine, at act **1704**, whether the device includes one or more sensors, and then subsequently, at act **1706**, determine whether the device additionally includes a microphone, etc.

In some embodiments, method **1700** is performed during an application initialization stage. For example, once the application is installed on the device (or anytime thereafter), the application may run a check in accordance with method **1700**. Based on the check, the case detection application **602** may select the appropriate method for when a trigger condition is detected. In other cases, method **1700** can be performed only after a trigger condition is detected (e.g., act **704** in method **700**, act **904** in method **900**, act **1204** in method **1200** and/or act **1604** in method **1600**).

Referring now to FIG. **18**, there is shown a method **1800** for training a machine learning model for detecting whether or not a protective case **130** is applied to an electronic device **100**. In various cases, the trained machine learning model can be used to analyze features, and feature-specific values, extracted from sound data (FIG. **7**) and/or sensor data (FIGS. **9**, **12** and **16**). For example, a trained machine learning model can be stored in memory **206**, and used in place of acts **712**-**714** (FIG. **7**), acts **912**-**914** (FIG. **9**), acts **1212**-**1214** (FIG. **12**) and acts **1610**-**1612** (FIG. **16**) to determine the presence of a protective case **130**. In various cases, a separate or single machine learning model can be generated for use in each of methods **700**, **900**, **1200** and **1600**.

The method **1800** can be carried out, for example, by a case detection application **602** executing on a processor **202** of electronic device **100**. In other cases, the method **1800** can be performed on an external/remote processor (e.g., an external server).

At act **1802**, training datasets are received for training the machine learning model. In particular, training datasets used at act **1802** may be analogous to the baseline sound and/or sensor data previously described in relation to act **712** of method **700**, act **912** of method **900**, act **1212** of method **1200**, and act **1610** of method **1600**. That is, the training data can correspond to example sound and/or sensor data for cases where a protective case **130** is applied, or otherwise not applied. The type of training data used can depend on which of methods **700**, **900**, **1200** or **1600** the machine learning model is trained to execute. In various cases, a plurality of training datasets are generated, wherein each dataset corresponds to a different set of test conditions (i.e., as described previously in relation to generating baseline datasets) when a protective case was applied, or otherwise is not applied, to the electronic device **100**.

In some cases, as previously explained, the sample training data (e.g., baseline data) may be pre-generated (e.g. by an application developer). For example, method **1800** may be performed remotely, off-line to generate trained machine learning models. Otherwise, as explained, the case detection application **602** may guide the user through the process of generating the baseline (or training) data on the device **100**.

At act **1804**, one or more features, and feature-specific values are extracted from the training data. For example, this is performed as previously explained in relation to act **710** of FIG. **7**, act **910** of FIG. **9**, act **1210** of FIG. **12**, or act **1608** of FIG. **16**.

At act **1806**, feature vectors are generated based on the extracted feature-specific values. In particular, for each training dataset, a the feature vector can be generated that can include feature-specific value data (e.g., feature-specific values) extracted from features corresponding to that training dataset.

Each feature vector can also include a "label" indicating whether the extracted feature-specific values correspond to a training dataset that was generated by applying a protective casing, or no protective casing. The labelled feature vectors are then used to train the machine learning model to map between feature-specific values, and cases where a protective case **130** was applied or not applied.

At act **1808**, a trained machine learning model is generated based on the input data (e.g., labeled feature vectors).

In various cases, to train the machine learning model, a supervised machine learning algorithm is applied. In particular, the supervised learning model can split the set of training data samples into two disjoint sets: the training set and the test set. The samples in the training set are given as input to the algorithm to develop the mathematical model, and the samples in the test set are then used to evaluate the developed model, e.g. evaluate what percentage of the samples in the test set, if the sample is given as input to the model, the model classifies the sample correctly. Techniques such as 10-fold cross validation can be used for this purpose. Accordingly, the trained machine learning model can then be used on training data, and can act as a binary classifier classify input sensors sample data into two mutually exclusive classes: with protective case **130** (positive class) and without protective case **130** (negative class).

