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Bowne et al.

(10) **Patent No.: US 8,930,229 B2**
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(54) **SYSTEMS AND METHODS USING A MOBILE DEVICE TO COLLECT DATA FOR INSURANCE PREMIUMS**

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(73) Assignee: **State Farm Mutual Automobile Insurance Company**, Bloomington, IL (US)

(*) 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.: **13/490,166**

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Related U.S. Application Data

(63) Continuation of application No. 13/477,793, filed on May 22, 2012, which is a continuation-in-part of application No. 13/172,240, filed on Jun. 29, 2011.

(51) **Int. Cl.**

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G06Q 10/06	(2012.01)
G06Q 10/08	(2012.01)
G06Q 40/08	(2012.01)

(52) **U.S. Cl.**

CPC ***G06Q 40/08*** (2013.01); ***G06Q 10/0639*** (2013.01); ***G06Q 10/0833*** (2013.01)

USPC **705/4**; 705/35

(58) **Field of Classification Search**

USPC 705/4, 35

See application file for complete search history.

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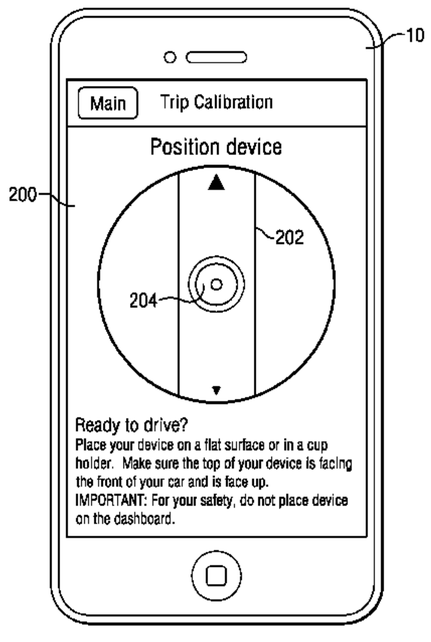
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(57) **ABSTRACT**

A system and method for determining a vehicle insurance premium for a period of time based at least in part on collected vehicle operation data, the system comprising: a mobile device, comprising: one or more sensors associated with the mobile device and configured to automatically collect vehicle operation data during a data collection session; a processor; a non-transitory storage medium; a display; a transmitter; and a set of computer readable instructions stored in the non-transitory storage medium and when executed by the processor configured to allow the mobile device to collect vehicle operation data and transmit the collected vehicle operation data; and a remote processing computer, comprising: a server that receives collected vehicle operation data; a database that stores collected vehicle operation data; and a rating engine that determines a vehicle insurance premium based at least in part on collected vehicle operation data.

19 Claims, 18 Drawing Sheets



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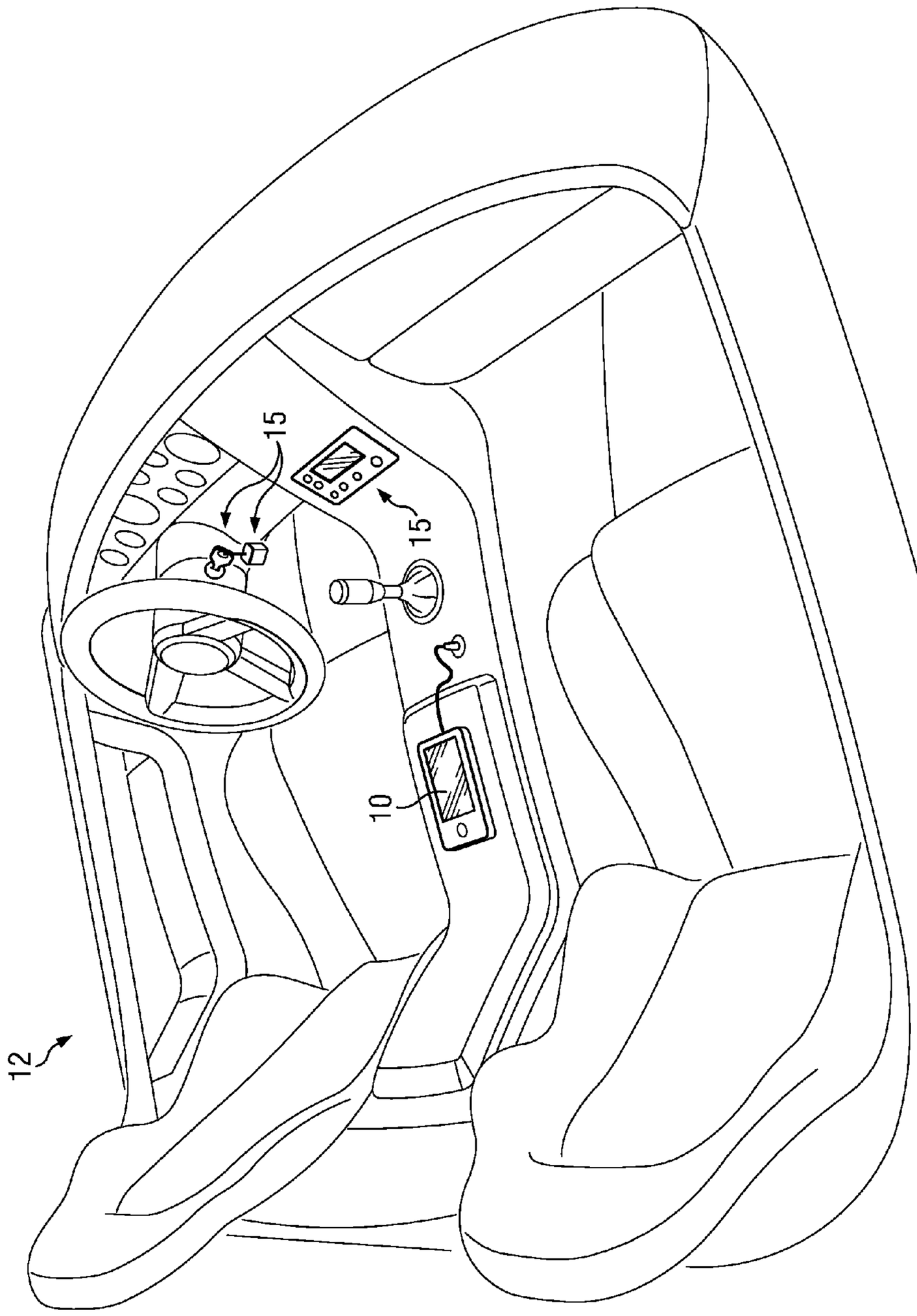


FIG. 1

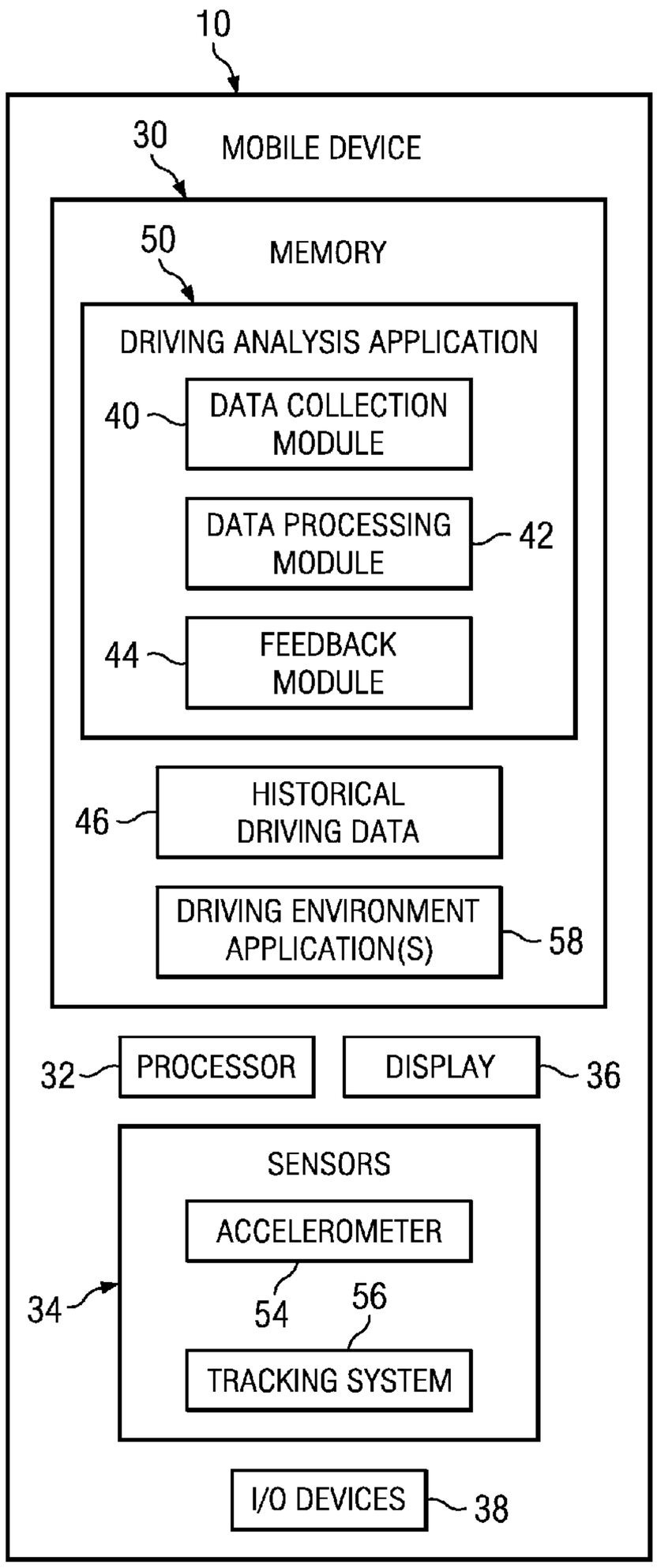

10
30
MOBILE DEVICE
50
MEMORY
DRIVING ANALYSIS APPLICATION
40
DATA COLLECTION MODULE
DATA PROCESSING MODULE
42
44
FEEDBACK MODULE
46
HISTORICAL DRIVING DATA
DRIVING ENVIRONMENT APPLICATION(S)
58
32
PROCESSOR
DISPLAY
36
SENSORS
ACCELEROMETER
34
54
56
TRACKING SYSTEM
I/O DEVICES
38

FIG. 2

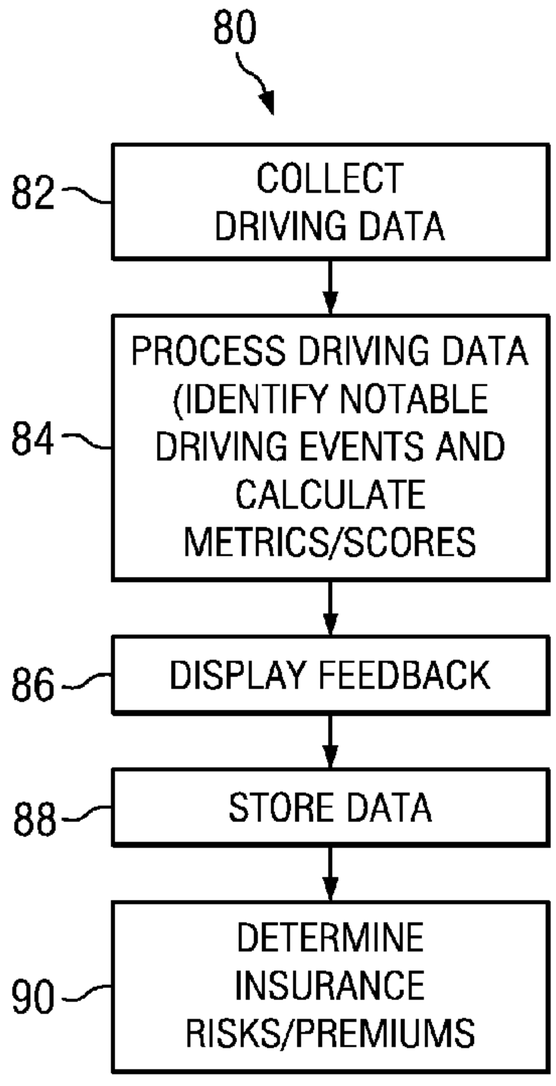

80
82
COLLECT DRIVING DATA
PROCESS DRIVING DATA (IDENTIFY NOTABLE DRIVING EVENTS AND CALCULATE METRICS/SCORES
84
86
DISPLAY FEEDBACK
88
STORE DATA
DETERMINE INSURANCE RISKS/PREMIUMS
90

FIG. 3

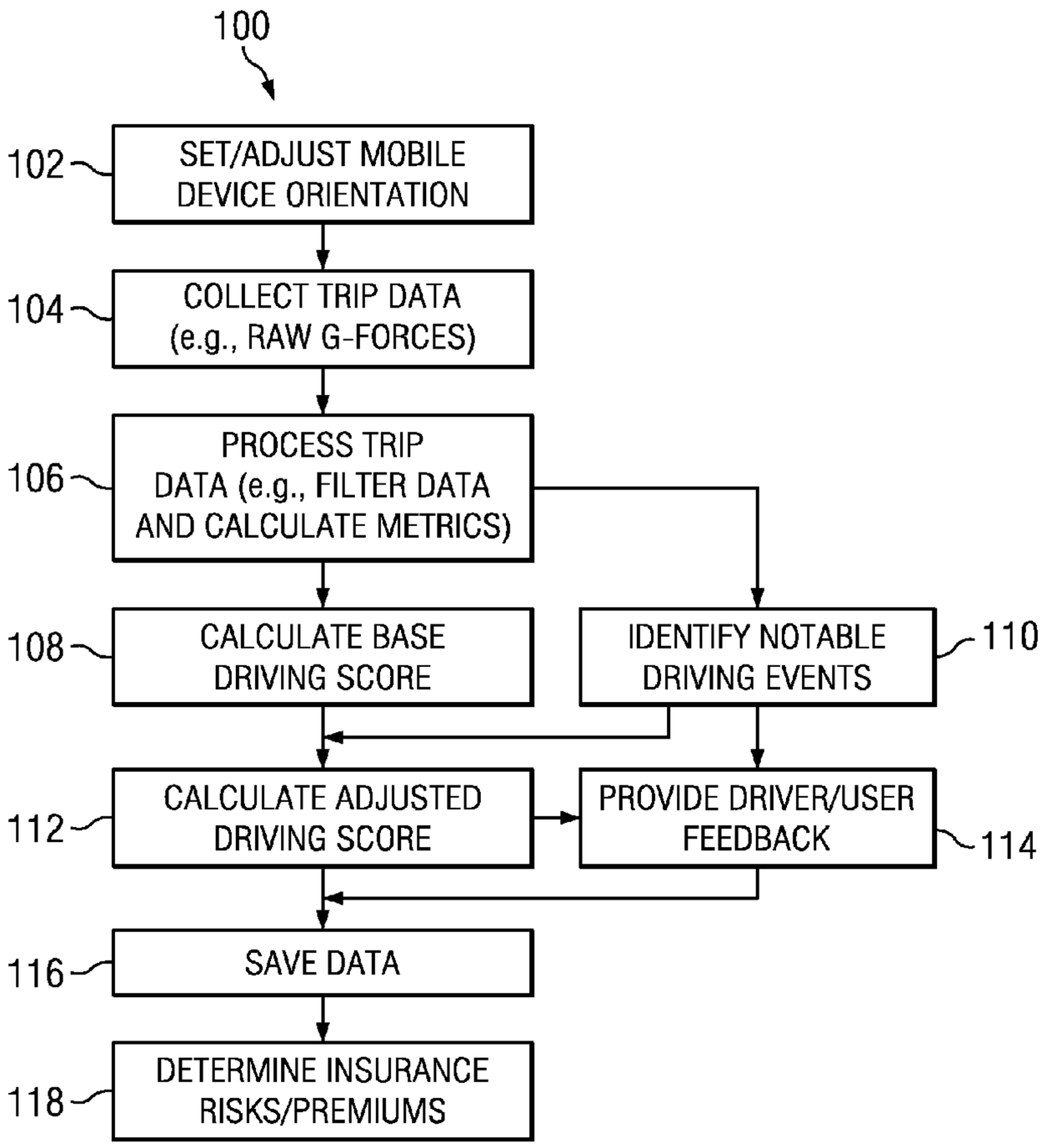

100
102
SET/ADJUST MOBILE DEVICE ORIENTATION
104
COLLECT TRIP DATA (e.g., RAW G-FORCES)
106
PROCESS TRIP DATA (e.g., FILTER DATA AND CALCULATE METRICS)
108
CALCULATE BASE DRIVING SCORE
110
IDENTIFY NOTABLE DRIVING EVENTS
112
CALCULATE ADJUSTED DRIVING SCORE
114
PROVIDE DRIVER/USER FEEDBACK
116
SAVE DATA
118
DETERMINE INSURANCE RISKS/PREMIUMS

FIG. 4

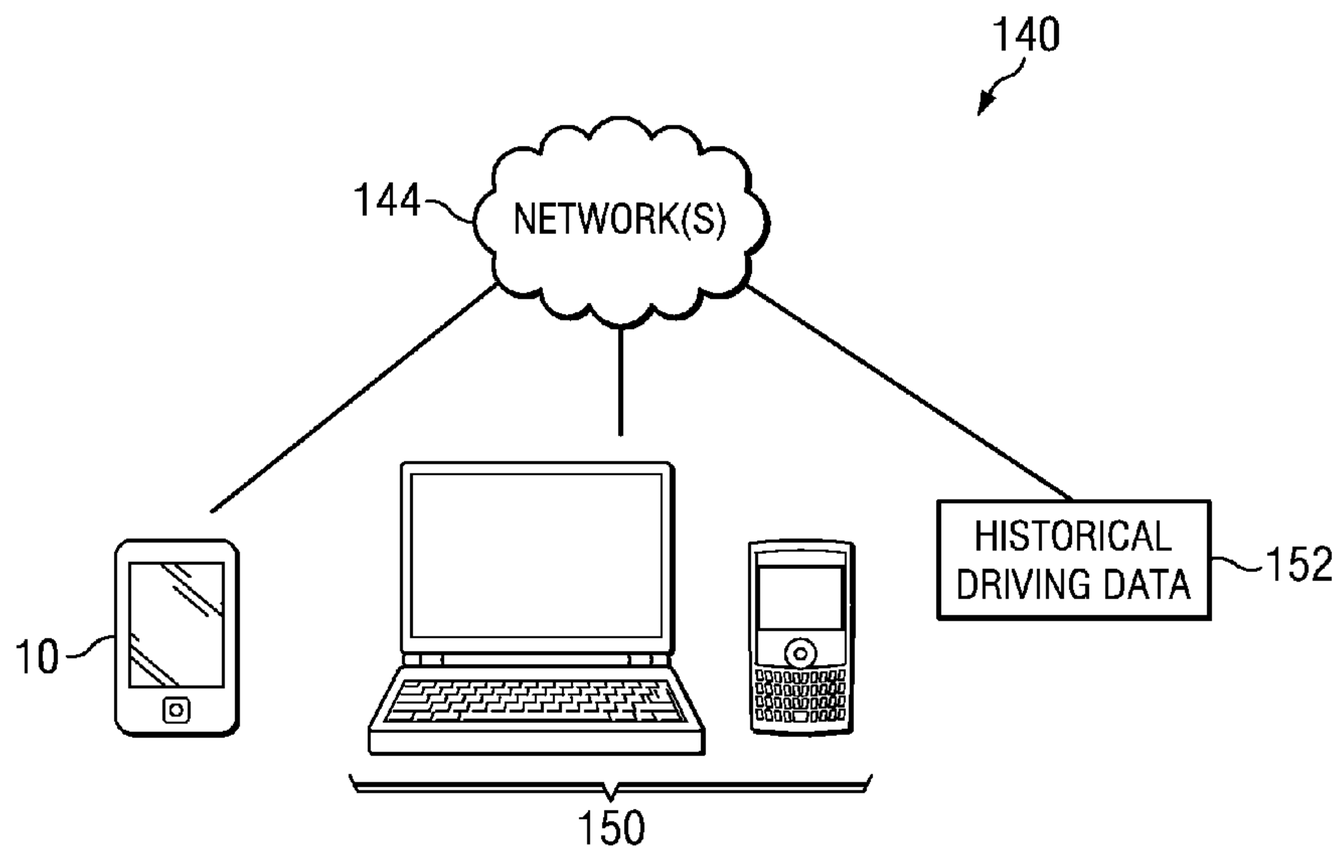

140
144
NETWORK(S)
10
150
HISTORICAL DRIVING DATA
152

FIG. 5

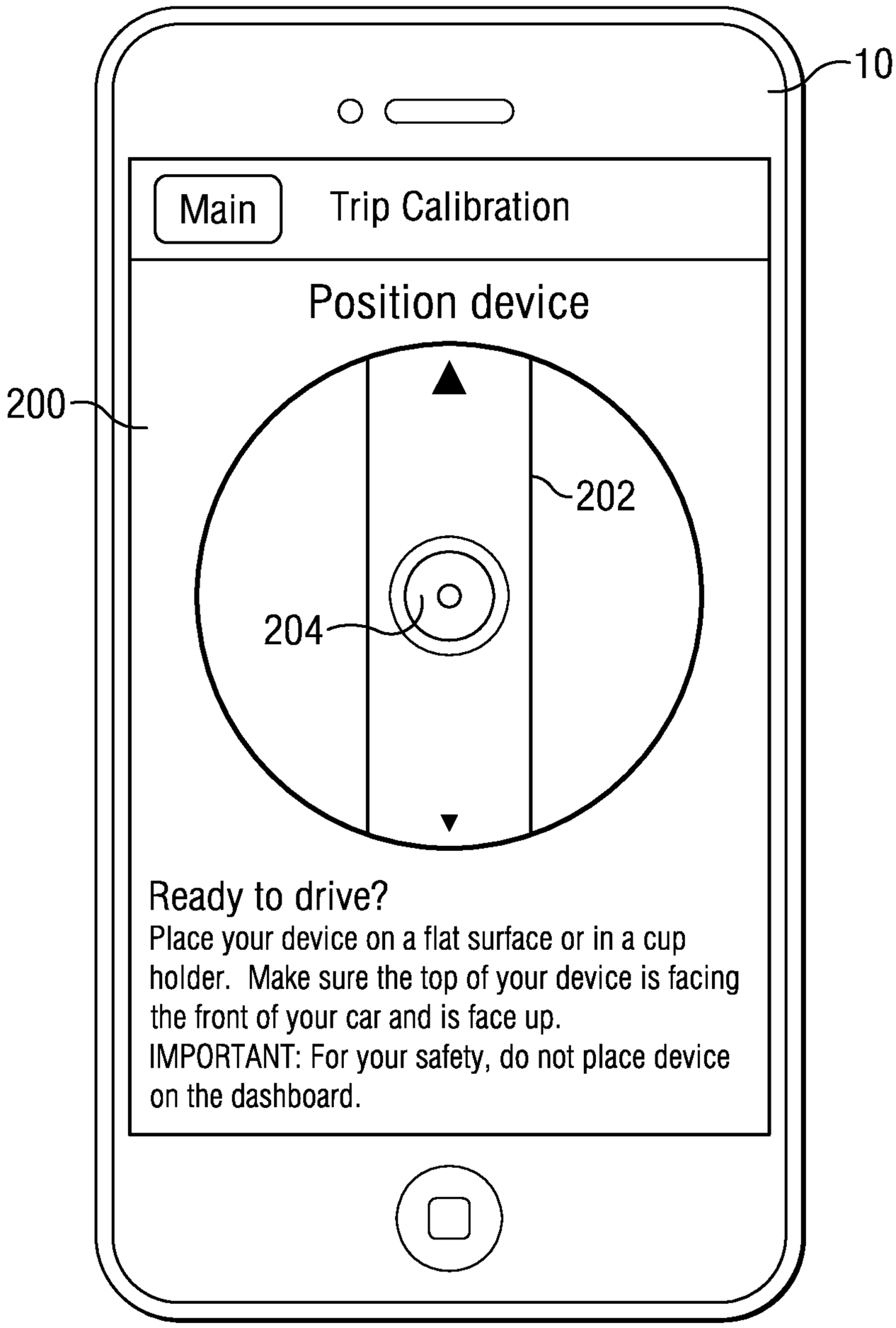

10
Main
Trip Calibration
Position device
200
202
204
Ready to drive?
Place your device on a flat surface or in a cup holder. Make sure the top of your device is facing the front of your car and is face up.
IMPORTANT: For your safety, do not place device on the dashboard.

