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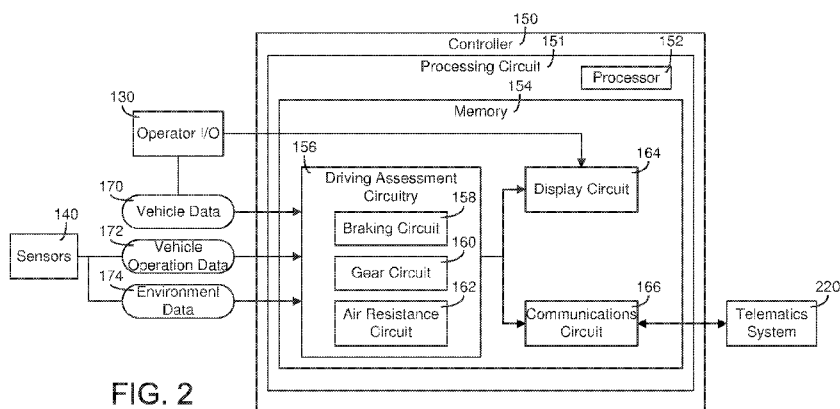


FIG. 2

(57) Abstract: An apparatus includes a driving assessment circuit and a display circuit. The driving assessment circuit is structured to receive vehicle data indicative of at least one attribute of a vehicle, receive vehicle operation data indicative of at least one operating characteristic of the vehicle, and determine an amount of fuel loss due to one or more driving inputs made by an operator of the vehicle based on the vehicle data and the vehicle operation data. The display circuit is structured to provide an indication of the amount of fuel loss on a display device to the operator of the vehicle in response to the one or more driving inputs.

DRIVING BEHAVIOR ASSESSMENT AND CORRECTION SYSTEM

BACKGROUND

[0001] Vehicle operators, especially inexperienced vehicle operators, may drive vehicles in ways that negatively impact the fuel economy of a vehicle. For example, by braking too suddenly or with more force than required for a given situation, vehicle operators do not always drive vehicles in the most fuel-efficient manner. Often, the vehicle operator is unaware of the impact such actions have on fuel economy or that driving the vehicle differently may result in better fuel economy. As such, vehicle operators are often not motivated to drive vehicles more efficiently or to take actions to correct fuel-inefficient driving habits or to refrain from repeating such fuel-inefficient maneuvers in the future.

SUMMARY

[0002] One embodiment relates to an apparatus. The apparatus includes a driving assessment circuit and a display circuit. The driving assessment circuit is structured to receive vehicle data indicative of at least one attribute of a vehicle, receive vehicle operation data indicative of at least one operating characteristic of the vehicle, and determine an amount of fuel loss due to one or more driving inputs made by an operator of the vehicle based on the vehicle data and the vehicle operation data. The display circuit is structured to provide an indication of the amount of fuel loss on a display device to the operator of the vehicle in response to the one or more driving inputs.

[0003] Another embodiment relates to a method. The method includes receiving, by a controller, vehicle data indicative of at least one attribute of a vehicle; receiving, by the controller, vehicle operation data indicative of at least one operating characteristic of the vehicle; determining, by the controller, an amount of fuel loss due to one or more driving inputs made by an operator of the vehicle based on the vehicle data and the vehicle operation data; and providing, by the controller on a display device to the operator of the vehicle, an indication of the amount of fuel loss in response to the one or more driving inputs.

[0004] Still another embodiment relates to system. The system includes one or more communication systems and an external monitoring system communicably coupled to the one or more communication systems. Each communication system is located onboard a respective vehicle and structured to transmit an assessment of one or more driving inputs made by a driver of the respective vehicle. The external system is structured to receive the assessment of the one or more driving inputs made by the driver from each of the one or more communication systems, and receive a display request for providing a graphical user interface to a display device. The display request includes configurable options for providing the graphical user interface in a desired graphical format for depicting the assessment of the one or more driving inputs made by the driver of each respective vehicle to facilitate monitoring each driver for fuel efficiency.

[0005] Yet another embodiment relates to a vehicle. The vehicle includes a display device and a controller communicably and operatively coupled to the display device. The controller is structured to receive vehicle data indicative of at least one attribute of the vehicle, receive vehicle operation data indicative of at least one operating characteristic of the vehicle, determine an amount of fuel loss due to one or more driving inputs made by an operator of the vehicle based on the vehicle data and the vehicle operation data, and provide an indication of the amount of fuel loss on the display device in response to the one or more driving inputs.

[0006] These and other features, together with the organization and manner of operation thereof, will become apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a schematic diagram of a vehicle with a controller, according to an example embodiment.

[0008] FIG. 2 is a schematic diagram of the controller used with the vehicle of FIG. 1, according to an example embodiment.

[0009] FIG. 3 is a schematic diagram of a fleet management system used with the vehicle of FIG. 1, according to an example embodiment.

[0010] FIG. 4 is a flow diagram of a method for assessing and correcting driving behavior, according to an example embodiment.

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DETAILED DESCRIPTION

[0011] Following below are more detailed descriptions of various concepts related to, and implementations of, methods, apparatuses, and systems for assessing and correcting driving behavior. The various concepts introduced above and discussed in greater detail below may be implemented in any of numerous ways, as the described concepts are not limited to any particular manner of implementation. Examples of specific implementations and applications are provided primarily for illustrative purposes.

[0012] Referring to the Figures generally, the various embodiments disclosed herein relate to systems, apparatuses, and methods relating to assessing and correcting driving behavior (e.g., to increase fuel efficiency of a vehicle, to provide training to drivers, etc.). Driving assessment systems, apparatuses, and methods may provide feedback to an operator of a vehicle in the form of a rating or scoring system. For example, based on an operator's driving behavior or a maneuver the operator makes, feedback may be provided in the form of a score on a defined rating scale. By way of example, if an operator makes a good maneuver or has good driving inputs, the feedback may provide a high score (e.g., 8, 9, 10, etc. of out 10, etc.). By way of another example, if an operator makes a bad maneuver or has bad driving inputs, the feedback may provide a low score (e.g., 1, 3, 5, etc. of out 10, etc.). While this may identify driving behavior as bad (e.g., inefficient, causes excess fuel loss, etc.) or good (e.g., efficient, minimizes excess fuel loss, etc.), the feedback is arbitrary and provides no motivation to an operator to take action to make better driving decisions. According to an example embodiment, the systems, apparatuses, and methods are further capable of providing feedback (e.g., in real-time, etc.) to an operator that identifies an amount of fuel loss experienced by the vehicle in response to the driving inputs made by an operator and/or driving behavior (e.g., gear selection, gear changes,

selected speed, braking habits, acceleration habits, etc.). In some embodiments, the systems, apparatuses, and methods of the present disclosure are structured to transmit information/data regarding the operator's driving inputs and/or behavior to an external system (e.g., a fleet management system, a remote server, a vehicle owner's selected device, etc.) to facilitate remote
5 monitoring of the driving inputs and/or behavior of the operator (e.g., an employee, a child, a vehicle renter, etc.).

[0013] An example operation of the controller may be as follows. Upon an operator making a driving maneuver (e.g., braking, shifting gears, accelerating, and/or selecting a speed via a driving input, including a position or state change of any mechanism or device that modifies a
10 vehicle operating characteristic, etc.), the controller receives vehicle data including at least one attribute of the vehicle including, but not limited to, an axle ratio, a tire size, a transmission ratio at each gear, a fuel efficiency map, a coefficient of aerodynamic drag, a vehicle aerodynamic drag area, and a vehicle weight. The controller receives vehicle operation data including at least one of, but not limited to, an engine speed, an engine torque, a vehicle speed, a current gear
15 selection, a gear change, a braking intensity, and an amount of aerodynamic drag. In some embodiments, the controller further receives environment data indicative of characteristics around the vehicle (e.g., road grade, road curvature, speed limit, traffic conditions, traffic light conditions, weather conditions, etc.). The controller may then determine an amount of fuel loss due to the one or more driving inputs made by the operator based on the vehicle data, the vehicle
20 operation data, and/or the environment data. The controller may provide an indication of the amount of fuel loss to the operator of the vehicle (e.g., via a display device, in real-time, etc.). The controller may additionally or alternatively transmit an assessment of the one or more driving inputs made by the operator of the vehicle to an external system (e.g., a fleet management system, a remote device or server, etc.). The external system may be accessed by a
25 third party (e.g., an owner of the vehicle, a parent of a child, a fleet manager, etc.) to facilitate remote monitoring of the driving behavior of the operator of the vehicle. These and other example configurations are explained more fully herein.

