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Lindsay

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(54) **DRIVER BEHAVIOR MONITORING**

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(60) Provisional application No. 61/792,148, filed on Mar. 15, 2013, provisional application No. 61/825,068, filed on May 19, 2013.

(51) **Int. Cl.**

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G07C 5/02	(2006.01)
G01S 19/01	(2010.01)
G01C 21/16	(2006.01)
G01C 21/26	(2006.01)
G08G 1/0967	(2006.01)
H04B 10/112	(2013.01)
B60W 40/10	(2012.01)
G08G 1/0962	(2006.01)
G08G 1/00	(2006.01)
H04W 84/00	(2009.01)
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CPC ***G07C 5/02*** (2013.01); ***B60W 40/10*** (2013.01); ***G01C 21/16*** (2013.01); ***G01C 21/26*** (2013.01); ***G01S 19/01*** (2013.01); ***G08G 1/0962*** (2013.01); ***G08G 1/096716*** (2013.01); ***G08G 1/096758*** (2013.01); ***G08G 1/096791*** (2013.01); ***G08G 1/165*** (2013.01); ***G08G 1/166*** (2013.01); ***G08G 1/22*** (2013.01); ***H04B 10/1123*** (2013.01); ***H04B 10/1129*** (2013.01); ***H04W 84/005*** (2013.01); ***H04W 84/18*** (2013.01); *B60Q 1/525* (2013.01); *G08G 1/162* (2013.01)

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USPC 340/425.5, 905; 701/1, 533, 532

See application file for complete search history.

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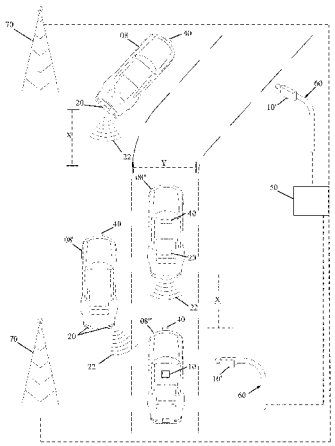
Primary Examiner — Hoi Lau

(74) *Attorney, Agent, or Firm* — John Lindsay

(57) **ABSTRACT**

Exemplary embodiments of the present invention are directed to a system for monitoring, recording, and analyzing driver activity. An exemplary system comprises a sensor module configured to receive data from one or more sensors that measure acceleration or deceleration associated with a vehicle. A stop detection module is configured to receive the sensor module data, process the sensor module data, and determine an abrupt acceleration or deceleration event. A location module is configured to retrieve the location of the vehicle simultaneous with an abrupt acceleration or deceleration event. The system stores the location of the abrupt acceleration or deceleration event in an event record in an event database.

8 Claims, 15 Drawing Sheets



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B60Q 1/52 (2006.01)
G08G 1/16 (2006.01)

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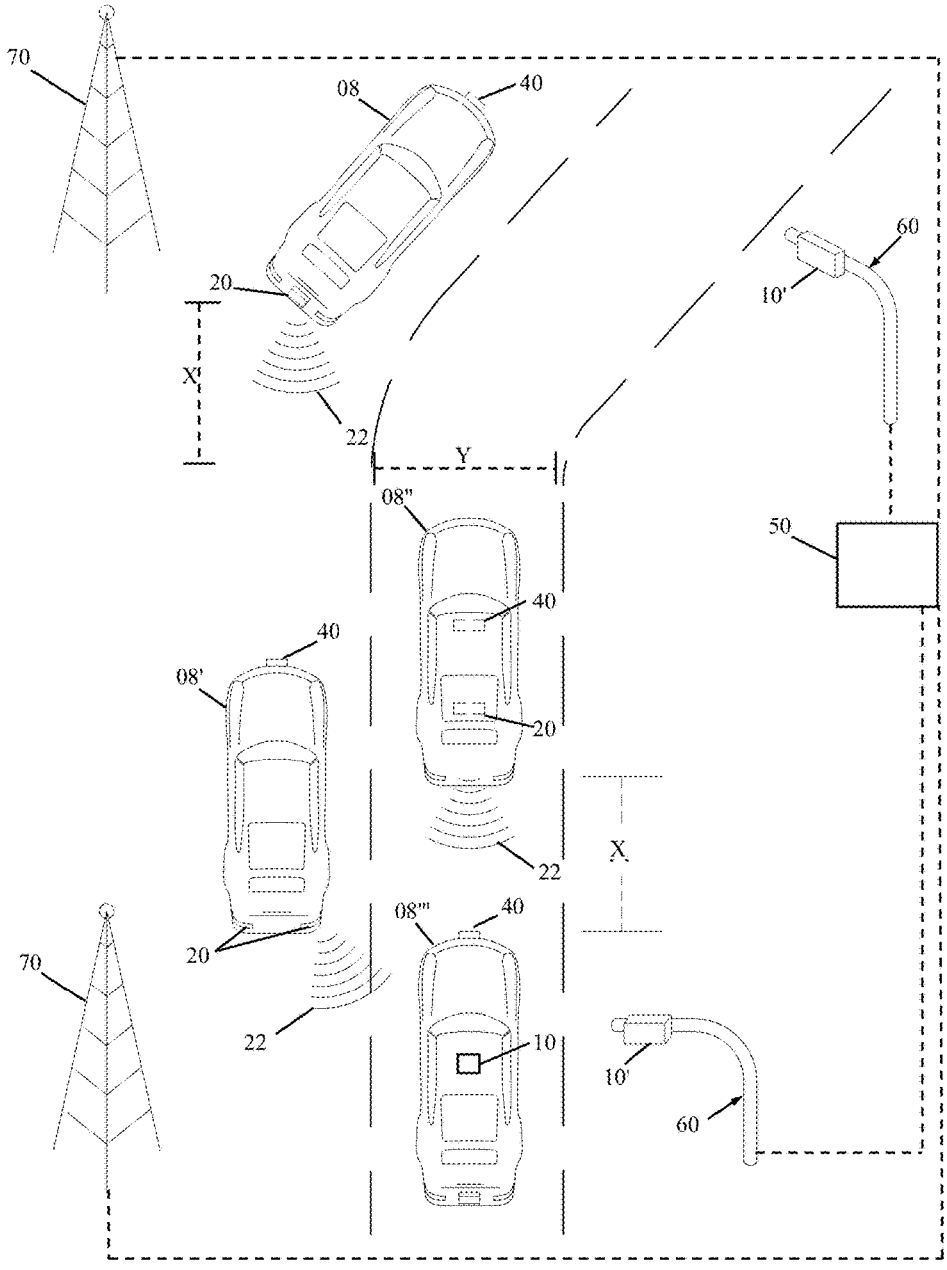