FIG. 6A

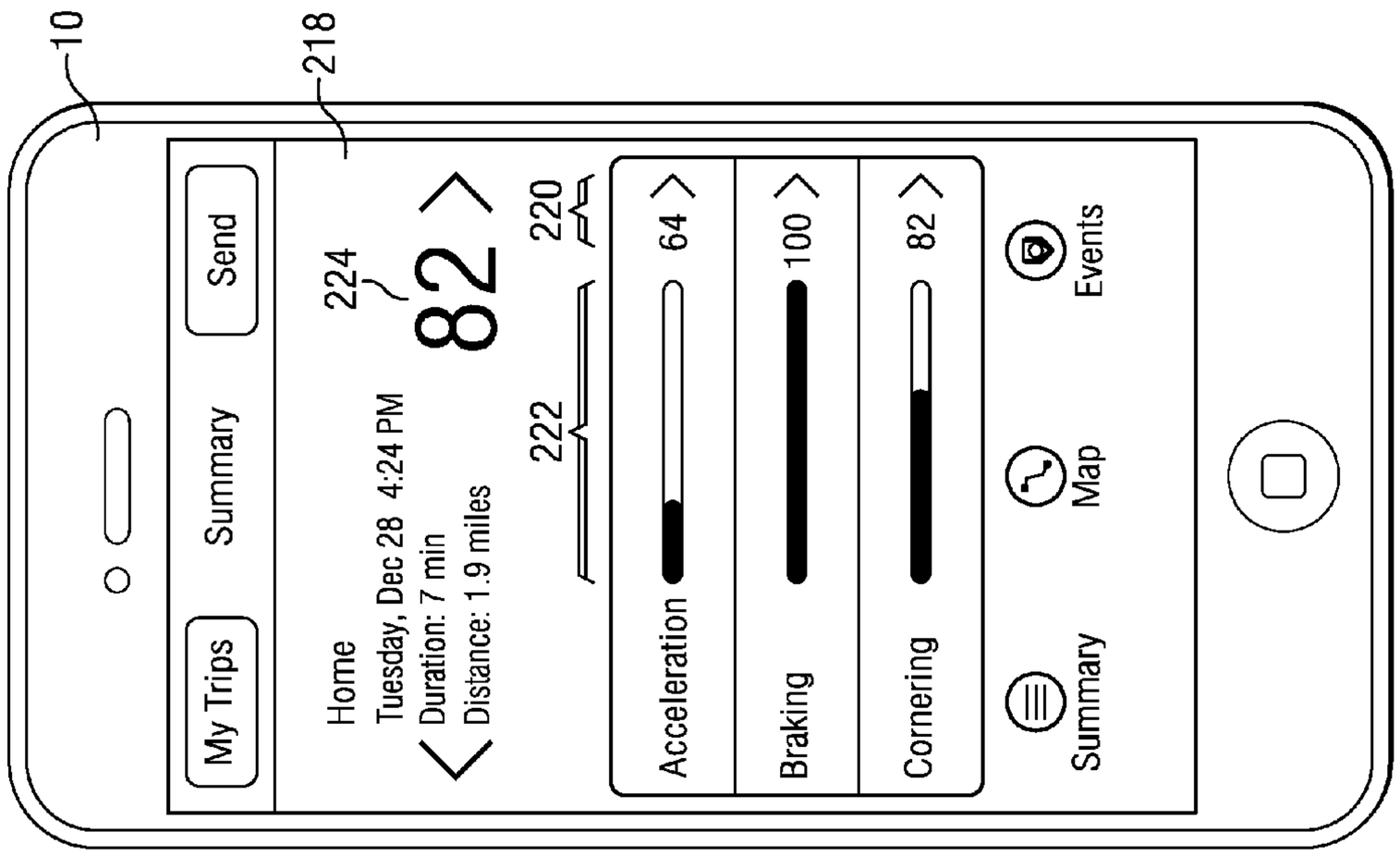

10
218
Summary
Send
My Trips
Home
Tuesday, Dec 28 4:24 PM
Duration: 7 min
Distance: 1.9 miles
224
82
220
222
Acceleration
64
Braking
100
Cornering
82
Events
Map
Summary

FIG. 6C

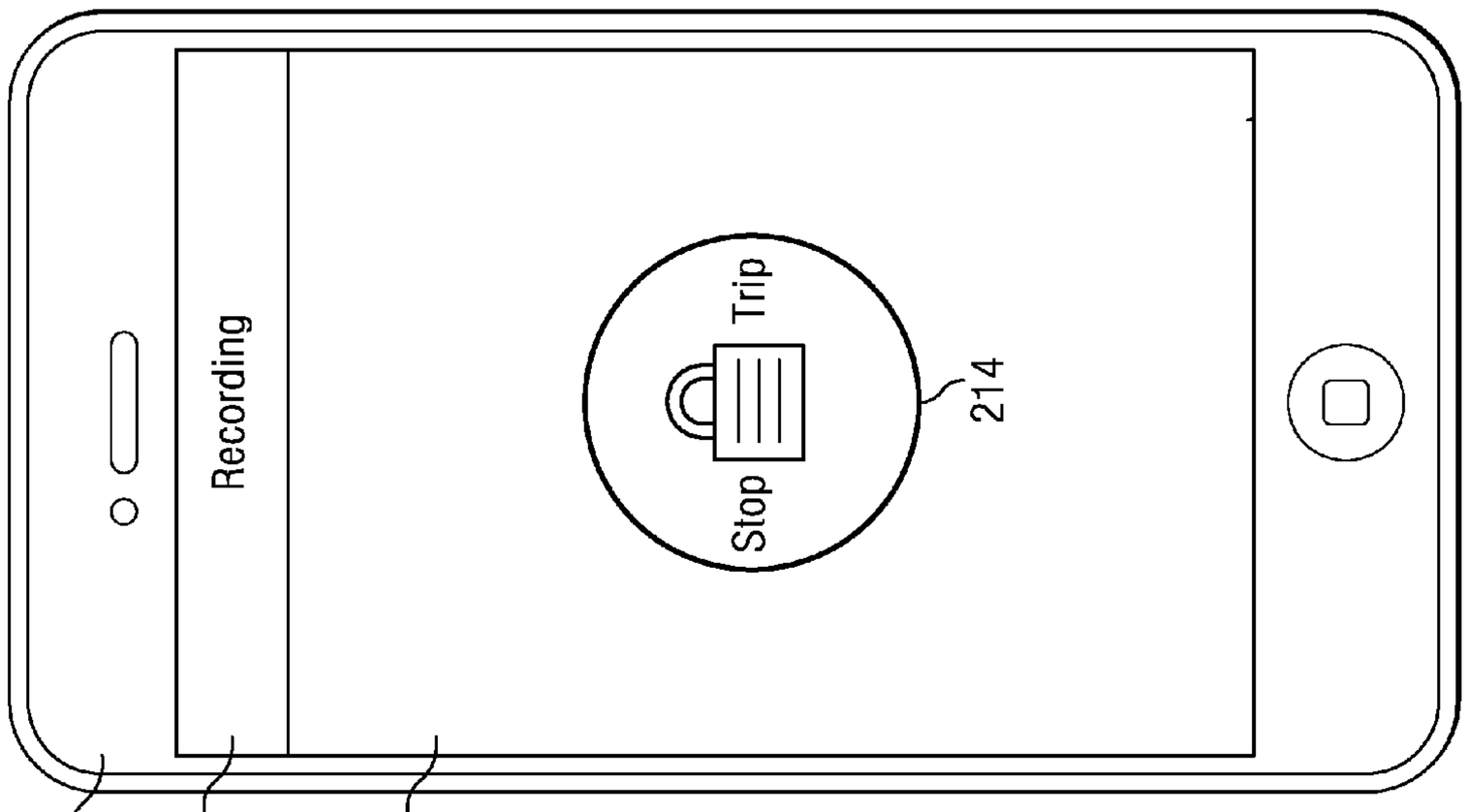

Recording
Trip
Stop
214
10
212
210

FIG. 6B

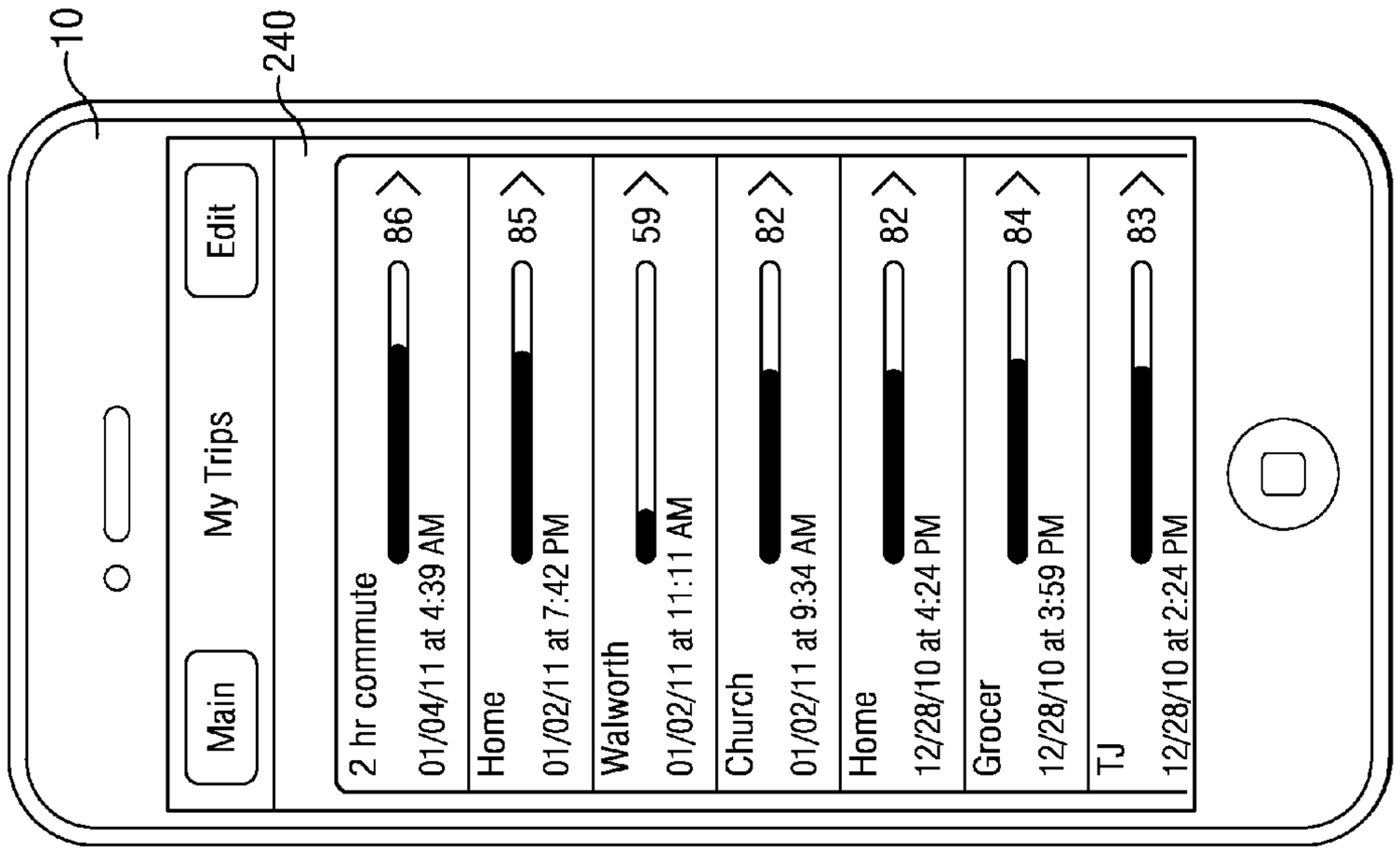

10
240
My Trips
Edit
Main
2 hr commute
01/04/11 at 4:39 AM
86
Home
01/02/11 at 7:42 PM
85
Walworth
01/02/11 at 11:11 AM
59
Church
01/02/11 at 9:34 AM
82
Home
12/28/10 at 4:24 PM
82
Grocer
12/28/10 at 3:59 PM
84
TJ
12/28/10 at 2:24 PM
83

FIG. 6E

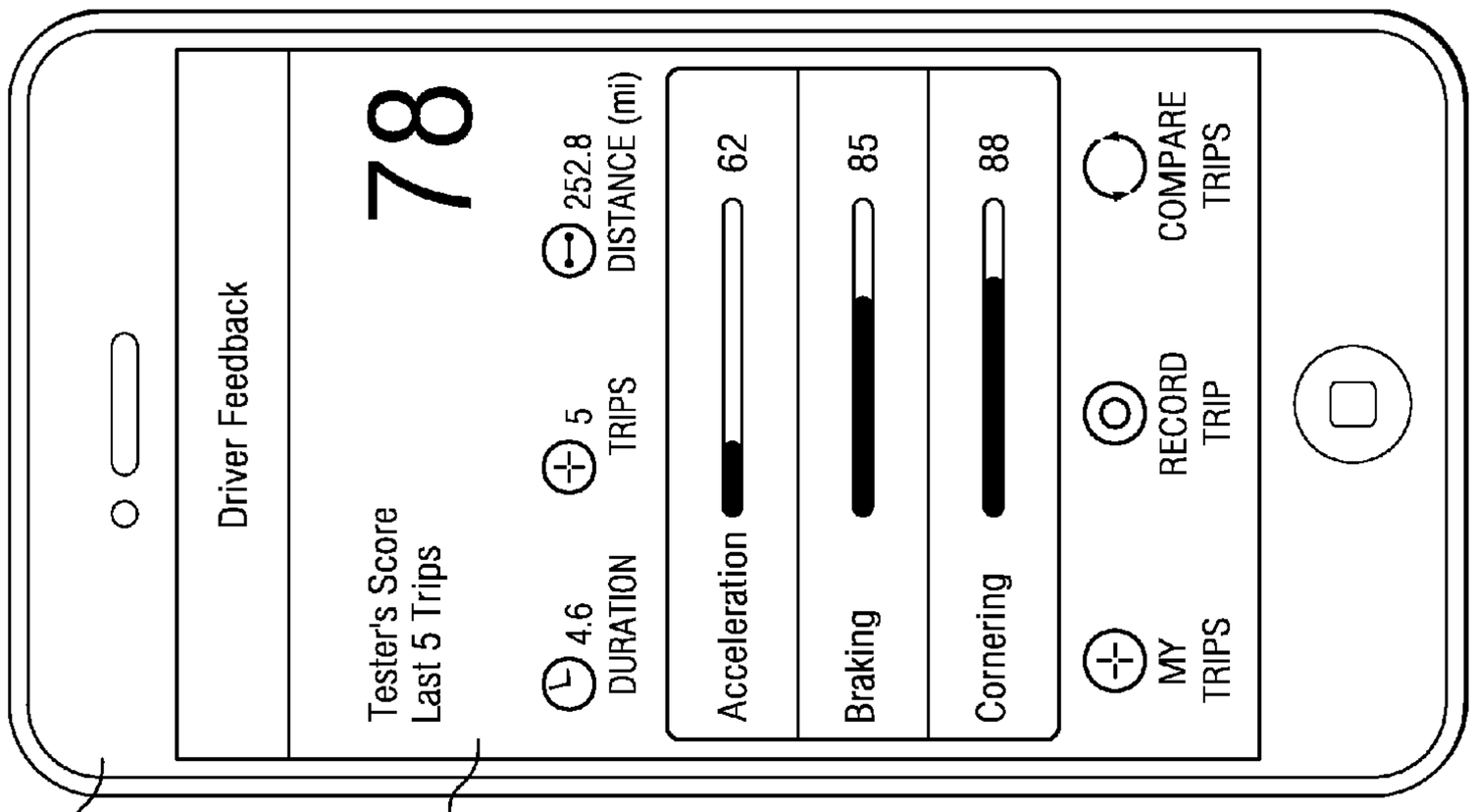

10
230
Driver Feedback
Tester's Score
Last 5 Trips
78
4.6
DURATION
5
TRIPS
252.8
DISTANCE (mi)
Acceleration
62
Braking
85
Cornering
88
MY
TRIPS
RECORD
TRIP
COMPARE
TRIPS

FIG. 6D

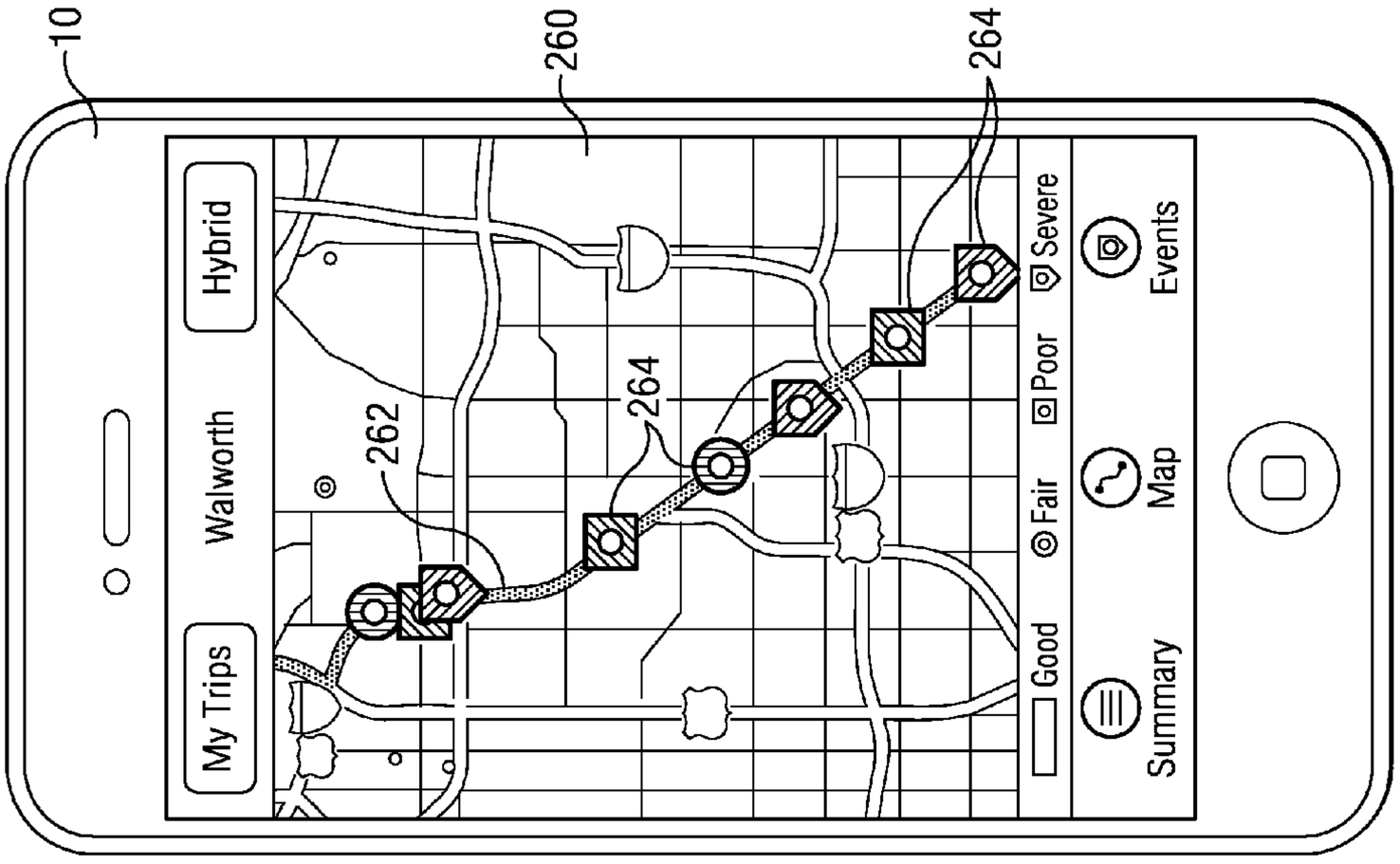

10
260
264
Hybrid
Walworth
262
264
My Trips
Severe
Poor
Fair
Good
Events
Map
Summary

FIG. 6G

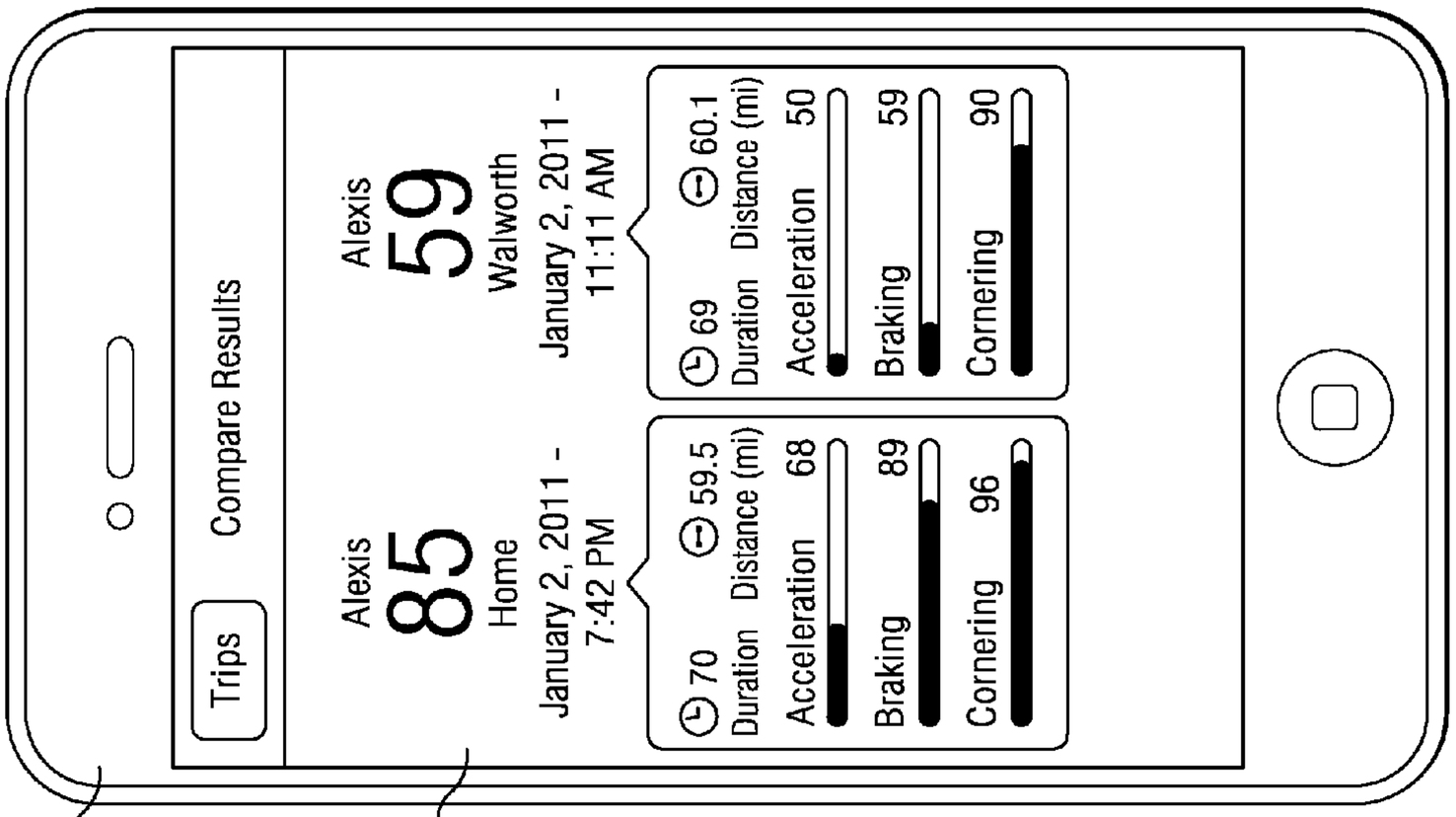

10
250
Compare Results
Trips
Alexis
59
Walworth
January 2, 2011 - 11:11 AM
69 Duration
60.1 Distance (mi)
Acceleration 50
Braking 59
Cornering 90
Alexis
85
Home
January 2, 2011 - 7:42 PM
70 Duration
59.5 Distance (mi)
Acceleration 68
Braking 89
Cornering 96

