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(54) **LEASE OBSERVATION AND EVENT RECORDING**

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

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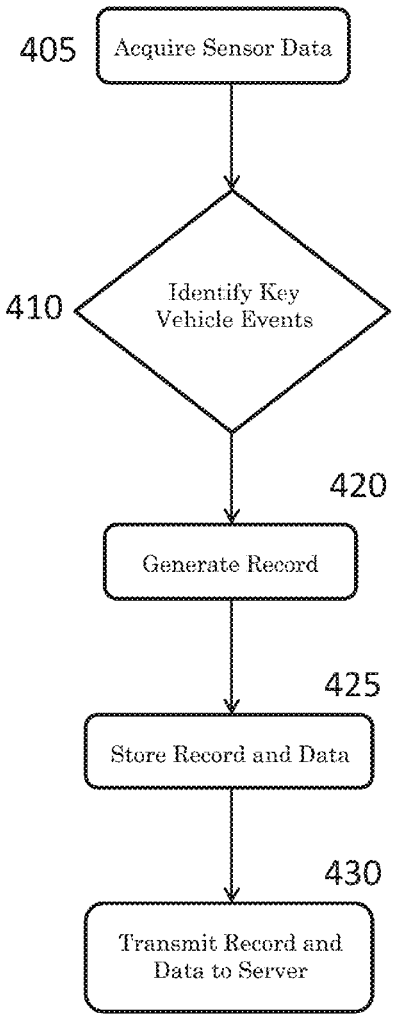
(57) **ABSTRACT**

A system and method for observing and reporting key vehicle events based upon information collected by a wide array of sensors already included in modern motor vehicles is provided. The system and method may be particularly valuable for electric vehicle applications.