Fig. 1

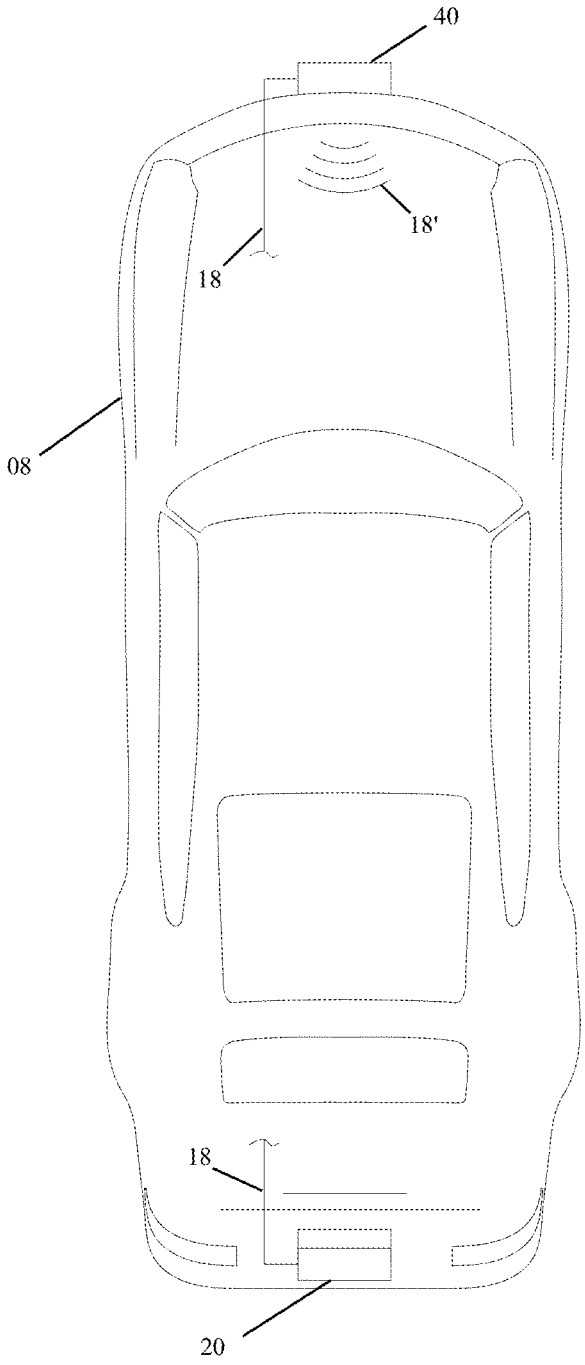


Fig. 2

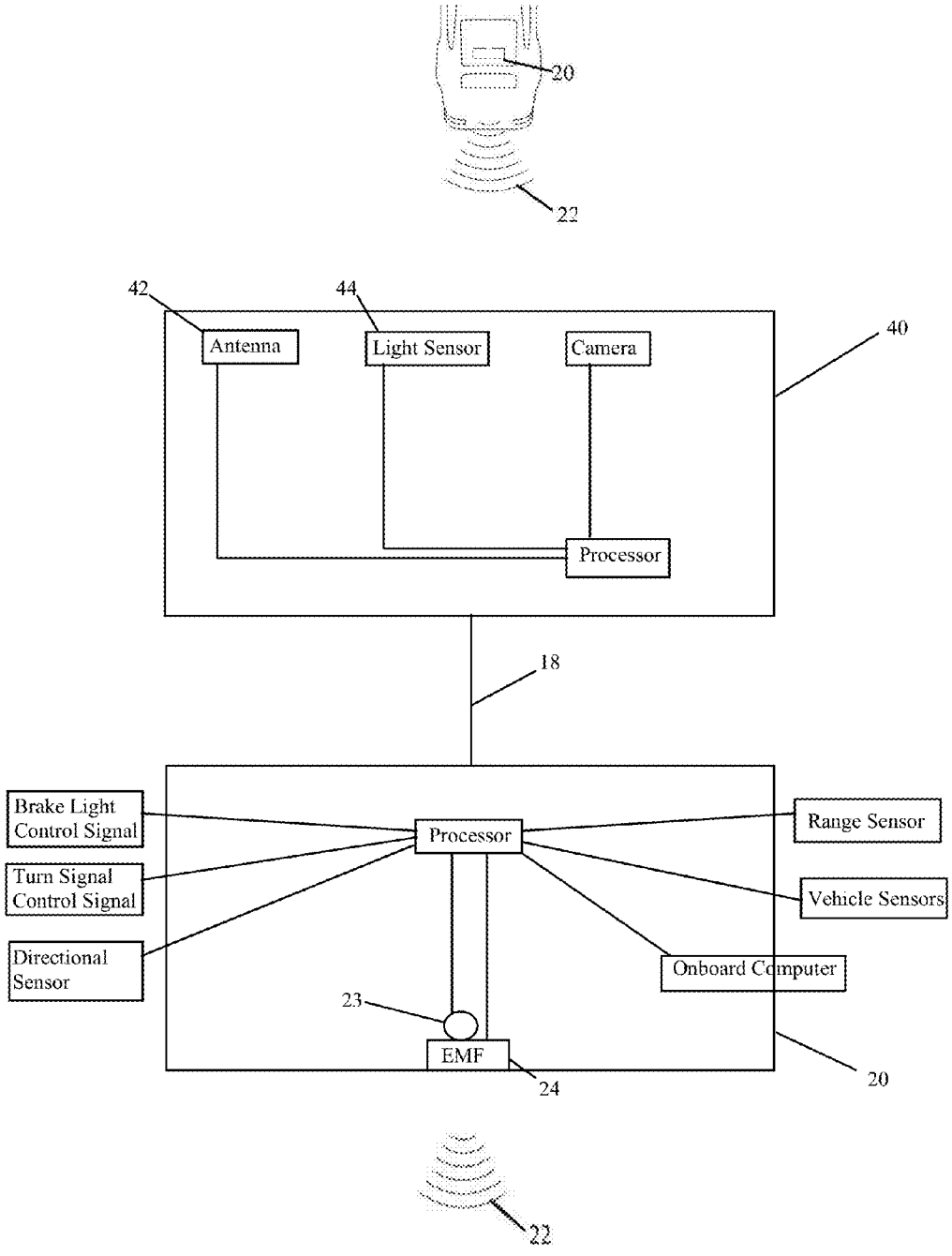

20
22
42
44
Antenna
Light Sensor
Camera
40
Processor
18
Brake Light Control Signal
Turn Signal Control Signal
Directional Sensor
Processor
Range Sensor
Vehicle Sensors
Onboard Computer
23
EMF
24
20
22

Fig. 3

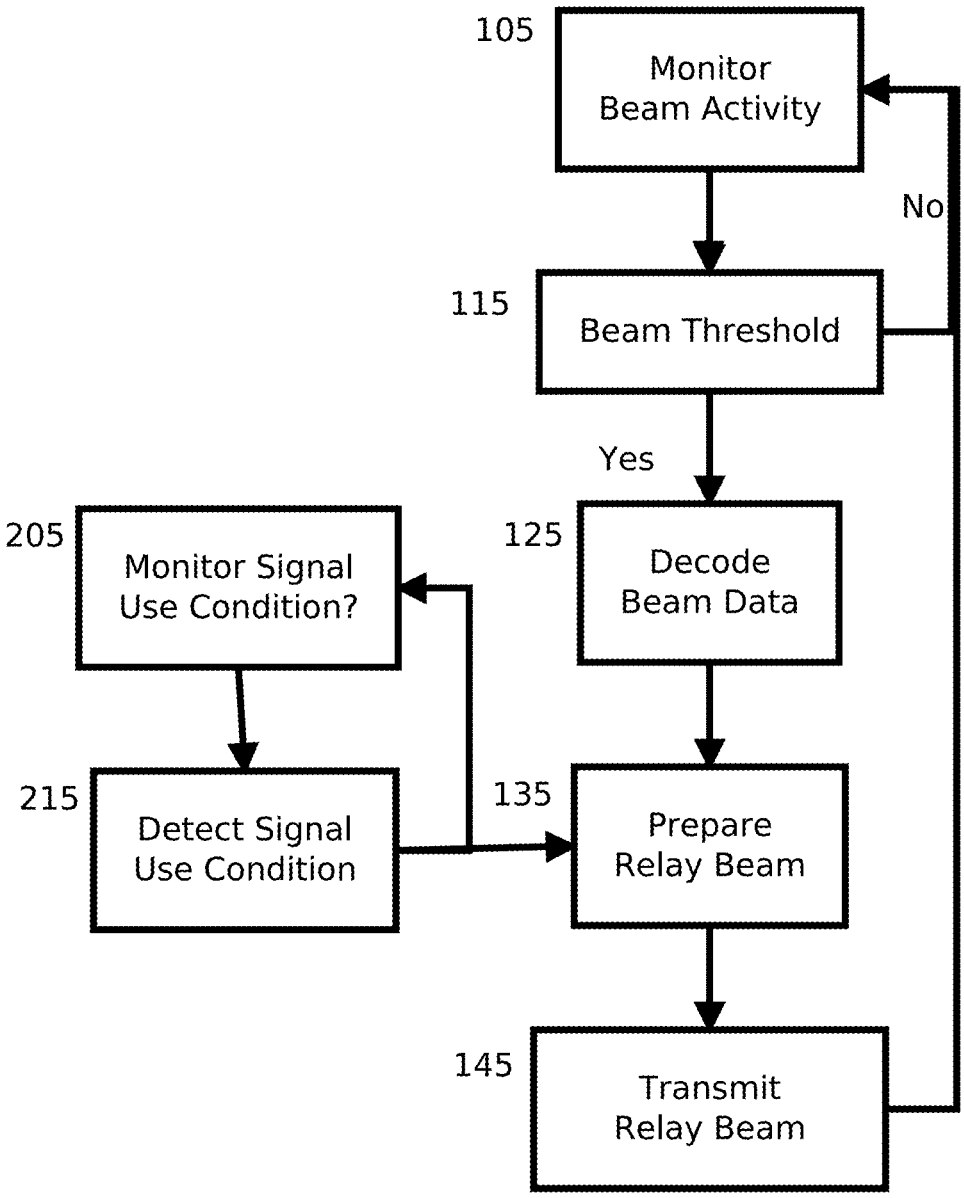

105
Monitor
Beam Activity
No
115
Beam Threshold
Yes
205
Monitor Signal
Use Condition?
125
Decode
Beam Data
215
Detect Signal
Use Condition
135
Prepare
Relay Beam
145
Transmit
Relay Beam