FIG. 6F

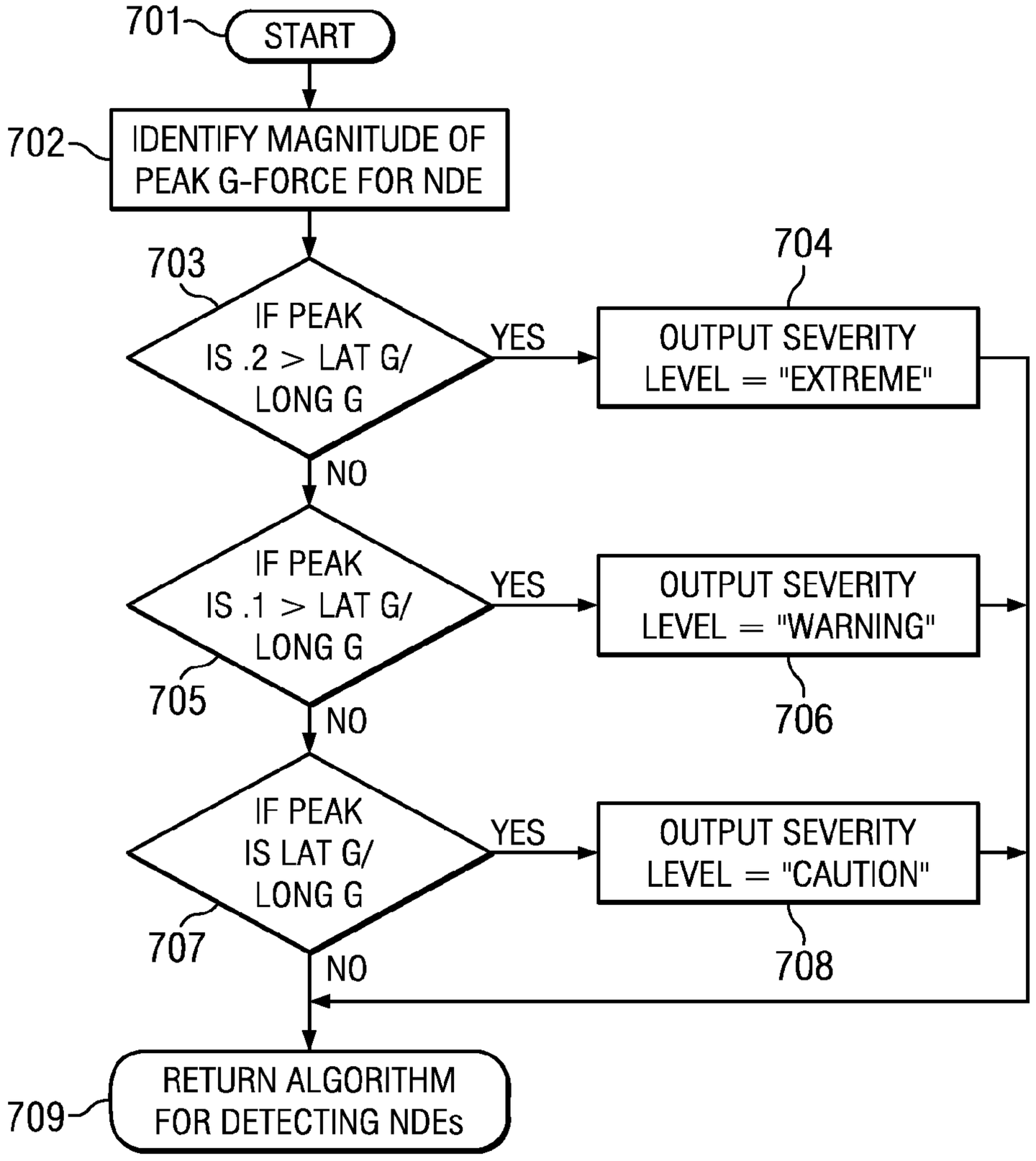

701
START
702
IDENTIFY MAGNITUDE OF PEAK G-FORCE FOR NDE
703
IF PEAK IS .2 > LAT G/ LONG G
YES
704
OUTPUT SEVERITY LEVEL = "EXTREME"
NO
IF PEAK IS .1 > LAT G/ LONG G
YES
OUTPUT SEVERITY LEVEL = "WARNING"
705
706
NO
IF PEAK IS LAT G/ LONG G
YES
OUTPUT SEVERITY LEVEL = "CAUTION"
707
708
NO
709
RETURN ALGORITHM FOR DETECTING NDEs

FIG. 7

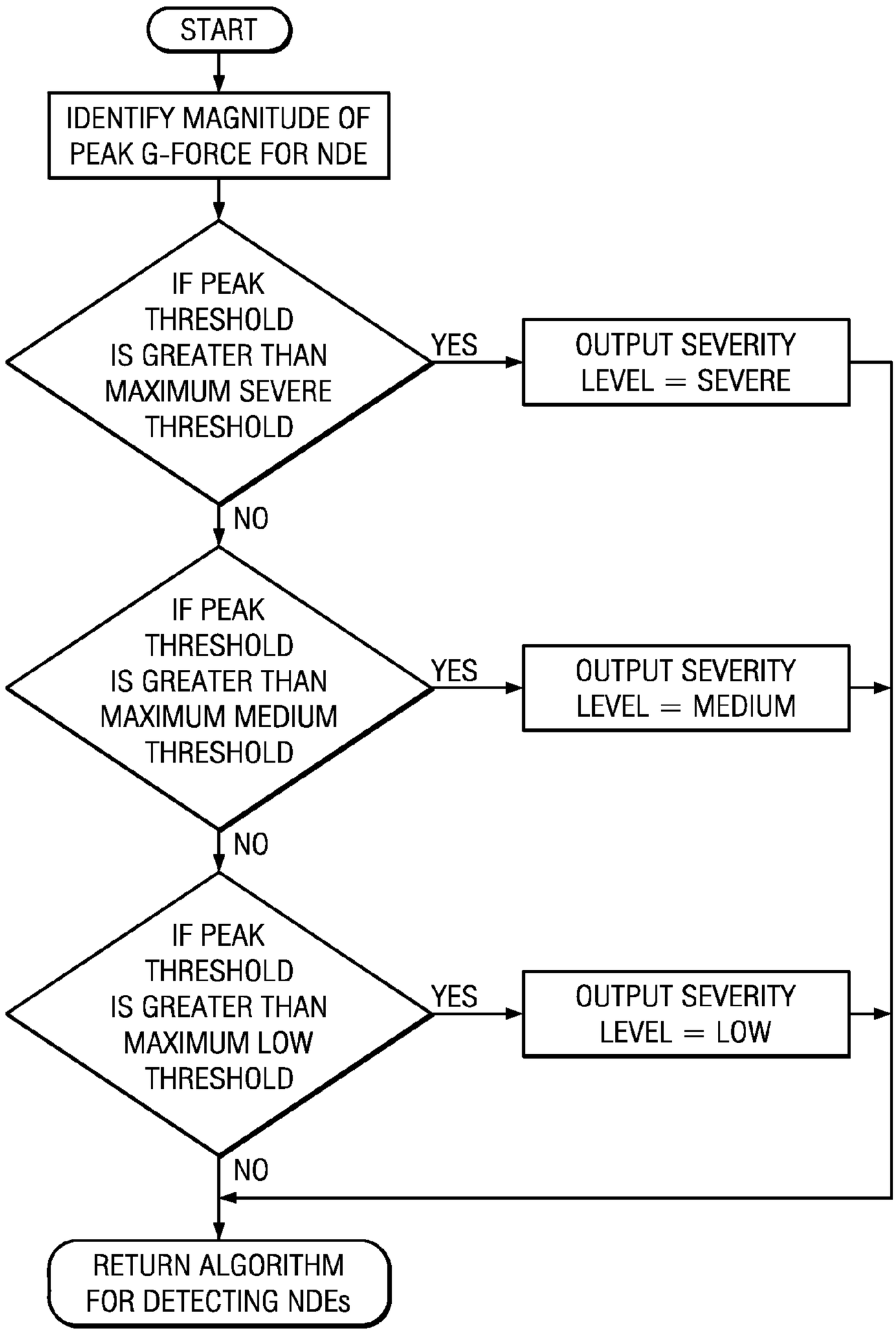

START
IDENTIFY MAGNITUDE OF PEAK G-FORCE FOR NDE
IF PEAK THRESHOLD IS GREATER THAN MAXIMUM SEVERE THRESHOLD
YES
OUTPUT SEVERITY LEVEL = SEVERE
NO
IF PEAK THRESHOLD IS GREATER THAN MAXIMUM MEDIUM THRESHOLD
YES
OUTPUT SEVERITY LEVEL = MEDIUM
NO
IF PEAK THRESHOLD IS GREATER THAN MAXIMUM LOW THRESHOLD
YES
OUTPUT SEVERITY LEVEL = LOW
NO
RETURN ALGORITHM FOR DETECTING NDEs

FIG. 8

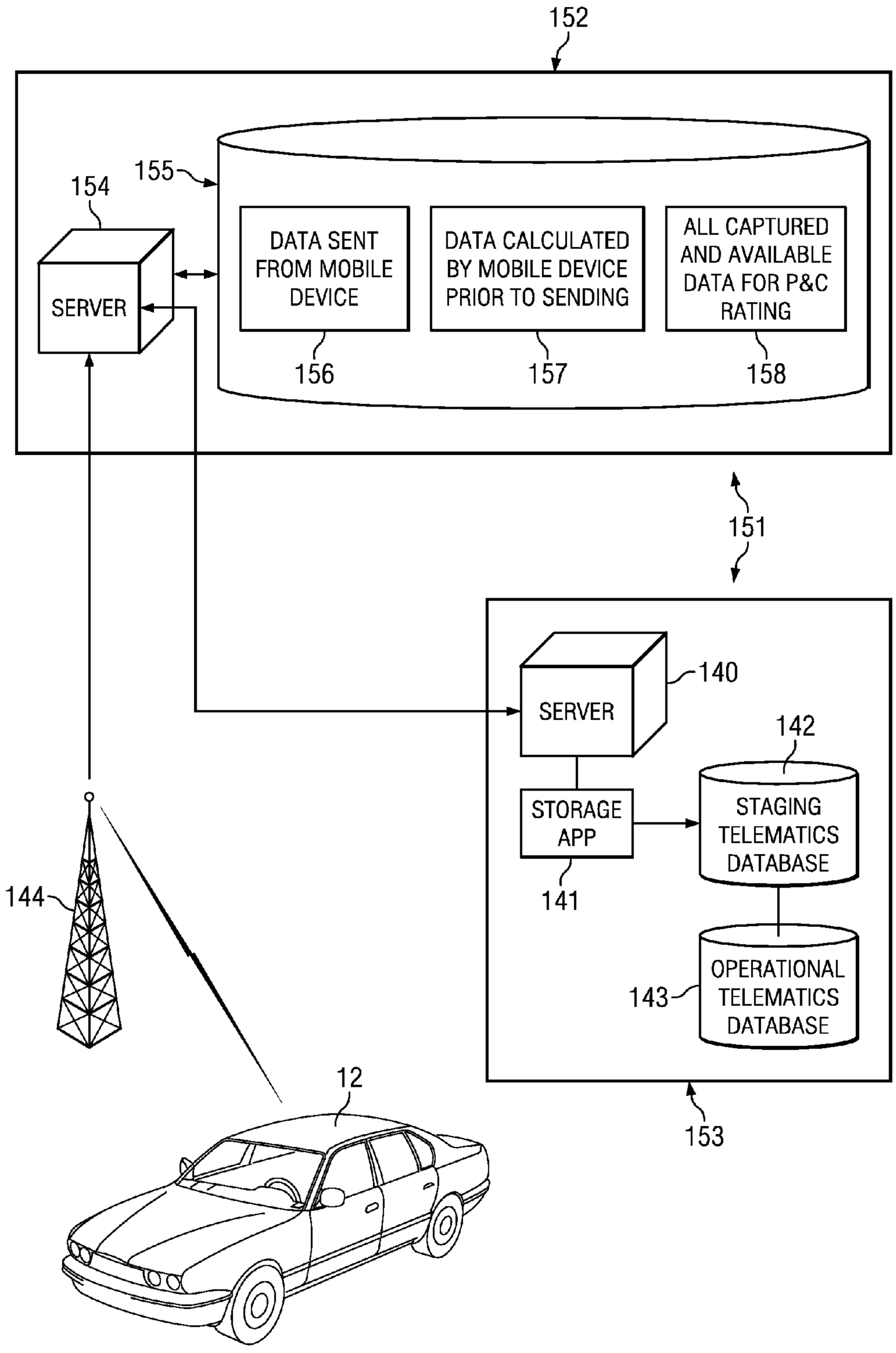

152
155
154
SERVER
DATA SENT FROM MOBILE DEVICE
DATA CALCULATED BY MOBILE DEVICE PRIOR TO SENDING
ALL CAPTURED AND AVAILABLE DATA FOR P&C RATING
156
157
158
151
140
SERVER
142
STORAGE APP
STAGING TELEMATICS DATABASE
141
OPERATIONAL TELEMATICS DATABASE
143
153
144
12

FIG. 9

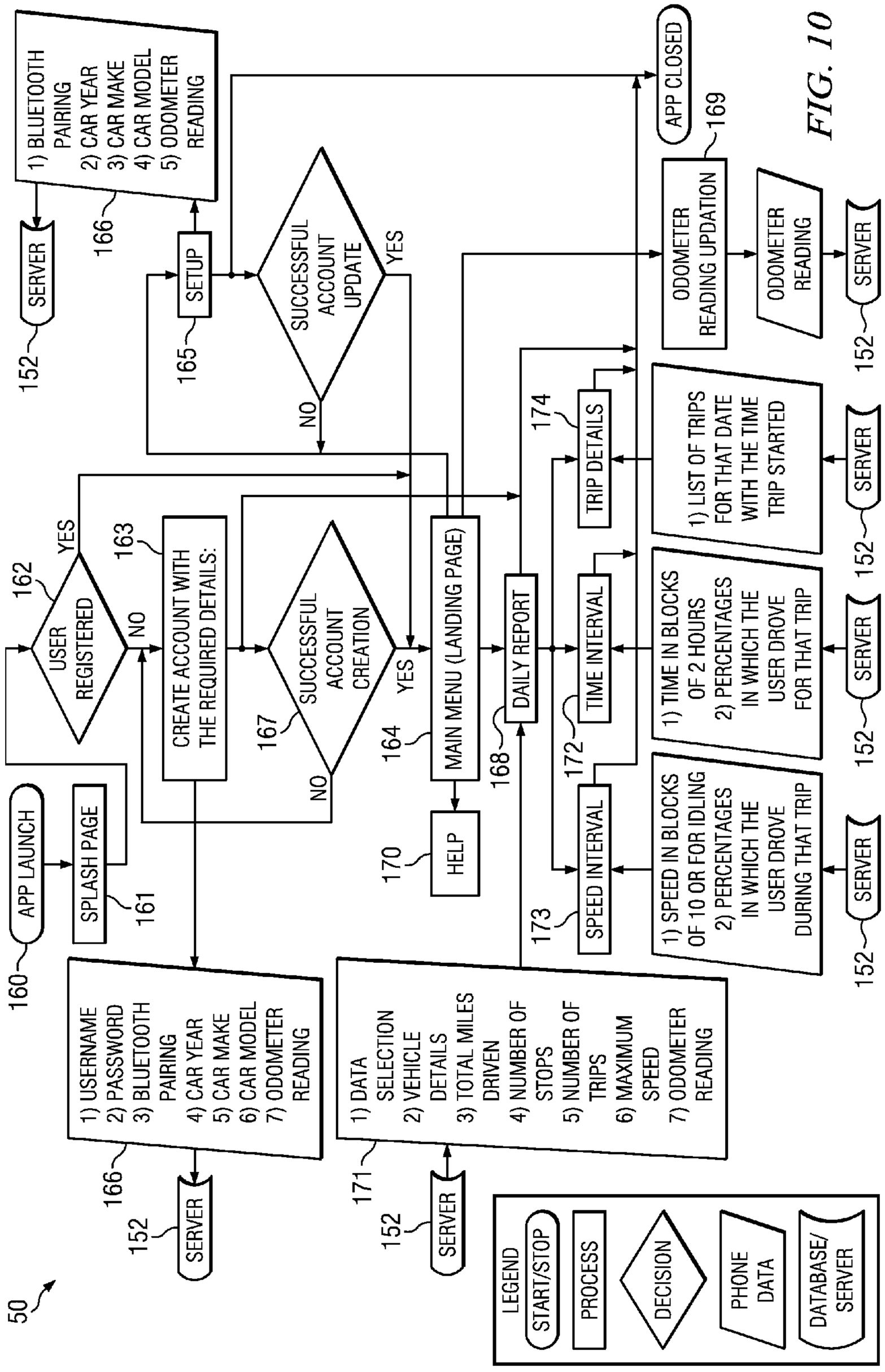

APP LAUNCH
160
SPLASH PAGE
161
USER REGISTERED
162
YES
NO
CREATE ACCOUNT WITH THE REQUIRED DETAILS:
163
SUCCESSFUL ACCOUNT CREATION
167
YES
NO
SETUP
165
SUCCESSFUL ACCOUNT UPDATE
YES
NO
APP CLOSED
1) BLUETOOTH PAIRING
2) CAR YEAR
3) CAR MAKE
4) CAR MODEL
5) ODOMETER READING
166
SERVER
152
MAIN MENU (LANDING PAGE)
164
HELP
170
DAILY REPORT
168
TIME INTERVAL
172
SPEED INTERVAL
173
TRIP DETAILS
174
ODOMETER READING UPDATION
169
ODOMETER READING
SERVER
152
1) USERNAME
2) PASSWORD
3) BLUETOOTH PAIRING
4) CAR YEAR
5) CAR MAKE
6) CAR MODEL
7) ODOMETER READING
166
SERVER
152
1) DATA SELECTION
2) VEHICLE DETAILS
3) TOTAL MILES DRIVEN
4) NUMBER OF STOPS
5) NUMBER OF TRIPS
6) MAXIMUM SPEED
7) ODOMETER READING
171
SERVER
152
1) SPEED IN BLOCKS OF 10 OR FOR IDLING
2) PERCENTAGES IN WHICH THE USER DROVE DURING THAT TRIP
SERVER
152
1) TIME IN BLOCKS OF 2 HOURS
2) PERCENTAGES IN WHICH THE USER DROVE FOR THAT TRIP
SERVER
152
1) LIST OF TRIPS FOR THAT DATE WITH THE TIME TRIP STARTED
SERVER
152
LEGEND
START/STOP
PROCESS
DECISION
PHONE DATA
DATABASE/ SERVER
50