[0014] Referring now to FIG. 1, a schematic diagram of a vehicle 100 with a controller 150 is shown according to an example embodiment. The vehicle 100 may be an on-road or an off-road vehicle including, but not limited to, line-haul trucks, mid-range trucks (e.g., pick-up truck), sedans, coupes, compacts, sport utility vehicles, and any other type of vehicle. Although FIG. 1 depicts the vehicle 100 as including an internal combustion engine 111, the vehicle 100 may be powered by any type of engine system. For example, the vehicle 100 may be a hybrid vehicle, a full electric vehicle, and/or an internal combustion engine powered vehicle as shown.

[0015] As shown in FIG. 1, the vehicle 100 generally includes a powertrain system 110, vehicle subsystems 120, an operator input/output (I/O) device 130, and sensors 140 that are all communicably coupled to the controller 150. Communication between and among the components of the vehicle 100 may be via any number of wired or wireless connections. For example, a wired connection may include a serial cable, a fiber optic cable, a CAT5 cable, or any other form of wired connection. In comparison, a wireless connection may include the Internet, Wi-Fi, cellular, radio, Bluetooth, Zigbee, etc. In one embodiment, a controller area network (CAN) bus provides the exchange of signals, information, and/or data. The CAN bus includes any number of wired and wireless connections. Because the controller 150 is communicably coupled to the systems and components in the vehicle 100 of FIG. 1, the controller 150 is structured to receive and/or interpret data from one or more of the components shown in FIG. 1. For example, the data may include vehicle data (e.g., an axle ratio, a tire size, a transmission ratio at each gear, a fuel efficiency map, a coefficient of aerodynamic drag, a vehicle aerodynamic drag area, a vehicle weight, etc.) predefined or stored within the controller 150, received by the operator I/O device 130, and/or received from one or more sensors, such as sensors 140. As another example, the data may include vehicle operation data (e.g., an engine speed, an engine torque, a vehicle speed, a current gear selection, a gear change, a braking intensity, an amount of aerodynamic drag, etc.) received from one or more sensors, such as sensors 140. In yet another example, the data may include environment data (e.g., road grade, road curvature, speed limit, traffic conditions, traffic light conditions, weather conditions, etc.) received from one or more sensors, such as sensors 140. As described more fully herein, with this data, the controller 150 determines an amount of fuel loss experienced by a vehicle (e.g., in

response to a vehicle operator's driving inputs, maneuvers, behaviors, etc.) to provide an indication of the amount of fuel loss to the operator to motivate and train the operator to make better, more fuel efficient decisions.

[0016] As shown in FIG. 1, the powertrain system 110 includes an engine 111, a transmission 112, a drive shaft 113, a differential 114, and a final drive 115. As a brief overview, the engine 111 receives a chemical energy input (e.g., a fuel such as gasoline, diesel, etc.) and combusts the fuel to generate mechanical energy, in the form of a rotating crankshaft. The transmission 112 receives the rotating crankshaft and manipulates the speed of the crankshaft to affect a desired drive shaft 113 speed. The rotating drive shaft 113 is received by a differential 114, which provides the rotation energy of the drive shaft 113 to the final drive 115. The final drive 115 then propels or moves the vehicle 100.

[0017] The engine 111 may be structured as any engine type: from an internal combustion engine to a full electric motor and combinations/variants thereof (e.g., a hybrid drive comprising an internal combustion engine and an electric motor, etc.). According to an example embodiment, the engine 111 is structured as an internal combustion engine (e.g., compression-ignition, spark-ignition, etc.) that may be powered by any fuel type (e.g., diesel, ethanol, gasoline, etc.). Similarly, the transmission 112 may be structured as any type of transmission, such as a continuous variable transmission, a manual transmission, an automatic transmission, an automatic-manual transmission, a dual clutch transmission, etc. Accordingly, as transmissions vary from geared to continuous configurations (e.g., continuous variable transmission, etc.), the transmission can include a variety of settings (gears, for a geared transmission) that affect different output speeds based on the engine speed. Like the engine 111 and the transmission 112, the drive shaft 113, the differential 114, and the final drive 115 may be structured in any configuration dependent on the application (e.g., the final drive 115 is structured as wheels in an automotive application and a propeller in an airplane application, etc.). Further, the drive shaft 113 may be structured as any type of drive shaft including, but not limited to, a one-piece, two-piece, and a slip-in-tube driveshaft based on the application.

[0018] The vehicle 100 is also shown to include vehicle subsystems 120. The vehicle subsystems 120 may include both electrically-powered vehicle accessories and engine driven vehicle accessories, as well any other type of subsystem in the vehicle 100. For example, a subsystem may include an exhaust aftertreatment system. The exhaust aftertreatment system may include any component used to reduce exhaust emissions (e.g., diesel exhaust emissions, gas exhaust emissions, etc.), such as selective catalytic reduction catalyst, a diesel oxidation catalyst, a diesel particulate filter, a diesel exhaust fluid doser with a supply of diesel exhaust fluid, and a plurality of sensors for monitoring the aftertreatment system (e.g., a NOx sensor, etc.). The vehicle accessories may include, but are not limited to, air compressors (for pneumatic devices), air conditioning systems, power steering pumps, engine coolant pumps, fans, and the like.

[0019] The operator I/O device 130 enables an operator of the vehicle 100 (or another passenger) to communicate with the vehicle 100 and the controller 150. For example, the operator I/O device 130 may include, but is not limited, an interactive display, a touchscreen device, one or more buttons and switches, voice command receivers, etc. In this regard, the device 130 may be structured as solely an output device, where the signals, values, messages, information, etc. may only be provided to an operator or passenger of the vehicle 100; solely as input device, where an operator or passenger may provide information, signals, messages, etc. to the controller 150; and/or a combination therewith like shown in the example of FIG. 1. Via the operator I/O device 130, the operator may input at least a portion of the vehicle data including, but not limited to, an axle ratio, a tire size, a transmission ratio at each gear, a fuel efficiency map, a coefficient of aerodynamic drag, a vehicle aerodynamic drag area, a vehicle weight, and the like. The controller 150 may provide a command to the operator I/O device 130 to display an indication (e.g., in real-time, etc.) to the operator of the vehicle 100 indicative of an amount of fuel loss due to one or more driving inputs made by the operator. This is explained more fully in regard to FIG. 2.

[0020] The sensors 140 may include, but are not limited to, a lidar, a radar, ultrasonic sensors, accelerometers, gyroscopes, a pitot tube and/or wind sensor, a brake sensor, a gear sensor, an

inclinometer, a camera device (e.g., still camera, video camera, etc.), and/or a fuel flow sensor, among other possible sensors. In one example, the lidar, radar, ultrasonic sensors, and/or camera device may be structured to acquire environment data indicative of surrounding traffic (e.g., vehicles, obstacles, etc.) proximate the vehicle 100. In another example, the lidar, radar, ultrasonic sensors, camera device, accelerometers, gyroscopes, and/or inclinometer may be structured to acquire environment data indicative of road grade, road curvature, and the like. In yet another example, the pitot tube and/or wind sensor may be structured to acquire vehicle operation data indicative of vehicle speed and/or environment data indicative of wind speed. In still another example, the brake sensor may be structure to acquire vehicle operation data indicative of an intensity of a braking event (e.g., a normal braking event, a hard braking event, an emergency braking event, etc.). In still another example, the gear sensor may be structured to acquire vehicle operation data indicative of a current, selected gear (e.g., of a transmission, etc.). In still yet another example, the fuel flow sensor may be structured to monitor an amount of fuel used during operation of the vehicle 100 (e.g., in response to various driving inputs such as gear shifts, braking events, acceleration, etc.).

[0021] As the components of FIG. 1 are shown to be embodied in the vehicle 100, in one embodiment the controller 150 may be embodied as an electronic control unit (ECU) or an add-on to an ECU. In some embodiments, the controller 150 may be a stand-alone tool that performs all required data logging, data tracking, data analysis, etc. needed to determine an amount of fuel loss in response to various driving maneuvers and/or characteristics. In some embodiments, the controller 150 is included in the ECU of the vehicle 100. The ECU may include a transmission control unit and any other vehicle control unit (e.g., exhaust aftertreatment control unit, powertrain control circuit, engine control circuit, etc.). In an alternative embodiment, the controller 150 is web based, server based, and/or application based (e.g., a smartphone app, a controller on the internet, etc.). The structure and function of the controller 150 is further described in regard to FIG. 2.

[0022] Referring now to FIG. 2, the function and structure of the controller 150 are shown according to an example embodiment. The controller 150 is shown to include a processing

circuit 151 including a processor 152 and a memory 154. The processor 152 may be implemented as a general-purpose processor, an application specific integrated circuit (ASIC), one or more field programmable gate arrays (FPGAs), a digital signal processor (DSP), a group of processing components, or other suitable electronic processing components. The one or more memory devices 154 (e.g., NVRAM, RAM, ROM, Flash Memory, hard disk storage, etc.) may store data and/or computer code for facilitating the various processes described herein. Thus, the one or more memory devices 154 may be communicably connected to the processor 152 and provide computer code or instructions to the processor 152 for executing the processes described in regard to the controller 150 herein. Moreover, the one or more memory devices 154 may be or include tangible, non-transient volatile memory or non-volatile memory. Accordingly, the one or more memory devices 154 may include database components, object code components, script components, or any other type of information structure for supporting the various activities and information structures described herein.