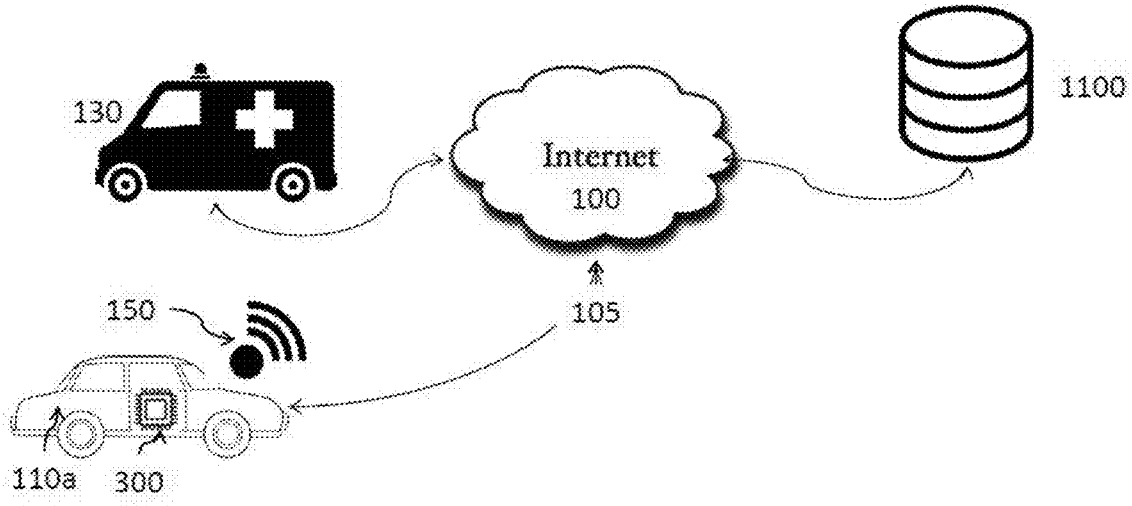


Fig. 1

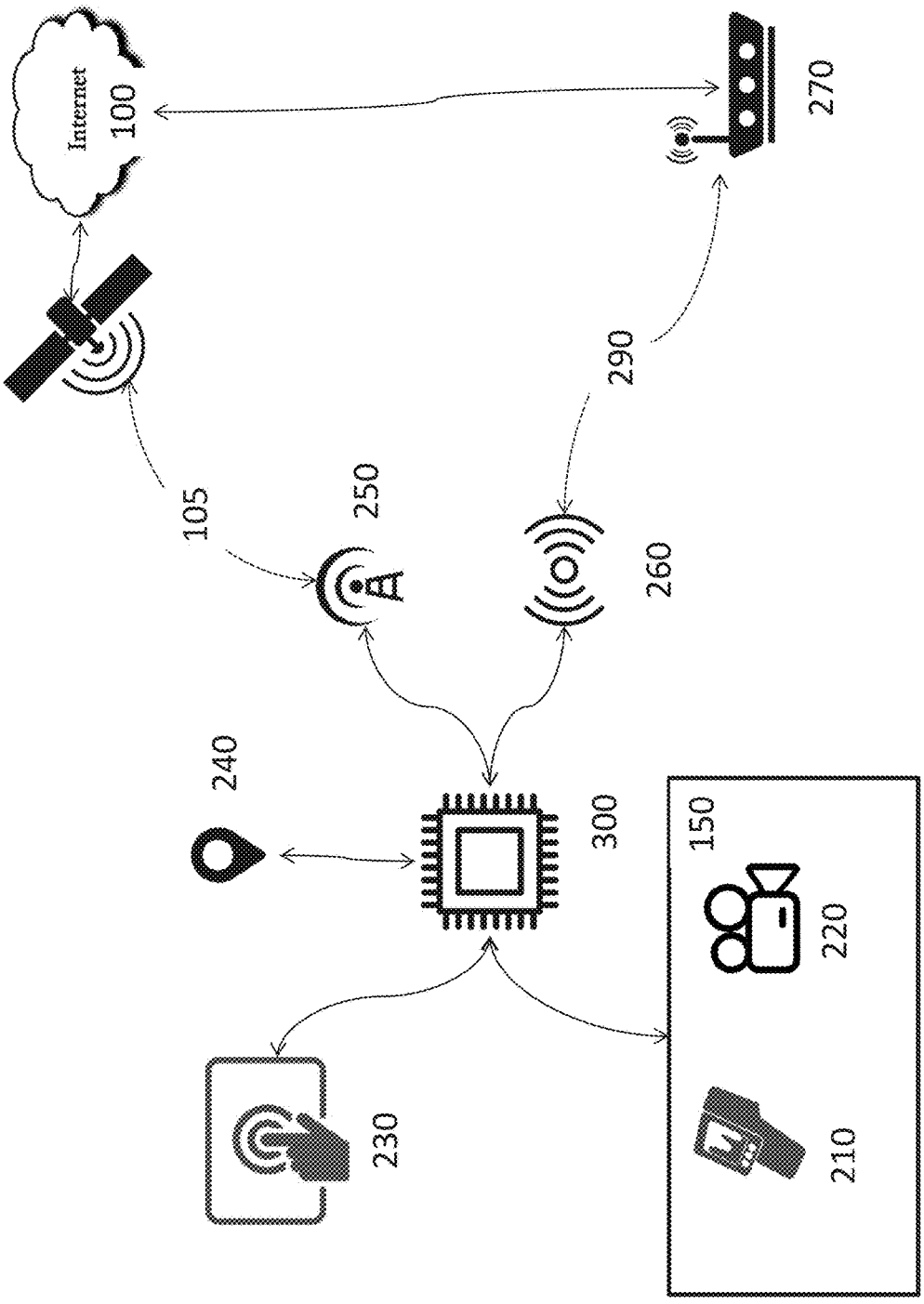


Fig. 2

Fig. 3

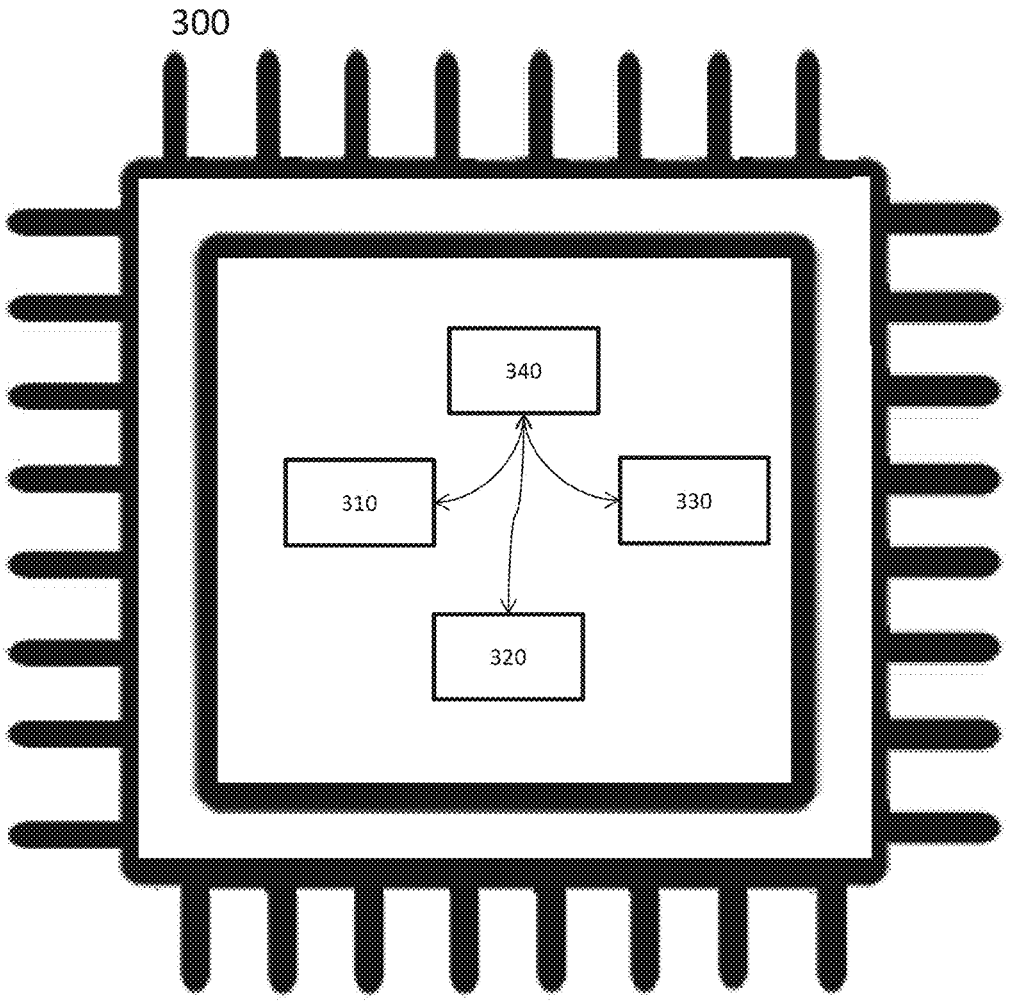


FIG. 4