FIG. 10

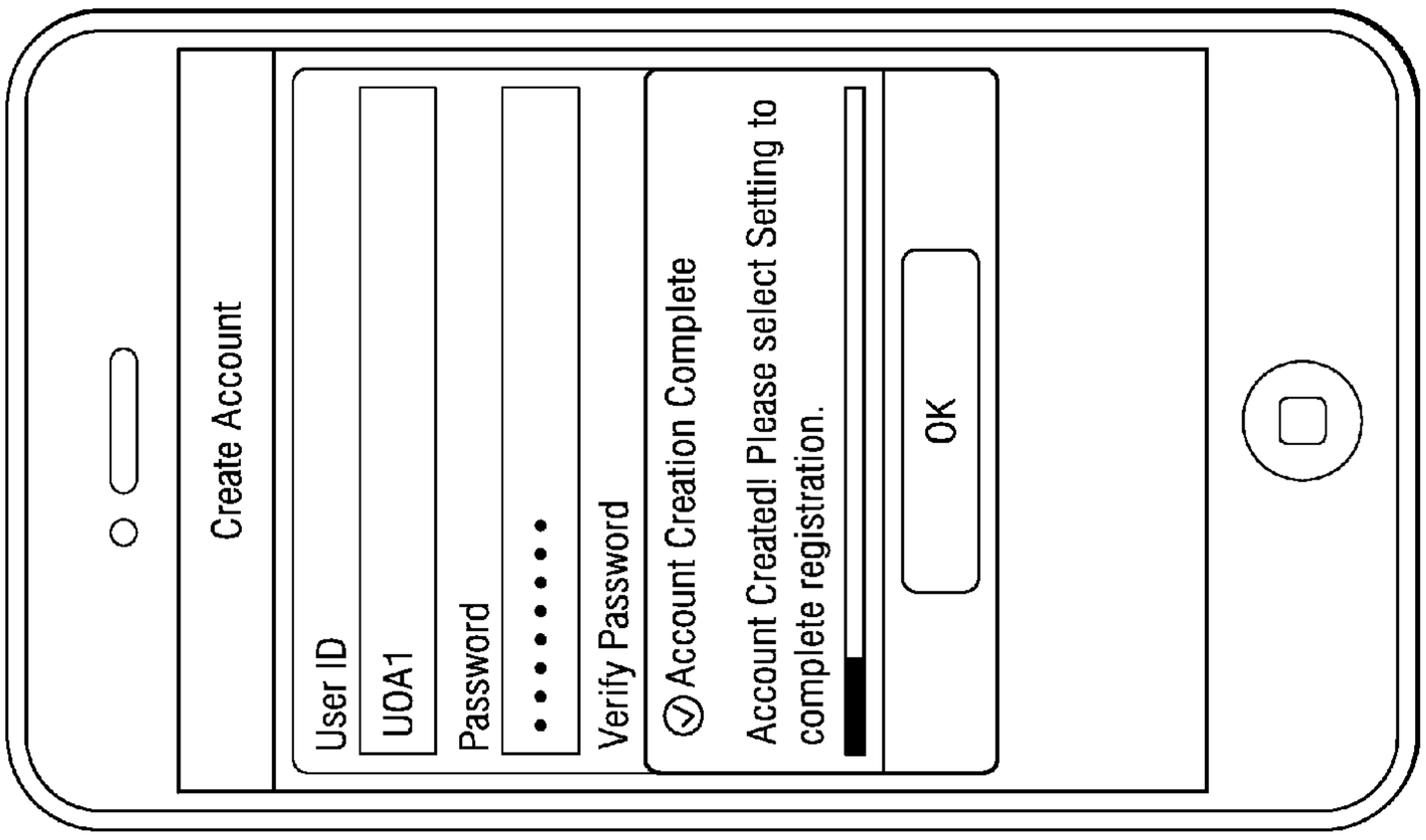


FIG. 11B

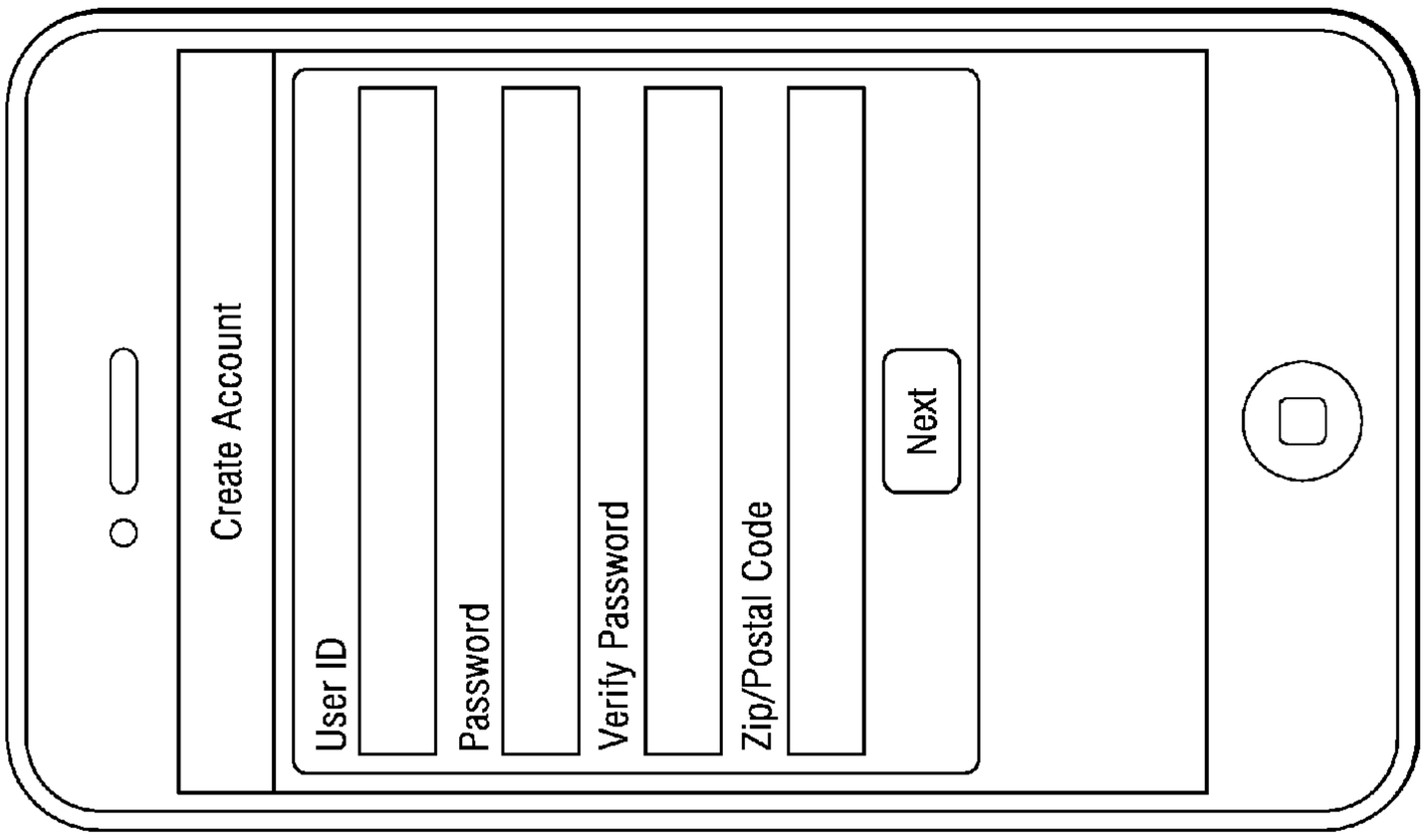


FIG. 11A

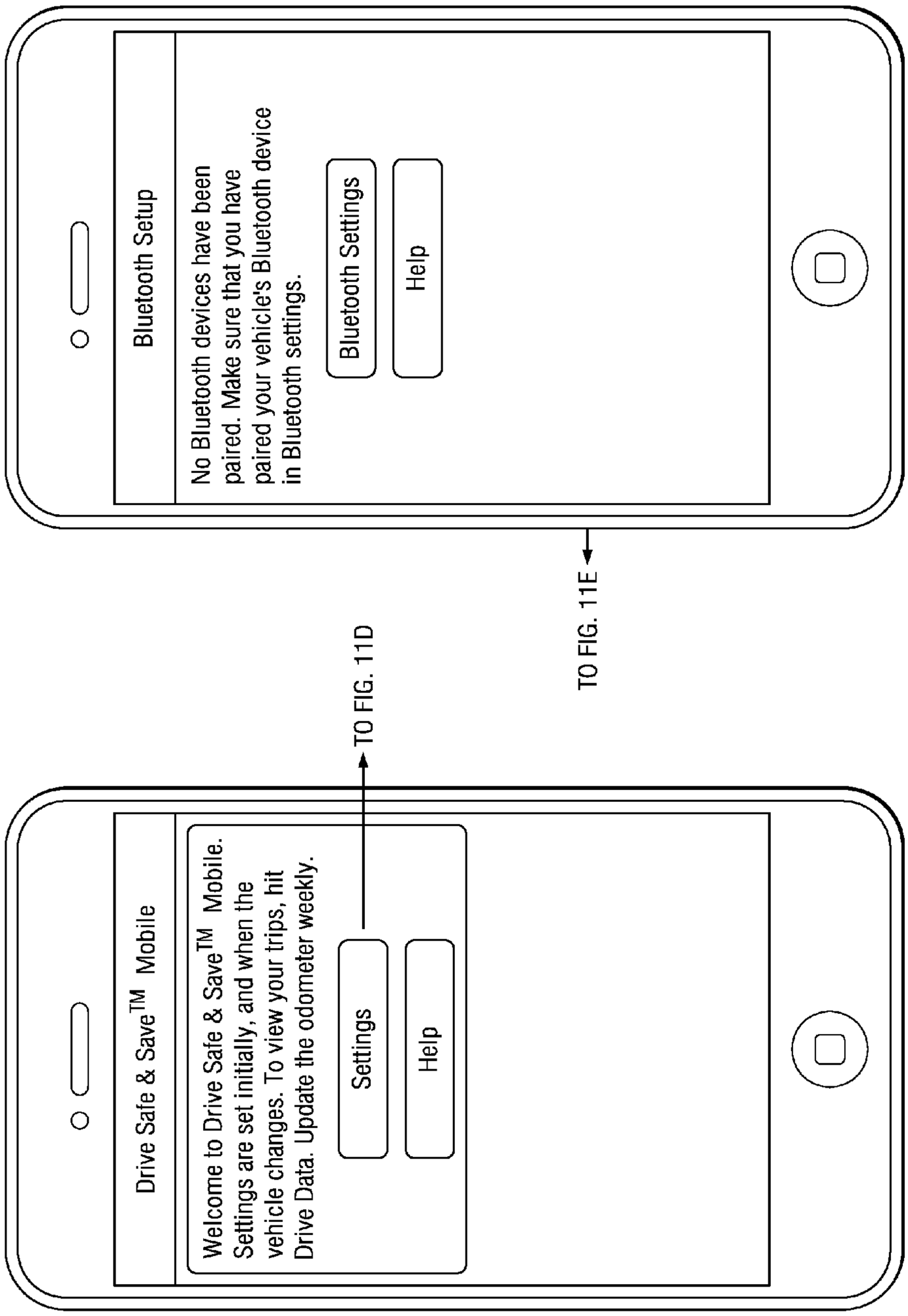


FIG. 11C

FIG. 11D

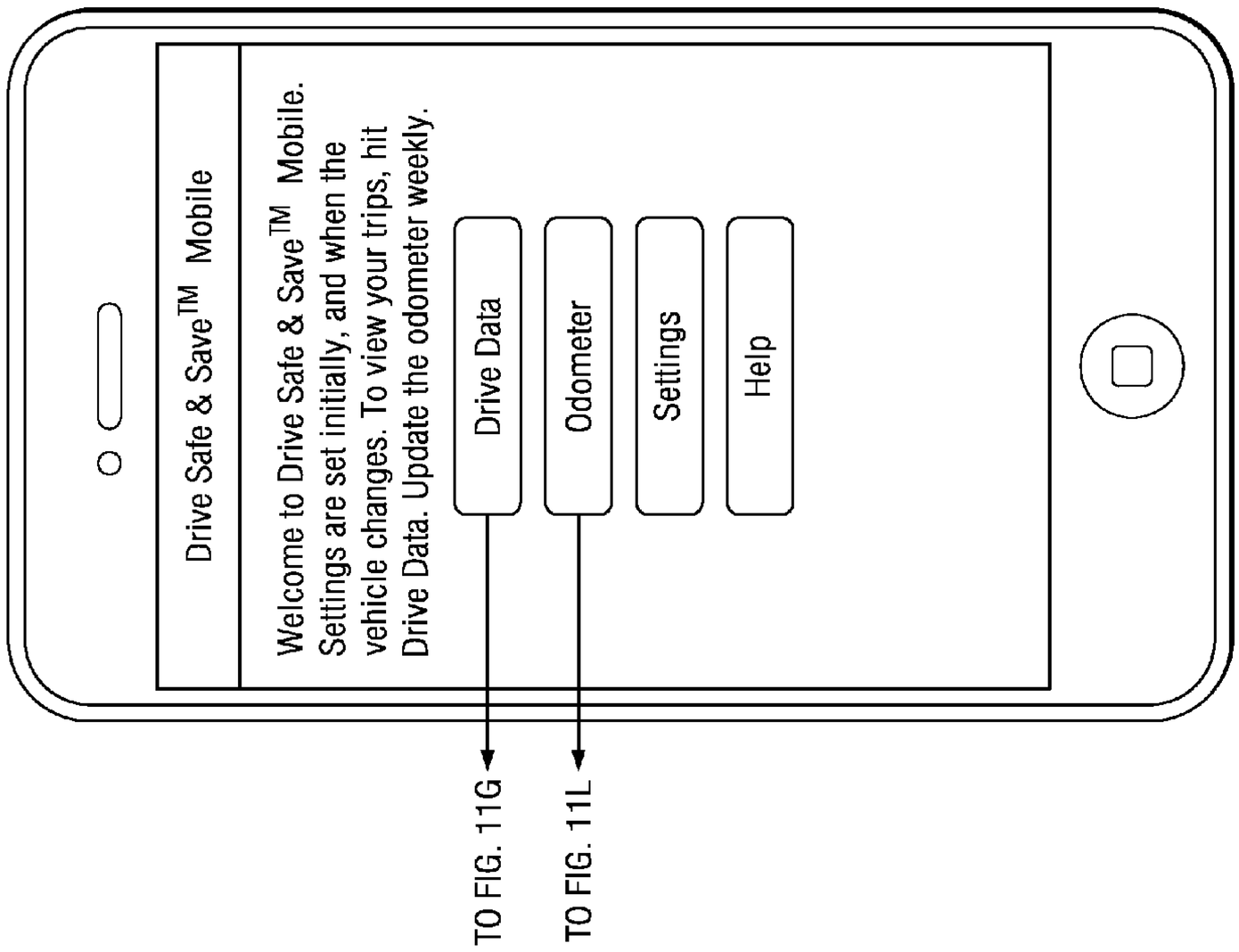


FIG. 11F

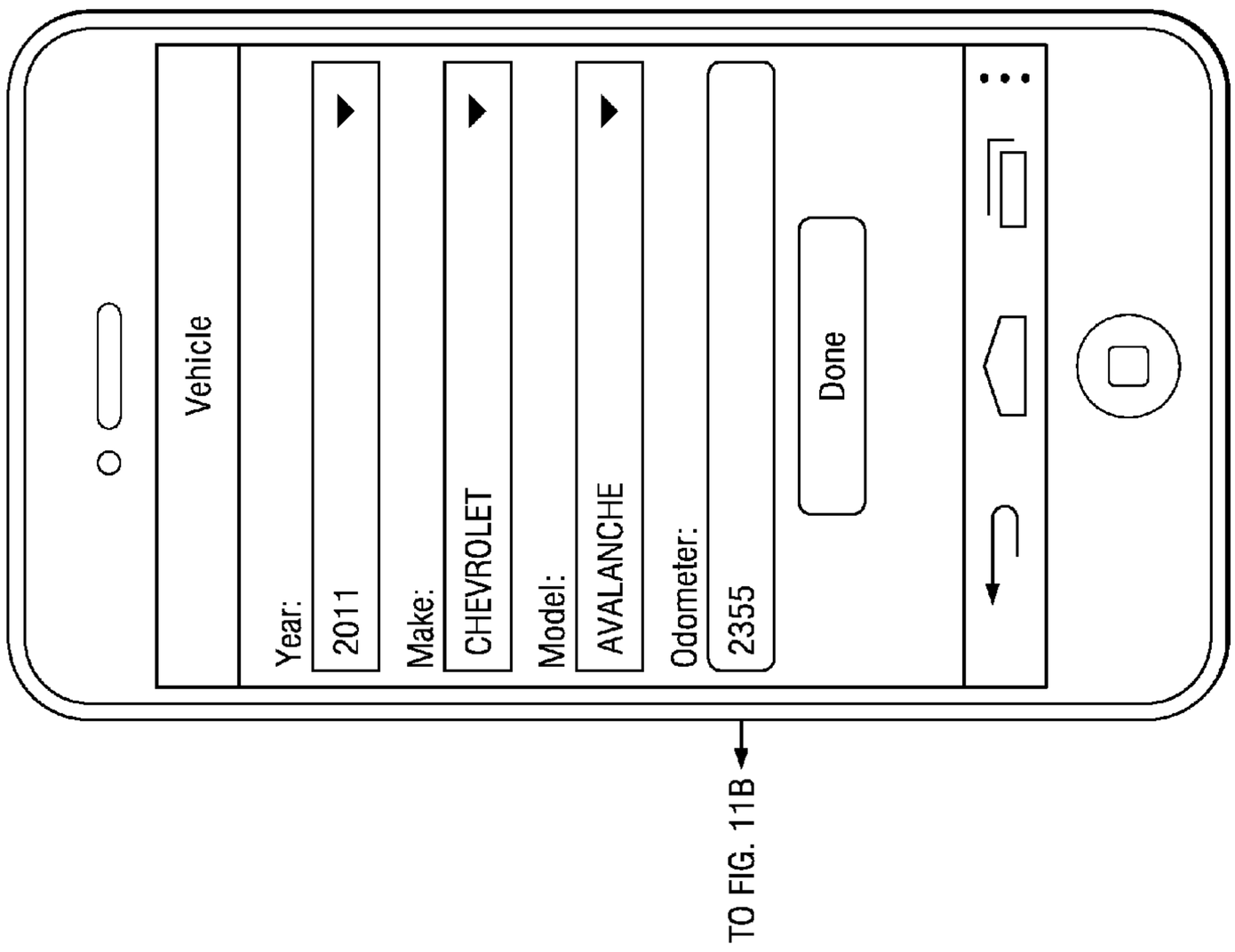


FIG. 11E

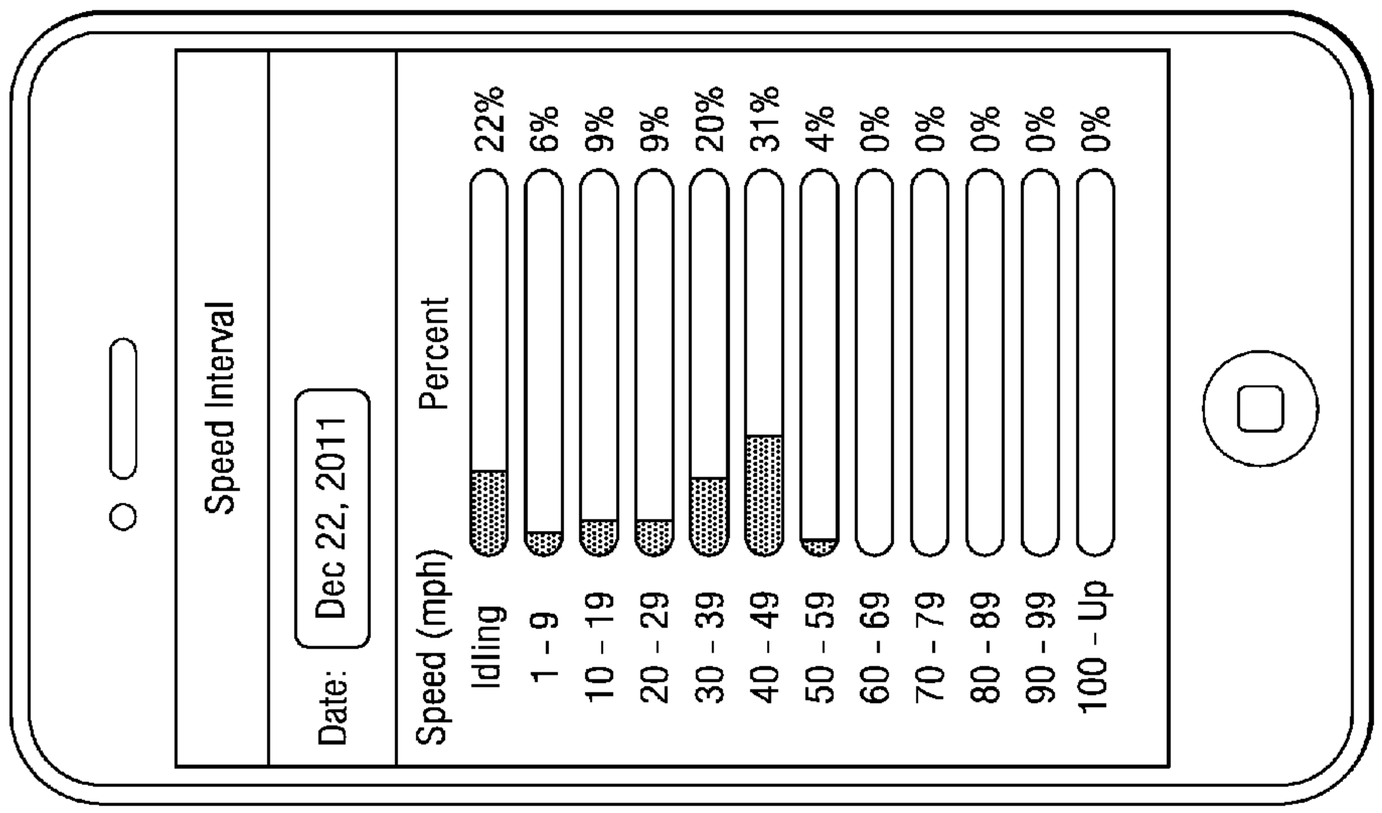


FIG. 11H

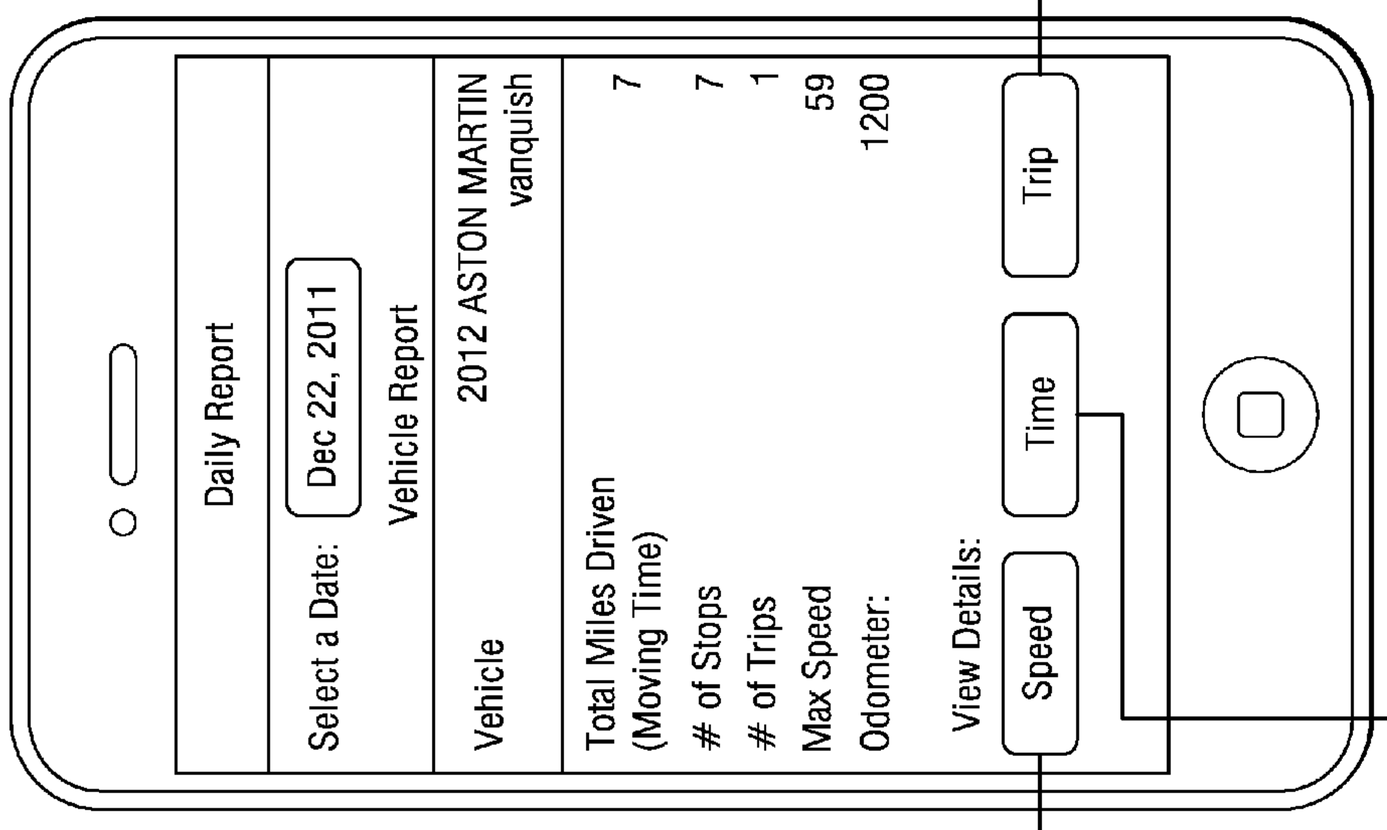


FIG. 11G

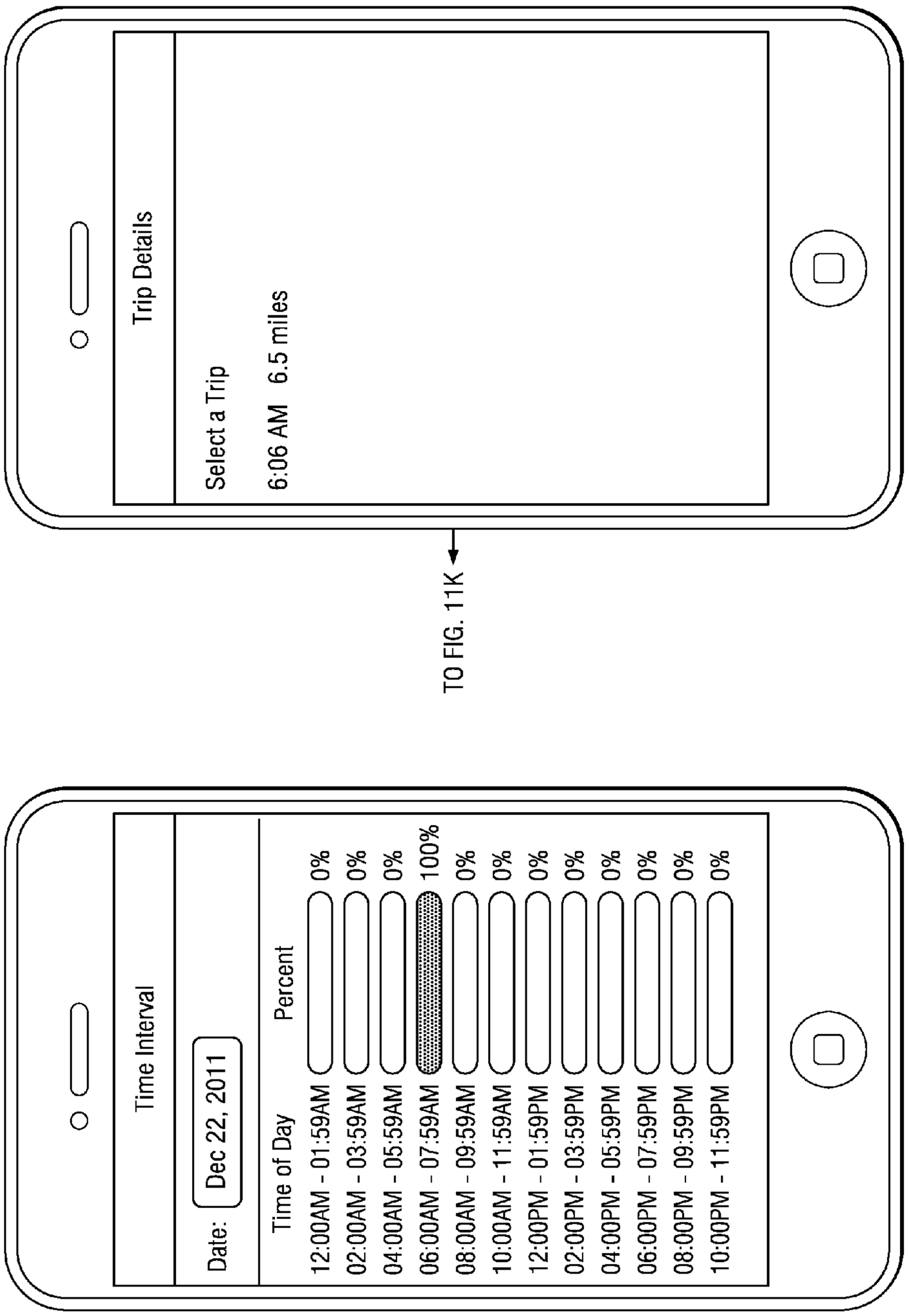


FIG. 11J

FIG. 11I

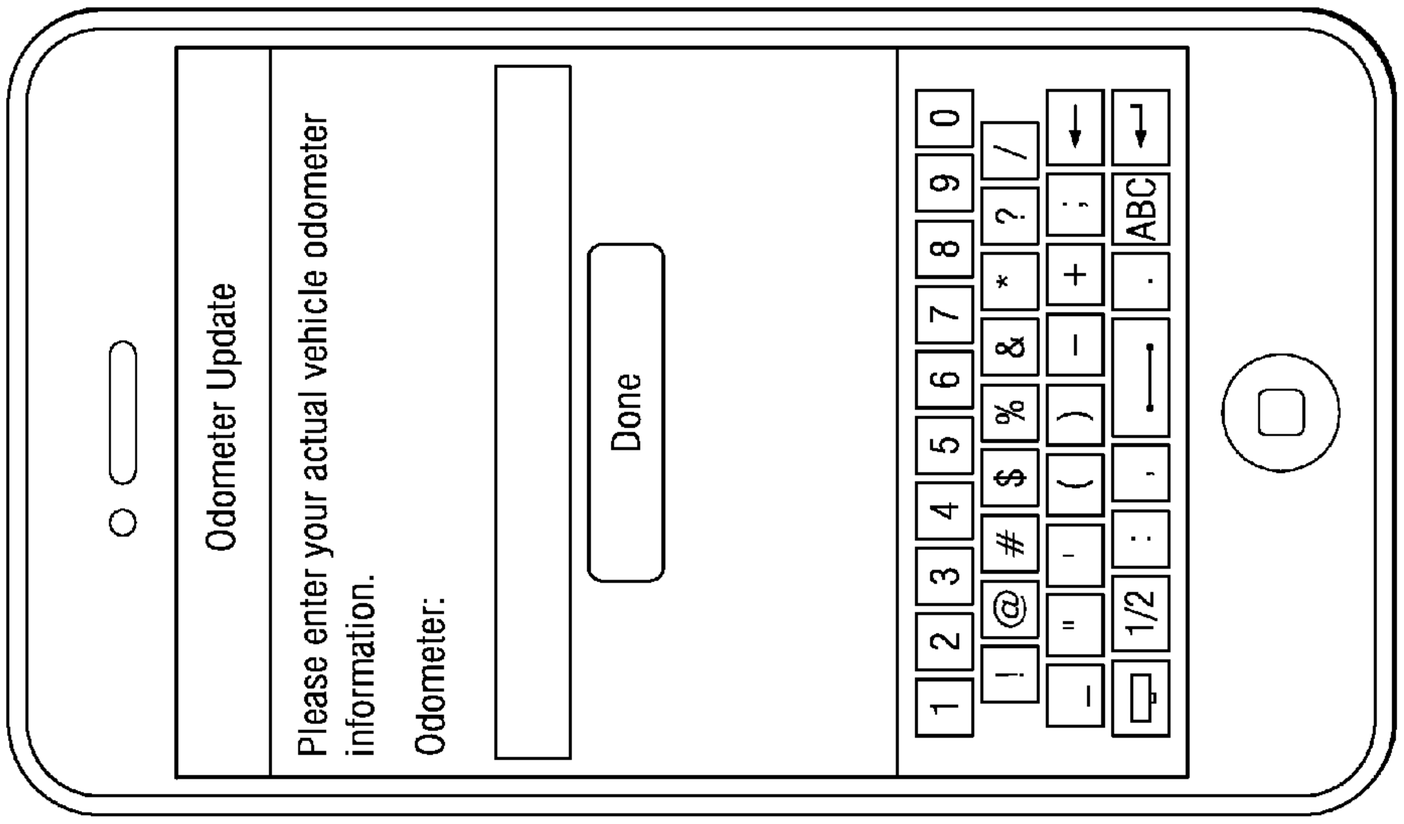


FIG. 11L

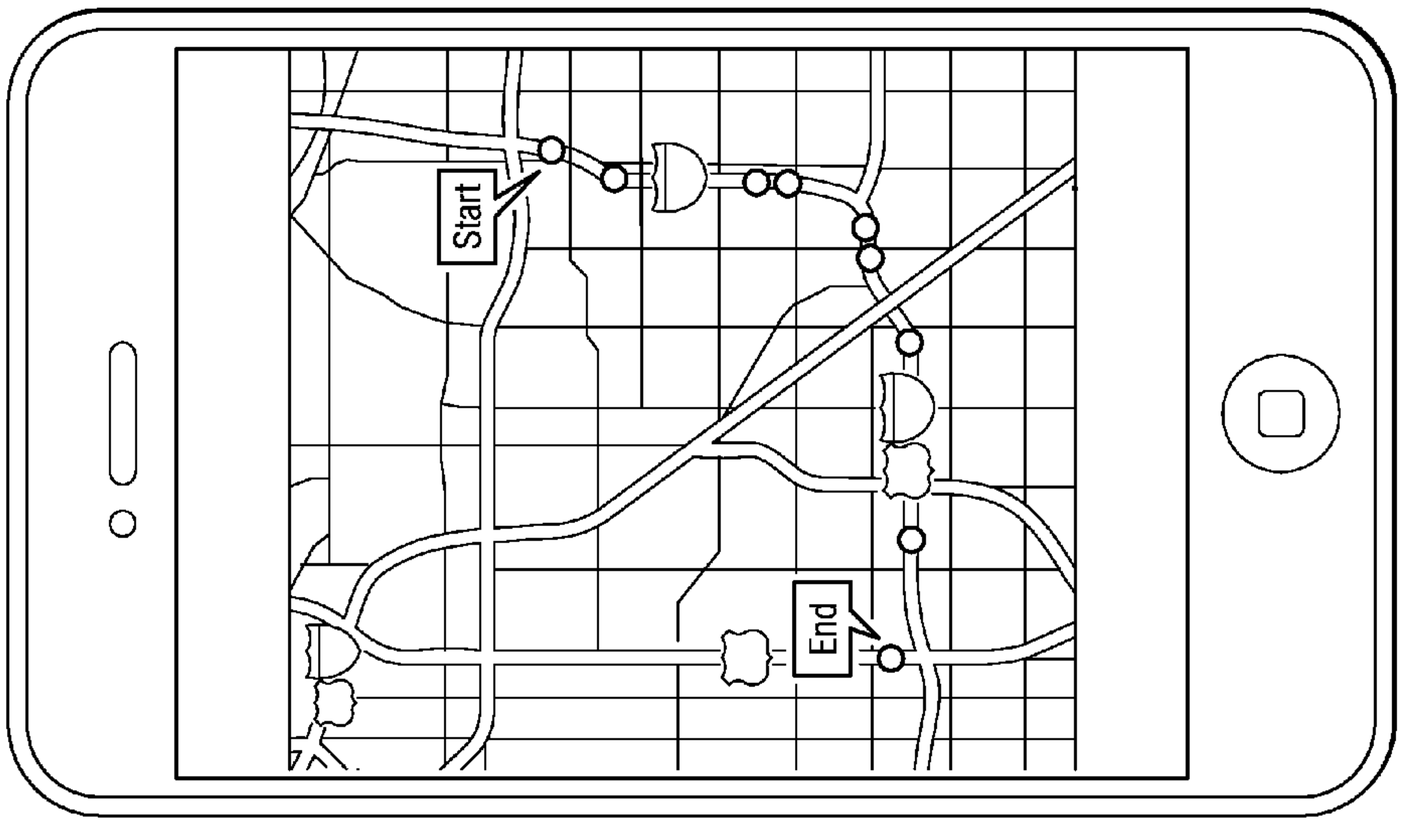


FIG. 11K

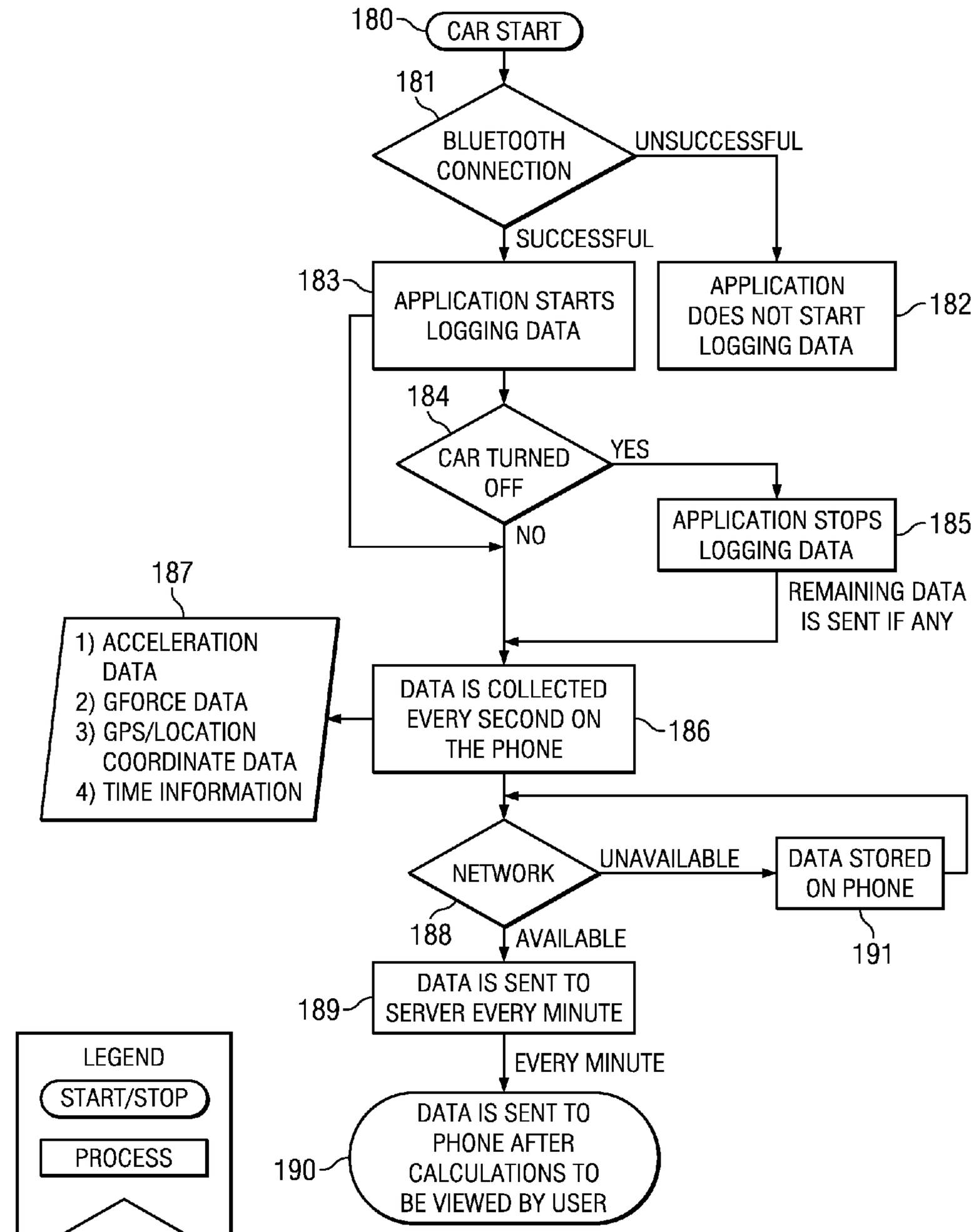

180
CAR START
181
BLUETOOTH CONNECTION
UNSUCCESSFUL
SUCCESSFUL
183
APPLICATION STARTS LOGGING DATA
APPLICATION DOES NOT START LOGGING DATA
182
184
CAR TURNED OFF
YES
NO
APPLICATION STOPS LOGGING DATA
185
REMAINING DATA IS SENT IF ANY
187
1) ACCELERATION DATA
2) GFORCE DATA
3) GPS/LOCATION COORDINATE DATA
4) TIME INFORMATION
DATA IS COLLECTED EVERY SECOND ON THE PHONE
186
NETWORK
UNAVAILABLE
DATA STORED ON PHONE
191
188
AVAILABLE
189
DATA IS SENT TO SERVER EVERY MINUTE
EVERY MINUTE
190
DATA IS SENT TO PHONE AFTER CALCULATIONS TO BE VIEWED BY USER
LEGEND
START/STOP
PROCESS
DECISION
PHONE DATA

FIG. 12

SYSTEMS AND METHODS USING A MOBILE DEVICE TO COLLECT DATA FOR INSURANCE PREMIUMS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation of U.S. application Ser. No. 13/477,793 filed May 22, 2012, which is a Continuation-in-Part of U.S. application Ser. No. 13/172,240 filed Jun. 29, 2011, the contents of which are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

The present disclosure relates generally to systems and methods for collecting and evaluating driving behavior data and/or driving environment data, and using such data to calculate insurance premiums. Aspects of the data collection, evaluation, and/or premium calculation may be provided by a mobile device, e.g., a smart phone.

BACKGROUND

Improvements in roadway and automobile designs have steadily reduced injury and death rates in developed countries. Nevertheless, auto collisions are still the leading cause of injury-related deaths, an estimated total of 1.2 million worldwide in 2004, or 25% of the total from all causes. Further, driving safety is particularly important for higher-risk drivers such as teens and elderly drivers, as well as higher-risk passengers such as infant and elderly passengers. For example, motor vehicle crashes are the number one cause of death for American teens.

Thus, driving safety remains a critical issue in today's society. Various efforts and programs have been initiated to improve driving safety over the years. For example, driving instruction courses (often referred to as "drivers ed") are intended to teach new drivers not only how to drive, but how to drive safely. Typically, an instructor rides as a passenger and provides instruction to the learning driver, and evaluates the driver's performance. As another example, "defensive driving" courses aim to reduce the driving risks by anticipating dangerous situations, despite adverse conditions or the mistakes of others. This can be achieved through adherence to a variety of general rules, as well as the practice of specific driving techniques. Defensive driving course provide a variety of benefits. For example, in many states, a defensive driving course can be taken as a way to dismiss traffic tickets, or to qualify the driver for a discount on car insurance premiums.

From the perspective of an automobile insurance provider, the provider seeks to assess the risk level associated with a driver and price an insurance policy to protect against that risk. The process of determining the proper cost of an insurance policy, based on the assessed risk level, is often referred to as "rating." The rating process may include a number of input variables, including experience data for the specific driver, experience data for a class of drivers, capital investment predictions, profit margin targets, and a wide variety of other data useful for predicting the occurrence of accidents as well as the amount of damage likely to result from such accidents.

In the industry today, driving behavior data for insurance rating purposes is collected by specialized devices that plug into vehicle data ports. For example, U.S. Pat. No. 6,832,141, issued to Skeen et al., discloses an onboard diagnostic

memory module that is configured to plug into the OBD II port. The memory module is preprogrammed with data collection parameters through microprocessor firmware by connection to a PC having programming software for the module firmware. Data is recorded on a trip basis. Intelligent interrogation occurs by interpretive software from an interrogating PC to retrieve a trip-based and organized data set including hard and extreme acceleration and deceleration, velocity (in discrete bands), distance traveled, as well as the required SAE-mandated operating parameters.

SUMMARY

In accordance with the teachings of the present disclosure, a mobile device, such as a smartphone, is used to collect and transmit vehicle operation data, rather than a specialized device that plugs into a vehicle data port.

According to one aspect of the invention, there is provided a system for determining a vehicle insurance premium for a period of time based at least in part on collected vehicle operation data, the system comprising: a mobile device, comprising: one or more sensors associated with the mobile device and configured to automatically collect vehicle operation data during a data collection session; a processor; a non-transitory storage medium; a display; a transmitter; and a set of computer readable instructions stored in the non-transitory storage medium and when executed by the processor configured to allow the mobile device to collect vehicle operation data and transmit the collected vehicle operation data; and a remote processing computer, comprising: a server that receives collected vehicle operation data; a database that stores collected vehicle operation data; and a rating engine that determines a vehicle insurance premium based at least in part on collected vehicle operation data.

A further aspect of the invention provides a system for a method for determining a vehicle insurance premium for a period of time based at least in part on collected vehicle operation data, the method comprising: collecting vehicle operation data via a mobile device while the mobile device is associated with an operating vehicle; transmitting the collected vehicle operation data from the mobile device to a remote computer; and calculating an insurance premium based at least in part on the collected vehicle operation data.

Still another aspect of the invention provides for a method for providing vehicle operation data to a remote computer for calculation of a vehicle insurance premium for a period of time based at least in part on collected vehicle operation data, the method comprising: collecting vehicle operation data via a mobile device while the mobile device is associated with an operating vehicle; and transmitting the collected vehicle operation data from the mobile device to a remote computer.

According to another aspect of the invention, there is provided a method for determining a vehicle insurance premium for a period of time based at least in part on collected vehicle operation data, the method comprising: receiving at a remote computer the collected vehicle operation data from a mobile device; and calculating an insurance premium based at least in part on the collected vehicle operation data.