[0023] The memory 154 is shown to include various circuits for completing the activities described herein. More particularly, the memory 154 includes driving assessment circuitry 156, a display circuit 164, and a communications circuit 166. The circuits 156–166 are structured to receive and interpret various data to determine an amount of fuel loss due to one or more driving inputs made by an operator of the vehicle 100 and provide an indication of the amount of fuel loss on the operator I/O device 130 to the operator of the vehicle 100 in response to the one or more driving inputs (e.g., for training purposes, to motivate the operator to drive more fuel efficiently, etc.). While various circuits with particular functionality are shown in FIG. 2, it should be understood that the controller 150 and memory 154 may include any number of circuits for completing the functions described herein. For example, the activities of multiple circuits may be combined as a single circuit, as additional circuits with additional functionality may be included, etc. Further, it should be understood that the controller 150 may further control other activity beyond the scope of the present disclosure.

[0024] Certain operations of the controller 150 described herein include operations to interpret and/or to determine one or more parameters. Interpreting or determining, as utilized herein,

includes receiving values by any method known in the art, including at least receiving values from a datalink or network communication, receiving an electronic signal (e.g. a voltage, frequency, current, or PWM signal) indicative of the value, receiving a computer generated parameter indicative of the value, reading the value from a memory location on a non-transient computer readable storage medium, receiving the value as a run-time parameter by any means known in the art, and/or by receiving a value by which the interpreted parameter can be calculated, and/or by referencing a default value that is interpreted to be the parameter value.

[0025] The driving assessment circuitry 156 may include or be operatively and communicably coupled to the operator I/O device 130 and/or the sensors 140 to receive at least one of vehicle data 170, vehicle operation data 172, and environment data 174. The driving assessment circuitry 156 may be structured to interpret the at least one of the vehicle data 170, the vehicle operation data 172, and the environment data 174 to determine an amount of fuel loss due to one or more driving inputs made by an operator of the vehicle 100 (e.g., based on the vehicle data 170, vehicle operation data 172, and/or environment data 174, etc.). The driving assessment circuitry 156 may be further structured to store the vehicle data 170, the vehicle operation data 172, the environment data 174, and/or the determinations made (e.g., regarding the amount of fuel loss, etc.) for future use by other circuits (e.g., the display circuit 164, the communications circuit 166, etc.).

[0026] According to one embodiment, the driving assessment circuitry 156 may include communication circuitry structured to facilitate the exchange of information, data, values, non-transient signals, etc. between and among the driving assessment circuitry 156, the operator I/O device 130, the sensors 140, the display circuit 164, and/or the communications circuit 166. For example, the communication circuitry may include a channel comprising any type of communication channel (e.g., fiber optics, wired, wireless, etc.), wherein the channel may include any additional component for signal enhancement, modulation, demodulation, filtering, and the like. In this regard, the driving assessment circuitry 156 may include communication circuitry including, but not limited to, wired and wireless communication protocol to facilitate

reception of the vehicle data 170, the vehicle operation data 172, and/or the environment data 174.

[0027] In another embodiment, the driving assessment circuitry 156 may include machine-readable media stored by the memory 154 and executable by the processor 152, wherein the machine-readable media facilitates performance of certain operations to receive the vehicle data 170, the vehicle operation data 172, and/or the environment data 174. For example, the machine-readable media may provide an instruction (e.g., command, etc.) to the sensors 140 to acquire the vehicle data 170, the vehicle operation data 172, and/or the environment data 174. In this regard, the machine-readable media may include programmable logic that defines the frequency of acquisition of the vehicle data 170, the vehicle operation data 172, and/or the environment data 174. In yet another embodiment, the driving assessment circuitry 156 may include any combination of machine-readable content, communication circuitry, the sensor 140, and the operator I/O device 130.

[0028] According to an example embodiment, the one or more driving inputs made by the operator may include at least one of (i) a braking event (and subsequent acceleration), (ii) a gear selection, (iii) a gear change (e.g., shifting, etc.), and (iv) a pedal position (e.g., an accelerator pedal position, a throttle position, etc.) associated with a selected vehicle speed corresponding with an amount of aerodynamic resistance experienced by the vehicle 100. According to an example embodiment, the vehicle data 170 is indicative of at least one attribute of the vehicle 100 and/or components thereof. The at least one attribute of the vehicle 100 may include at least one of an axle ratio, a tire size, a transmission ratio at each gear, a fuel efficiency map, a coefficient of aerodynamic drag, a vehicle aerodynamic drag area, and a vehicle weight. In one embodiment, the vehicle data 170 is received by the driving assessment circuitry 156 via an input from an operator using the operator I/O device 130. As may be discerned from the types of vehicle data 170 described above, the vehicle data 170 may be predefined in the controller 150 (e.g., vehicle mass/weight, etc.) to take into consideration constants for the vehicle 100. As the controller 150 of the present disclosure may be used with other vehicles, an operator may simply download or select the vehicle 100 (e.g., from a drop down menu, etc.) that will use the controller 150 to

populate or receive the vehicle data 170 specific to that vehicle 100. In some embodiments, at least a portion of the vehicle data 170 is acquired by one or more of the sensors 140. According to an example embodiment, the vehicle operation data 172 is indicative of at least one operating characteristic of the vehicle 100 and/or components thereof. The at least one operating

5 characteristic of the vehicle 100 may include an engine speed, an engine torque, a vehicle speed, a current gear selection, a gear change, a braking intensity, and an amount of aerodynamic drag.

In one embodiment, at least a portion of the vehicle operation data 172 is acquired by one or more of the sensors 140. In some embodiments, at least a portion of the vehicle operation data 172 is determined using one of a look-up table, an algorithm, or the like. According to an

10 example embodiment, the environment data 174 is indicative of at least one environmental characteristic around the vehicle 100. The at least one environmental characteristic may include road grade, road curvature, speed limit, traffic conditions, traffic light conditions, and/or weather conditions (e.g., wind speed, temperature, snow, rain, etc.), among others. In one embodiment, at least a portion of the environment data 174 is acquired by one or more of the sensors 140. In
15 some embodiments, at least a portion of the environment data 174 is received from an external system such as a route manager, a global positioning system (GPS), an electronic horizon system, a weather system, among other possible external systems (e.g., via the communications circuit 166, etc.).

[0029] As shown in FIG. 2, the driving assessment circuitry 156 includes a braking circuit 158,
20 a gear circuit 160, and an air resistance circuit 162. The braking circuit 158 may include or be operatively and communicably coupled to at least one of the sensors 140 for receiving the vehicle operation data 172 and/or the environment data 174. The braking circuit 158 may be structured to receive and interpret the vehicle operation data 172 and/or the environment data 174 acquired by the sensors 140. For example, the sensors 140 may include a brake sensor that
25 monitors the intensity of a braking event. In some embodiments, the intensity of the braking event may be based on a stopping power, a pedal input (e.g., a brake pedal input, etc.), a temperature (e.g., of a braking system from friction, etc.), and/or an amount of friction generated. The intensity of the braking event may be categorized as a normal braking event, a hard braking event, or an emergency braking event.

[0030] According to an example embodiment, the braking circuit 158 is structured to determine an amount of fuel loss in response to a braking event (and/or a subsequent acceleration). For example, the braking circuit 158 may determine an actual type of braking based on the one or more driving inputs. The actual type of braking may be selected from potential types of braking including normal braking, hard braking, and emergency braking. The braking circuit 158 may then determine an amount of fuel loss in response to the actual type of braking. In some embodiments, the determination of the amount of fuel loss in response to a braking event incorporates the impact of the subsequent acceleration needed by the vehicle 100 to reach a specific or desired speed (e.g., a speed limit, a previous vehicle speed, etc.). In some embodiments, the braking circuit 158 may determine an estimated amount of fuel loss for the potential types of braking that did not occur. The braking circuit 158 may then provide a command to the display circuit 164 to at least one of (i) provide an indication of the amount of fuel loss on the operator I/O device 130 in response to the actual type of braking, and (ii) provide an indication of the estimated amount of fuel loss on the operator I/O device 130 for the potential types of braking that did not occur. The feedback may aid in teaching a vehicle operator to perform gentler accelerations and to be predictive to traffic environments to reduce the occurrences of hard braking events.