Fig. 4

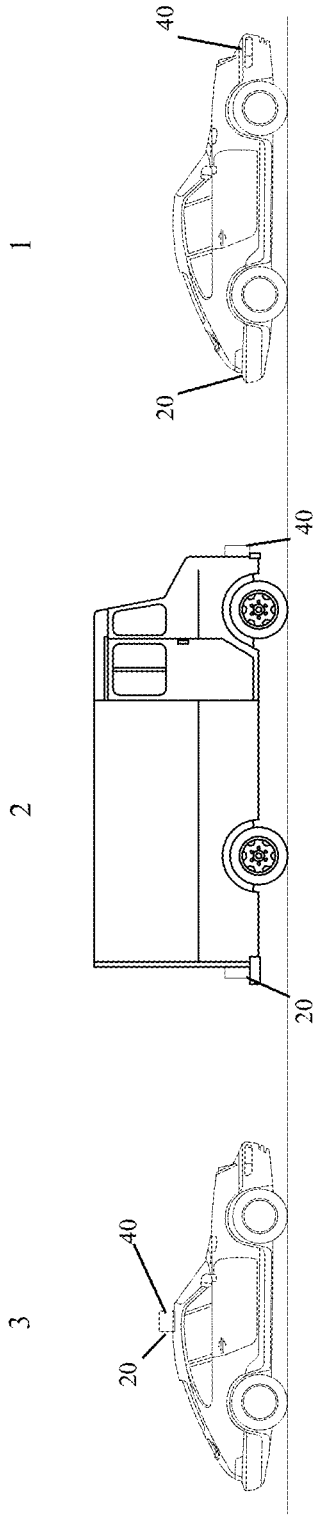


Fig. 5a

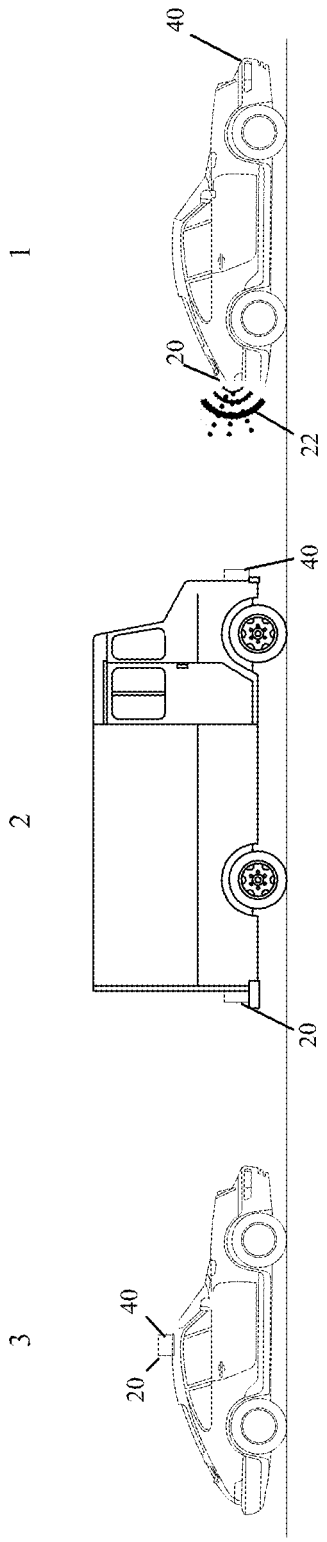


Fig. 5b

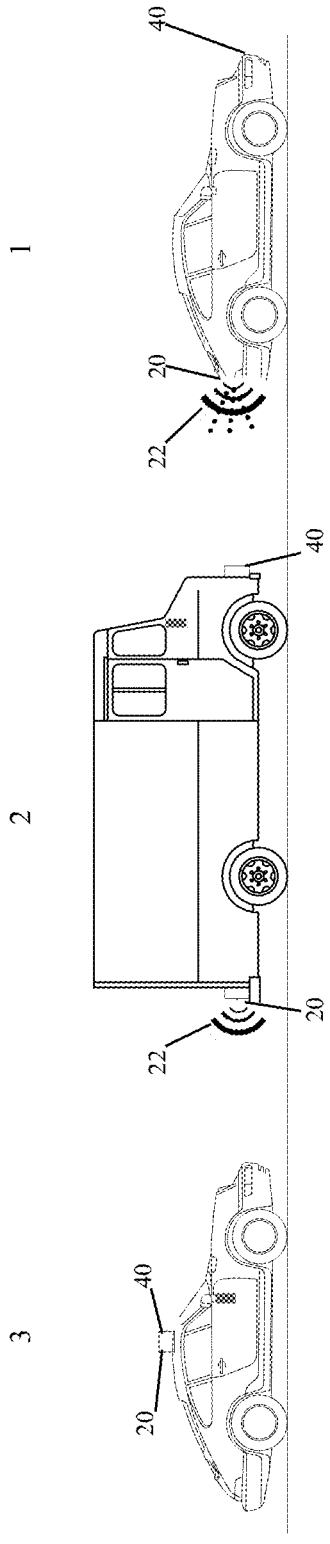


Fig. 5c

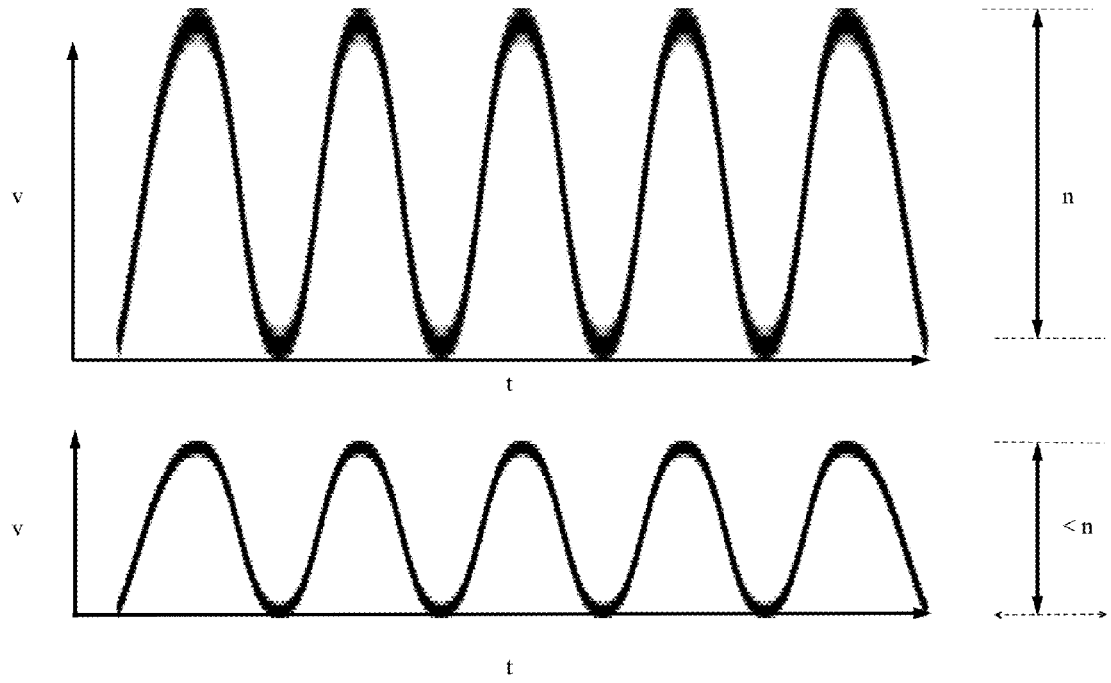


Fig. 6

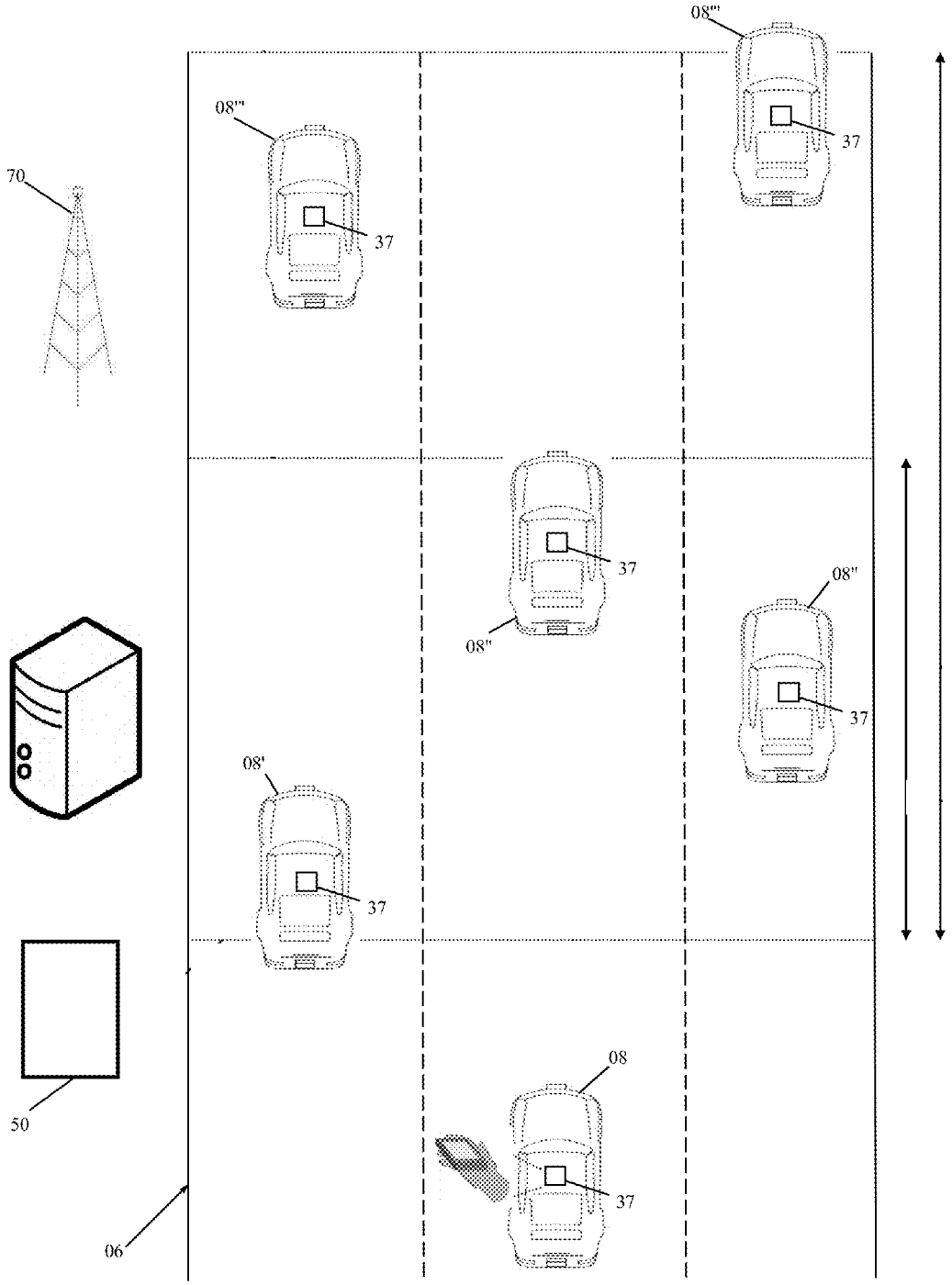


Fig. 7a

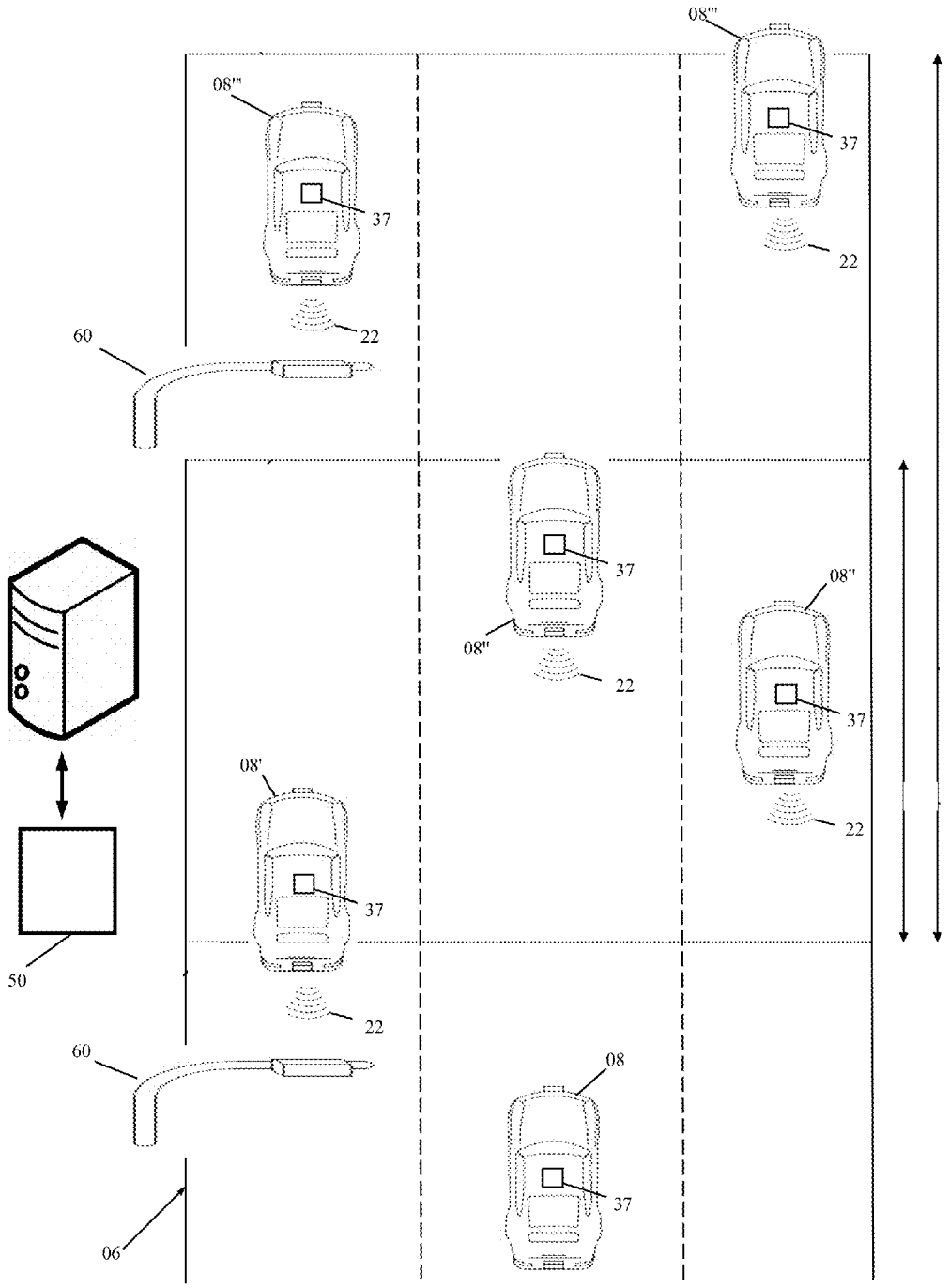


Fig. 7b

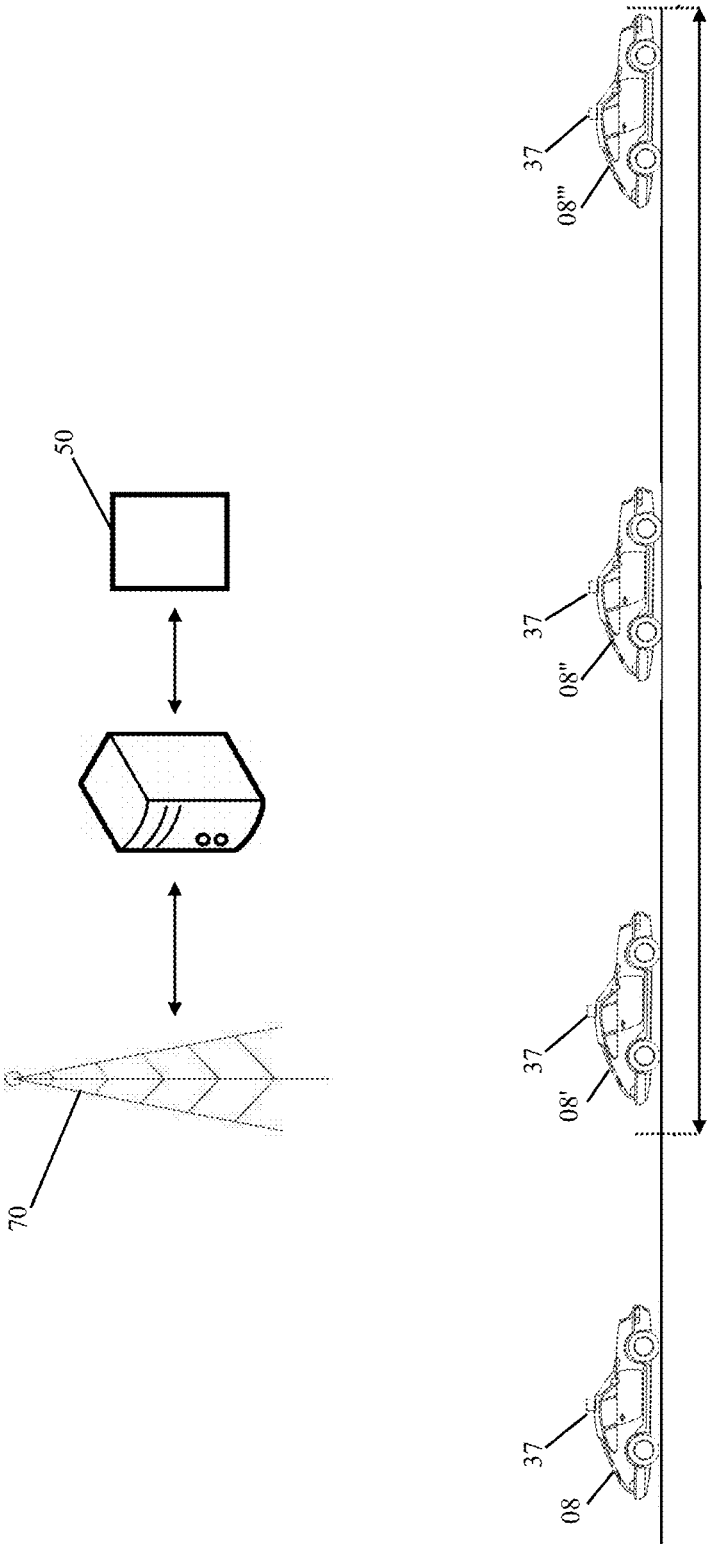


Fig. 8

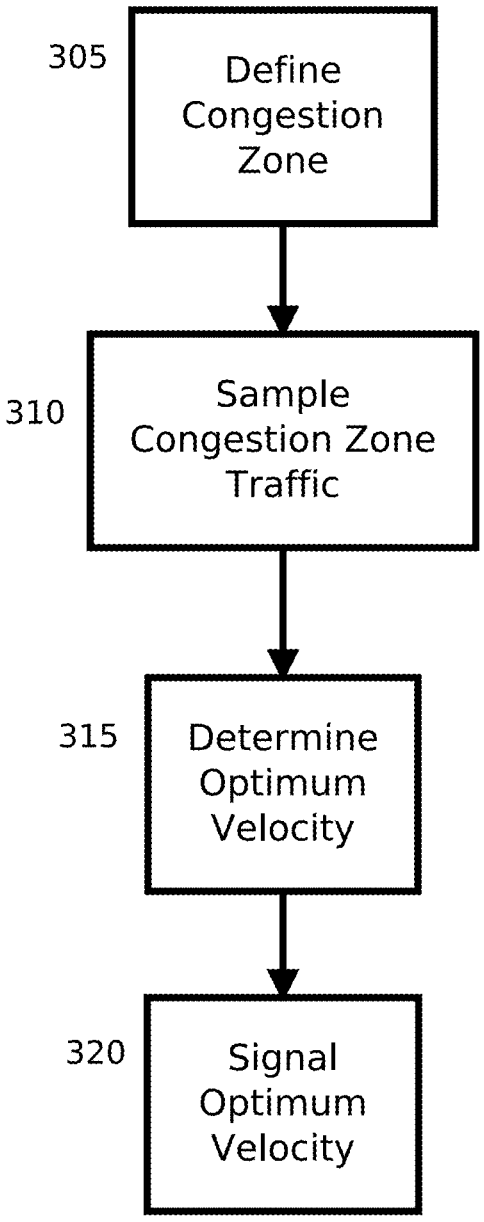

305
Define Congestion Zone
310
Sample Congestion Zone Traffic
315
Determine Optimum Velocity
320
Signal Optimum Velocity

Fig. 9

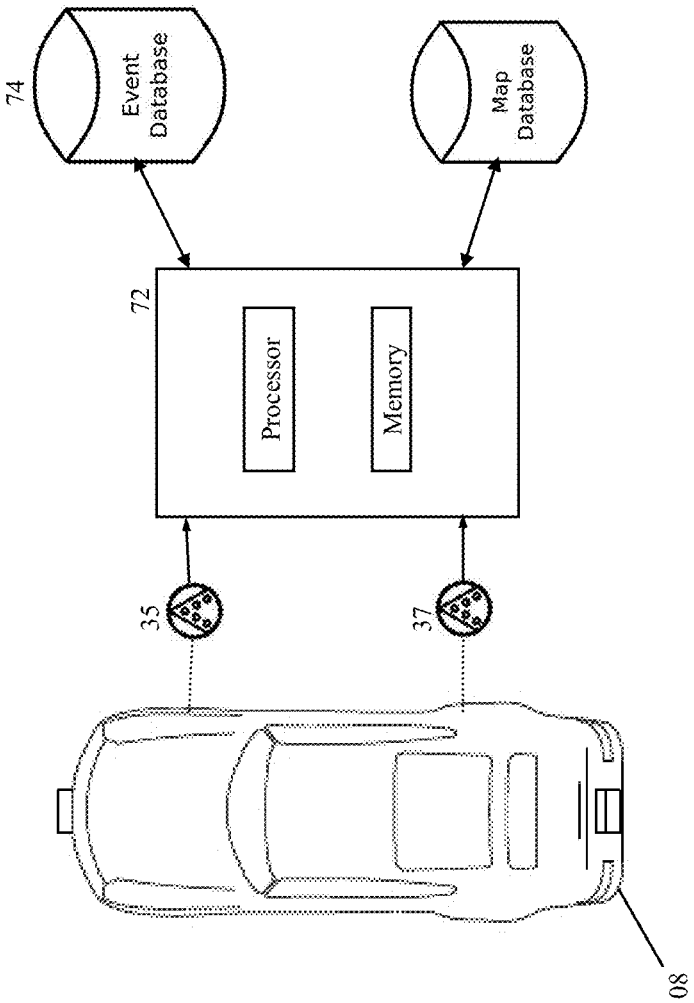


Fig. 10

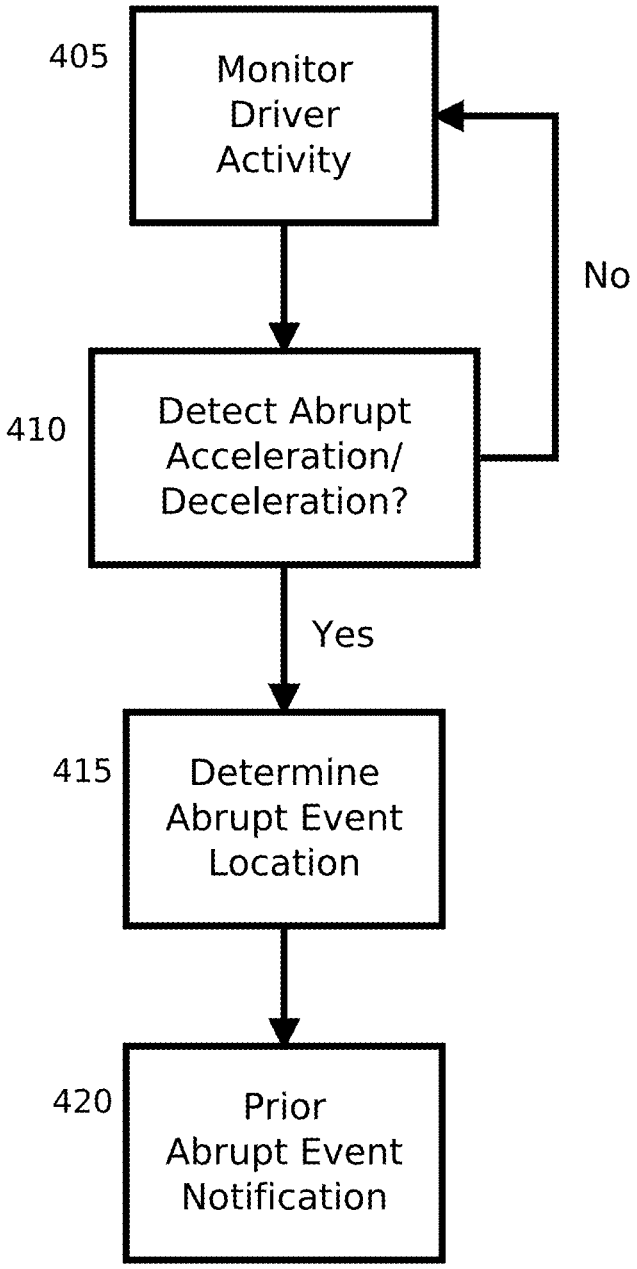

405
Monitor Driver Activity
No
410
Detect Abrupt Acceleration/ Deceleration?
Yes
415
Determine Abrupt Event Location
420
Prior Abrupt Event Notification

Fig. 11

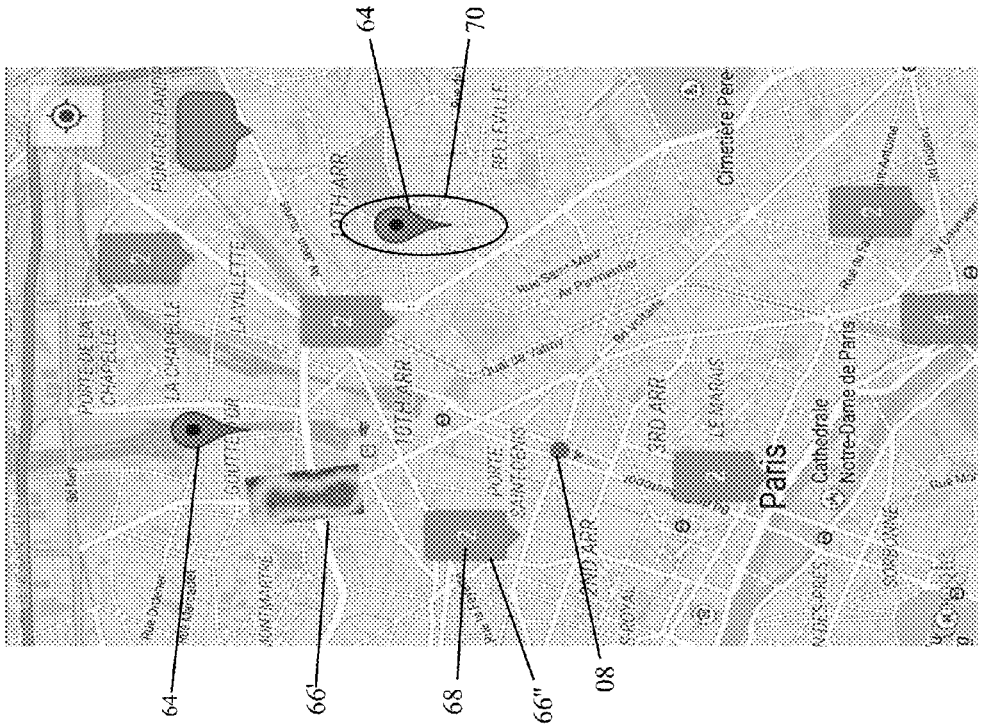


Fig. 12B

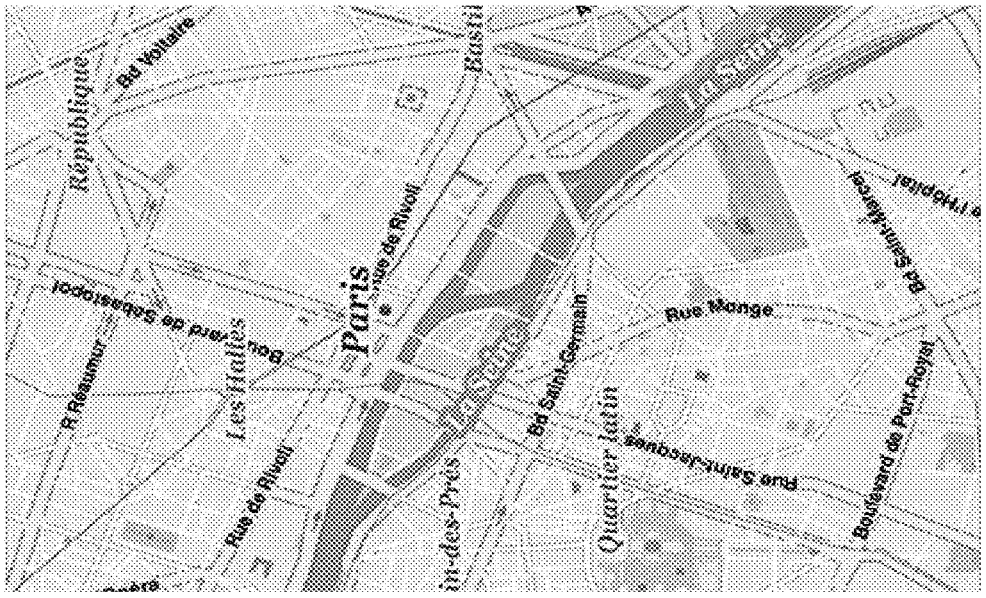


Fig. 12A

DRIVER BEHAVIOR MONITORING

PRIORITY

The present invention claims priority to U.S. patent application Ser. No. 14/710,553, which has a filing date of May 12, 2015. U.S. patent application Ser. No. 14/710,553 claims priority to PCT patent application PCT/US2014/030086, which has a filing date of Mar. 15, 2014. PCT patent application PCT/US2014/030086 claims priority to provisional application 61/792,148, which has a filing date of Mar. 15, 2013. PCT patent application PCT/US2014/030086 claims priority to provisional application 61/825,068, which has a filing date of May 19, 2013.

BACKGROUND

Field of the Invention