Another aspect of the invention provides a tangible computer readable storage medium containing instructions that, when executed on by a processor, perform the following steps: collecting vehicle operation data via a mobile device while the mobile device is associated with an operating vehicle; and transmitting the collected vehicle operation data from the mobile device to a remote processing computer.

According to still a further aspect of the invention, there is provided a mobile device comprising: at least one sensor that

detects a characteristic of the mobile device selected from distance traveled, location, time, and g-force dynamics; a processor; a tangible computer readable storage medium containing instructions that, when executed on by the processor, perform the following steps: collecting vehicle operation data via the at least one sensor while the mobile device is associated with a vehicle in operation; and transmitting the collected vehicle operation data from the mobile device to a remote processing computer.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features, and wherein:

FIG. **1** illustrates an example mobile device located in a vehicle, the mobile device including a driving analysis system, according to certain embodiments of the present disclosure;

FIG. **2** illustrates example components of the mobile device relevant to the driving analysis system, according to certain embodiments;

FIG. **3** illustrates an example method of collecting and processing driving data, according to certain embodiments;

FIG. **4** illustrates an example method of collecting and processing driving data using example algorithms, according to certain embodiments;

FIG. **5** illustrates an example system for sharing driving data between a mobile device including a driving analysis system and other external devices, according to certain embodiments;

FIGS. **6**A-**6**G illustrate example screen shots generated by an example driving analysis application on a mobile device, according to certain embodiments;

FIG. **7** is a flow chart of an illustrative algorithm for determining severity levels of notable driving events (NDE) identified during data collection sessions;

FIG. **8** is a flow chart of an illustrative algorithm for determining severity levels of notable driving events (NDE) identified during data collection sessions;

FIG. **9** is schematic illustration of an infrastructure for collecting vehicle operation data, transmitting vehicle operation data, receiving vehicle operation data and calculating insurance premiums based on vehicle operation data, wherein the infrastructure comprises a remote data storage system and a property and casualty system;

FIG. **10** is a flowchart of a driving analysis application that may be downloaded onto a mobile device;

FIG. **11**A is a screen shot of a graphic user interface of a Create Account screen of a driving analysis application;

FIG. **11**B is a screen shot of a graphic user interface of an Account Creation Complete screen of a driving analysis application;

FIG. **11**C is a screen shot of a graphic user interface of a Settings screen of a driving analysis application;

FIG. **11**D is a screen shot of a graphic user interface of a Bluetooth Setup screen of a driving analysis application;

FIG. **11**E is a screen shot of a graphic user interface of a Vehicle screen of a driving analysis application;

FIG. **11**F is a screen shot of a graphic user interface of a Main Menu (Landing Page) screen of a driving analysis application;

FIG. **11**G is a screen shot of a graphic user interface of a Daily Report screen of a driving analysis application;

FIG. **11**H is a screen shot of a graphic user interface of a Speed Interval screen of a driving analysis application;

FIG. **11**I is a screen shot of a graphic user interface of a Time Interval screen of a driving analysis application;

FIG. **11**J is a screen shot of a graphic user interface of a Trip Details screen of a driving analysis application;

FIG. **11**K is a screen shot of a graphic user interface of a Trip Map screen of a driving analysis application;

FIG. **11**L is a screen shot of a graphic user interface of a Odometer Update screen of a driving analysis application; and

FIG. **12** is a flowchart of a process for collection and analysis of vehicle operation data.

DETAILED DESCRIPTION

Preferred embodiments and their advantages over the prior art are best understood by reference to FIGS. **1-12** below. The present disclosure may be more easily understood in the context of a high level description of certain embodiments.

According to certain embodiments of the invention, a smartphone based telematics technology solution may be implemented that requires no additional hardware or sensing equipment in an insured's vehicle. A mobile device equipped with software may capture and transmit the miles driven and vehicle dynamics (g-force events such as hard stops, sharp turns, fast accelerations, etc.) in an automated fashion. Thus, individual driver's may collect and transmit driving behavior and use information to their insurance company via their mobile device.

Insurance companies may receive, store and use the collected driving behavior and use information to calculate and charge insurance premiums. Software programs operating on insurance company servers may provide a telematics data infrastructure to receive, process, present and transform telematics data for insurance rating purposes.

Insurance customers may be incentivized to provide driving behavior and use information to their insurance company via their mobile device by subsidization of consumers' smartphones and/or smartphone data plan fees through business relationships between insurance providers and wireless data carriers.

A software application ("APP") may be provided for operating systems such as those employed by iPhone, iPad and Android systems. Once the APP is downloaded to the smartphone and launched for initial set up, no additional start/stop activities by the user may be required. The APP may collect data using sensors in the smartphone to determine miles driven, location, time, and vehicle dynamics (g-force events such as hard stops, sharp turns, fast accelerations, etc.).

Computing infrastructure may be provided for receiving telematics data from customer smartphones in real time. The infrastructure may be a cloud computing infrastructure.

In one embodiment of the invention, the APP may utilize sensors in a smartphone to automatically start and stop the application once initially setup on the smartphone. Automated tracking may use algorithms to use the smartphone/server architecture to determine driving, mileage, etc. The APP may turn itself "on" as soon as the smartphone detects that it is in an automobile with its engine running. The smartphone may communicate with the vehicle via Bluetooth to determine that the smartphone is inside the vehicle and that the engine is running Once detected, the APP may then turn itself on and begin tracking miles driven, location, time, and vehicle dynamics (g-force data). The APP may be configured so that interaction with a driver is limited, such that the APP will run automatically on the smartphone after initial setup,

wherein automatic start and stop capabilities may be accomplished using smartphone sensors.