[0031] In another example, the sensors 140 may include a camera device, lidar, radar, ultrasonic sensor, or the like to monitor the surrounding environment of the vehicle 100. According to an example embodiment, the braking circuit 158 is structured to estimate an amount of fuel loss in response to a potential braking event based on the surrounding environment and vehicle speed. For example, the braking circuit 158 may determine an appropriate intensity of braking based on the surrounding environment and the current vehicle speed. By way of example, if the vehicle 100 is approaching a red light with no nearby cars at a reasonable speed (e.g., the vehicle 100 does not need to rapidly decelerate to avoid a collision or prevent running a red light, etc.), the braking circuit 158 may determine that a normal braking event is acceptable. The braking circuit 158 may provide a command to the display circuit 164 to provide an indication of the suggested braking type (e.g., intensity, etc.) and fuel loss or savings compared to if other braking intensities were implemented. In yet another example, the braking circuit 158 is structured to determine

whether the operator made a good or bad decision regarding braking intensity based on the surrounding environment and the current vehicle speed. For example, if the operator made a good decision (e.g., braked the vehicle 100 at the appropriate intensity, etc.), the braking circuit 158 may determine fuel savings as compared to other possible braking intensities. If the operator
5 make a bad decision, the braking circuit 158 may determine the amount of fuel loss in response to the braking event and potential savings if the operator made a different braking decision (e.g., braking with less intensity, etc.). In some embodiments, the braking circuit 158 is structured to take into account various weather conditions (e.g., rain, snow, etc.) when determining a suggested braking intensity or potential fuel losses/savings.

10 **[0032]** By way of another example, the braking circuit 158 may communicate via the communications circuit 166 with objects, such as stop lights or other vehicles. For example, the braking circuit 158 via the communications circuit 166 may receive information/data regarding one or more other vehicles or stop lights. The communication between the vehicles and/or stop lights may be vehicle-to-vehicle, vehicle-to-stop light, vehicle-to-server-to-vehicle, or vehicle-to-
15 server-to-stop light. The vehicle-to-vehicle or vehicle-to-stop light communication may be performed via any suitable short to medium range wireless communications protocol (e.g., Wi-Fi, infrared, radio, RFID, near-field communications (NFC), Bluetooth, etc.). The vehicle-to-server-to-vehicle or vehicle-to-server-to-stop light communication may be performed via any suitable long range wireless communications protocol. The braking circuit 158 may determine a
20 suggested braking intensity to minimize fuel losses as a vehicle brakes in front of the vehicle 100 and/or stop lights change from green to red (e.g., based on the current vehicle speed, the distance between the vehicle 100 and other vehicles or stop lights, etc.).

[0033] According to one embodiment, the braking circuit 158 may include communication circuitry structured to facilitate the exchange of information, data, values, non-transient signals,
25 etc. between and among the sensors 140, the display circuit 164, and the communications circuit 166. For example, the communication circuitry may include a channel comprising any type of communication channel (e.g., fiber optics, wired, wireless, etc.), wherein the channel may include any additional component for signal enhancement, modulation, demodulation, filtering,

and the like. In this regard, the braking circuit 158 may include communication circuitry including, but not limited to, wired and wireless communication protocols to facilitate reception of the vehicle operation data 172 and/or the environment data 174. In another embodiment, the braking circuit 158 may include machine-readable media stored by the memory 154 and

5 executable by the processor 152, wherein the machine-readable media facilitates performance of certain operations to receive the vehicle operation data 172 and/or the environment data 174. For example, the machine-readable media may provide an instruction (e.g., command, etc.) to the sensors 140 to acquire the vehicle operation data 172 and/or the environment data 174. In this regard, the machine-readable media may include programmable logic that defines the frequency
10 of acquisition of the vehicle operation data 172 and/or the environment data 174. In yet another embodiment, the braking circuit 158 may include any combination of machine-readable content, communication circuitry, and the sensors 140.

[0034] The gear circuit 160 may include or be operatively and communicably coupled to at least one of the sensors 140 for receiving the vehicle operation data 172 (e.g., engine speed,
15 engine torque, vehicle speed, gear selection, a gear change, etc.) and/or the environment data 174. The gear circuit 160 may include or be operatively and communicably coupled to the operator I/O device 130 for receiving the vehicle data 170 (e.g., rear axle ratio, tire size, transmission ratio at each gear, fuel efficiency map, etc.). The gear circuit 160 may be structured to receive and interpret the vehicle data 170, the vehicle operation data 172, and/or the environment data 174.
20 For example, the sensors 140 may include a gear sensor that monitors the current selected gear of the transmission 112 of the vehicle 100. The current selected gear may indicate the gear ratio of the transmission 112. According to an example embodiment, the gear circuit 160 is structured to determine an amount of fuel loss in response to a gear selection or gear change by the operator of the vehicle 100 and based on the vehicle data 170, the vehicle operation data 172, and/or the
25 environment data 174. The gear circuit 160 may be further structured to determine a suggested gear selection to reduce the amount of fuel loss and determine the potential fuel savings by changing to the suggested gear selection (e.g., based on the vehicle data 170, the vehicle operation data 172, and/or the environment data 174, etc.). The gear circuit 160 may then provide a command to the display circuit 164 to at least one of (i) provide an indication of the amount of

fuel loss on the operator I/O device 130 in response to the gear selection or gear change by the operator, (ii) provide an indication of the suggested gear selection on operator I/O device 130, (iii) and provide an indication of the potential fuel savings by changing to the suggested gear selection on operator I/O device 130. The feedback may aid in teaching a vehicle operator when
5 to shift gears and/or what gear should be used in certain situations for optimal performance and fuel efficiency (e.g., based on vehicle speed, road grade, road curvature, etc.).

[0035] According to one embodiment, the gear circuit 160 may include communication circuitry structured to facilitate the exchange of information, data, values, non-transient signals, etc. between and among the operator I/O device 130, the sensors 140, the display circuit 164, and
10 the communications circuit 166. For example, the communication circuitry may include a channel comprising any type of communication channel (e.g., fiber optics, wired, wireless, etc.), wherein the channel may include any additional component for signal enhancement, modulation, demodulation, filtering, and the like. In this regard, the gear circuit 160 may include communication circuitry including, but not limited to, wired and wireless communication
15 protocol to facilitate reception of the vehicle data 170, the vehicle operation data 172, and/or the environment data 174. In another embodiment, the gear circuit 160 may include machine-readable media stored by the memory 154 and executable by the processor 152, wherein the machine-readable media facilitates performance of certain operations to receive the vehicle data 170, the vehicle operation data 172, and/or the environment data 174. For example, the
20 machine-readable media may provide an instruction (e.g., command, etc.) to the sensors 140 to acquire the vehicle operation data 172 and/or the environment data 174. In this regard, the machine-readable media may include programmable logic that defines the frequency of acquisition of the vehicle operation data 172 and/or the environment data 174. In yet another embodiment, the gear circuit 160 may include any combination of machine-readable content,
25 communication circuitry, and the sensors 140.

[0036] The air resistance circuit 162 may include or be operatively and communicably coupled to at least one of the sensors 140 for receiving the vehicle operation data 172 (e.g., vehicle speed, etc.) and/or the environment data 174 (e.g., wind speed, etc.). The air resistance circuit 162 may

include or be operatively and communicably coupled to the operator I/O device 130 for receiving the vehicle data 170 (e.g., a coefficient of aerodynamic drag, a vehicle aerodynamic drag area, etc.). The air resistance circuit 162 may be structured to receive and interpret the vehicle data 170, the vehicle operation data 172, and/or the environment data 174. According to an example
5 embodiment, the air resistance circuit 162 is structured to determine an amount of fuel loss in response to a pedal position (e.g., of a throttle, of an accelerator pedal, etc.) and/or a current gear which may be associated with a current vehicle speed. The current vehicle speed may correspond with an amount of aerodynamic resistance experienced by the vehicle 100 (e.g., determined based on the vehicle data 170, the vehicle operation data 172, and/or the environment data 174). The
10 air resistance circuit 162 may then provide a command to the display circuit 164 to provide an indication of the amount of fuel loss on the operator I/O device 130 in response to the current vehicle speed.

[0037] The air resistance circuit 162 may be further structured to determine a suggested vehicle speed to reduce the amount of aerodynamic resistance experienced by the vehicle 100 and the
15 amount of fuel loss (e.g., based on the vehicle data 170, the vehicle operation data 172, and/or the environment data 174, etc.). The air resistance circuit 162 may then provide a command to the display circuit 164 to provide an indication of the amount of fuel savings (e.g., relative to the current speed, etc.) on the operator I/O device 130 in response to changing the speed of the vehicle 100 to the suggested vehicle speed. The air resistance circuit 162 may be further
20 structured to determine a change in travel time based on the suggested vehicle speed. The air resistance circuit 162 may then provide a command to the display circuit 164 to provide an indication of the change in time (e.g., relative to the current, estimated arrival time, etc.) on the operator I/O device 130 that may result in response to changing the speed of the vehicle 100 to the suggested vehicle speed.