The present invention relates to vehicle activity monitoring systems, more specifically to systems for monitoring, recording, and analyzing vehicle activity.

Description of the Related Art

For certain driving conditions, communications from one vehicle to a subset of other proximate vehicles is desirable. Two such example situations are a braking or turn signal usage. In such situations, alerting vehicles outside the signaling vehicle's lane of travel would result in false alerts to those other vehicles.

In a braking situation, reaction time is one of the most significant factors in causes of rear-end vehicular collisions. Driver reaction times are greatly affected by whether the driver is alerted to the need to brake. In a representative problem scenario illustrated in FIG. **5***a*, there is a leading vehicle **1**, a first trailing vehicle **2**, and a second trailing vehicle **3**. When the leading vehicle **1** directly ahead of the first trailing vehicle **2** stops, the driver of the first trailing **2** vehicle is alert, visual conditions are excellent, and the driver notices the brake signal or turn signal of the leading vehicle **1**, the best possible reaction time is achieved. However, where the second trailing vehicle **3** is further behind and obscured by the first trailing vehicle **2**, the driver of that second trailing vehicle **3** is unable to see the braking or other signal lights of that leading vehicle **1**. That driver must rely on the reaction time and driving style of the vehicles between him and the leading vehicle **1** and rely on the driver of the intervening first trailing vehicle **2** in order to maximize reaction time and apply the brakes at the earliest possible opportunity.

Even where there is no intervening vehicle, it may not be possible for the first trailing vehicle's **2** driver to see the signal lights of a vehicle directly in front of the driver under poor visual conditions such as fog or heavy rain.

In such cases, the driver loses valuable time needed to interpret the event, decide upon the response, and then apply brakes, steer, or other suitable response. To a great extent, available reaction time depends on the distance of the lead vehicle **1** to the trailing vehicles **2 3** when it activates its signal light. Differences in drivers' attention and reaction time in tenths of a second or lower can limit accidents and decrease high stress driving.

These problems are exaggerated in congestion zones or peak driving times, leading to frequent hard stopping, frequent acceleration, and a poor driving experience. Hard acceleration or braking is a driver event when more force than normal is applied to the vehicle's brake or accelerator. It can be an indicator of aggressive or unsafe driving. It can also arise from road design and traffic patterns. At a minimum, this style of driving is wasteful and uneconomic. Furthermore, it should also be noted that hard braking and acceleration events can also indicate crash avoidance, or that a driver has been involved in an accident. Thus it would be desirable for a system which enables change of driver behavior in order to minimize such situations.