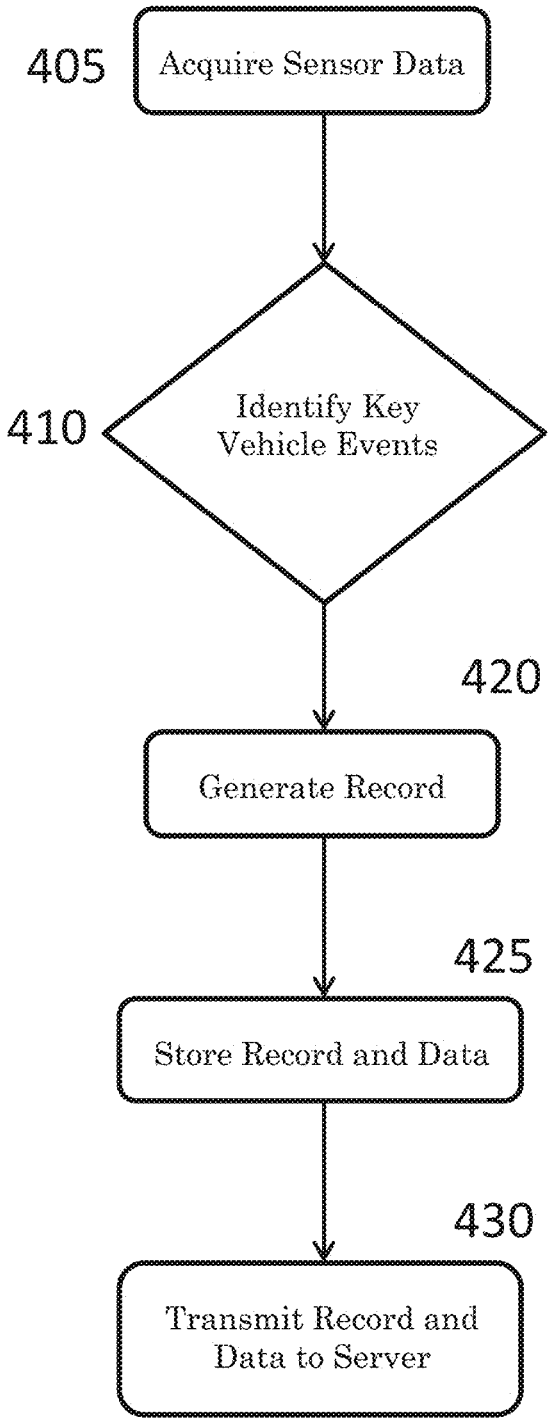

405
Acquire Sensor Data
410
Identify Key Vehicle Events
420
Generate Record
425
Store Record and Data
430
Transmit Record and Data to Server