Referring now to FIG. **19**, which shows a simplified block diagram of an example embodiment of a system environment **1900** for use in determining whether a protective case **130** is applied to an electronic device **100**.

As shown, the system **1900** includes the electronic device **100** which is connected, via network **1902** to a remote server **1904**. The server **1904** may include a server processor coupled to a server memory and/or a server communication interface (not shown). While the server **1904** is shown as a physical device, it will be appreciated that the server **1904** may be a cloud server. It will also be appreciated that while only a single server **1904** is illustrated, the system **1900** can include more than one server.

In some embodiments, the server memory may store a software program, which when executed by the server processor, is configured to—at least partially—execute any one of the methods provided herein (e.g., method **700**, **900**, **1200** and/or **1600**).

For example, in some cases, the server **1904** can receive—via network **1902**—sound and/or sensor data in real-time, or near real-time, from device **100**. For example, the electronic device **100** may automatically—or upon request from the server **1904**—transmit sound and/or sensor data via communication interface **204** after detecting a trigger condition. The data may then be received by the server's communication interface, via network **1902**. Based on the received data, the server **1904** may perform acts **710**-**718** of FIG. **7**, acts **910** — **918** of FIG. **9**, acts **1210**-**1219** of FIG. **12**, acts **1608**-**1616** of FIG. **16**.

In other cases, the server **1904** may simply receive the output of each of methods **700**, **900**, **1200** and/or **1600**. In some embodiments, the server **1904** may be associated with a warranty provider, and accordingly, the received outputs can be used to validate a warranty claim.

In other embodiments, the server **1904** can be used to host a trained a machine learning model (e.g., method **1800** of FIG. **18**), which can be used to determine the presence of a protective case **130** on a device based on received sound and/or sensor data. In other cases, the trained machine learning model can be pushed (e.g., transmitted) to one or more electronic devices for storage on device memory **206**. For example, server **1904** may update and refine the model based on collective (e.g., aggregated) data and outputs received from a plurality of electronic devices, and may occasionally transmit the updated models to one or more devices **100** for use in determining the presence of a protective case **130**.

Network **1902** may be connected to the internet. Typically, the connection between network **1902** and the Internet may be made via a firewall server (not shown). In some cases, there may be multiple links or firewalls, or both, between network **1902** and the Internet. Some organizations may operate multiple networks **1902** or virtual networks **1902**, which can be internetworked or isolated. These have been omitted for ease of illustration, however it will be understood that the teachings herein can be applied to such systems. Network **1902** may be constructed from one or more computer network technologies, such as IEEE 802.3 (Ethernet), IEEE 802.11 and similar technologies.

While the above description describes features of example embodiments, it will be appreciated that some features and/or functions of the described embodiments are susceptible to modification without departing from the spirit and principles of operation of the described embodiments. For example, the various characteristics which are described by means of the represented embodiments or examples may be selectively combined with each other. Accordingly, what has been described above is intended to be illustrative of the claimed concept and non-limiting. It will be understood by persons skilled in the art that other variants and modifications may be made without departing from the scope of the invention as defined in the claims appended hereto. The scope of the claims should not be limited by the preferred embodiments and examples, but should be given the broadest interpretation consistent with the description as a whole.

The invention claimed is:

1. An electronic device for detecting the presence of a protective case on the electronic device, the electronic device comprising:

one or more sensors;

a device memory storing an application including programs instructions for performing a method for detecting the presence of the protective case;

a device processor coupled to the device memory and the one or more sensors, the device processor, upon execution of the application, being configured to:

monitor, via at least one first sensor of the one or more sensors, a trigger condition for detecting the presence of the protective case;

detect the trigger condition;

in response to detecting the trigger condition, cause the electronic device to vibrate for a pre-determined period of time;

collect, via at least one second sensor of the one or more sensors, sensor data during the pre-determined time;

extract at least one feature from the sensor data;

based on the extracted at least one feature, determine whether the protective case is applied to the electronic device; and

generate an output indicating whether the protective case is applied to the electronic device.