FIG. **1** illustrates an example mobile device **10** located in a vehicle **12**, according to certain embodiments or implementations of the present disclosure. Mobile device **10** may comprise any type of portable or mobile electronics device, such as for example a smartphone, a cell phone, a mobile telephone, personal digital assistant (PDA), laptop computer, tablet-style computer, or any other portable electronics device. For example, in some embodiments, mobile device **10** may be a smart phone, such as an iPhone by Apple Inc., a Blackberry phone by RIM, a Palm phone, or a phone using an Android, Microsoft, or Symbian operating system (OS), for example. In some embodiments, mobile device **10** may be a tablet, such as an iPad by Apple, Inc., a Galaxy by Samsung, or Eee Pad Transformer by ASUS, and Latitude ST Tablet PC by Dell, for example.

In some embodiments, mobile device **10** may be configured to provide one or more features of a driving analysis system, such as (a) collection of driving data (e.g., data regarding driving behavior and/or the respective driving environment), (b) processing of collected driving data, and/or (c) providing collected driving data and/or processed driving data to a server or database via telecommunication or telematics. Accordingly, mobile device **10** may include one or more sensors, a driving analysis application, a display, and transmitters.

The sensor(s) may collect one or more types of data regarding driving behavior and/or the driving environment. For example, mobile device **10** may include a built-in accelerometer configured to detect acceleration in one or more directions (e.g., in the x, y, and z directions). As another example, mobile device **10** may include a GPS (global positioning system) device or any other device for tracking the geographic location of the mobile device. As another example, mobile device **10** may include sensors, systems, or applications for collecting data regarding the driving environment, e.g., traffic congestion, weather conditions, roadway conditions, or driving infrastructure data. In addition or alternatively, mobile device **10** may collect certain driving data (e.g., driving behavior data and/or driving environment data) from sensors and/or devices external to mobile device **10** (e.g., speed sensors, blind spot information sensors, seat belt sensors, GPS device, etc.).

The driving analysis application ("APP") on mobile device **10** may process any or all of this driving data collected by mobile device **10** and/or data received at mobile device **10** from external sources to calculate one or more driving behavior metrics and/or scores based on such collected driving data. For example, driving analysis application may calculate acceleration, braking, and cornering metrics based on driving behavior data collected by the built-in accelerometer (and/or other collected data). Driving analysis application may further calculate scores based on such calculated metrics, e.g., an overall driving score. As another example, driving analysis application may identify "notable driving events," such as instances of notable acceleration, braking, and/or cornering, as well as the severity of such events. In some embodiments, the driving analysis application may account for environmental factors, based on collected driving environment data corresponding to the analyzed driving session(s). For example, the identification of notable driving events may depend in part on environmental conditions such as the weather, traffic conditions, road conditions, etc. Thus, for instance, a particular level of braking may be identified as a notable driving event in the rain, but not in dry conditions.

The driving analysis application may display the processed data, e.g., driving behavior metrics and/or driving scores. In embodiments in which mobile device **10** includes a GPS or other geographic location tracking device, the application may also display a map showing the route of a trip, and indicating the location of each notable driving event. The application may also display tips to help drivers improve their driving behavior.

The driving analysis application may display some or all of such data on the mobile device **10** itself. In addition or alternatively, the driving analysis application may communicate some or all of such data via a network or other communication link for display by one or more other computer devices (e.g., smart phones, personal computers, etc.). Thus, for example, a parent or driving instructor may monitor the driving behavior of a teen or student driver without having to access the mobile device **10**. As another example, an insurance company may access driving behavior data collected/processed by mobile device **10** and use such data for risk analysis of a driver and determining appropriate insurance products or premiums for the driver according to such risk analysis (i.e., performing rating functions based on the driving behavior data collected/processed by mobile device **10**).

FIG. **2** illustrates example components of mobile device **10** relevant to the driving analysis system discussed herein, according to certain embodiments. As shown, mobile device **10** may include a memory **30**, processor **32**, one or more sensors **34**, a display **36**, and input/output devices **38**.

Memory **30** may store a driving analysis application **50** and historical driving data **46**, as discussed below. In some embodiments, memory **30** may also store one or more environmental data applications **58**, as discussed below. Memory **30** may comprise any one or more devices suitable for storing electronic data, e.g., RAM, DRAM, ROM, internal flash memory, external flash memory cards (e.g., Multi Media Card (MMC), Reduced-Size MMC (RS-MMC), Secure Digital (SD), MiniSD, MicroSD, Compact Flash, Ultra Compact Flash, Sony Memory Stick, etc.), SIM memory, and/or any other type of volatile or non-volatile memory or storage device. Driving analysis application **50** may be embodied in any combination of software, firmware, and/or any other type of computer-readable instructions.

Application **50** and/or any related, required, or useful applications, plug-ins, readers, viewers, updates, patches, or other code for executing application **50** may be downloaded via the Internet or installed on mobile device **10** in any other known manner.

Processor **32** may include a microprocessor, a microcontroller, a digital signal processor (DSP), an application specific integrated controller (ASIC), electrically-programmable read-only memory (EPROM), or a field-programmable gate array (FPGA), or any other suitable processor(s), and may be generally operable to execute driving analysis application **50**, as well as providing any other functions of mobile device **10**.

Sensors **34** may include any one or more devices for detecting information regarding a driver's driving behavior and/or the driving environment. For example, as discussed above, sensors **34** may include an accelerometer **54** configured to detect acceleration of the mobile device **10** (and thus, the acceleration of a vehicle in which mobile device **10** is located) in one or more directions, e.g., the x, y, and z directions. As another example, mobile device **10** may include a location tracking system **56**, such as a GPS tracking system or any other system or device for tracking the geographic location of the mobile device. A solid state compass, with two or three magnetic field sensors, may provide data to a microprocessor

to calculate direction using trigonometry. The mobile device **10** may also include proximity sensors, a camera or ambient light.

Display **36** may comprise any type of display device for displaying information related to driving analysis application **50**, such as for example, an LCD screen (e.g., thin film transistor (TFT) LCD or super twisted nematic (STN) LCD), an organic light-emitting diode (OLED) display, or any other suitable type of display. In some embodiments, display **36** may be an interactive display (e.g., a touch screen) that allows a user to interact with driving analysis application **50**. In other embodiments, display **36** may be strictly a display device, such that all user input is received via other input/output devices **38**.

Input/output devices **38** may include any suitable interfaces allowing a user to interact with mobile device **10**, and in particular, with driving analysis application **50**. For example, input/output devices **38** may include a touch screen, physical buttons, sliders, switches, data ports, keyboard, mouse, voice activated interfaces, or any other suitable devices.

As discussed above, driving analysis application **50** may be stored in memory **30**. Driving analysis application **50** may be described in terms of functional modules, each embodied in a set of logic instructions (e.g., software code). For example, as shown in FIG. **2**, driving analysis application **50** may include a data collection module **40**, a data processing module **42**, and a feedback module **44**.

Data collection module **40** may be operable to manage the collection of driving data, including driving behavior data and/or the driving environment data. Data collection module **40** may collect such data from any number and types of data sources, including (a) data sources provided by mobile device **10** (e.g., sensors **34**, environmental data application **58**), (b) data sources in vehicle **12** but external to mobile device **10** (e.g., on-board vehicle computer, seat belt sensors, GPS system, etc.), and/or (c) data sources external to vehicle **12** (e.g., data sources accessible to mobile device **100** by a satellite network or other telecommunication links). In certain embodiments, the mobile device **10** may communicate with data source in vehicle **12** but external to mobile device **10** via a hardwire connection, Bluetooth® or other wireless means, optical signal transmission, or any other known manner. Sources in vehicle **12** but extended to mobile device **10** may include: engine RPM, speedometer, fuel usage rate, exhaust components or other combination indications, suspension system monitors, seat belt use indicators, tracking systems for other vehicles in vicinity, blind spot indicators.

In some embodiments, data collection module **40** may control the start and stop of driving data collection, e.g., from sources such as accelerometer **54**, location tracking system **56**, other sensor(s) **34** provided by mobile device **10**, or other sensors or sources of driving data external to mobile device **10**. In some embodiments or situations, driving data collection is manually started and stopped by the driver or other user, e.g., by interacting with a physical or virtual object (e.g., pressing a virtual "start recording" button) on mobile device **10**.

In other embodiments or situations, data collection module **40** may automatically start and/or stop collection of driving data in response to triggering signals received by mobile device **10** from one or more triggering devices **15** associated with vehicle **12** (see FIG. **1**). For example, triggering device **15** may include a vehicle on-board computer, ignition system, car stereo, GPS system, a key, key fob, or any other device that may be configured to communicate signals to mobile device **10**. Triggering signals may include any signals that may indicate the start or stop of a driving trip. For example, triggering signals may include signals indicating the key has been inserted into or removed from the ignition, signals indicating the ignition has been powered on/off, signals indicating whether the engine is running, signals indicating the radio has been powered on/off, etc. or signals indicating the transmission has been set in a forward gear position. Such triggering device(s) may communicate with mobile device **10** in any suitable manner, via any suitable wired or wireless communications link. As another example, data collection module **40** may automatically start and/or stop collection of driving data in response to determining that the mobile device **10** is likely travelling in an automobile, e.g., based on a real time analysis of data received from accelerometer **54**, location tracking system **56**, or other sensors **34** provided by mobile device **10**. For example, data collection module **40** may include algorithms for determining whether mobile device **10** is likely travelling in an automobile based on data from accelerometer **54** and/or location tracking system **56**, e.g., by analyzing one or more of (a) the current acceleration of mobile device **10** from accelerometer **54**, (b) the current location of mobile device **10** from location tracking system **56** (e.g., whether mobile device **10** is located on/near a roadway), (c) the velocity of mobile device **10** from location tracking system **56**, (d) any other suitable data, or (e) any combination of the preceding.

In some embodiments or situations, data collection module **40** may allow or trigger the start and stop (including interrupting and re-starting) of driving data collection based on the orientation of mobile device **10** (relative to vehicle **12**), e.g., based on whether the orientation is suitable for collecting driving data. For example, data collection module **40** may allow driving data collection to be manually or automatically started (or re-started after an interruption). Further, during driving data collection, module **40** may automatically stop or interrupt the driving data collection if mobile device **10** is moved such that it is no longer suitably able to collect driving data.

In some embodiments, data collection module **40** may manage the physical orientation of mobile device **10** relative to the vehicle **12**. Module **40** may determine the orientation of mobile device **10** within the vehicle **12** by comparing GPS and position information for the mobile device **10** with GPS and position information for the vehicle **12**. This comparison of data may allow the user to adjust the mobile device **10** such that the orientation of mobile device **10** is suitable for collecting driving data. For example, data collection module **40** may determine the orientation of mobile device **10**; determine whether the orientation is suitable for collecting driving data; if so, allow data collection to begin or continue; and if not, instruct or notify the user to adjust the orientation of mobile device **10** (e.g., by indicating the direction and/or extent of the desired adjustment). Once mobile device **10** has been adjusted to a suitable orientation for collecting driving data, module **40** may notify the user and allow data collection to begin or continue. Module **40** may continue to monitor the orientation of mobile device **10** relative to the vehicle during the driving data collection session, and if a change in the orientation is detected, interact with the user to instruct a correction of the orientation.

In other embodiments, mobile device **10** is capable of automatically compensating for the orientation of mobile device **10** for the purposes of processing collected driving data (e.g., by data processing module **42**), such that data collection may start and continue despite the orientation of mobile device **10**, or changes to the orientation of the mobile device **10** relative to the vehicle **12**. Module **40** may continue to monitor the orientation of mobile device **10** relative to the

vehicle during the driving data collection session, and if a change in the orientation is detected, automatically compensate for the changed orientation of mobile device **10** for processing driving data collected from that point forward. In such embodiments, data processing module **42** may include any suitable algorithms for compensating for the orientation of mobile device **10** (relative to automobile **12**) determined by data collection module **40**. Such aspects of the invention allow the mobile device to collect accurate g-force data from the sensors of the mobile device regardless of the position of the mobile device in the vehicle. The quality of this data is improved by adjusting the data based on the orientation of the mobile device in the vehicle such as upside down, sideways, in a pocket or in a purse.

As used herein, the term "user" refers to the driver or other person interacting with driving analysis application **50** on mobile device **10**.

Data collection module **40** may collect data over one or more data collection sessions corresponding to one or more driving sessions. As used herein, a "driving session" may refer to any period of driving, which may comprise a single uninterrupted trip, a portion of a trip, or a series of multiple distinct trips. A "data collection session" may generally correspond to one driving session, a portion of a driving session, or multiple distinct driving sessions. Further, a data collection session may comprise an uninterrupted period of data collection or may include one or more interruptions (e.g., in some embodiments, if mobile device **10** is moved out of proper orientation for data collection). Thus, in some embodiments, each interruption of data collection initiates a new data collection session; in other embodiments, e.g., where a data collection session generally corresponds to a driving trip, an interrupted data collection session may reconvene after the interruption.

Thus, based on the above, data collection module **40** may trigger or control the start and stop of data collection sessions and/or start and the stop of interruptions within a data collection session.

Any or all data collected by data collection module **40** may be time stamped (e.g., time and date), either by data collection module **40** itself or by another device that collected or processed particular data before sending the data to data collection module **40**. The time stamping may allow for data from different sources (e.g., data from accelerometer **54**, location tracking system **56**, a seat belt sensor, etc.) to be synchronized for analyzing the different data together as a whole (e.g., to provide the driving context for a particular reading of accelerometer **54**, as discussed below).

Data collection module **40** may collect data corresponding to physical parameters or characteristics of the vehicle.

Data processing module **42** may be operable to process or analyze any of the driving data (e.g., driving behavior data and/or the driving environment data) collected by mobile device **10** itself and/or collected by external devices and communicated to mobile device **10**, and based on such collected driving data, calculate one or more driving behavior metrics and/or scores. For example, data processing module **42** may calculate the driving behavior metrics of acceleration, braking, and/or cornering metrics based on driving behavior data collected by an accelerometer **54**, location tracking system **56**, and/or other collected data. Further, data processing module **42** may calculate one or more driving scores based on the calculated driving behavior metrics (e.g., acceleration, braking, cornering, etc.) and/or based on additional collected data, e.g., driving environment data collected by environmental data applications **58**. For example, data processing module **42** may apply algorithms that calculate a driving score based on weighted values for each respective driving behavior metric, and environmental correction values based on the relevant driving environment data, such as weather, traffic conditions, road conditions, etc.

Data processing module **42** may calculate individual driving behavior metrics (e.g., acceleration, braking, cornering, etc.) and/or driving scores for individual data collection sessions. Similarly, data processing module **42** may calculate driving behavior metrics and/or driving scores corresponding to a group of data collection sessions, which may be referred to as group-session metrics/scores. Data processing module **42** may calculate group-session metrics/scores may using averaging, filtering, weighting, and/or any other suitable algorithms for determining representative metrics/scores corresponding to a group of data collection sessions. A "group" of data collection sessions may be specified in any suitable manner, for example:

The n most recent data collection sessions;

The n most recent data collection sessions corresponding to one or more specific driving conditions or other preset conditions, such as for example: nighttime driving, daytime driving, driving within specific times of day (e.g., specific hours), weekend driving, weekday driving, highway driving, city driving, rush-hour driving, good-weather driving, bad-weather driving, driving in specific weather conditions (e.g., rain, snow, etc.), trips of specified distances (e.g., trips shorter than a threshold distance, longer than a threshold distance, or within any present range of distances, trips associated with a certain geographic area (e.g., trips within or near a specific city), trips between specific points (e.g., trips between the driver's home and work, which may be determined for example by GPS data or entered into application **50** by the driver), trips following a specific route (e.g., which may be determined for example by GPS data or entered into application **50** by the driver), driving alone (e.g., which status may be entered into application **50** by the driver), driving with passengers (e.g., which status may be entered into application **50** by the driver),

All data collection sessions within a specified time period, e.g., all data collection sessions in the last day, week, 30 days, 90 days, year, or any other specified time period.

All data collection sessions within a specified time period that also correspond to one or more specific driving conditions or other preset conditions, e.g., any of the conditions listed above.

All data collection sessions after a particular starting point, e.g., all data collection sessions after a user initiates application **50**, or after a user resets a particular average or filtered metric/score (or all average or filtered metrics/scores).

All data collection sessions within a specified time period that also correspond to one or more specific driving conditions or other preset conditions, e.g., any of the conditions listed above.

All data collection sessions related to a particular driver.

Any combination or variation of any of the above.

The number n may be any multiple number (2, 3, 4, 5, etc.), which may be automatically determined by application **50**, selected by a user, or otherwise determined or selected. Further, as mentioned briefly above, data processing module **42** may identify "notable driving events," such as instances of notable acceleration, braking, and cornering, as well as the severity of such events. Data processing module **42** may identify notable driving events using any suitable algorithms. For example, an algorithm may compare acceleration data from accelerometer **54** (raw or filtered) to one or more pre-

defined thresholds for notable acceleration, braking, or cornering. In some embodiments, data processing module **42** may analyze the acceleration data in combination with contextual data, which may provide a context for the acceleration data, and analyze the acceleration data based on the context data. Thus, for example, particular acceleration data may or may not indicate "notable acceleration" depending on the contextual data corresponding (e.g., based on time stamp data) to the particular acceleration data being analyzed. Data processing module **42** may utilize algorithms that analyze the acceleration data together with the relevant contextual data.

Contextual data may include, for example, location data and/or driving environment data. Module **42** may use location data (e.g., from location tracking system **56**) in this context to determine, for example, the type of road the vehicle is travelling on, the speed limit, the location of the vehicle relative to intersections, traffic signs/light (e.g., stop signs, yield signs, traffic lights), school zones, railroad tracts, traffic density, or any other features or aspects accessible from location tracking system **56** that may influence driving behavior. Module **42** may use driving environment data (e.g., from environmental data applications **58**) in this context to determine, for example, the relevant weather, traffic conditions, road conditions, etc.

In some embodiments, data processing module **42** may apply different thresholds for determining certain notable driving events. For example, for determining instances of "notable cornering" based on acceleration data from accelerometer **54** and weather condition data (e.g., from sensors on the vehicle, sensors on mobile device **10**, data from an online weather application (e.g., www.weather.com), or any other suitable source), module **42** may apply different thresholds for identifying notable cornering in dry weather conditions, rainy weather conditions, and icy weather conditions. As another example, for determining instances of "notable braking" based on acceleration data from accelerometer **54** and location data (e.g., from a GPS system), module **42** may apply different thresholds for identifying notable braking for highway driving, non-highway driving, low-traffic driving, high-traffic driving, approaching a stop sign intersection, approaching a stop light intersection, etc.

Further, in some embodiments, data processing module **42** may define multiple levels of severity for each type (or certain types) of notable driving events. For example, module **42** may define the following levels of notable braking: (1) significant braking, and (2) extreme braking. As another example, module **42** may define the following three progressively severe levels of particular notable driving events: (1) caution, (2) warning, and (3) extreme. Each level of severity may have corresponding thresholds, such that the algorithms applied by module **42** may determine (a) whether a notable event (e.g., notable braking event) has occurred, and (b) if so, the severity level of the event. Each type of notable driving event may have any number of severity levels (e.g., 1, 2, 3, or more).

In some embodiments, data processing module **42** may calculate the number of each type of notable driving events (and/or the number of each severity level of each type of notable driving event) for a particular time period, for individual data collection sessions, or for a group of data collection sessions (e.g., using any of the data collection session "groups" discussed above).

Environmental data applications **58** may comprise any applications or interfaces for collecting driving environment data regarding the driving environment corresponding to a driving data collection session. For example, environmental data applications **58** may comprise any applications or interfaces operable to collect data from one or more sensors on vehicle **12** or from one or more devices external to vehicle **12** (via a network or communication links) regarding the relevant driving environment. For example, such driving environment data may include any of (a) traffic environment characteristics, e.g., congestion, calmness, or excitability of traffic, quantity and type of pedestrian traffic, etc., (b) weather environment characteristics, e.g., ambient temperature, precipitation, sun glare, darkness, etc., (c) roadway environment characteristics, e.g., curvature, skid resistance, elevation, gradient and material components, etc., (d) infrastructure environment characteristics, e.g., lighting, signage, type of road, quantity and type of intersections, lane merges, lane markings, quantity and timing of traffic lights, etc., and/or (e) any other type of driving environment data.

According to some embodiments of the invention, data collection module **40** collects information and data sufficient to enable the data processing module **42** to analyze how driving has impacted fuel efficiency. The feedback module **44** may report notable driving events that had positive or negative impact on the fuel efficiency of the vehicle **12**. For example, if the vehicle **12** has a normal transmission and the driver allows the engine to reach excessive RPMs before shifting to a higher gear, each occurrence may be reported as a notable driving event that impacts fuel efficiency. The feedback may assist the driver to develop driving habits that enable more fuel efficient vehicle operation.

Feedback module **44** may be operable to display any data associated with application **50**, including raw or filtered data collected by data collection module **40** and/or any of the metrics, scores, or other data calculated or proceed by data processing module **42**. For the purposes of this description, unless otherwise specified, "displaying" data may include (a) displaying data on display device **36** of mobile device **10**, (b) providing audible feedback via a speaker of mobile device **10**, providing visual, audible, or other sensory feedback to the driver via another device in the vehicle (e.g., through the vehicle's radio or speakers, displayed via the dashboard, displayed on the windshield (e.g., using semi-transparent images), or using any other known techniques for providing sensory feedback to a driver of a vehicle, (d) communicating data (via a network or other wired or wireless communication link or links) for display by one or more other computer devices (e.g., smart phones, personal computers, etc.), or (e) any combination of the preceding. To provide feedback to the driver visual, audible, or other sensory feedback to the driver via a feedback device in the vehicle other than mobile device **10**, mobile device **10** may include any suitable communication system for wired or wireless communication of feedback signals from mobile device **10** to such feedback device.

Further, feedback module **44** may also initiate and/or manage the storage of any data associated with application **50**, including raw or filtered data collected by data collection module **40** and/or any of the metrics, scores, or other data calculated or proceed by data processing module **42**, such that the data may be subsequently accessed, e.g., for display or further processing. For example, feedback module **44** may manage short-term storage of certain data (e.g., in volatile memory of mobile device **10**), and may further manage long-term storage of certain data as historical driving data **46** (e.g., in non-volatile memory of mobile device **10**). As another example, feedback module **44** may communicate data associated with application **50** via a network or other communication link(s) to one or more other computer devices, e.g., for display by remote computers **150** and/or for storage in a remote data storage system **152**, as discussed in greater detail below with reference to FIG. **5**.

Feedback module **44** may be operable to display metrics, scores, or other data in any suitable manner, e.g., as values, sliders, icons (e.g., representing different magnitudes of a particular metric/score value using different icons or using different colors or sizes of the same icon), graphs, charts, etc. Further, in embodiments in which mobile device **10** includes a GPS or other location tracking system **56**, feedback module **44** may display one or more maps showing the route travelled during one or more data collection sessions or driving sessions, and indicating the location of "notable driving events." Notable driving events may be identified on the map in any suitable manner, e.g., using representative icons. As an example only, different types of notable driving events (e.g., notable acceleration, notable braking, and notable cornering) may be represented on the map with different icons, and the severity level of each notable driving event may be indicated by the color and/or size of each respective icon.

Feedback module **44** may also display tips to help drivers improve their driving behavior. For example, feedback module **44** may analyze the driver's driving behavior metrics and/or driving scores to identify one or more areas of needed improvement (e.g., braking or cornering) and display driving tips specific to the areas of needed improvement.

In some embodiments, feedback module **44** may provide the driver real time feedback regarding notable driving events, via any suitable form of feedback, e.g., as listed above. For example, feedback module **44** may provide audible feedback (e.g., buzzers or other sound effects, or by human recorded or computer-automated spoken feedback) through a speaker of mobile device **10** or the vehicle's speakers, or visual feedback via display **36** of mobile device **10** or other display device of the vehicle. Such real-time audible or visual feedback may distinguish between different types of notable driving events and/or between the severity level of each notable driving event, in any suitable manner. For example, spoken feedback may indicate the type and severity of a notable driving event in real time. Non-spoken audible feedback may indicate the different types and severity of notable driving events by different sounds and/or different volume levels.