FIG. 5

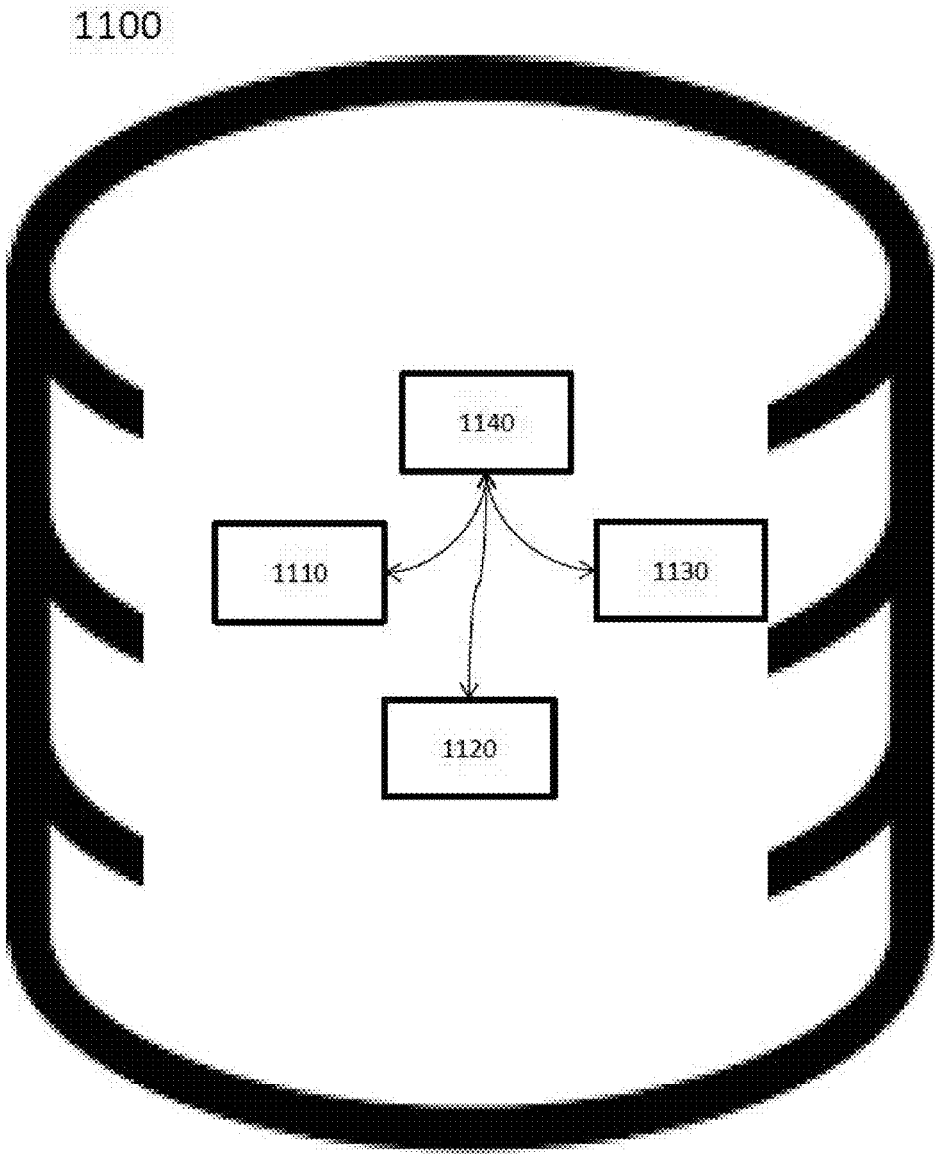
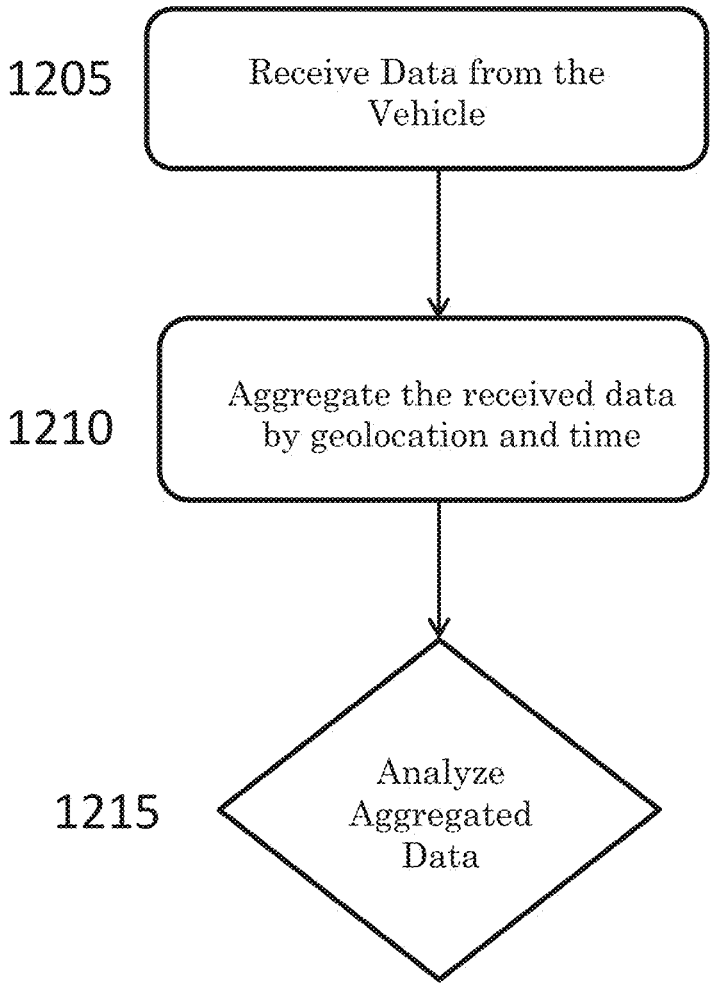


FIG. 6


1205
Receive Data from the Vehicle
1210
Aggregate the received data by geolocation and time
1215
Analyze Aggregated Data

LEASE OBSERVATION AND EVENT RECORDING

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application No. 62/430,626 having a filing date of Dec. 6, 2016 which is incorporated by reference as if fully set forth.

FIELD OF INVENTION

[0002] The present disclosure relates to vehicle status observation and recording for application in vehicle dealer situations.

BACKGROUND

[0003] When a vehicle is leased, it is reviewed on ownership transfer both at the beginning and end of the lease. Typically during reviews, however, the vehicle is only visually inspected. This visual inspection may examine the vehicle for scratches, tire tread, windshield cracks, etc. If the vehicle is approved of during a review, ownership of the car is transferred. Vehicle reviews, however, are extremely subjective. The individual conducting the visual inspection has significant leeway as to approval of a vehicle. Only if the individual conducting the review believes and notes that certain vehicle items require repair prior to ownership transfer will those parts actually be repaired. This subjectivity during vehicle review can therefore lead to inaccurate or falsely-blamed reviews.

[0004] In addition, nothing is recorded between inspection regarding the state of the engine, motor, battery system, suspension, vehicle structure, etc. These items therefore remain unknown during the review. Thus, the individual performing the review and the manufacturer are not aware of the state of abuse the vehicle has endured. The abuse that the car has sustained is not necessarily transparent to the inspector who visually approves the vehicle at the beginning and end of the lease.

[0005] Involving a third party to conduct more thorough vehicle reviews may be time consuming, inefficient, and stressful to the owner and lessee. The owner typically already knows the status of the vehicle. In addition, the data of vehicle criteria is already available. Modern vehicles have advanced driver assistance systems (ADAS) that contain upwards of 10 sensors. Thus, there is an unrealized potential to utilize the over 10 sensors on the vehicle to collect detailed information regarding the vehicle's status and key events. It would therefore be useful to offer a system and method of observing key vehicle events using these sensors and storing such vehicle information in a database to allow for a more thorough review of the vehicle prior to and after leasing or purchase.