25 [0038] According to one embodiment, the air resistance circuit 162 may include communication circuitry structured to facilitate the exchange of information, data, values, non-transient signals, etc. between and among the operator I/O device 130, the sensors 140, the display circuit 164, and the communications circuit 166. For example, the communication

circuitry may include a channel comprising any type of communication channel (e.g., fiber optics, wired, wireless, etc.), wherein the channel may include any additional component for signal enhancement, modulation, demodulation, filtering, and the like. In this regard, the air resistance circuit 162 may include communication circuitry including, but not limited to, wired and
5 wireless communication protocols to facilitate reception of the vehicle data 170, the vehicle operation data 172, and/or the environment data 174. In another embodiment, the air resistance circuit 162 may include machine-readable media stored by the memory 154 and executable by the processor 152, wherein the machine-readable media facilitates performance of certain operations to receive the vehicle data 170, the vehicle operation data 172, and/or the environment
10 data 174. For example, the machine-readable media may provide an instruction (e.g., command, etc.) to the sensors 140 to acquire the vehicle operation data 172 and/or the environment data 174. In this regard, the machine-readable media may include programmable logic that defines the frequency of acquisition of the vehicle operation data 172 and/or the environment data 174. In yet another embodiment, the air resistance circuit 162 may include any combination of
15 machine-readable content, communication circuitry, and the sensors 140.

[0039] In some embodiments, the driving assessment circuitry 156 is structured to track the amount of fuel loss and/or savings over a period of time and/or for a given driving event. For example, the driving assessment circuitry 156 may track the amount of fuel loss and/or savings over a current drive cycle, between fueling events (e.g., for a single tank of gas, etc.), for a life of
20 the vehicle, over a trip, for an employee's career, a chosen or preset time frame, a chosen or preset distance, and/or other periods of time and/or driving events. The driving assessment circuitry 156 may provide a command to the display circuit 164 to provide an indication of the amount of fuel savings and/or losses for the period of time and/or for the given driving event, to which the display circuit 164 may provide the indication of the operator I/O device 130. In some
25 embodiments, the driving assessment circuitry 156 is configured to compare fuel losses to an optimal fuel efficiency for the given period.

[0040] In some embodiments, the driving assessment circuitry 156 includes a route management system. The route management system is a system structured to receive horizon

data regarding an attribute of a route of the vehicle 100 at a future or potential future location of the vehicle 100. The horizon data may include data regarding a current road being traveled on and/or possible upcoming roads. For example, an operator may input a preferred destination into the route management system, which in turn may gather the horizon data for the planned route.

5 In another example, the route management system may receive the horizon data as the vehicle travels along a road and a network of possible alternative roads (e.g., different routes, anticipating potential route changes, etc.). The horizon data provided by the route management system may be based on GPS-based vehicle position and a digital map database. The horizon data (e.g., route look-ahead data, electronic horizon, etc.) may include, but is not limited to, a
10 speed limit, a road grade (e.g., increase in road grade, decrease in road grade, etc.), a road curvature (e.g., a slight curve, a substantial curve, etc.), a road type (e.g., local, collector, arterial, highway, etc.), a number of lanes, and the like. For example, the horizon data may indicate a decrease in grade (e.g., a downhill slope, etc.) and/or an upcoming bend in a road. In one embodiment, the various circuits of the driving assessment circuitry 156 (e.g., the braking circuit
15 158, the gear circuit 160, the air resistance circuit 162, etc.) determine a future driving input or maneuver (e.g., braking type, vehicle speed selection, gear selection, gear change, etc.) that should be performed by the operator of the vehicle 100 to minimize fuel loss based on the horizon data.

[0041] The display circuit 164 may be communicably coupled to the operator I/O device 130
20 and is structured to receive one or more inputs from an operator, passenger, or other user in the vehicle 100 and/or provide an indication of the amount of fuel loss on the operator I/O device 130 to the operator of the vehicle 100 (e.g., due to the one or more driving inputs made by the operator or maneuvers taken, etc.). For example, the display circuit 164 may provide at least one of an indication of an amount of fuel loss based on a selected gear, a suggested gear, and an
25 amount of fuel savings by changing to the suggested gear on the operator I/O device 130. In another example, the display circuit 164 may provide at least one of an indication of an amount of fuel loss based on a current vehicle speed corresponding with an amount of aerodynamic resistance experienced by the vehicle 100, a suggested vehicle speed, an amount of fuel savings by changing to the suggested vehicle speed, and a change in travel time by changing to the

suggested vehicle speed on the operator I/O device 130. In yet another example, the display circuit 164 may provide at least one of an indication of an amount of fuel loss in response to a braking event and potential losses or savings based on different braking intensities (e.g., normal, hard, emergency, etc.). In some embodiments, the display circuit 164 is structured to display any combination of the aforementioned indications on the operator I/O device 130.

[0042] The communications circuit 162 is structured to communicate with at least one of another vehicle, a stop light (e.g., via short-range to long-range wireless communication, etc.), and an external system or server (e.g., a fleet manager, a traffic center, global positioning systems, a route management system, a telematics system 220, etc.). The communications circuit 162 may send and/or receive data (e.g., the vehicle data 170, the vehicle operation data 172, the environment data 174, etc.) regarding the vehicle 100, other vehicles, traffic conditions, road conditions, and the like. According to an example embodiment, the communications circuit 166 is structured to transmit an assessment of the one or more driving inputs made by an operator (e.g., based on the vehicle data 170, the vehicle operation data 172, and/or the environment data 174, etc.) to an external system (e.g., a fleet manager, via the telematics system 220, etc.).

[0043] Referring now to FIG. 3, a schematic diagram of a driving input monitoring system 200 with a plurality of vehicular data input/outputs coupled to an external system is shown according to one embodiment. The driving input monitoring system 200 generally includes a vehicle fleet 10 coupled to a telematics system 220, and a user input/output (I/O) device 230. The plurality of inputs/outputs devices are communicably coupled over a network 210 to an external system, shown as fleet management system 250. The fleet management system 250 is structured to facilitate remote monitoring of the driving inputs and/or behavior of an operator of a vehicle 100 (e.g., by an employee, a parent's child, a vehicle renter, etc.). The fleet management system 250 may be accessed by a web interface (e.g., a website, etc.) and/or an application interface (e.g., a smartphone, tablet, computer application, etc.). In some embodiments, the fleet management system 250 may send notifications directly to an owner of the vehicle 100 (e.g., via an email, a push notification, a text message, etc.).

[0044] The network 210 may be any type of communication protocol that facilitates the exchange of information between and among the fleet management system 250 and the one or more input/output devices (e.g., the telematics system 220, the user I/O device 230, etc.). In this regard, the communication protocol may include any type and number of wired and wireless protocols (e.g., any standard under IEEE 802, etc.). For example, a wired connection may include a serial cable, a fiber optic cable, a CAT5 cable, or any other form of wired connection. In comparison, a wireless connection may include the Internet, Wi-Fi, Bluetooth, Zigbee, cellular, radio, etc. In one embodiment, a controller area network (CAN) bus including any number of wired and wireless connections that provide the exchange of signals, information, and/or data. Further, the network 210 may include a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

[0045] As shown in FIG. 3, the vehicle fleet 10 includes a plurality of vehicles 100. In one embodiment, the vehicle fleet 10 represent the vehicles 100 owned and/or operated by a user (e.g., a customer, a fleet manager, a vehicle owner, etc.) of the driving input monitoring system 200. A user of the driving input monitoring system 200 may have any number of vehicles 100 in the vehicle fleet 10 (e.g., 1, 2, 3, 100, 1000, etc.). In another embodiment, the vehicle fleet 10 represents the vehicles 100 owned and/or operated by a plurality of users of the driving input monitoring system 200 (e.g., a compilation of all vehicles 100 in all vehicles fleets 10 of the driving input monitoring system 200, etc.). The driving input monitoring system 200 may be structured to segregate data by customer, user, driver, and/or vehicle (e.g., Customer A may only see data associated with Customer A's fleet, etc.). The driving input monitoring system 200 may be structured to also segregate data of an individual user based on access permissions (e.g., a regional manager only has access to data regarding vehicles in his/her region, etc.). The driving input monitoring system 200 may also be structured to allow administrative rights to a user (e.g., a "super-user", etc.) such that the user is able to see all the data for all vehicle fleets 10.

[0046] The vehicles 100 of the vehicle fleet 10 may include one or more on-board diagnostic (OBD) tools (e.g., the controller 150, etc.) structured to monitor the vehicles 100 (e.g., gather

operating characteristics, etc.) during operation (e.g., while driving, etc.). The OBD tools may gather vehicle data 170, vehicle operation data 172, and/or environment data 174 to be transmitted to the fleet management system 250 over the network 210 via the telematics system 220. The telematics system 220 is structured to facilitate the transfer of an assessment of the driving inputs made by an operator of a respective vehicle 100 to the fleet management system 250 over the network 210.