Feedback module **44** may manage user interactions with application **50** via input/output devices **38** (e.g., a touch screen display **36**, keys, buttons, and/or other user interfaces). For example, feedback module **44** may host a set or hierarchy of displayable objects (e.g., screens, windows, menus, images etc.) and facilitate user navigation among the various objects. An example set of displayable objects, in the form of screens, is shown and discussed with reference to FIGS. **6**A-**6**G.

In some embodiments, feedback module **44** may generate a series of user-navigable screens, windows, or other objects for display on display device **36** on mobile device **10**. FIGS. **6**A-**6**G illustrate example screen shots generated by driving analysis application **50** on an example mobile device **10**, according to certain embodiments.

FIG. **6**A illustrates an example screenshot of a screen **200** of a device orientation feature provided by application **50** for assisting a user with the proper alignment or orientation of mobile device **10** within the automobile or vehicle. In this example, an alignment image **202** may indicate the physical orientation (e.g., angular orientation) of mobile device **10** relative to the automobile. For example, alignment image **202** may rotate relative to the rest of the display as mobile device **10** is reoriented. Alignment image **202** may include arrows or other indicators to assist the use in orienting mobile device **10**. An indicator **204** (e.g., a lighted icon) may indicate when mobile device **10** is suitably oriented for data collection, e.g., with the front of mobile device **10** facing toward the front of the automobile or vehicle.

In embodiments requiring manual starting of data recording (i.e., starting a data collection session), a screen or image for starting data recording may appear upon the mobile device **10** being properly oriented. Thus, data collection module **40** may then start (or re-start) collection of driving data upon a manual instruction (e.g., a user pressing a "Start Recording" button that is displayed on display **36** once mobile device **10** is properly oriented).

In embodiments that provide for automatic starting of data recording (i.e., starting a data collection session), data collection module **40** may start (or re-start) driving data collection automatically upon the proper orientation of mobile device **10**, or automatically in response to an automatically generated triggering signal (assuming mobile device **10** is properly oriented).

FIG. **6**B illustrates an example screenshot of a screen **210** during a data collection session. The display may indicate that driving data is being recorded (image **212**) and may provide a selectable image **214** for stopping the recording of driving data (i.e., ending the data collection session).

FIG. **6**C illustrates an example screenshot of a summary screen **218** for a single data collection session, including three driving behavior metrics (Acceleration, Braking, and Cornering) and a driving score ("224") calculated by data processing module **42** for the single data collection session. For the illustrated data collection session, the driving score **224** calculated to be "82." The metrics and score may be displayed in real time (e.g., evaluating the driving behavior during an ongoing trip), after conclusion of a trip (e.g., evaluating the completed trip or a group of trips), or at any other time. As shown, screen **218** includes values **220** and corresponding bar graphs **222** indicating the Acceleration, Braking, and Cornering metrics, as well a visual representation **224** of the driving score ("82") calculated by data processing module **42**. The driving score may be calculated based on the Acceleration, Braking, and Cornering metrics using any suitable algorithm. For example, the driving score may be a straight or weighted average of the metrics, a sum or weighted sum of the metrics, or any other representation. The algorithm for calculating the driving score may also account for data other than the metrics, such as the identity of the driver, the time, duration, and/or distance of the data collection session, the weather conditions, traffic conditions, and/or any other relevant data accessible to data processing module **42**.

FIG. **6**D illustrates an example screenshot of a summary screen **230** for a group of multiple data collection sessions, including three multi-session driving behavior metrics (Acceleration, Braking, and Cornering) and a multi-session driving score ("78") calculated by data processing module **42** for the group of data collection sessions. Each multi-session driving behavior metric, as well as the driving score, for the group of sessions may be calculated based on any number of data collection sessions, and using any suitable algorithm. For example, each multi-session metric/score may be an average (e.g., straight or weighted average) of the respective metrics/scores determined for the n most recent data collection sessions. Further, the multi-session metric/score may be filtered according to preset or user-selected criteria. For example, each multi-session metric/score may be an average (e.g., straight or weighted average) of the respective metrics/scores determined for the n most recent data collection sessions that meet one or more preset or user-selected criteria regarding the respective data collection session, e.g., the particular driver, time of day, trip distance, trip duration, geographic area of

travel, weather conditions, traffic conditions, or any other relevant data accessible to data processing module **42**. Thus, for instance, module **42** may calculate multi-session driving behavior metrics and driving scores for the five most recent trips by Bob, which were further than 3 miles, within the geographic limits of a particular city, and during good weather conditions.

The number of data collection sessions included in a particular multi-session driving metric/score may be automatically or manually selected in any suitable manner, e.g., a predetermined number of sessions, a number automatically determined by module **42** (e.g., all sessions occurring within a predetermined time period), a number manually selected by a user, or determined in any other manner.

In embodiments in which particular multi-session driving metrics/scores represent weighted averages, each individual-session metric (e.g., each individual-session Braking metric) to be averaged into a weighted average may be weighted based on recentness (e.g., based on the elapsed time since that session, or the sequential order position of that session (e.g., the 3^{rd} most recent session)), trip duration, trip distance, or any other relevant criteria accessible to data processing module **42**. Thus, for instance, the weighting of each individual-session metric to be averaged into a weighted average may be weighted proportionally according to the number of days since each respective session, such that a trip that occurred 20 days ago is weighted twice as much as a trip that occurred 20 days ago. As another example, the 1^{st} most recent, 2^{nd} most recent, 3^{rd} most recent, and 4^{th} most recent sessions may be assigned predefined weighting factors of 0.50, 0.30, 0.15, 0.05, respectively. As another example, a 6-mile trip may be weighted the same as, or twice as much, as a 3-mile trip, depending on the specific embodiment. As another example, a 30-minute trip may be weighted the same as, or three times as much, a 10-minute trip, depending on the specific embodiment.

Alternatively, instead of displaying the average of the metrics/scores determined for a group of data collection sessions, summary screen **230** may display the median value for particular metrics/scores. Thus, for example, summary screen **230** may display for each metric the median value for that metric over the last seven trips. As another alternative, summary screen **230** may display the lowest or highest value for particular metrics/scores. Thus, for example, summary screen **230** may display for each metric the lowest value for that metric over the last seven trips.

It should be understood that multi-session driving metrics/scores may be determined using any combination of techniques or algorithms discussed above, or using any other suitable techniques or algorithms.

FIG. **6**E illustrates an example screenshot of a screen **240** summarizing various data for each of multiple data collection sessions. In this example, screen **240** indicates for each data collection session for a particular driver: a trip description (manually entered by a user or automatically determined by module **42**, e.g., based on GPS data), trip date, trip time (e.g., session start time, end time, or midpoint), and driving score (indicated by a bar graph and numerical value). In addition to or instead of displaying the driving score for each session, screen **240** may display one or more driving behavior metrics for each session, and/or other data relevant to each session (e.g., weather conditions, traffic conditions, trip distance, trip duration, etc.). Any number of sessions may be displayed, and the particular sessions that are displayed may be filtered, e.g., according to any of the criteria discussed above. In the illustrated example, the user may scroll down on screen **240** to view data for additional sessions.

FIG. **6**F illustrates an example screenshot of a screen **250** in which multiple trips can be compared. In this example, two trips by the same driver are compared. However, trips by different drivers may similarly be compared. The trips being compared may be selected by a user, or automatically selected by module **42** based on any suitable criteria. The compare function may be used to test drivers against a particular test course. For example, a driver education instructor could collect driving behavior metrics for himself by driving a test course. Later, students could collect driving behavior metrics while driving the same test course as previously driven by the instructor. The driving behavior metrics of the instructor could then be used as a standard against which to compare the driving behavior metrics of the students.

FIG. **6**G illustrates an example screenshot of a map screen **260**, indicating the path **262** of a recorded trip, which may be generated based on data collected by location tracking system **56** (e.g., GPS data). Screen **260** may also display icons **264** indicating the locations of notable driving events (NDEs). Such icons **264** may indicate the type and/or severity level of each NDE. In the illustrated example, the type of NDE (e.g., type "L", "R", "A", or "D") is indicated by the shape of the respective icon **264**, and the severity level of the NDE is indicated by the color of the icon **264**, indicated in FIG. **6**G by different shading. In some embodiments, the user may select a particular icon **264** to display (e.g., via a pop-up window or new screen) additional details regarding the respective NDE.

It should be understood that driving analysis application **50** may generate any number of additional screens for displaying the various information collected or processed by application **50**.

FIG. **3** illustrates an example method **80** of providing driver feedback, according to certain embodiments. Any or all of the steps of method **80** may be performed by the various modules of driving analysis application **50**.

At step **82**, data collection module **40** may collect driving data during a data collection session (which may correspond to a driving trip, a portion of a driving trip, or multiple driving trips). The collected driving data may include, e.g., driving behavior data collected by accelerometer **54**, location tracking system **56**, etc. and/or driving environment data collected by environmental data applications **58**. The collected driving data may also include driving behavior data and/or driving environment data collected by external devices and communicated to mobile device **10**.

Data collection module **40** may control the start and stop of the data collection session either manually or automatically, as discussed above. In some embodiments, this may include interacting with the user (driver or other person) to manage the physical orientation of mobile device **10** in order to allow the driving data collection to begin (or re-start after an interruption), as discussed above.

At step **84**, data processing module **42** may process or analyze any or all of the driving data collected at step **82**, and calculate one or more driving behavior metrics and/or scores corresponding to the data collection session, e.g., as discussed above. In addition, data processing module **42** may identify "notable driving events" (NDEs) and determine the severity of such events, e.g., as discussed above. In some embodiments, data processing module **42** may process the collected data in real time or substantially in real time. In other embodiments, data processing module **42** may process the collected data after some delay period, upon the end of the data collection session, in response to a request by a user (e.g., a user of mobile device **10**, a user at remote computer **150**, or

other user), upon collection of data for a preset number of data collection session, or at any other suitable time or in response to any other suitable event.

In some embodiments, data processing module **42** may calculate one or more individual driving behavior metrics (e.g., acceleration, braking, cornering, etc.) and/or driving scores for the current or most recent data collection session. Further, data processing module **42** may calculate one or more individual driving behavior metrics and/or driving scores for multiple data collection sessions. For example, data processing module **42** may calculate filtered or averaged driving behavior metrics and/or driving scores for a group of data collection sessions (e.g., as discussed above), including the current or most recent data collection session.

At step **86**, feedback module **44** may display any of the data collected by data collection module **40** at step **82** (e.g., raw data or filtered raw data) and/or any of the metrics, scores, or other data calculated or proceed by data processing module **42** at step **84**. This may include any manner of "displaying" data as discussed above, e.g., displaying data on display device **36**, providing visual, audible, or other sensory feedback to the driver via mobile device **10** or other device in the vehicle, communicating data to remote computer devices for remote display, etc. In some embodiments, feedback module **44** may facilitate user interaction with application **50** (e.g., via a touch screen display **36** or other input devices **38**) allowing the user to view any of the data discussed above, e.g., by user selection or navigation of displayed objects).

At step **88**, feedback module **44** may initiate and/or manage the storage of any of the data collected by data collection module **40** at step **82** (e.g., raw data or filtered raw data) and/or any of the metrics, scores, or other data calculated or proceed by data processing module **42** at step **84**, such that the stored data may be subsequently accessed, e.g., for display or further processing. For example, feedback module **44** may store data in local volatile memory for display, in local non-volatile memory as historical driving data **46**, and/or in remote memory as historical driving data **152**.

As shown in FIG. **3**, method **80** may then return to step **82** for the collection of new driving data. It should be understood that the steps shown in FIG. **3** may be performed in any suitable order, and additional steps may be included in the process. Further, certain steps may be performed continuously (e.g., the data collection step **82** may continue throughout the data collection process). Further, multiple steps may be performed partially or fully simultaneously.

In some embodiments, steps **82-88** (or at least portions of such steps) may be executed in real time or substantially in real time such that steps **82-88** are continuously performed, or repeated, during a particular data collection session. In such embodiments, at step **86** data may be prepared for subsequent display rather than being displayed in real time, while the process continues to collect, process, and store new driving data. However, as discussed above, certain feedback may be provided at step **86** in real time, e.g., real time feedback indicating the occurrence of notable driving events. In other embodiments, one or more steps may not be performed in real time. For example, some or all of the processing, display, and storage steps may be performed after the completion of the data collection session, e.g., when more processing resources may be available. For instance, collected raw data may be stored in first memory (e.g., cache or other volatile memory) during the data collection session; and then after the end of the data collection session, the collected data may be processed, displayed, stored in second memory (e.g., stored in non-volatile memory as historical driving data **46**), and/or communicated to remote entities for storage, processing, and/or display.

As discussed above, in some embodiments, driving data collected by application **50** may be used by various third parties for various purposes. Thus, for example, at step **90**, an insurance provider may receive or access driving behavior metrics and/or driving scores collected by application **50** (e.g., by receiving or accessing historical driving data **46** directly from mobile device **10** and/or by receiving or accessing historical driving data **152** from external storage), and analyze such data for performing risk analysis of the respective driver. The insurance provider may determine appropriate insurance products or premiums for the driver according to such risk analysis.

FIG. **4** illustrates an example method **100** of providing driver feedback using example algorithms, according to certain embodiments. Any or all of the steps of method **100** may be performed by the various modules of driving analysis application **50**.

At step **102**, data collection module **40** may interact with the user to adjust the mobile device **10** such that the orientation of mobile device **10** is suitable for collecting driving data. For example, data collection module **40** may instruct the user to position the mobile device **10** towards the front of the vehicle and with the top end of the mobile device **10** facing the front of the vehicle.

Once data collection module **40** determines that mobile device **10** is properly oriented, data collection module **40** may begin collecting driving data, i.e., start a data collection session, at step **104**. For example, data collection module **40** may begin collecting raw G-force data (i.e., acceleration data) from built-in accelerometer **54**. The collected G-force data may provide data for multiple different acceleration directions, e.g., lateral G-force data regarding lateral acceleration and longitudinal G-force data regarding longitudinal acceleration. Module **40** may time stamp the collected data. Further, module **40** may filter or truncate the beginning and end of the data collection session, the extent of which filtering or truncation may depend on the length of the data collection session. For example, if the data collection session exceeds 4 minutes, module **40** may erase data collected during the first and last 60 seconds of the data collection session; whereas if the data collection session does not exceed 4 minutes, module **40** may erase data collected during the first and last 3 seconds of the data collection session. The particular values of 4 minutes, 60 seconds, and 3 seconds are example values only; any other suitable values may be used.

At step **106**, data processing module **42** may process the collected driving data. For example, module **42** may calculate a one-second moving average of the G-force. Thus, if the data collection is for instance 5 Hz, the 5-step moving average may be calculated. Module **42** may then calculate the "jerk" at each time stamp T, wherein jerk at a particular time stamp T, is defined as follows:

$$\text{Jerk} = abs(\text{moving averaged } G\text{-force at time stamp } T_j - \text{moving averaged } G\text{-force at time stamp } T_{j-1}) / \text{unit_time(1 second)}$$

(Alternatively, jerk may be calculated using raw G-forces data instead of averaged G-force data.)

Module **42** may then calculate the one-second moving average of the jerk.

Module **42** may then determine one or more driving behavior metrics based on the moving averaged jerk and G-force data. For example, module **42** may determine a G-force percentile and a jerk percentile at each time stamp T_i by access-

ing look-up tables corresponding to one or more relevant parameters. For instance, a portion of an example look-up table for an example set of relevant parameters is provided below:

Relevant Parameters:
Vehicle: Impala
Vehicle type: Sedan
Acceleration direction (lateral or longitudinal): Lateral
Type of data (G-force or Jerk): G-force
Speed range: 0-100 mph

TABLE 1

G-force Percentile Look-Up Table

G-force range		Percentile
0.000	0.012	0
0.013	0.025	1
0.026	0.038	2
0.039	0.051	3
0.052	0.064	4
0.065	0.077	5
0.078	0.090	6

Module **42** may store or have access to any number of such look-up tables for various combinations of relevant parameters. For example, module **42** may store a look-up table (similar to Table 1) for determining the jerk percentile. As another example, module **42** may store similar look-up tables for determining G-force and jerk percentiles for different combinations of vehicles, vehicle types, speed ranges, acceleration direction (lateral or longitudinal), etc.

At step **108**, data processing module **42** may calculate a Base Driving Score for the data collection session, according to the following equation:

$$\text{Base Driving Score}=(AVG_{13}\ G\text{-force_percentile})*W1+(AVG_\text{Jerk_percentile})*W2$$

wherein:

AVG_G-force_percentile is the average of the G-force percentiles for all time stamps T_i during the data collection session;

AVG_Jerk_percentile is the average of the jerk percentiles for all time stamps T_i during the data collection session; and

W1 and W2 are weighting constants used to weight the relative significance of G-force data and jerk data as desired.

As another example, the base driving score may be calculated according to the following equations:

$$T_i\ \text{Driving Score}=\min(100,250-(2*T_i\ \text{percentile}))$$

$$\text{Base Driving Score}=\text{average of all } T_i \text{ Driving Scores in which max } G\text{-force(lateral,longitudinal)}<\text{predefined minimal value.}$$

wherein:

T_i percentile is a percentile determined for each time stamp T_i (e.g., G-force percentile, jerk percentile, or a weighted average of G-force percentile and jerk percentile for the time stamp T_i);

T_i Driving Score is a driving score for each time stamp T_i; and

T_i Driving Scores in which max G-force (lateral, longitudinal)<predefined minimal value indicates that data from time stamps in which the max (lateral, longitudinal) G-force is less than some predefined minimal value (e.g., 0.01) is excluded from the calculations. For example, due to the fact that g-forces may be less than some predefined minimal value (e.g., 0.01) at some or many time stamps (e.g., during highway cruise driving), as well as the issue of unstable g-force reading (below) a predefined minimal value, module **42** may ignore data from time stamps in which the max (lateral, longitudinal) G-force is less than the predefined minimal value.

At step **110**, data processing module **42** may identify and analyze any notable driving events during the data collection session, based on the collected/processed G-force data and jerk data. For example, module **42** may compare the lateral and longitudinal G-force data to corresponding threshold values to identify the occurrence of notable driving events. For example, module **42** may execute the following example algorithms to identify the occurrence and type of a notable driving event (NDE) for a Chevrolet Impala:

lat_magnitude_gf=max(0, abs(LatG)−0.40);
lon_magnitude_gf=max(0, abs(LonG)−0.30);
magnitude_gf=max(lat_magnitude_gf, lon_magnitude_gf);
if magnitude_gf=lat_magnitude_gf and latG.>0 then NDE_type="L";
else if magnitude_gf=lat_magnitude_gf and latG.<=0 then NDE_type="R";
else if magnitude_gf=lon_magnitude_gf and lonG<0 then NDE_type="A";
else if magnitude_gf=lon_magnitude_gf and lonG>=0 then NDE_type="D";
else no NDE identified.
wherein:
LatG=lateral G-forces detected by the accelerometer;
LonG=longitudinal G-forces detected by the accelerometer;
NDE_type "L"=Left Cornering
NDE_type "R"=Right Cornering
NDE_type "A"=Acceleration
NDE_type "D"=Deceleration

The threshold values used in such algorithms (e.g., the LatG and LonG threshold values 0.40 and 0.30 shown above) may be specific to one or more parameters, such that module **42** applies appropriate thresholds based on the parameter(s) relevant to the data being analyzed. For example, module **42** may store different threshold values for different types of vehicles. To illustrate an example, module **42** may store the following threshold values for three different vehicles: Impala, Camaro, and FordVan:

Impala (shown above)
LatG threshold=0.40
LonG threshold=0.30
Camaro
LatG threshold=0.60
LonG threshold=0.40
Ford Van
LatG threshold=0.30
LonG threshold=0.30

It should be understood that the threshold values shown above are examples only, and that any other suitable values may be used.

Data processing module **42** may further determine the severity level of each notable driving event (NDE) identified during the data collection session. For example, FIG. **7** provides an illustrative flow chart wherein module **42** may execute the following algorithm to determine the severity level (e.g., caution, warning, or extreme) of each NDE:

start **701** the algorithm
identify **702** the G-force magnitude peak associated with the NDE;

if the G-force magnitude peak is at least 0.2 above the relevant LatG/LonG threshold **703**, the NDE severity level is "extreme" **704**;

else if the G-force magnitude peak is at least 0.1 above the relevant LatG/LonG threshold **705**, the NDE severity level is "warning" **706**;

else if the G-force magnitude peak is above the caution threshold **707**, the NDE severity level is "caution" **708**; and

return **709** to the algorithm for detecting NDEs.

It should be understood that the threshold values shown above (0.2 and 0.1) are examples only, and that any other suitable values may be used.

FIG. **8** is a flow chart of an alternative illustrative algorithm for determining severity levels of notable driving events (NDE) identified during data collection sessions. In this embodiment, the output severity levels are "severe," "medium" and "low."

Data processing module **42** may further "de-dupe" identified NDEs, i.e., eliminate or attempt to eliminate double counting (or more) of the same NDE. For example, module **42** may apply an algorithm that applies a 30 second rule for de-duping the same type of NDE (e.g., L, R, A, or D), and a 4 second rule for de-duping different types of NDEs. Thus, if multiple NDEs of the same type (e.g., two L-type events) are identified within a 30 second window, module **42** assumes that the same NDE is being counted multiple times, and thus treats the multiple identified NDEs as a single NDE. Further, if multiple NDEs of different types (e.g., one L-type event and one R-type event) are identified within a 4 second window, module **42** assumes that the same NDE is being counted multiple times, and thus treats the multiple identified NDEs as a single NDE, and applies any suitable rule to determine the NDE type that the NDE will be treated as (e.g., the type of the first identified NDE controls, or a set of rules defining that particular NDE types control over other NDE types).

It should be understood that the de-duping time limits shown above (30 seconds and 4 seconds) are examples only, and that any other suitable time limits may be used.

Referring again to FIG. **4**, at step **116** feedback module **44** may initiate and/or manage the storage of any of the data collected by data collection module **40** at step **104** (e.g., raw data or filtered raw data) and/or any of the metrics, scores, or other data calculated or processed by data processing module **42** at steps **106-112**, such that the stored data may be subsequently accessed, e.g., for display or further processing. For example, feedback module **44** may store data in local volatile memory for display, in local non-volatile memory as historical driving data **46**, and/or communicate data to remote devices **150** and/or remote driving data storage **152**.

As discussed above, in some embodiments, driving data collected by application **50** may be used by various third parties for various purposes. Thus, for example, at step **118**, an insurance provider may receive or access driving behavior metrics and/or driving scores collected by application **50** (e.g., by receiving or accessing historical driving data **46** directly from mobile device **10** and/or by receiving or accessing historical driving data **152** from external storage), and analyze such data for performing risk analysis of the respective driver. The insurance provider may determine appropriate insurance products or premiums for the driver according to such risk analysis.

At step **112** (see FIG. **4**), data processing module **42** may calculate an Adjusted Driving Score for the data collection session, by adjusting the Base Driving Score certain values calculated at step **108** based on NDEs determined at step **110**. For example, module **42** may deduct from the Base Driving Score based on the number, type, and/or severity level of NDEs determined at step **110**. In some embodiments, only certain types and/or severity levels of NDEs are deducted from the Base Driving Score. For example, module **42** may execute the following algorithm, in which only "warning" and "extreme" level NDEs (but not "caution" level NDEs) are deducted from the Base Driving Score:

NDE Penalty for each NDE=50*(G-force−G-force_warning_threshold);

Adjusted Driving Score=Base Driving Score−sum (NDE Penalties)

It should be understood that this algorithm is an example only, and that any other suitable algorithms for determining an Adjusted Driving Score may be used.

At step **114**, feedback module **44** may display any of the data collected by data collection module **40** at step **104** (e.g., raw data or filtered raw data) and/or any of the metrics, scores, or other data calculated or processed by data processing module **42** at steps **106-112**. This may include any manner of "displaying" data as discussed above, e.g., displaying data on display device **36** on mobile device **10**, providing visual, audible, or other sensory feedback to the driver via mobile device **10** or other device in the vehicle, communicating data to remote computer devices for remote display, etc. In some embodiments, feedback module **44** may facilitate user interaction with application **50** (e.g., via a touch screen display **36** or other input devices **38**) allowing the user to view any of the data discussed above, e.g., by user selection or navigation of displayed objects).