SUMMARY

[0006] A system and method for observing and recording key vehicle events which are stored into a database to be analyzed for vehicle inspections and reviews is provided. The system may be applied to observation and recordation during a lease term as well as to vehicle purchases.

[0007] The system may comprise a vehicle and a database server. The vehicle may include one or more sensors, one or more thermal imagers, one or more high definition imagers, a real time communication interface, a short range communication interface, and a vehicle computer communicatively coupled to the other components in the vehicle. The database server may include a communication interface, a memory, storage, and a processor communicatively coupled to the other components in the database server.

[0008] The system may track vehicle condition and life status through a method of recording key vehicle events using the several sensors existing on the vehicle. The vehicle computer may acquire a plurality of sensor data from the sensors, a plurality of thermal images from the thermal imagers, and a plurality of high definition images from the high definition imagers. The vehicle computer may then analyze the information to find data containing key vehicle events. Key vehicle events may include acceleration criteria, break usage, battery charge information, engine status, oil service, tire wear and alignment, suspension details, and vehicle structure information. The vehicle computer may store the information provided from the plurality of sensors. The vehicle computer may then selectively transmit the data containing key vehicle events to a database server to store the data in a database.

[0009] Thus, the data stored in the database may be inspected and reviewed by manufacturers and vehicle owners to determine the life status of the vehicle, to detect any necessary repairs before or after transfer of ownership, and to provide a potential vehicle rating for leasing or purchasing based on analysis of the information. In addition, the information may provide the lessor or vehicle purchaser with reports regarding risky use and behavior of the vehicle. Cameras may capture vehicle and pedestrian interaction, and may be potentially triggered by sound. This data may be subsequently used to inspect and validate the leased vehicle as well as to determine and assign a life criterion during inspection and review of the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

[0011] FIG. **1** is an example vehicle observation and event recording system.

[0012] FIG. **2** is a communication diagram for a vehicle.

[0013] FIG. **3** is a block diagram of the electric vehicle computer.

[0014] FIG. **4** is a block diagram for a process of observing a vehicle and recording key events.

[0015] FIG. **5** is a block diagram of the database server.

[0016] FIG. **6** is a block diagram for a process of observing a vehicle and recording key events.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] A wide array of sensors is required for the modern operation of a motor vehicle. These sensors are required for the vehicle to navigate, avoid collisions with other cars, and adjust the operating parameters of vehicle drive systems. However, the data collected by these sensors is confined to the vehicle, is not stored, and is thus ephemeral and not used during vehicle lease review and inspection. The present disclosure provides a scheme which utilizes the data already being collected by the motor vehicle to convert the motor vehicle into a "rolling laboratory" for observing vehicle life

status and key vehicle events. Further, the system may aggregate the data and may store the data in a database for review and inspection over multiple time periods.

[0018] Advanced driver assistance systems (ADAS) automate and enhance the safety system and performance of a vehicle and provide a more pleasurable driving experience. Examples of ADAS systems currently available include Adaptive Cruise Control, Lane Departure Warning Systems, Blind Spot Detectors, and Hill Decent Control. In order to implement these systems, a wide array of sensors is utilized.

[0019] The present scheme may include a vehicle equipped with an ADAS system that is constantly collecting data about the vehicle and the environment surrounding the vehicle. This collected information may then be analyzed by a vehicle computer. The vehicle computer may then determine key life events of the vehicle as well as vehicle life and health status. Then, based on the determined events and status, the vehicle computer may transmit the data to a server to be stored in a database for analyzation during future reviews or inspection.

[0020] FIG. **1** depicts a diagram of an example system practicing the method of vehicle observation and event recording. In the system, a vehicle **110***a* may be communicatively coupled to a database server **1100** and be connected to the Internet **100** via a wireless channel **105**. The wireless communication channels **105** may be of the form of any wireless communication protocol such as LTE, 3G, WiMax, or any other known or proprietary communications protocol.

[0021] The vehicle **110***a* may contain a vehicle computer (VC) **300** that is communicatively coupled to a plurality of sensors **150**. The sensors **150** may include thermal imagers, LIDAR, radar, ultrasonic and High Definition (HD) cameras. In addition, sensors **150** may also detect criteria including, but not limited to engine health, motor functionality, battery life, oil status, suspension, and tire pressure, which are used to monitor various systems of the vehicle.

[0022] The communicative connections of the VC **300** are graphically shown in FIG. **2**. The VC **300** is communicatively coupled to a user interface **230**. The VC **300** may instruct the user interface **230** to display information stored in the memory **310** or storage **320** of the VC **300**. In addition, the VC **300** may instruct the user interface **230** to display alert messages. The user interface **230** may include a touch screen that enables the user to input information to the VC **300**. The user interface **230** may be a discrete device or integrated into an existing vehicle entertainment or navigation system.

[0023] The VC **300** may also be able to communicate with the Internet **100** via a wireless communication channel **105**. A database server **1100** is also connected to the Internet **100** via communication channel **125**. It should be understood that the Internet **100** may represent any network connection between respective components.