[0047] The user I/O device 230 enables a user of the driving input monitoring system 200 to communicate with the driving input monitoring system 200, and more specifically the fleet management system 250. In some embodiments, the user I/O device 230 is communicably coupled to the fleet management system 250 via the network 210 (e.g., remotely, wirelessly, etc.). In some embodiments, the user I/O device 230 is directly communicably coupled to the fleet management system 250 (e.g., with a wired connection, etc.). The user I/O device 230 may include an input device and a display device. The input device may include, but is not limited to, a keyboard, a mouse, a touchscreen device, one or more buttons and switches, voice command receivers, etc. The display device is structured to provide a graphical user interface (GUI) to the user of the driving input monitoring system 200. The display device may include, but is not limited to, a touchscreen display, a projector and projection screen, a monitor or television (e.g., a LCD, LED, CRT, plasma, DLP, etc.), augmented reality glasses, a portable device (e.g., a smartphone, tablet, laptop, etc.), and/or any other known display devices that can provide a GUI. According to an example embodiment, input device enables a user to provide an input to the driving input monitoring system 200. The input may include a display request including various configurable options for providing the GUI in a desired graphical format. The desired graphical format may present the vehicle data 170, the vehicle operation data 172, the environment data 174, and/or other features (e.g., an assessment of the driving inputs made by one or more operators of one or more vehicles 100, etc.), which are described more fully herein.

[0048] The fleet management system 250 is shown to include a processing circuit 251 including a processor 252 and a memory 254. The processor 252 may be implemented as a general-purpose processor, an application specific integrated circuit (ASIC), one or more field

programmable gate arrays (FPGAs), a digital signal processor (DSP), a group of processing components, or other suitable electronic processing components. The one or more memory devices 154 (e.g., NVRAM, RAM, ROM, Flash Memory, hard disk storage, etc.) may store data and/or computer code for facilitating the various processes described herein. Thus, the one or
5 more memory devices 254 may be communicably connected to the processor 252 and provide computer code or instructions to the processor 252 for executing the processes described in regard to the fleet management system 250 herein. Moreover, the one or more memory devices 254 may be or include tangible, non-transient volatile memory or non-volatile memory. Accordingly, the one or more memory devices 254 may include database components, object
10 code components, script components, or any other type of information structure for supporting the various activities and information structures described herein.

[0049] The memory 254 is shown to include various circuits for completing the activities described herein. More particularly, the memory 254 includes an aggregation circuit 256, a configurable circuit 258, and a data visualization circuit 260. The circuits 256–260 are
15 structured to provide various data and/or information (e.g., vehicle data 170, vehicle operation data 172, environment data 174, driving assessments, etc.) to a user via a GUI that is formatted based on user selected options. While various circuits with particular functionality are shown in FIG. 3, it should be understood that the fleet management system 250 and memory 254 may include any number of circuits for completing the functions described herein. For example, the
20 activities of multiple circuits may be combined as a single circuit, as additional circuits with additional functionality may be included, etc. Further, it should be understood that the fleet management system 250 may further control other activity beyond the scope of the present disclosure.

[0050] Certain operations of the fleet management system 250 described herein include
25 operations to interpret and/or to determine one or more parameters. Interpreting or determining, as utilized herein, includes receiving values by any method known in the art, including at least receiving values from a datalink or network communication, receiving an electronic signal (e.g. a voltage, frequency, current, or PWM signal) indicative of the value, receiving a computer

generated parameter indicative of the value, reading the value from a memory location on a non-transient computer readable storage medium, receiving the value as a run-time parameter by any means known in the art, and/or by receiving a value by which the interpreted parameter can be calculated, and/or by referencing a default value that is interpreted to be the parameter value.

5 [0051] The aggregation circuit 256 may be communicably coupled to the one or more vehicles 100 (e.g., via the telematics system 220, etc.) over the network 210. According to an example embodiment, the aggregation circuit 256 is structured to receive the vehicle data 170, the vehicle operation data 172, the environment data 174, and/or an assessment of the driving inputs made by operators of the vehicles 100 (e.g., determined by the controllers 150 based on the vehicle
10 data 170, the vehicle operation data 172, and/or the environment data 174, etc.). In some embodiments, the aggregation circuit 256 provides the vehicle data 170, the vehicle operation data 172, the environment data 174, and/or the assessments of the driving inputs made by operators of the vehicles 100 to the data visualization circuit 260 for display via the display device of the user I/O device 230. In other embodiments, the aggregation circuit 256 provides at
15 least a portion of the vehicle data 170, the vehicle operation data 172, and/or the environment data 174 to an analysis circuit for further processing (e.g., the controller 150 does not provide an assessment of the driving inputs to the fleet management system 250, the fleet management system assesses the driving inputs made by each operator of the vehicles 100, etc.).

[0052] According to one embodiment, the aggregation circuit 256 may include communication
20 circuitry structured to facilitate the exchange of information, data, values, non-transient signals, etc. between and among the aggregation circuit 256, the analysis circuit, the data visualization circuit 260, and/or the telematics system 220 (e.g., the one or more vehicles 100, etc.). For example, the communication circuitry may include a channel comprising any type of communication channel (e.g., fiber optics, wired, wireless, etc.), wherein the channel may
25 include any additional component for signal enhancement, modulation, demodulation, filtering, and the like.

[0053] In this regard, the aggregation circuit 256 may include communication circuitry including, but not limited to, wired and wireless communication protocols to facilitate reception

of the vehicle data 170, the vehicle operation data 172, the environment data 174, and/or the assessments of the driving inputs made by the operators of the vehicles 100. In another embodiment, the aggregation circuit 256 may include machine-readable media stored by the memory 254 and executable by the processor 252, wherein the machine-readable media

5 facilitates performance of certain operations to receive the vehicle data 170, the vehicle operation data 172, the environment data 174, and/or the assessments. For example, the machine-readable media may provide an instruction (e.g., command, etc.) to the network 210 operatively coupled to the vehicles 100 to monitor and acquire the vehicle data 170, the vehicle operation data 172, the environment data 174, and/or the assessments. In this regard, the machine-readable media
10 may include programmable logic that defines the frequency of acquisition of the vehicle data 170, the vehicle operation data 172, the environment data 174, and/or the assessments. In yet another embodiment, the aggregation circuit 256 may include any combination of machine-readable content and communication circuitry.

[0054] The configurable circuit 258 is structured to receive user inputs from the user I/O
15 device 230 indicative of a display request. The user input may include configurable options for providing the GUI in a desired graphical format including the at least one of the vehicle data 170, the vehicle operation data 172, the environment data 174, and the assessment of the driving inputs made by an operator for the one or more vehicles 100 of the vehicle fleet 10. In some
embodiments, the configurable circuit 258 may include or be communicably coupled to the user
20 I/O device 230 for controlling which of the configurable options the user may select via the user I/O device 230 (e.g., based on the selected graphical format, etc.). The configurable circuit 258 may provide the display request to the data visualization circuit 260. According to one
embodiment, the configurable circuit 258 may include communication circuitry structured to
facilitate the exchange of information, data, values, non-transient signals, etc. between and
25 among the configurable circuit 258, the data visualization circuit 260, and/or the user I/O device 230. For example, the communication circuitry may include a channel comprising any type of communication channel (e.g., fiber optics, wired, wireless, etc.), wherein the channel may include any additional component for signal enhancement, modulation, demodulation, filtering, and the like.

[0055] The configurable circuit 258 may include communication circuitry including, but not limited to, wired and wireless communication protocol to facilitate reception of the user input. In another embodiment, the configurable circuit 258 may include machine-readable media stored by the memory 254 and executable by the processor 252, wherein the machine-readable media facilitates performance of certain operations to receive the user input. For example, the machine-readable media may provide an instruction (e.g., command, etc.) to the network 210 operatively coupled to the user I/O device 230 (or directly to the user I/O device 230) to acquire the user input. The machine-readable media may include programmable logic that defines the frequency of acquisition of the user input. In yet another embodiment, the configurable circuit 258 may include any combination of machine-readable content and communication circuitry.

[0056] According to an example embodiment, the display request includes a selection of the desired graphical format. The configurable options may include the various graphical formats and various filtering options to filter data displayed in the respective graphical formats. For example, the filtering options may include, but are not limited to, an account of the user (i.e., the respective vehicle fleet 10), an identification number of a respective vehicle 100 (e.g., a model number, a serial number, a VIN number, etc.), and/or an identifier of an operator (e.g., an operator's name, etc.), among other possibilities.