2. The electronic device of claim **1**, wherein the trigger condition comprises detecting a sensor value, generated by the at least one first sensor, that is greater than a pre-determined sensor value threshold.

3. The electronic device of claim **1**, wherein the electronic device further comprises a vibrating device, and causing the device to vibrate comprises activating the vibrating device.

4. The electronic device of claim **1**, wherein the electronic device further comprises an audio speaker, and when the electronic device is caused to vibrate the device processor further activates the audio speaker to emit an audio tone.

5. The electronic device of claim **1**, wherein the at least one first sensor comprises one or more of an accelerometer and a gyroscope, and the at least one second sensor comprises one or more of an accelerometer, gyroscope and microphone.

6. The electronic device of claim **1**, wherein the extracted feature comprises at least one of amplitude, frequency, energy and a Fast Fourier Transform (FFT) of the sensor data.

7. The electronic device of claim **1**, wherein the device processor is further configured to determine, for each extracted feature, one or more feature-specific values.

8. The electronic device of claim **7**, wherein determining whether the protective case is applied to the electronic device comprises comparing the one or more feature-specific values to at least one of baseline feature-specific values corresponding to a positive case indicating a presence of a protective case, and baseline feature-specific values corresponding to a negative case indicating an absence of a protective case.

9. The electronic device of claim **8**, wherein the comparing comprises determining a similarity measure between the one or more feature-specific values to at least one of the positive case and negative case baseline feature-specific values.

10. The electronic device of claim **1**, wherein determining whether the protective case is applied to the electronic device comprises inputting the one or more feature-specific values into a trained machine learning model.

11. A method for detecting the presence of a protective case on an electronic device, the method comprising:

monitor, via at least one first sensor of the one or more sensors of the electronic device, a trigger condition for detecting the presence of the protective case;

detect, via a device processor of the electronic device, the trigger condition;

in response to detecting the trigger condition, cause the electronic device to vibrate for a pre-determined period of time;

collect, via at least one second sensor of the one or more sensors of the electronic device, sensor data during the pre-determined time;

extract, using the device processor, at least one feature from the sensor data;

based on the extracted at least one feature, determine, using the device processor, whether the protective case is applied to the electronic device; and

generate, using the device processor, an output indicating whether the protective case is applied to the electronic device.

12. The method of claim **11**, wherein the trigger condition comprises detecting a sensor value, generated by the at least one first sensor, that is greater than a pre-determined sensor value threshold.

13. The method of claim **11**, wherein causing the electronic device to vibrate for a pre-determined period of time comprises activating a vibration device of the electronic device.

14. The method of claim **11**, wherein causing the electronic device to vibrate for a pre-determined period of time comprises activating an audio speaker of the electronic device to emit an audio tone.

15. The method of claim **11**, wherein the at least one first sensor comprises one or more of an accelerometer and a gyroscope, and the at least one second sensor comprises one or more of an accelerometer, gyroscope and microphone.

16. The method of claim **11**, wherein the extracted feature comprises at least one of amplitude, frequency, energy and a Fast Fourier Transform (FFT) of the sensor data.

17. The method of claim **11**, wherein the method further comprises determining, using the device processor, for each extracted feature, one or more feature-specific values.

18. The method of claim **17**, wherein determining whether the protective case is applied to the electronic device comprises comparing, using the device processor, the one or more feature-specific values to at least one of baseline feature-specific values corresponding to a positive case indicating a presence of a protective case, and baseline feature-specific values corresponding to a negative case indicating an absence of a protective case.

19. The method of claim **18**, wherein the comparing comprises determining, using the device processor, a similarity measure between the one or more feature-specific values to at least one of the positive case and negative case baseline feature-specific values.

20. The method of claim **11**, wherein determining whether the protective case is applied to the electronic device comprises inputting the one or more feature-specific values into a trained machine learning model stored on a device memory of the electronic device.

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