[0024] The VC **300** is also communicatively coupled to a real time communication interface **250**. The real time communication interface **250** enables the VC **300** to access the Internet **100** over wireless communication channel **105**. This enables the VC **300** to store and retrieve information stored in database server **1100** in real time. This information may also be displayed in the user interface **230**. The real time communication interface **250** may include one or more antennas, receiving circuits, and transmitting circuits. The wireless communication channel **105** provides near real time communication of the VC **300** to the database **1100** while the vehicle is in motion.

[0025] Additionally, the VC **300** may communicate with the Internet **100** through short range wireless interface **260** over short range wireless communication channel **290** via an access point **270**. Wireless channel **290** may be 802.11 (WiFi), 802.15 (Bluetooth) or any similar technology. Access point **270** may be integrated in the charging unit of an electric vehicle, located at a gas refueling station, or be located in an owner's garage. The wireless channel **290** allows the VC **300** to quickly and cheaply transmit large amounts of data when the vehicle is not in motion, and real time data transmission is not required.

[0026] When the VC **300** detects that the short range wireless interface **260** is connected to the Internet **1100**, the VC **300** transmits the data stored in storage **320** to the database **1100** over short range wireless channel **290**. The VC **300** may then delete the data stored in storage **320**.

[0027] The VC **300** may also be communicatively linked to the plurality of sensors **150**. The VC **300** may further be communicatively linked to one or more thermal imager **210** and one or more High Definition Camera **220**. The thermal imager **210** may include any form of thermographic cameras such as a Forward Looking Infrared (FLIR) camera. The high definition cameras **220** may include any form of digital imaging device that captures images in the visible light spectrum.

[0028] FIG. **3** depicts a block diagram of the VC **300**. The VC **300** includes an Input/Output interface **330**. The Input/Output interface **330** may facilitate communication of data with the plurality of sensors **150**, user interface **230**, real time communication interface **250** and short range wireless interface **260**. The VC **300** also includes a processor **330** that is communicatively linked to the Input/Output interface **330**, the memory **310** and the storage **320**. The storage **320** may be a hard disk drive, solid state drive or any similar technology for the nonvolatile storage and retrieval of data.

[0029] FIG. **4** depicts a method for vehicle observance and vehicle event recordation that may be implemented by the processor **330**. A plurality of data items are acquired (**405**) from the sensors **150**, thermal imager **210**, and the HD Camera **220**. In one embodiment, the acquired data is then analyzed (**410**) to determine if the data indicates key vehicle events. If the analysis of the data reveals a key vehicle event, a record is generated (**420**). Examples of key vehicle events may include, but are not limited to, charging the vehicle at various charging levels, oil servicing and maintenance, engine status, tire wear and tread, suspension and structural information, and abusive conditions on the vehicle, which may include vehicle damage from other cars or pedestrians.

[0030] The record includes the time, date, and geo-location data obtained by the geolocation system **240**. The record may be generated every time data is provided by the sensors **150**, thermal imager **210**, and the HD camera **220**; or the record may be generated as an average over a certain number of time intervals when data is provided. In addition, the record also contains the data from the sensors **150** that result in the determination of the key vehicle event. This information is then stored (**425**) in the storage **320**. The record and data are then transmitted to the database server **1100**.

[0031] In another embodiment, the plurality of data items are acquired (**405**) from the sensors **150**, thermal imager

210, and the HD Camera **220** and may immediately generate records to be stored in the storage **320** and transmitted to the database server **1100**.

[0032] FIG. **5** depicts the components of the database server **1100**. The database server **1100** may include a memory **1110**, storage **1120**, a communication interface **1130**, and a processor **1140**. The record and data generated by the sensors **150**, thermal imager **210**, and HD camera **220**, are transmitted to the database server **1100**. In one embodiment, the record may be transmitted every time the record is generated. In another embodiment, the record may be transmitted as an average over a certain number of time intervals when the record is generated. The record is then stored in storage **1120** in the database server **1100**. The processor **1140** is able to transmit and receive information from the Internet **100** via the communication interface **1130**. In addition, the processor **1140** is able to store data received by the communication **1130**.

[0033] FIG. **6** is a block diagram for the process implemented by the database server **1100** for observing and recording key vehicle events based on data acquired from the vehicle **110***a*. Data acquired is received (**1205**) from the vehicle via the real time communication channel **105** and the short range communication channel **290**. The data may include the raw data collected by the plurality of sensors **150**, thermal images acquired by the thermal imager **210**, high definition images captured by HD camera **220**, and data when the information was recorded. In one embodiment, the data may be acquired and received every time data is provided by the sensors **150**, thermal imager **210**, and the HD camera **220**. In another embodiment, the data may be acquired and received as an average over a certain number of time intervals when data is provided.

[0034] The received data is then aggregated (**1210**) based on the location where the data was collected and the time when it was collected. In one embodiment, the aggregated data is then analyzed (**1215**) to determine if a key vehicle event has been detected. If the result of the analysis **1215** is that a key vehicle event is detected, for example, the vehicle hitting a large pothole, the vehicle being charged to 100% at a fast charge level, the vehicle driving at a top speed more or less frequently, or how hard the driver typically takes turns, the data is transmitted to the database server **1100** to be stored in a database. Data received that is determined to not be key vehicle events may not be stored. Vehicle owners and manufacturers may then use the stored data from this post hoc analysis during inspection to determine the status of the vehicle.