SUMMARY

Exemplary embodiments of the present invention are directed to a system for monitoring, recording, and analyzing driver activity. An exemplary system comprises a sensor module configured to receive data from one or more sensors that measure acceleration or deceleration associated with a vehicle. A stop detection module is configured to receive the sensor module data, process the sensor module data, and determine an abrupt acceleration or deceleration event. A location module is configured to retrieve the location of the vehicle simultaneous with an abrupt acceleration or deceleration event. The system stores the location of the abrupt acceleration or deceleration event in an event record in an event database.

These and other features, aspects, and advantages of the invention will become better understood with reference to the following description, appended claims, and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a top view of embodiments of the invention as it may exist in operation;

FIG. **2** illustrates a top view of an embodiment of the invention as it may exist in operation;

FIG. **3** illustrates a block diagram of the embodiment illustrated in FIG. **1**; and

FIG. **4** illustrates an embodiment of a process implemented to the system of FIG. **1**;

FIGS. **5***a*-**5***c* illustrate side views of embodiments of the system as they may exist in operation;

FIG. **6** illustrates traffic analysis module aggregate traffic data and suggested traffic signals;

FIGS. **7***a* and **7***b* illustrate top view diagrams of embodiments of traffic analysis module systems as they may exist in operation;

FIG. **8** illustrates a side view diagram of an embodiment of a traffic analysis module system as it may exist in operation;

FIG. **9** illustrates an embodiment of a process of traffic analysis;

FIG. **10** illustrates an embodiment of a system for driver behavior monitoring;

FIG. **11** illustrates an embodiment of a process of driver behavior monitoring; and

FIGS. **12**A and **12**B illustrate sample maps before and after driver behavior monitoring as they may exist in operation.

DETAILED DESCRIPTION

Detailed descriptions of the preferred embodiment are provided herein. It is to be understood, however, that the present invention may be embodied in various forms. Therefore, specific details disclosed herein are not to be interpreted as limiting, but rather as a basis for the claims and as a representative basis for teaching one skilled in the art to employ the present invention in virtually any appropriately detailed system, structure, or manner.

The current invention relates to a device for directed vehicle to vehicle communication. A representative scenario is relaying a vehicle's signal condition to trailing vehicles in the same lane. FIG. **1** illustrates a plurality of vehicles **08** equipped with vehicle to vehicle communication systems **10** (shown separately in FIG. **3**) as they may exist in operation. The vehicle to vehicle communication system **10** includes an emitter **20** and a receiver **40** for attachment to a single vehicle **08**. As shown, the emitter **20** and receiver **40** can be configured for different spatial placement on a vehicle **08**. They can be housed in a single unit **08'''** for attachment to the vehicle ceiling or roof. The system **10** can be configured for receiver **40** placement on the front of the vehicle **08** **08'** or toward the front of the vehicle **08''**. The vehicle to vehicle communication system **10** can be configured for emitter **20** placement on the rear of the vehicle **08** **08'** or toward the rear of the vehicle **08''**.

FIG. **2** illustrates an embodiment of the vehicle to vehicle communication system **10** deployed to a vehicle **08**. Depicted is an emitter **20** in communication with a receiver **40**. FIG. **3** illustrates a block diagram of the embodiment of FIG. **2**. The emitter **20** is operable to signal in response to threshold signal input to the receiver **40** or a signal use condition of the subject vehicle. A signal use condition is one in which a signal light is in use or its use is warranted. Exemplary signal use conditions include brake signal use or turn signal use. For example, a switch may be mounted inline with the signal for the brake light or turn signal in the vehicle. In an automated driving system, a control signal for a brake light or turn signal activation can be monitored. Alternatively, the emitter **20** can employ sensors to detect the use condition. In such a configuration, the emitter **20** can include a light sensor mounted proximate the signal light of the vehicle **08**. When a driver of the vehicle **08** depresses the brake pedal or uses the turn signal switch, the vehicle **08** activates the corresponding signal light. The emitter **20** detects the control signal or the light therefrom. Another example signal condition is a road hazard such as a pothole.

In one configuration, the emitter **20** includes a configured visual signal. The exemplary signal is one which is different than current brake signals. Representative visual signals include selected shapes, colors, brightness, flashing sequences, unique indicia, or the like.

In an alternate configuration, the emitter **20** contains an electromagnetic radiation source **24**, configured to transmit a directional beam **22** from the vehicle **08**. In one configuration, the electromagnetic radiation source **24** includes a coherent light source such as a laser. In an alternate configuration, the electromagnetic radiation source **24** includes a light source such as a filament or LED. In yet another configuration, the electromagnetic radiation source **24** includes a radio wave source.

In exemplary configuration, to the extent that the electromagnetic radiation source **24** permits, the beam **22** width is transmitted such that it has less than a configured signal strength outside a configured width y and less than a configured signal strength at a pre-configured distance x for a given set of environmental conditions. In exemplary operation, the beam **22** width is less than about one traffic lane wide at distance x or has a lower signal strength outside the configured width. Beam **22** width is controlled using processes known in the art. In certain configurations, a laser is included. In other configurations, an LED or filament coupled with a lens is included. Radio frequency is controlled by using reflectors, antennae arrays, apertures, and/or specific wavelengths in order to control beam **22** width.

It is within the scope of this invention to vary the signal strength of the beam **22**. For example, the signal strength can be altered in response to rain, fog, or other conditions which alter signal transmission. It is also within the scope of the invention to incorporate multiple electromagnetic radiation sources **24**. In certain configurations, the emitter **20** energizes one or more of the electromagnetic radiation sources **24** during operation. For example, the emitter **20** can include both a light source and a radio frequency source and transmit radio frequency where light transmission may be suboptimal.

In exemplary configuration, to the extent that the electromagnetic radiation source **24** permits, the beam **22** width is configured to have configured signal strength or range of signal strength in order to have less than a configured signal strength at a pre-configured distance x for a given set of environmental conditions. For example, the beam **22** can be configured with a transmission strength such that the beam **22** signal strength is approximately zero or below a threshold signal strength at distance x. Alternatively, the beam **22** may be configured for transmission where the beam **22** signal strength is a known amount at distance x for given conditions. In certain configurations, the beam **22** transmission strength is adjusted based on input for environmental conditions which would affect transmission distance. For example, a humidity sensor can provide input for rain or fog conditions that could impede light or radio wave transmission.

Optionally, the emitter **20** is configured to direct the beam **22** in response to turning conditions of the vehicle. The emitter **20** can receive steering wheel use, position data, accelerometer, global positioning system (GPS) data, or other similar sensing to detect a turn condition. In response, the emitter **20** employs a beam director **23** to alter the beam **22** direction proportionate to the turn angle of the vehicle, as shown in vehicle **08**. In an alternate configuration, the emitter **20** is deactivated during a turn condition.

In certain embodiments, the emitter **20** encodes data into the beam **22**. One such data element that the beam **22** can incorporate is relay count data, which facilitates peer to peer, vehicle to vehicle network type communication. That is to say a "chain" of vehicles relay data as nodes. Relay count data facilitates configurable conditional signal transmission through the vehicular chain. A base relay count can be provided by the receiver **40**, as will be disclosed below. Relayed data through the vehicular chain is variable. For example, a total relay count is the number of vehicles that have relayed a signal (ie a "hop count"). In such a situation, the emitter **20** can increment the received active relay count data prior to encoding for transmission to trailing vehicles. An active relay count is the instantaneous number of signal use conditions, such as activated vehicle signals, within range of one or more vehicle to vehicle communication systems **10** in the chain. In exemplary usage scenarios, active relay count is the number of vehicles in the same lane in front of the subject vehicle with activated vehicle signal lights, such as applying brakes or turn signals.

In certain configurations, other data is encoded in the beam **22**, such as a car identifier, accelerometer data, velocity data, directional data, GPS data, lane indication data, other data from the subject vehicle, other vehicle(s) signal relay systems **10** data, or derived data can be encoded within the beam **22**. The received data for encoding can include sources from the vehicle computer, sensors, portable computers of a vehicle occupant, or other vehicle to vehicle communication systems **10**. For example, the beam **22** can incorporate inter-vehicle distance data, such as that between

the leading vehicle and the subject vehicle from a range sensor system. Moreover, the vehicle to vehicle communication systems **10** can process the data prior to encoding. To illustrate, the emitter **20** can accumulate the distance data of leading vehicles and add distance between the subject vehicle and leading vehicle for encoding and transmission.

Referring to FIG. **3**, the emitter **20** is in communication with the receiver **40** via a cable **18** or wirelessly **18'**. In certain configurations, the receiver **40** is operable to monitor, receive, and decode beams of the emitters **20** of similarly configured vehicle to vehicle communication systems **10** of other vehicles. During monitoring, the receiver **40** monitors receipt of a beam **22** at an antenna **44** or light sensor **42**. Upon receipt of a beam **22**, the receiver **40** optionally determines signal strength. Where the signal strength of the beam **22** is lower than a pre-determined threshold, the receiver **40** may cease further signal or relay processing steps.

The receiver **40** decodes the data of the beam **22** of a leading vehicle, including the relay count and other data. The decoded data is stored for retrieval and use by the emitter **20**, the notification system of the vehicle **08**, vehicle computer, or other systems. In one configuration, the receiver **40** signals the notification system of the vehicle **08**, where the notification system activates a signal to alert the driver of the subject vehicle via a dash indicator or window display, optionally signaling the active relay count. In yet another configuration, the receiver **40** conditionally transmits a notification or beam data when the relay count is less than a pre-configured threshold. In another configuration, the receiver **40** transmits the decoded data to a display or vehicle computer. In yet another configuration, the receiver **40**, outputs a control signal for an automated vehicle control system input. In another configuration, the receiver **40** communicates the active relay count and other data to the emitter **20**, optionally incrementing the relay count. When beam **22** transmission and receipt terminates or is below the threshold, receiver **40** post-beam processing activity terminates. The receiver **40** then can indicate a non-signal or below threshold state.