[0057] The data visualization circuit 260 is structured to receive at least one of the vehicle data 170, the vehicle operation data 172, the environment data 174, the assessment of driving inputs made by one or more operators of the vehicles 100 (e.g., determined by the controllers 150, determined by the analysis circuit of the fleet management system 250, etc.), and/or the display request and filtering options for the desired graphical format of the data. In some embodiments, the data visualization circuit 260 may include or be communicably coupled to the user I/O device 230 for controlling the user I/O device 230. As such, the data visualization circuit 260 is further structured to provide a graphical user interface including the vehicle data 170, the vehicle operation data 172, the environment data 174, and/or assessments of the driving inputs made by the operators of the vehicles 100 to the user I/O device 230 in a visual/graphical format based on the display request and filtering options. The data visualization circuit 260 may facilitate the

display of the data, the assessments, or a combination thereof. The data visualization circuit 260 may further control which of the filtering options are displayed on the user I/O device 230 for the user to select via user I/O device 230 (e.g., based on a selected graphical format, etc.). According to one embodiment, the data visualization circuit 260 may include communication circuitry
5 structured to facilitate the exchange of information, data, values, non-transient signals, etc. between and among the data visualization circuit 260, the aggregation circuit 256, the analysis circuit, the configurable circuit 258, and/or the user I/O device 230. For example, the communication circuitry may include a channel comprising any type of communication channel (e.g., fiber optics, wired, wireless, etc.), wherein the channel may include any additional
10 component for signal enhancement, modulation, demodulation, filtering, and the like.

[0058] The data visualization circuit 260 may include communication circuitry including, but not limited to, wired and wireless communication protocols to facilitate reception of the vehicle data 170, the vehicle operation data 172, the environment data 174, the assessments of the driving inputs, and/or the user input. In another embodiment, the data visualization circuit 260
15 may include machine-readable media stored by the memory 254 and executable by the processor 252, wherein the machine-readable media facilitates performance of certain operations to receive and/or display the vehicle data 170, the vehicle operation data 172, the environment data 174, the assessments, and/or the desired GUI (e.g., based on the user input, etc.). For example, the machine-readable media may provide an instruction (e.g., command, etc.) to the network 210
20 operatively coupled to the user I/O device 230 to display the vehicle data 170, the vehicle operation data 172, the environment data 174, and/or the assessments, with a desired GUI. The machine-readable media may include programmable logic that defines the frequency of acquisition and display of the vehicle data 170, the vehicle operation data 172, the environment data 174, the assessments. In yet another embodiment, the data visualization circuit 260 may
25 include any combination of machine-readable content and communication circuitry.

[0059] The display of the vehicle data 170, the vehicle operation data 172, the environment data 174, and/or the assessments of the one or more driving inputs made by the operators of each respective vehicle 100 facilitates remote monitoring of each operator (e.g., for fuel efficiency,

etc.). A user may interpret the data and/or assessments to manage drivers and identify potential problems. In one example, the user of the driving input monitoring system 200 may use the assessments and/or data to identify improper, careless, and/or bad driving inputs made by operators driving vehicles 100 within the vehicle fleet 10 (e.g., behavior that causes fuel inefficiencies, etc.). The user may then take action to change the driving behavior of select operators. Such actions may include reprimanding the operator(s) (e.g., penalties, fines, leave of absence, etc.) and/or further training the operator(s). In another example, the user of the driving input monitoring system 200 may use the assessments and/or data to identify trends based on vehicle, route, and/or operator. For example, certain vehicles may be less fuel efficient along certain routes and/or an operator may drive certain vehicles better (e.g., more fuel efficient, etc.) than other vehicles.

[0060] Referring now to FIG. 4, a method 400 for assessing and correcting driving behavior is shown according to an example embodiment. Method 400 corresponds with the controller 150 interpreting vehicle data 170, vehicle operation data 172, and/or environment data 174. In one example embodiment, method 400 may be implemented with the controller 150 of FIGS. 1-2 and/or the fleet management system 250 of FIG. 3. Accordingly, method 400 may be described in regard to FIGS. 1-3.

[0061] At process 402, the controller 150 receives vehicle data (e.g., the vehicle data 170, etc.). As described above, the vehicle data may be inputted via an operator I/O device (e.g., the operator I/O device 130, etc.), predefined within the memory 154 of the controller 150, and/or received from one or more sensors (e.g., the sensors 140, etc.). The vehicle data may include data indicative of characteristics of the vehicle and/or components of the vehicle such as an axle ratio, a tire size, a transmission ratio at each gear, a fuel efficiency map, a coefficient of aerodynamic drag, a vehicle aerodynamic drag area, and a vehicle weight. At process 404, the controller 150 acquires vehicle operation data (e.g., the vehicle operation data 172, etc.). The vehicle operation data may be acquired/determined via sensors, look-up tables, algorithms, or any other suitable method. As described above, the vehicle operation data may include data indicative of, but not limited to, an engine speed, an engine torque, a vehicle speed, a current

gear selection, a gear change, a braking intensity, and an amount of aerodynamic drag experienced by the vehicle. At process 406, the controller 150 receives environment data indicative of characteristics around the vehicle (e.g., road grade, road curvature, speed limit, traffic conditions, traffic light conditions, weather conditions, etc.). In some embodiments, process 406 is omitted.

[0062] At process 408, the controller 150 determines an amount of fuel loss due to one or more driving inputs (e.g., gear selection, a gear change, selected speed, braking habits, acceleration habits, etc.) of an operator of the vehicle based on the vehicle data, the vehicle operation data, and/or the environment data. At process 410, the controller 150 provides an indication of the amount of fuel loss to the operator of the vehicle (e.g., via the operator I/O device 130, etc.) in response to the one or more driving inputs. In some embodiments, the controller 150 is structured to determine a suggested gear selection to reduce the amount of fuel loss and provide an indication of the suggested gear selection to the operator (e.g., via the operator I/O device 130, etc.). In some embodiments, the controller 150 is structured to determine a suggested vehicle speed to reduce an amount of aerodynamic resistance experienced by the vehicle and to reduce the amount of fuel loss, as well as provide an indication of the suggested vehicle speed to the operator (e.g., via the operator I/O device 130, etc.). In some embodiments, the controller 150 is further structured to provide an indication of a change in travel time based on the suggested vehicle speed.

[0063] In some embodiments, the controller 150 is structured to determine an amount of fuel loss from a braking event. The braking event may be one of a normal braking event, a hard braking event, and an emergency braking event. For example, the controller 150 may determine an actual type of braking (e.g., normal braking, etc.) based on the one or more driving inputs (e.g., pressing a brake pedal, pulling a brake lever, etc.). The actual type of braking may be selected from potential types of braking including normal braking, hard braking, and emergency braking. The controller 150 may determine an amount of fuel loss from the actual type of braking. The controller 150 may then determine an estimated amount of fuel loss for the potential types of braking that did not occur (e.g., hard braking, emergency braking, etc.). The

controller 150 may then provide an indication of the amount of fuel loss in response to the actual type of braking and/or provide an indication of the estimated amount of fuel loss or savings for the potential types of braking that did not occur (e.g., via the operator I/O device 130, etc.). In an alternative embodiment, the controller 150 is structured to provide an indication of a potential amount of fuel loss if an operator of a vehicle were to perform one of a normal braking event, a hard braking event, and/or an emergency braking event (e.g., prior to braking occurring, etc.).

[0064] At process 412, the controller 150 transmits an assessment of the one or more driving inputs made by the operator to an external system (e.g., a remote server, a remote device, the fleet management system 250, via the telematics system 220 over the network 210, etc.). In other embodiments, the controller 150 additionally or alternatively transmits the vehicle data, the vehicle operation data, and/or the environment data to the external system. In such cases, the external system may assess and interpret the vehicle data, the vehicle operation data, and/or the environment data individually or in combination with the controller 150. At process 414, the external system aggregates the assessments (and/or data) of the one or more driving inputs for one or more operators of vehicles associated with the external system (e.g., vehicles 100 and/or operators associated with the same vehicle fleet 10, etc.). At process 416, the external system displays the assessments of at least one of the one or more operators based on a received display request (e.g., via the user I/O device 230, etc.) to facilitate remote monitoring of the one or more operators (e.g., for fuel efficiency purposes, etc.).

[0065] It should be understood that no claim element herein is to be construed under the provisions of 35 U.S.C. § 112(f), unless the element is expressly recited using the phrase “means for.” The schematic flow chart diagrams and method schematic diagrams described above are generally set forth as logical flow chart diagrams. As such, the depicted order and labeled steps are indicative of representative embodiments. Other steps, orderings and methods may be conceived that are equivalent in function, logic, or effect to one or more steps, or portions thereof, of the methods illustrated in the schematic diagrams. Further, reference throughout this specification to “one embodiment”, “an embodiment”, “an example embodiment”, or similar language means that a particular feature, structure, or characteristic described in connection with

the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases “in one embodiment”, “in an embodiment”, “in an example embodiment”, and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

5 [0066] Additionally, the format and symbols employed are provided to explain the logical steps of the schematic diagrams and are understood not to limit the scope of the methods illustrated by the diagrams. Although various arrow types and line types may be employed in the schematic diagrams, they are understood not to limit the scope of the corresponding methods. Indeed, some arrows or other connectors may be used to indicate only the logical flow of a
10 method. For instance, an arrow may indicate a waiting or monitoring period of unspecified duration between enumerated steps of a depicted method. Additionally, the order in which a particular method occurs may or may not strictly adhere to the order of the corresponding steps shown. It will also be noted that each block of the block diagrams and/or flowchart diagrams, and combinations of blocks in the block diagrams and/or flowchart diagrams, can be
15 implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and program code.