[0035] By aggregating the data over an extended period of time, the database server **1100** may be able to identify key vehicle events in determining the vehicle status upon lease review and inspection. For instance, vehicle event recording by the HD camera **220** can reveal abusive behavior to the vehicle by capturing interactions with pedestrians and other cars. Subsequent owners and manufacturers may then look up this recording to determine whether they have legitimate claims as to the abused condition of the vehicle.

[0036] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, any of the steps described above may be automatically performed by either the VC **300** or database server **1100**.

[0037] Furthermore, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and non-transitory computer-readable storage media. Examples of non-transitory computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media, such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs).

1. An apparatus for observing and recording vehicle events, the apparatus, comprising:
- one or more sensors;
- one or more thermal imagers;
- one or more high definition imagers, wherein the one or more thermal imagers and one or more high definition imagers are part of an advanced driver assistance system (ADAS) that continuously collects data about the vehicle and the environment surrounding the vehicle;
- a real time communication interface;
- a short range communication interface; and
- a vehicle computer communicatively coupled to the one or more sensors, the one or more thermal imagers, the one or more high definition imagers, the real time communication interface, and the short range communication interface;
- wherein the vehicle computer:
- acquires a plurality of sensor data from the one or more sensors,
- acquires a plurality of thermal images from the one or more thermal imagers,
- acquires a plurality of high definition images from the one or more high definition imagers,
- identifies one or more key vehicle events based on the plurality of the sensor data, the plurality of the thermal images, and the plurality of the high definition images,
- generates a record based on data identified as the one or more key vehicle events,
- stores the record, and
- selectively transmits, via the real time communication interface, information based on the plurality of the sensor data, the plurality of the thermal images, and the plurality of the high definition images containing the one or more key vehicle events to a database server.

2. The apparatus according to claim **1**, wherein the vehicle is an electric vehicle, wherein the key vehicle event is one or more of acceleration criteria, break usage, battery charge information, engine status, oil service status, tire wear and alignment, suspension details, tire pressure, and vehicle structure information, and wherein the one or more key vehicle events are determined from actions or events taken by the vehicle or applied to the vehicle.

3. The apparatus according to claim **1**, wherein the real time communication interface selectively transmits the plurality of sensor data, the plurality of thermal images, and the plurality of high definition images to a database server, based on the plurality of sensor data, the plurality of thermal images, and the plurality of high definition images containing the one or more key vehicle events and wherein the database server identifies, from the one or more key vehicle

events one or more of a life status of the vehicle, a necessary repair of the vehicle before or after transfer of ownership, a potential vehicle rating for leasing or purchasing of the vehicle, and a report regarding risky use and behavior of the vehicle.

4. The apparatus according to claim **2**, wherein the key vehicle event is one or more of charging the vehicle at various charging levels, oil servicing and maintenance, engine status, tire wear and tread, suspension and structural information, and abusive conditions of the vehicle, wherein the vehicle computer is configured to selectively display an alert on a display communicatively coupled to the vehicle computer based on the plurality of the sensor data, the plurality of the thermal images, and the plurality of the high definition images containing the one or more key vehicle events, and wherein the one or more key vehicle events is an interaction between the vehicle and a pedestrian.

5. The apparatus according to claim **1**, wherein the vehicle is an electric vehicle, wherein the vehicle is leased, wherein the one or more high definition imagers comprises a Forward Looking Infrared camera, wherein the key vehicle event is one or more of the vehicle hitting a large pothole, the vehicle being charged to 100% at a fast charge level, the vehicle driving at a top speed more or less frequently, and how hard a driver takes a turn in the vehicle, and wherein the database server:

receives the plurality of the sensor data, the plurality of the thermal images, and the plurality of the high definition images,

aggregates the received data and images by geolocation and time, and

analyzes the aggregated data to determine if a key vehicle event has been detected, wherein the database server, based on the analysis, one or more of validates a condition of a leased vehicle and determines and assigns a life criterion during inspection and review of the leased vehicle.

6. A method for observing and recording vehicle events, the method comprising:

acquiring, by a vehicle computer, a plurality of sensor data from one or more sensors;

acquiring, by a vehicle computer, a plurality of thermal images from one or more thermal imagers;

acquiring, by the vehicle computer, a plurality of high definition images from one or more high definition imagers, wherein the one or more thermal imagers and one or more high definition imagers are part of an advanced driver assistance system (ADAS) that continuously collects data about the vehicle and the environment surrounding the vehicle;

identifying one or more key vehicle events based on the plurality of the sensor data, the plurality of the thermal images, and the plurality of the high definition images,

generating a record based on data identified as one or more key vehicle events,

storing the record in a database, and

selectively transmitting, via a real time interface of the vehicle, computer information based on the plurality of sensor data, the plurality of thermal images, and the plurality of high definition images containing the one or more key vehicle events to a database server.

7. The method according to claim **6**, wherein the vehicle is an electric vehicle, wherein the key vehicle event is one or more of acceleration criteria, break usage, battery charge information, engine status, oil service status, tire wear and alignment, suspension details, tire pressure, and vehicle structure information, and wherein the one or more key vehicle events are determined from actions or events taken by the vehicle or applied to the vehicle.