Having described elements of the vehicle to vehicle communication system **10**, representative methods of operation are disclosed. FIG. **5***a* depicts a leading vehicle **1**, a first trailing vehicle **2**, and a second trailing vehicle **3**, driving in a lane in sequence and each equipped with a vehicle to vehicle communication system **10**. FIG. **4** depicts a process of an embodiment of the vehicle to vehicle communication system **10** in operation.

A leading vehicle's **1** vehicle to vehicle communication system **10** monitors for a signal use condition of the vehicle **1 205**. Upon detection of a signal use condition **215**, the vehicle to vehicle communication system **10** prepares a beam and transmits a beam for transmission **135 145**. FIG. **5***b* illustrates the leading vehicle **1** with an activated brake signal and a simultaneous beam **22** of pre-configured width and signal strength. Below is the state of leading vehicle **1** in a braking signal use condition and its vehicle to vehicle communication system **10**.

Signal Use Condition	Signal Activated?	Beam Activated?	Total Relay Count	Active Relay Count	Leading Vehicle Signaling?
True	Brake	True	0	0	n/a

The receiver **40** of first trailing vehicle **2** monitors for beam **22** activity from leading vehicles **1** equipped with similarly configured vehicle to vehicle communication systems **105**. As described above, a signal use condition of a brake light and beam **22** of pre-configured width and signal strength is activated from the leading vehicle **1**. Beam **22** is received by the first trailing vehicle **2** and the receiver **40** determines whether the beam **22** signal strength threshold is reached **115**. If the beam **22** signal strength threshold is reached, the beam **22** data is decoded, displayed, and/or communicated to the emitter **125**. In one configuration, the emitter **20** of the subject vehicle **2** activates its visual signal in response. The emitter **20** prepares beam data **135**, retrieving and processing the necessary data. It increments the total relay count, conditionally incrementing active relay count with input from the receiver **205 215**, retrieves the car identifier, and appends other data for encoding. The encoded beam **22** is transmitted **145**. As illustrated in FIG. **5***c*, notifications of the brake light signal use condition of the leading vehicle **1** is shown in the trailing vehicles **2 3**. Below is the state of first trailing vehicle **2** and its vehicle to vehicle communication system **10**.

Signal Use Condition	Signal Activated?	Beam Activated?	Total Relay Count	Active Relay Count	Leading Vehicle Signaling?
False	False	True	1	1	True

The receiver **40** of second trailing vehicle **2** monitors for beam **22** activity from leading vehicles, in this scenario vehicle **2**, equipped with similarly configured vehicle to vehicle communication systems **105**. As described above, a signal use condition of a brake light and beam **22** of pre-configured width and signal strength is activated from the leading vehicle **1** and first trailing vehicle **2** transmits a relay signal **22** of the leading vehicle **1** signal use condition. Beam **22** is received by the second trailing vehicle **3** and the receiver **40** determines whether the beam **22** signal strength threshold is reached **115**. The beam **22** data is decoded, displayed, and/or communicated to the emitter **125**. In this scenario, the vehicle to vehicle communication system **10** is configured to only transmit relay beams **22** where the total relay count is less than or equal to one, thus it does not prepare beam data or transmit a beam **22**. Below is the state of second trailing vehicle **3** and its vehicle to vehicle communication system **10**.

Signal Use Condition	Signal Activated?	Beam Activated?	Total Relay Count	Active Relay Count	Leading Vehicle Signaling?
False	False	False	2	1	True

Now referring to FIGS. **1** and **6**, in an alternate embodiment, the invention further includes a traffic analysis module **50** for traffic analysis of a plurality of vehicles **08** equipped with vehicle to vehicle communication systems **10** in a traffic zone. In exemplary operation, the traffic analysis module **50** conditionally transmits instructions in response to the traffic analysis. The traffic analysis module **50** includes a processor and memory. The traffic analysis module **50** defines one or more traffic zones to be monitored, a zone through which a plurality of vehicles **10** equipped with vehicle to vehicle communication systems **10** may pass. The traffic analysis module **50** receives beam **22** data from the

vehicle to vehicle communication systems **10** of the vehicles or other sources. It should be appreciated that this communication may be in-band or out-of-band with the beam data **22** communications disclosed above. The traffic analysis module **50** associates position data with a particular vehicle **08** in order to confirm presence in the traffic zone. Optionally, the traffic analysis module **50** determines a position or relative position of a particular vehicle within the traffic zone.

Referring to FIG. **1**, in one configuration, the traffic analysis module is in communication with at least one tower **60**, and in exemplary configuration, a plurality of towers **60** in communication with each other and disposed at known locations within and adjacent the traffic zone. The exemplary tower **60** includes a traffic module receiver **40'** and traffic module emitter **20'** similar to those disclosed above. The receiver **40'** and emitter **20'** are preferably mounted above the vehicle heights for improved beam **22** reception by line of sight to plural vehicles. Optional configurations of the signal use emitter **20'** include widened beam **22** width and increased signal transmission strength for multi-vehicle transmissions. In alternate configurations, the position data of a particular vehicle to vehicle communication system **10** is based on an associated GPS, an associated portable computer, an associated portable phone and cell phone tower **70**, or similar systems.

The traffic analysis module **50** processes received vehicular signal system **10** data for suboptimal traffic conditions, such as frequent sharp velocity changes or frequent signal use conditions. The module **50** may receive beam **22** data of a single vehicle **08**, a sample of vehicles **08**, or larger data set(s) of vehicles **08** within the traffic zone for analysis. In one configuration, the traffic analysis module **50** processes the velocity of the vehicles in the traffic zone and calculates peak to trough variations n over time, a representation of which is shown in the upper graph of FIG. **6**. In an alternate configuration, the traffic analysis module **50** processes the number of active signal conditions over time. To illustrate, the module **50** may use the number of active brake lights per second within the traffic zone.

The traffic analysis module **50** optionally determines suggested instructions for optimizing traffic within the traffic zone, vehicles at the perimeter of the traffic zone, vehicles just adjacent and entering the traffic zone, or traffic control signals in or adjacent the traffic zone. The instructions correlate to the method employed to determine the suboptimal traffic condition. For example, in the disclosed peak to trough velocity analysis, the traffic analysis module may send suggested deceleration signals in order to decrease the peak to trough velocity and "flatten the curve," as shown in the bottom graph of FIG. **6**. In the disclosed simultaneous active signal process, the module **50** can also suggest deceleration signals. The method of communicating the suggested instructions varies. Representative methods includes a visual signal proximate the tower **60**, a signal from the emitter **40'** of the tower **60** to subject vehicles, a message to a portable computer associated with the vehicle, a message from the cell phone tower **70** to a phone associated with the vehicle, or the like.

Now referring to FIG. **10**, alternate embodiments of systems and processes for monitoring driver behavior are disclosed, specifically systems and processes for monitoring abrupt deceleration or acceleration. A vehicle **08** having an associated computer **72** is monitored for abrupt deceleration or acceleration. Certain embodiments of the vehicle monitoring system include a computer **72**, sensors **35 37**, and an event database **74**. An exemplary process for monitoring abrupt deceleration or acceleration is depicted in FIG. **11**. The acceleration/deceleration activity of the vehicle is monitored **405**. Using the acceleration/deceleration activity as input, the system monitors for an abrupt acceleration/deceleration event **410**. Upon an abrupt acceleration/deceleration event, the abrupt event location is determined **415**. Notifications of prior abrupt acceleration/deceleration events are provided **420**. More consideration of each of the steps will be considered below.

Exemplary processes of the embodiments are on computers or microelectronics. For instance, the computer **72** may be implemented using one or more personal computers (PCs), servers, mobile devices (e.g., a smartphone), tablet devices, and/or any other appropriate devices. The various devices may work alone or in conjunction (e.g., some components of the computer system may be provided by a mobile device while other components are provided by a server). Certain processes and modules described above may be implemented as software processes that are specified as at least one set of instructions recorded on a non-transitory storage medium. When these instructions are executed by one or more computational element(s) (e.g., microprocessors, microcontrollers, application-specific integrated circuits (ASIC), field programmable gate arrays (FPGA), etc.) the instructions cause the computational element(s) to perform actions specified in the instructions.

At step **405**, vehicle **08** activity is monitored, specifically acceleration/deceleration activity of a driver is monitored **405**. Acceleration or deceleration activity occurs during driving activity such as increasing speed, braking, turning, or shifting gears. A sensor module **76** operable to receive data from one or more sensors receives input from sensors in order to directly or indirectly detect and measure instantaneous acceleration or deceleration or velocity. Various sensors **35 37** may be used to determine the various driving activities indicating acceleration and deceleration. Sensor **35 37** input is received. In certain configurations, sensors **35 37** are affixed directly to the vehicle **08**. In certain configurations, sensors **35 37** are effectively paired with the driver of the vehicle **08**, such as the driver carrying a portable computer **72**.

Representative sensors may include inertial sensors **35** (e.g. accelerometers, gyroscopes, and the like), wheel speed sensors, differential speed sensors, global navigation satellite systems such as GPS **37**, and/or any other appropriate sensors. The sensors may provide information related to the vehicle, such as speed, odometer readings, rotations per minute, pedal position (e.g., gas or brake), gear position, or other direct or indirect measures of location or velocity.

The sensors may be adapted to communicate with the sensor module **76** in various appropriate ways such as a local bus, a controller area network bus, wireless communication links, on board diagnostics (OBD) ports, third party software modules, or other suitable communication systems. For example, the sensors may be included in the vehicle **08** and communicated over the OBD port. Alternatively, the sensors may be included in a smartphone **72** and communicated locally. In yet another example, the sensors may be included in a retrofit system for the vehicle **08** and communicated wirelessly.

In certain configurations, the sensor module **76** provides output in the form of raw sensor values. In certain configurations, the sensor module **76** provides output in the form of the received sensor data converted into speed, inertia, location, or other values for later processing. In certain configurations, the sensor module **76** provides output in the form of a curve, the curve representing values over time.