FIG. **5** illustrates an example system **140** for sharing driving data between a mobile device **10** including driving analysis application **50** and other external systems or devices, according to certain embodiments. As shown, mobile device **10** may be communicatively connected to one or more remote computers **150** and/or remote data storage systems **152** via one or more networks **144**.

Computers **150** may include any one or more devices operable to receive driving data from mobile device **10** and further process and/or display such data, e.g., mobile telephones, personal digital assistants (PDA), laptop computers, desktop computers, servers, or any other device. In some embodiments, a computer **150** may include any suitable application(s) for interfacing with application **50** on mobile device **10**, e.g., which application(s) may be downloaded via the Internet or otherwise installed on computer **150**.

In some embodiments, one or more computers **150** may be configured to perform some or all of the data processing discussed above with respect to data processing module **42** on mobile device **10**. Such a computer may be referred to herein as a remote processing computer. For example, mobile device **10** may communicate some or all data collected by data collection module **40** (raw data, filtered data, or otherwise partially processed data) to a remote processing computer **150**, which may process (or further process) the received data, e.g., by performing any or all of the driver data processing discussed above with respect to data processing module **42**, and/or additional data processing. After processing the data, computer **150** may then communicate the processed data back to mobile device **10** (e.g., for storage and/or display), to other remote computers **150** (e.g., for storage and/or display), and/or to remote data storage **152**.

The data processing and communication of data by computer **150** may be performed in real time or at any other suitable time. In some embodiments, computer **150** may process driving data from mobile device **10** and communicate the processed data back to mobile device **10** such that the data may be displayed by mobile device **10** substantially in real

time, or alternatively at or shortly after (e.g., within seconds of) the completion of a driving data collection session.

Using one or more computers **150** to perform some or all of the processing of the driving data may allow for more processing resources to be applied to the data processing (e.g., thus providing for faster or additional levels of data processing), as compared to processing the data by mobile device **10** itself. Further, using computer(s) **150** to perform some or all of the data processing may free up processing resources of mobile device **10**, which may be advantageous.

Remote data storage devices **152** may include any one or more data storage devices for storing driving data received from mobile device **10** and/or computers **150**. Remote data storage **152** may comprise any one or more devices suitable for storing electronic data, e.g., RAM, DRAM, ROM, flash memory, and/or any other type of volatile or non-volatile memory or storage device. A remote data storage device **152** may include any suitable application(s) for interfacing with application **50** on mobile device **10** and/or with relevant applications on computers **150**.

Network(s) **144** may be implemented as, or may be a part of, a storage area network (SAN), personal area network (PAN), local area network (LAN), a metropolitan area network (MAN), a wide area network (WAN), a wireless local area network (WLAN), a virtual private network (VPN), an intranet, the Internet or any other appropriate architecture or system that facilitates the communication of signals, data and/or messages (generally referred to as data) via any one or more wired and/or wireless communication links. The network(s) **144** may include any communication link known to persons of skill, including for example, cloud, cellular or satellite transmission, magnetic or optical media, radio frequency transmission, microwave or fiber optic transmission, or communications via Internet, cable, or satellite providers.

Referring to FIG. **9**, an example of an architectural design for an infrastructure according to embodiments of the invention. An infrastructure **151** according to one embodiment comprises a remote data storage system **152** and a property and casualty system **153**. Data may be transmitted via a network **144** from a mobile device **10** in a vehicle **12** to a remote data storage system **152**.

The remote data storage system **152** comprises a server **154** and a database **155**. The database **155** stores various data and information transmitted to it via the server **154**, including: data received from a mobile device **156**, data calculated by a mobile device prior to receiving **157**, and captured and available data for property and casualty rating **158**. Data received from a mobile device **156** may comprise: device identification; Bluetooth MAC address; trip number; location—latitude; location—longitude; location—coarse/fine indicator; speed; acceleration—X; acceleration—Y; acceleration—Z; GPS date and time; turn indicator and/or GPS accuracy. Prior to sending, the mobile device **10** may also calculate information. Data calculated by a mobile device prior to receiving **157** may include: turn indicator; lateral G force; longitudinal G force; turn radius; average lateral G force; average longitudinal G force; average turn radius; X midpoint; X now; X back **1**; X back **2**; Y midpoint; Y now; Y back **1**; Y back **2**; tangent calculation for radius **1**; tangent calculation for radius **2**; time change between locations; longitude G with local gravity; lateral G with local gravity; lateral G calculated; lateral G second derivative; and/or parallel G slope. Examples of captured and available data for property and casualty rating **158** may include: vehicle information (age, manufacturer, model, value), driver information (age, sex, marital status, driving record, accident history, residence), and insurance information (liability, uninsured motorists, comprehensive, collision, liability limits, deductibles, rebates, discounts).

The property and casualty system **153** comprises a server **140**, a storage application **141**, a staging telematics database **142** and an operational telematics data base **143**. The property and casualty system **153** uses the data captured by the remote data storage system **152** to calculate property and casualty premiums for the operators of vehicles. Threshold metrics may be established for driving behaviors so that property and casualty premiums may be identified to correspond to the driving behaviors. This system may be automated so that the property and casualty premiums may be charge to the operators of vehicles in real time depending on their driving behaviors.

FIG. **10** provides a flow chart for a driving analysis application **50**. The application launches **160** on a mobile device **10** (see FIG. **1**) and splashes **161** an introductory page publishing the name of the application and appropriate logos to identify the application. The application queries the user **162** to determine whether the user is registered. If the user is not registered, the application **50** will prompt the user to create an account **163**. When the user is registering for the first time, the user may enter details like: username; password; vehicle make; vehicle year; vehicle model; and/or vehicle odometer reading. The application **50** may then determine if an account is successfully created **167**, and if not again prompt the user to create an account **163**. If an account is successfully created **167**, the user may be directed to a main menu (landing page) **164** that may have options: (1) a Bluetooth pairing setup **165** for completing the registration or modifying the car which is being used; (2) a daily summary **168** giving details regarding the trips of the user; (3) an odometer option **169** for updating the odometer reading of the paired vehicle; and (4) a help section **170** for the user to report technical difficulties with the application **50** or to answer questions that the user may have.

From the main menu (landing page) **164**, the user may select a Bluetooth pairing setup **165** for completing the registration or modifying the vehicle which is being operated by completing a Bluetooth pairing. If the user exits the application prior to Bluetooth pairing, then the user may not able to access the daily summary and odometer details. If the Bluetooth pairing **165** is successful, then the data **166** (Bluetooth pairing; vehicle year; vehicle model; and/or vehicle odometer reading) may be transmitted to a server **154**. If the Bluetooth pairing **165** is unsuccessful, the application **50** may return to the main menu (landing page) **164**. Once as user has successfully created an account **163** and Bluetooth paired **165** the mobile device **10** with the vehicle **12**, the application **50** always runs in the background for collection of data. As soon as the user starts the vehicle, the data logging starts to take place. Collected data is automatically transmitted to the server **154**, described more fully below. During the whole process certain data is sent to the server **154** from the mobile device **10**, and similarly after calculations are made, data may be received by the mobile device **10** from the server **154**. Data sent to the server **154** may include: Username; Password; Vehicle Make; Vehicle Year; Vehicle Model; Odometer Reading; and Bluetooth Mac address. Data received from the server **154** may include: Date Selection; Vehicle Details; Total Miles Driven; Number of Stops; Number of Trips; Maximum Speed; Odometer Reading; Time Specific Details; Speed Specific Details; and Trip List.

In alternative embodiments of the invention, any trigger may be used to tell the application **50** to begin logging data. For example, a threshold engine speed (RPM) may trigger data logging. As a further example, movement of the vehicle **12** may trigger data logging.

FIG. **10** further shows that, from the main menu (landing page) **164**, the user may select a daily summary **168** giving details regarding the trips of the user. Based on the trips for that particular day a daily report is available to the user. The daily report includes vehicle use data **171**, which may be transmitted from the remote data storage device **152** to the mobile device **10**. The vehicle use data **171** may include: 1) "date selection" for the user to select the date of which he wants the details; 2) "vehicle details" that were entered by the user at the start; 3) "total miles driven" are recorded by the application **50** once the user has registered; 4) "number of stops" provides information about the vehicle not moving, i.e., idling or being at 0 mph; 5) "number of trips" provides the total trips on that particular day; 6) "maximum speed" is the max speed reached on that particular day; and 7) "odometer reading" is the total odometer reading (User Entered Value+ Total Miles Driven). The daily report may also allow the user to view: time specific details **172**; speed specific details **173**; and trip specific details **174**.

Time specific details (Time Interval) **172** may include time in blocks of 2 hours displayed on the left hand side, which is helpful for the user to know in which times he has driven the most. Time specific details may be relevant to insurance providers to know whether the user is driving in high, moderate or low traffic times. Time specific details (Time Interval) **172** may also include trip percentages, so the user can see what percent of total daily driving each trip comprised.

Speed Specific Details (Speed Interval) **173** may include time in blocks of 10, with a separate section for idling displayed on the left hand side, which may be helpful for the user to know the speed range he has driven the most. It may be relevant to insurance providers to know whether the user is driving at high, moderate or low speeds to determine risks of potential accidents. Speed Specific Details (Speed Interval) **173** may also include percentages in which the user drove at particular speed ranges, wherein the percentages add up to a total of 100% for that day.

Different Trip Details **174** may contain a list of trips by the user on that particular day. When the user selects a particular trip, the application **50** may provide the user the route that was traversed on the trip, which is similar to a GPS plot on a map.

Turning to FIGS. **11**A-**11**K, example screen shots of the application user interface are provided. FIG. **11**A illustrates an user interface for prompting the user to create an account **163**, wherein fields are provided for a user ID, password, and zip code. If the user successfully creates an account, the application **50** prompts the user to select Setting to complete registration as shown in FIG. **11**B. A Settings tab (see FIG. **11**C) allows the user to navigate to a Bluetooth Setup window as shown in FIG. **11**D. From this window, the user may select a Bluetooth Settings tab, which will enable the application **50** to cause the mobile device **10** to search for a signal from a vehicle **12** and pair the mobile device **10** to the vehicle **12**. After pairing, a Vehicle screen is displayed to the user so that the user is prompted to enter the year, make, model and odometer of the paired vehicle **12**, as shown in FIG. **11**E. Once paired with the vehicle, registration is complete.

FIG. **11**F shows a screen shot for a main menu (landing page) **164**. The user is provided tabs for Drive Data, Odometer, Settings, and Help. The Drive Data tab allows the user to navigate to a Daily Report screen as shown in FIG. **11**G. For any given day selectable by the user, the Daily Report identifies the vehicle, provides the total miles driven (moving time), the number of stops, the number of trips, the maximum speed, and the odometer. The Daily Report screen also provides the user three tabs: Speed, Time, and Trip. The Speed tab navigates to a screen as shown in FIG. **11**H, which shows speed ranges in increments of 10 miles per hour, for example, and the percent of time the vehicle was operated within each speed range during the day. In this illustration for a vehicle operated on Dec. 22, 2011, the vehicle idled for 22% of the time, was operated between 1-9 mph for 6% of the time, was operated between 10-19 mph for 9% of the time, was operated between 20-29 mph for 9% of the time, was operated between 30-39 mph for 20% of the time, was operated between 40-49 mph for 31% of the time, and was operated between 50-59 mph for 4% of the time. The Time tab shown in FIG. **11**G navigates to a screen as shown in FIG. **11**I, which provides periods of time during the day and the percent of operation during each time period. In this illustration for a vehicle operated on Dec. 22, 2011, 100% of the operation was between 6:00-7:59 am. The Trip tab shown in FIG. **11**G navigates to a screen as shown in FIG. **11**J, which provides a listing of trips for the selected date. In this example, only one trip (6:06 AM 6.5 miles) was recorded on the selected day. If the user selects a trip displayed on the screen of FIG. **11**J, the application **50** navigates to a map with the trip plotted thereon, as shown in FIG. **11**K.

Referring again to FIG. **11**F, if the user selects the Odometer tab from the main menu (landing page) **164**, the application navigates to an Odometer Update screen as shown in FIG. **11**L. This screen prompts the user to enter the actual vehicle odometer reading.

FIG. **12** illustrates a flow chart for the collection and analysis of vehicle use data according to certain embodiments of the invention. When the user starts **180** the engine of the vehicle, a Bluetooth connection is made **181** between the mobile device **10** and the vehicle **12**. If the Bluetooth connection is unsuccessful, the application **50** does not start logging data **182**. If the Bluetooth connection is successful, the application **50** does start logging data **183**. The application **50** will log vehicle use data until the vehicle engine is turned off. The status of the engine is monitored **184** and if the engine is turned off, the application **50** stops logging data **185**. Any data collected on the mobile device when the engine is turned off is sent to the server **154** of the remote data storage system **152**. As long as the vehicle engine is not turned off, data is collected **186** every second on the mobile device **10**. Data collected every second **187** may include: (1) Acceleration Data from accelerometer or sensor used for determining speed, stops, acceleration, and turns; (2) G-force Data for very high speed brakes, hard brakes, smooth brakes, very high speed turns, hard turns, smooth turns, very high speed acceleration, hard acceleration, or smooth acceleration; (3) GPS/Location Coordinate Data used for plotting the route and speed; and (4) Time based information for telling time periods of operation. Data is transmitted **188** from the mobile device **10** to the server **154** of the remote data storage system **152** via a network **144**. Every 1 minute of data is sent 189 to the server for backend calculations if the network is readily available. In the case of non availability of network or intermittent availability the data is stored 191 on the mobile device **10** until that batch is sent to the server. It is sent as soon as the network is available on the user's mobile device **10**. Data is sent back **190** from the server after calculations for the users Daily Report and also to allow the user to see the data in the terms of the time, trip and speed. When the vehicle is turned off, the application stops logging the data **185**, and the remaining data is then sent to the server for calculations at the point of disconnection of the Bluetooth.

While some embodiments of the invention use a Bluetooth pairing between the mobile device **10** and the vehicle **12**, any pairing methodology known to persons of skill may be

employed. For example, an audio signal may fingerprint the vehicle **12** for the mobile device **10**. Radio frequency signals may also be used.

According to different aspects of the invention, software may reside on the mobile device **10** in the application **50** to perform various calculations and manipulation of data, or software may reside on a remote processing computer **150** or a remote data storage system **152** to perform these functions. Depending on the storage and communication capabilities of the mobile device **10**, it may be more efficient to perform functions on the mobile device **10** or on the on a remote processing computer **150** or a remote data storage system **152**.

A rating engine according to embodiments of the present invention may be used to generate or calculate use-based insurance premiums, which may be applied prospectively or retrospectively. Based on the collected data, a previously paid insurance premium may be adjusted by providing a rebate for low risk driving behaviors or charging a surcharge for high risk driving behaviors. In this retrospective case, the cost of insurance may be the sum of a base premium and the surcharge or rebate. In a prospective case, use data may be collected for a given month and used as a basis to set an insurance premium for a subsequent month.

A rating engine may be used to calculate an insurance premium based on the data collected from the mobile device **10**. From the data collected from the mobile device **10**, individual factors tending to have predictive power may be isolated and fed into the automated rating engine. The individual factors may be placed in context with other known information about the insured user to increase the predictive power of the automated rating engine to set an appropriate insurance premium for the particular insured user. Insurance premiums are typically calculated based on actuarial classifications, which may be required for underwriting. These classifications may include: vehicle type, vehicle age, user age, user sex, driving history, place of residence, place of employment, traffic violations, vehicle equipment (airbags, antilock breaks, theft control), etc. Data collected from the mobile device **10** may be used to supplement these actuarial classifications to calculate an insurance premium.

The rating engine may employ use-based information from many drivers to identify factors that have greater or less predictive power. As more data is collected on a larger number of vehicle users, over time, the rating engine may be improved to place greater weight on those use factors that tend to have greater predictive power.

The use data collected from vehicles may be inserted into an insurance company's normal data streams to allow the rating engine to calculate insurance premiums based on all available information. Normal billing cycles and processes for communicating premium information to insured users may proceed without disruption as the rating engine proceeds as normal, except that it now incorporates use-based information into the premium calculation.

To encourage vehicle users to register their mobile devices **10** and download the application **50** so as to take advantage of use-based insurance products, wireless service providers may discount service provider premiums in exchange for users registering their mobile devices **10** for use-based insurance. Wireless service providers and carriers currently offer a number of discounts and/or subsidizing programs for phone and data plans. Participants in use-based insurance programs may be offered discounts or subsidized programs relative to their phone or data plans.

Embodiments of the invention may be used in a variety of applications. For example, a driver feedback mobile device could be used to proctor a driver's test for a candidate to obtain a driver's license. It may be used to educate drivers about how to drive in ways that promote better fuel efficiency. The invention may be used to leverage mobile devices to quantify and differentiate an individual's insurance risk base on actual driving behaviors and/or driving environment. The invention may be used to provide data that could be used as a basis to provide a potential customer a quote for insurance. Embodiments of the invention may be used by driver education instructors and systems to educate drivers about safe driving behaviors.

Although the disclosed embodiments are described in detail in the present disclosure, it should be understood that various changes, substitutions and alterations can be made to the embodiments without departing from their spirit and scope.

What is claimed is:

1. A method for collecting and processing vehicle operation data by a mobile device of a user, the method comprising:

during a driving session, collecting, by the mobile device of the user, vehicle operation data associated with operation of a vehicle while the vehicle is operating, the vehicle operation data comprising at least one of global positioning system (GPS) data and mobile device position data by one or more integrated sensors or devices in the mobile device;

during the driving session and while collecting the vehicle operation data, monitoring, by the mobile device, an orientation of the mobile device changing relative to the vehicle;

wherein said step of during the driving session and while collecting the vehicle operation data, monitoring, by the mobile device, the orientation of the mobile device changing relative to the vehicle comprises:

analyzing the at least one of GPS data and mobile device position data collected by the one or more integrated sensors or devices during the driving session;

based at least on the analysis of the at least one of GPS data and mobile device position data collected by the one or more integrated sensors or devices, automatically determining, by the mobile device, changes in the orientation of the mobile device relative to the vehicle during the driving session and while the vehicle operation data is being collected;

adjusting, by the mobile device, via execution of a compensation algorithm, at least a portion of the collected vehicle operation data based on the determined changes in the orientation of the mobile device relative to the vehicle during the driving session and while the vehicle operation data is being collected;

processing, by the mobile device, the automatically adjusted vehicle operation data; and

wirelessly transmitting, by the mobile device, the processed vehicle operation data to a remote computer for calculating an insurance premium based on the transmitted data.

2. The method of claim **1**, wherein said user's mobile device is a device selected from the group consisting of a smartphone, a cell phone, a mobile telephone, a personal digital assistant (PDA), a laptop computer, and a tablet-style computer.

3. The method of claim **1**, wherein the step of collecting vehicle operation data by the mobile device comprises sensing a characteristic of the mobile device selected from distance traveled, location, time, and g-force dynamics by one or more sensors associated with the mobile device.

4. The method of claim 1, wherein the step of collecting vehicle operation data by the mobile device comprises:

detecting, by the mobile device, the orientation of the mobile device relative to the vehicle prior to the collection of the vehicle operation data by the mobile device;

determining, by the mobile device, whether the detected orientation of the mobile device relative to the vehicle prior to the collection of the vehicle operation data is suitable for vehicle data collection; and

initiating, by the mobile device, the collection of the vehicle operation data by the mobile device only if it is determined that the detected orientation of the mobile device is suitable for vehicle data collection.

5. The method of claim 1, wherein the step of collecting vehicle operation data by the mobile device comprises collecting vehicle operation data periodically during the driving session.

6. The method of claim 1, wherein the step of wirelessly transmitting the processed vehicle operation data from the mobile device to a remote computer comprises wirelessly transmitting periodically.

7. The method of claim 1, further comprising loading the driving analysis application onto the user's mobile device prior to the step of collecting the vehicle operation data by executing a driving analysis application.

8. The method of claim 1, wherein the step of collecting, by the mobile device, vehicle operation data associated with operation of a vehicle while the vehicle is operating comprises beginning to collect the vehicle operation data in response to a triggering event selected from vehicle engine start, threshold vehicle engine RPM, and vehicle mobility.

9. The method of claim 1, wherein the step of collecting, by the mobile device, vehicle operation data associated with operation of a vehicle while the vehicle is operating comprises stopping collection of the vehicle operation data in response to a triggering event selected from vehicle engine stop, threshold vehicle engine RPM, and vehicle immobility.

10. The method of claim 1, wherein:

the step of processing, by the mobile device, the automatically adjusted vehicle operation data comprises calculating, by the mobile device, one or more driving behavior metrics; and

the step of wirelessly transmitting, by the mobile device, the processed vehicle operation data to the remote computer comprises wirelessly transmitting, by the mobile device, the calculated one or more driving behavior metrics to the remote computer.

11. The method of claim 1, wherein the step of processing, by the mobile device, the automatically adjusted vehicle operation data comprises preparing, by the mobile device, the automatically adjusted vehicle operation data for transmission to the remote computer.

12. A handheld mobile device configured to collect and process vehicle operation data, the handheld mobile device comprising:

one or more data collection devices configured to collect, during a driving session, vehicle operation data associated with operation of a vehicle while the vehicle is operating during a driving session, the one or more devices including at least one sensor or device configured to collect at least one of global positioning system (GPS) data and mobile device position data during the driving session;

a processor;

memory;

a driving analysis application stored in the memory and executable by the processor to:

monitor an orientation of the mobile device changing relative to the vehicle during the driving session and while the vehicle operation data is being collected by the one or more data collection devices;

wherein monitoring the orientation of the mobile device changing relative to the vehicle during the driving session and while the vehicle operation data is being collected by the one or more data collection devices comprises:

analyzing the at least one of GPS data and mobile device position data collected by the one or more integrated sensors or devices during the driving session; and

based at least on the analysis of the at least one of GPS data and mobile device position data collected by the one or more integrated sensors or devices, automatically determining changes in the orientation of the mobile device relative to the vehicle during the driving session and while the vehicle operation data is being collected;

adjust, via execution of a compensation algorithm, at least a portion of the collected vehicle operation data based on the determined changes in the orientation of the mobile device relative to the vehicle during the driving session and while the vehicle operation data is being collected; and

process the automatically adjusted vehicle operation data; and

a wireless transmitter configured to wirelessly transmit the processed vehicle operation data to a remote computer for calculating an insurance premium based on the transmitted data.

13. The handheld mobile device of claim 12, wherein the handheld mobile device is selected from the group consisting of a smartphone, a cell phone, a mobile telephone, a personal digital assistant (PDA), a laptop computer, and a tablet-style computer.

14. The handheld mobile device of claim 12, wherein the one or more data collection devices configured to collect at least one of distance traveled data and geographic location data.

15. The handheld mobile device of claim 12, wherein the driving analysis application is further executable by the processor to:

detect the orientation of the mobile device relative to the vehicle prior to the collection of the vehicle operation data during the driving session by the mobile device;

determine whether the detected orientation of the mobile device relative to the vehicle prior to the collection of the vehicle operation data is suitable for vehicle data collection; and

initiate the collection of the vehicle operation data by the mobile device only if it is determined that the detected orientation of the mobile device is suitable for vehicle data collection.

16. The handheld mobile device of claim 12, wherein the one or more data collection devices are configured to collect vehicle operation data periodically during the driving session.

17. The handheld mobile device of claim 12, wherein the wireless transmitter is configured to wirelessly transmit the processed vehicle operation data to the remote computer periodically during the driving session.

18. The handheld mobile device of claim 12, wherein the driving analysis application is executable by the processor to:

calculate one or more driving behavior metrics; and

cause the wireless transmitter to wirelessly transmit the calculated one or more driving behavior metrics to the remote computer.

19. The handheld mobile device of claim 12, wherein the driving analysis application is executable by the processor to prepare the automatically adjusted vehicle operation data for transmission to the remote computer.

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