8. The method according to claim **6**, wherein the key vehicle event is one or more of charging the vehicle at various charging levels, oil servicing and maintenance, engine status, tire wear and tread, suspension and structural information, and abusive conditions of the vehicle and further comprising selectively displaying an alert on a display communicatively coupled to the vehicle computer based on the plurality of the sensor data, the plurality of the thermal images, and the plurality of the high definition images containing the one or more key vehicle events, wherein the one or more key vehicle events is an interaction between the vehicle and a pedestrian.

9. The method according to claim **7**, wherein the real time communication interface is configured to selectively transmit the plurality of sensor data, the plurality of thermal images, and the plurality of high definition images to a database server, based on the plurality of sensor data, the plurality of thermal images, and the plurality of high definition images containing the one or more key vehicle events and wherein the database server identifies, from the one or more key vehicle events one or more of a life status of the vehicle, a necessary repair of the vehicle before or after transfer of ownership, a potential vehicle rating for leasing or purchasing of the vehicle, and a report regarding risky use and behavior of the vehicle.

10. The method according to claim **6**, wherein the vehicle is an electric vehicle, wherein the vehicle is leased, wherein the one or more high definition imagers comprises a Forward Looking Infrared camera, wherein the key vehicle event is one or more of the vehicle hitting a large pothole, the vehicle being charged to 100% at a fast charge level, the vehicle driving at a top speed more or less frequently, and how hard a driver takes a turn in the vehicle, and further comprising:

receiving, by the database server, the plurality of the sensor data, the plurality of the thermal images, and the plurality of the high definition images,

aggregating the received data by geolocation and time, and

analyzing the aggregated data to determine if a key vehicle event has been detected, wherein the database server, based on the analysis, one or more of validates a condition of a leased vehicle and determines and assigns a life criterion during inspection and review of the leased vehicle.

11. A system for observing and recording vehicle events, the system comprising:

a vehicle, wherein the vehicle includes:

one or more sensors

one or more thermal imagers,

one or more high definition imagers,

a real time communication interface,

a short range communication interface, and

a vehicle computer communicatively coupled to the one or more sensors, the one or more thermal imagers, the one or more high definition imagers, the real time communication interface, and the short range communication interface; and

a database server communicatively coupled to the vehicle, wherein the database server includes:

a communication interface,

a memory,

storage, and

a processor communicatively coupled to the memory, the storage, and the communication interface;

wherein the processor of the database server:

receives, via the communication interface, a plurality of sensor data and plurality of images from the vehicle, wherein the plurality of images include images acquired by the one or more thermal imagers and the one or more high definition imagers,

aggregates the plurality of sensor data and images based on geolocation information and temporal information provided by the vehicle to form aggregated data, and

analyzes the aggregated data to determine if a key vehicle event has been detected.

12. The system according to claim **11**, wherein the one or more thermal imagers and one or more high definition imagers are part of an advanced driver assistance system (ADAS) that continuously collects data about the vehicle and the environment surrounding the vehicle, wherein the vehicle is an electric vehicle, wherein the key vehicle event is one or more of acceleration criteria, break usage, battery charge information, engine status, oil service status, tire wear and alignment, suspension details, tire pressure, and vehicle structure information, and wherein the one or more key vehicle events are determined from actions or events taken by the vehicle or applied to the vehicle.

13. The system according to claim **12**, wherein the processor of the database server is further configured to store the data containing one or more key vehicle events in a database and wherein the database server identifies, from the one or more key vehicle events one or more of a life status of the vehicle, a necessary repair of the vehicle before or after transfer of ownership, a potential vehicle rating for leasing or purchasing of the vehicle, and a report regarding risky use and behavior of the vehicle.

14. The system according to claim **11**, wherein the vehicle is configured to:

acquire a plurality of sensor data from the one or more sensors,

acquire a plurality of thermal images from the one or more thermal imagers,

acquire a plurality of high definition images from the one or more high definition imagers,

identify one or more key vehicle events based on the plurality of the sensor data, the plurality of the thermal images, and the plurality of the high definition images,

generate a record based on data identified as the one or more key vehicle events,

store the record in a database, and

selectively transmit, via the real time communication interface, the database containing the record based on the plurality of the sensor data, the plurality of the thermal images, and the plurality of the high definition images containing the one or more key vehicle events to a database server and wherein the key vehicle event is one or more of charging the vehicle at various charging levels, oil servicing and maintenance, engine status, tire wear and tread, suspension and structural information, and abusive conditions of the vehicle.

15. The system according to claim **14**, wherein the vehicle is an electric vehicle, wherein the vehicle is leased, wherein the one or more high definition imagers comprises a Forward Looking Infrared camera, wherein the key vehicle event is one or more of the vehicle hitting a large pothole, the vehicle being charged to 100% at a fast charge level, the vehicle driving at a top speed more or less frequently, and how hard a driver takes a turn in the vehicle, and wherein the real time communication interface is configured to selectively transmit the plurality of sensor data, the plurality of thermal images, and the plurality of high definition images to a database server, based on the plurality of sensor data, the plurality of thermal images, and the plurality of high definition images containing the one or more key vehicle events.

16. The system according to claim **14**, wherein the vehicle computer is configured to selectively display an alert on a display communicatively coupled to the vehicle computer based on the plurality of the sensor data, the plurality of the thermal images, and the plurality of the high definition images containing one or more key vehicle events and wherein the database server, based on the analysis, one or more of validates a condition of a leased vehicle and determines and assigns a life criterion during inspection and review of the leased vehicle.

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