Using the input of acceleration and deceleration activity, the vehicle monitoring system monitors for an abrupt deceleration event **410**. A stop detection module **78** is adapted to process sensor module **76** data and detect an abrupt acceleration or deceleration event. The stop detection module **78** receives and processes the sensor data from the sensor module **76** in order to determine an abrupt acceleration or deceleration event.

In certain configurations, the stop detection module **78** compares the sensor data against threshold values. The stop detection module **78** may compare a single received instantaneous acceleration or deceleration sensor data values, such as accelerometer **35** output, against threshold values. Threshold values may be defined as a threshold g value (acceleration of gravity). For example, stop detection module **78** may determine an abrupt deceleration event exists where the deceleration is greater than 0.4 g. In other configurations, the stop detection module **78** may determine an abrupt deceleration event exists where the deceleration is greater than 0.75 g, 1.0 g, or other suitable values. The stop detection module **78** may compare plural received acceleration or deceleration sensor data values against an evaluation deceleration curve. Such comparison may result in identification and quantification of various differences between the evaluation curve and the subject curve. Such comparison may compare relative peaks or overlap regions of the respective curves. Suitable deceleration curves are those which indicate an undesirable deceleration, such as a certain slope or pattern.

In other configurations, the stop detection module **78** may compare velocity changes over time, such as post-processed GPS **35** output, against threshold values. Threshold values may be defined as a threshold change in speed, such as a change in miles per hour (MPH) per second. For example, the stop detection module **78** may determine an abrupt deceleration event exists where the velocity change is greater than 4 MPH/s (−4 MPH/s). In other configurations, the stop detection module **78** may determine an abrupt deceleration event exists where the deceleration is greater than 7 MPH/s, 10 MPH/s, or other suitable values. The stop detection module **78** may compare plural received velocity changes against an evaluation velocity change curve. Such comparison may result in identification and quantification of various differences between the evaluation curve and the subject curve. Such comparison may regions relative peaks or overlap regions of the respective curves. Suitable velocity change curves are those which indicate an undesirable velocity change, such as by a certain slope or pattern.

Upon an abrupt acceleration or deceleration event, the abrupt event location is determined **415**. A location module **79** is operable to determine the location of the vehicle **08**, commonly in the form of latitude and longitude, simultaneous with the abrupt acceleration or deceleration event. In certain configurations, the location module **79** receives position information from sensors such as the GPS **37** in order to determine the location. In certain configurations, the location module **79** receives position information from third party software modules.

The position information of the abrupt acceleration or deceleration event is stored to the event database **74**. In certain configurations, a timestamp for the abrupt acceleration or deceleration event, a driver identifier, a vehicle identifier, group identifier, and other data are associated with the abrupt acceleration or deceleration event and stored in the event database **74** as an event record.

Notifications of prior abrupt stop events are provided **420**. A notification module **79** is operable to notify a driver of prior abrupt acceleration or deceleration events. The notification module **79** retrieves event records from the event database **74** and generates a positional notification. One or more abrupt acceleration or deceleration event records are retrieved from the event database **74** for notifications. The retrieved events may be selected by location, driver identifier, a vehicle identifier, a group identifier, time and/or other available stored data of the event records.

The notification module **79** may provide real-time notifications to users. The notification module **79** may, for example, display information on a vehicle display, heads-up display, instrument cluster, dashboard, and/or other appropriate location. The notification module **79** may be adapted to emit sounds and/or voice alerts. The notification module **79** may be adapted to provide other warning methods such as seat and/or steering wheel vibration, colored and/or flashing lights, alphanumeric messages, graphic messages, and/or other appropriate alert methods. Such notifications may be based on various appropriate factors.

In certain configurations, the notification module **79** displays a map **62**, such as that of FIG. **12**A, at a certain scale or zoom level. A map database includes map data elements indicating various features associated with paths of travel for vehicles. A map database may store data related to roads and their features, and the respective locations thereof. A map database may include information such as information regarding speed limits, traffic signals and/or signage, number of travel lanes, road classes, etc. The map database may include elevation, surface type, steepness, curve radius, etc. In communication with the location module **79**, the notification module **79** may receive the vehicle **08** position to match the vehicle **08** position to a position on a road segment received from the map data and correspondingly overlay the vehicle's **08** position on the map **62**.

In certain configurations, the notification module **79** displays notifications **64 66 68** as overlays on a map **62** such as that of FIG. **12**B. As previously disclosed, the notification module **79** retrieves one or more abrupt acceleration or deceleration event records for notification, which includes the position information for the event. In one configuration, the notification module **79** retrieves the position information for the abrupt event and overlays an indicator **64** at the corresponding position on the map **62**. Where multiple retrieved events are in proximity to each other, the notification module **79** may display the plural retrieved events as a cluster **66**, depending on factors such as proximity of the events, the scale or zoom level of the map, the speed of the vehicle **08**, and other factors. Representative suitable cluster event displays may be in the form of a gradient **66"** indicator or an indicator with an event count **68** for the cluster **66**. In certain configurations, the notification module **79** generates a notification when the vehicle **08** is within a proximity region **70** of a retrieved event's location.

In example usage of a vehicle monitoring system, a user enters a vehicle **08** having a portable computer **72** with an integrated accelerometer **35** and integrated GPS **37**. As the vehicle **08** travels, deceleration activity is monitored **405**. The sensor module **76** receives periodic output from the accelerometer **35** and GPS **37** and processes it to determine if an abrupt deceleration event has occurred **410**. If an abrupt deceleration event occurs, the location module **79** provides position information **415**. The position information is stored in the event database **74**. As the vehicle **08** travels, the notification module **80** retrieves selected prior abrupt events from the event database **74**, retrieving the position information of the abrupt events. In communication with the location module **79**, the vehicle **08** position is monitored and a

map **62** is displayed in the area proximate the vehicle **08**, such as the map of FIG. **12**A. The maps includes indicators **64** **66** of prior abrupt events overlaid at their respective position on the map **62**, such as the map of FIG. **12**B. Additional notifications are generated when the vehicle **08** travels within a proximity region **70** bounding a retrieved event's location.

Insofar as the description above and the accompanying drawing disclose any additional subject matter that is not within the scope of the single claim below, the inventions are not dedicated to the public and the right to file one or more applications to claim such additional inventions is reserved.

What is claimed is:

1. A system for monitoring, analyzing, and storing driver activity, the system comprising:

a sensor module configured to receive data from one or more sensors that measure acceleration or deceleration associated with a vehicle;

a stop detection module configured to receive said sensor module data, process said sensor module data, and determine an abrupt acceleration or deceleration event;

a location module configured to retrieve the location of said vehicle simultaneous with said abrupt acceleration or deceleration event;

storing said location of said abrupt acceleration or deceleration event in an event record in an event database;

further comprising a notification module, said notification module retrieving at least one of said abrupt acceleration or deceleration event records for positional notification, wherein said notification module displays a map segment and retrieves the location information of said retrieved abrupt acceleration or deceleration event records and overlays notifications on said map segment corresponding to said retrieved abrupt acceleration or deceleration event location information;

wherein plural of said retrieved abrupt acceleration or deceleration event notifications within a threshold proximity are grouped and displayed as single notification.

2. The system of claim **1**, wherein plural of said retrieved abrupt acceleration or deceleration event notifications within a threshold proximity are grouped and displayed as a single cluster notification.

3. The system of claim **2**, wherein said cluster notification is displayed as a gradient, the gradient proportional to the number of proximate retrieved abrupt acceleration or deceleration event notifications in said cluster notification.

4. The system of claim **2**, wherein said cluster notification includes a numeric indicator of the number of proximate retrieved abrupt acceleration or deceleration event notifications in said cluster notification.

5. The system of claim **1**, wherein said notification module retrieves the location information of said retrieved abrupt acceleration or deceleration event records;

said notification module defines a proximity region bounding a retrieved abrupt acceleration or deceleration event location;

said notification module periodically receives vehicle position updates from said location module; and

said notification module generates a notification when said vehicle travels within said proximity region.

6. A system for monitoring, analyzing, and storing driver activity, the system comprising:

a sensor module configured to receive data from one or more sensors that measure acceleration or deceleration associated with a vehicle;

a stop detection module configured to receive said sensor module data, process said sensor module data, and determine an abrupt acceleration or deceleration event;

a location module configured to retrieve the location of said vehicle simultaneous with said abrupt acceleration or deceleration event;

storing said location of said abrupt acceleration or deceleration event in an event record in an event database;

said notification module periodically receiving position updates of said vehicle from said location module, displaying a map segment, and overlaying said vehicle on said map segment corresponding its position; and

said notification module retrieving the location information of abrupt acceleration or deceleration event records proximate said vehicle and overlaying notifications on the map corresponding to the retrieved abrupt acceleration or deceleration event location information;

wherein plural of said retrieved abrupt acceleration or deceleration event notifications within a threshold proximity are grouped and displayed as a single cluster notification.

7. The system of claim **6**, wherein said cluster notification includes a numeric indicator of the number of proximate retrieved abrupt acceleration or deceleration event notifications in said cluster notification.

8. A system for monitoring, analyzing, and storing driver activity, the system comprising:

a sensor module configured to receive data from one or more sensors that measure acceleration or deceleration associated with a vehicle;

a stop detection module configured to receive said sensor module data, process said sensor module data, and determine an abrupt acceleration or deceleration event;

a location module configured to retrieve the location of said vehicle simultaneous with said abrupt acceleration or deceleration event;

storing said location of said abrupt acceleration or deceleration event in an event record in an event database;

said notification module periodically receiving position updates of said vehicle from said location module, displaying a map segment, and overlaying said vehicle on said map segment corresponding its position; and

said notification module retrieving the location information of abrupt acceleration or deceleration event records proximate said vehicle and overlaying notifications on the map corresponding to the retrieved abrupt acceleration or deceleration event location information;

wherein said notification module retrieves the location information of said retrieved abrupt acceleration or deceleration event records;

said notification module defines a proximity region bounding a retrieved abrupt acceleration or deceleration event location;

said notification module periodically receives position updates from said location module; and

said notification module generates a notification when said vehicle travels within said proximity region.

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