[0067] Many of the functional units described in this specification have been labeled as circuits, in order to more particularly emphasize their implementation independence. For example, a circuit may be implemented as a hardware circuit comprising custom very-large-scale integration
20 (VLSI) circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A circuit may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

[0068] As mentioned above, circuits may also be implemented in machine-readable medium
25 for execution by various types of processors, such as processor 152 of FIG. 2 or processor 252 of FIG. 3. An identified circuit of executable code may, for instance, comprise one or more physical or logical blocks of computer instructions, which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified circuit need not be

physically located together, but may comprise disparate instructions stored in different locations which, when joined logically together, comprise the circuit and achieve the stated purpose for the circuit. Indeed, a circuit of computer readable program code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among
5 different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within circuits, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network.

10 **[0069]** The computer readable medium (also referred to herein as machine-readable media or machine-readable content) may be a tangible computer readable storage medium storing the computer readable program code. The computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, holographic, micromechanical, or semiconductor system, apparatus, or device, or any suitable combination of
15 the foregoing. As alluded to above, examples of the computer readable storage medium may include but are not limited to a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a portable compact disc read-only memory (CD-ROM), a digital versatile disc (DVD), an optical storage device, a magnetic storage device, a holographic storage medium, a
20 micromechanical storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, and/or store computer readable program code for use by and/or in connection with an instruction execution system, apparatus, or device.

[0070] The computer readable medium may also be a computer readable signal medium. A
25 computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electrical, electro-magnetic, magnetic, optical, or any suitable combination thereof. A computer readable

signal medium may be any computer readable medium that is not a computer readable storage medium and that can communicate, propagate, or transport computer readable program code for use by or in connection with an instruction execution system, apparatus, or device. As also alluded to above, computer readable program code embodied on a computer readable signal medium may be transmitted using any appropriate medium, including but not limited to wireless, 5 wireline, optical fiber cable, Radio Frequency (RF), or the like, or any suitable combination of the foregoing. In one embodiment, the computer readable medium may comprise a combination of one or more computer readable storage mediums and one or more computer readable signal mediums. For example, computer readable program code may be both propagated as an electro-magnetic signal through a fiber optic cable for execution by a processor and stored on RAM 10 storage device for execution by the processor.

[0071] Computer readable program code for carrying out operations for aspects of the present invention may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and 15 conventional procedural programming languages, such as the "C" programming language or similar programming languages. The computer readable program code may execute entirely on the user's computer (such as via the controller 150 or fleet manager system 250 of FIGS. 1-3), partly on the user's computer, as a stand-alone computer-readable package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the 20 latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

[0072] The program code may also be stored in a computer readable medium that can direct a 25 computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions which implement the function/act specified in the schematic flowchart diagrams and/or schematic block diagrams block or blocks.

[0073] Accordingly, the present disclosure may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the disclosure is, therefore, indicated by the appended claims rather than by the foregoing description. All
5 changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

WHAT IS CLAIMED IS:

1. An apparatus, comprising:
a driving assessment circuit structured to:
receive vehicle data indicative of at least one attribute of a vehicle;
receive vehicle operation data indicative of at least one operating characteristic of the vehicle; and
determine an amount of fuel loss due to one or more driving inputs made by an operator of the vehicle based on the vehicle data and the vehicle operation data; and
a display circuit structured to provide an indication of the amount of fuel loss on a display device to the operator of the vehicle in response to the one or more driving inputs.
2. The apparatus of claim 1, wherein the one or more driving inputs include at least one of (i) a braking event, (ii) a gear selection, (iii) a gear change, and (iv) a pedal position associated with a selected vehicle speed corresponding with an amount of aerodynamic resistance experienced by the vehicle.
3. The apparatus of claim 2, wherein the driving assessment circuit is further structured to determine a suggested gear selection to reduce the amount of fuel loss.
4. The apparatus of claim 3, wherein the display circuit is structured to provide an indication of the suggested gear selection on the display device.
5. The apparatus of claim 2, wherein the driving assessment circuit is further structured to determine at least one of (i) a suggested vehicle speed to reduce the amount of aerodynamic resistance experienced by the vehicle and the amount of fuel loss, and (ii) a change in travel time based on the suggested vehicle speed.
6. The apparatus of claim 5, wherein the display circuit is further structured to provide an indication of at least one of the suggested vehicle speed and the change in travel time on the display device.

7. The apparatus of claim 2, wherein the driving assessment circuit is further structured to determine an actual type of braking based on the one or more driving inputs, wherein the actual type of braking is selected from potential types of braking including normal braking, hard braking, and emergency braking, and wherein the display circuit is structured to provide an indication of the amount of fuel loss on the display device in response to the actual type of braking.

8. The apparatus of claim 7, wherein the driving assessment circuit is further structured to determine an estimated amount of fuel loss for the potential types of braking that did not occur, and wherein the display circuit is structured to provide an indication of the estimated amount of fuel loss on the display device for the potential types of braking that did not occur.

9. The apparatus of claim 1, further comprising a communications circuit structured to transmit an assessment of the one or more driving inputs to an external system.

10. The apparatus of claim 1, wherein the at least one attribute of the vehicle includes at least one of an axle ratio, a tire size, a transmission ratio at each gear, a fuel efficiency map, a coefficient of aerodynamic drag, a vehicle aerodynamic drag area, and a vehicle weight.

11. The apparatus of claim 1, wherein the at least one operating characteristic of the vehicle includes at least one of an engine speed, an engine torque, a vehicle speed, a current gear selection, a gear change, a braking intensity, and an amount of aerodynamic drag.

12. The apparatus of claim 1, wherein the driving assessment circuitry is further structured to track the amount of fuel loss over at least one of a period of time and for a driving event, and wherein the display circuit is further structured to provide an indication of the amount of fuel loss for at least one of the period of time and the driving event.

13. A method, comprising:
receiving, by a controller, vehicle data indicative of at least one attribute of a vehicle;
receiving, by the controller, vehicle operation data indicative of at least one operating characteristic of the vehicle;
determining, by the controller, an amount of fuel loss due to one or more driving inputs made by an operator of the vehicle based on the vehicle data and the vehicle operation data; and
providing, by the controller on a display device to the operator of the vehicle, an indication of the amount of fuel loss in response to the one or more driving inputs.
14. The method of claim 13, wherein the one or more driving inputs include at least one of (i) a braking event, (ii) a gear selection, (iii) a gear change, and (iv) a pedal position associated with a selected vehicle speed corresponding with an amount of aerodynamic resistance experienced by the vehicle.
15. The method of claim 14, further comprising:
determining, by the controller, a suggested gear selection to reduce the amount of fuel loss; and
providing, by the controller on the display device, an indication of the suggested gear selection.
16. The method of claim 14, further comprising:
determining, by the controller, a suggested vehicle speed to reduce the amount of aerodynamic resistance experienced by the vehicle and the amount of fuel loss; and
providing, by the controller on the display device, an indication of the suggested vehicle speed.

17. The method of claim 16, further comprising:
determining, by the controller, a change in travel time based on the suggested vehicle speed; and
providing, by the controller on the display device, an indication of the change in travel time.
18. The method of claim 14, further comprising:
determining, by the controller, an actual type of braking based on the one or more driving inputs, wherein the actual type of braking is selected from potential types of braking including normal braking, hard braking, and emergency braking; and
providing, by the controller on the display device, an indication of the amount of fuel loss in response to the actual type of braking.
19. The method of claim 13, further comprising transmitting, by the controller to an external system, an assessment of the one or more driving inputs.
20. The method of claim 13, further comprising:
tracking, by the controller, the amount of fuel loss over at least one of a period of time and for a driving event; and
providing, by the controller on the display device, an indication of the amount of fuel loss for at least one of the period of time and the driving event.

21. A system, comprising:

- one or more communication systems, each communication system located onboard a respective vehicle and structured to transmit an assessment of one or more driving inputs made by a driver of the respective vehicle;
- an external monitoring system communicably coupled to the one or more communication systems, the external system structured to:
 - receive the assessment of the one or more driving inputs made by the driver from each of the one or more communication systems; and
 - receive a display request for providing a graphical user interface to a display device, wherein the display request includes configurable options for providing the graphical user interface in a desired graphical format for depicting the assessment of the one or more driving inputs made by the driver of each respective vehicle to facilitate monitoring each driver for fuel efficiency.

22. The driving input monitoring system of claim 21, wherein the one or more driving inputs include at least one of (i) a braking event, (ii) a gear selection, (iii) a gear change, and (iv) a pedal position associated with a selected vehicle speed corresponding with an amount of aerodynamic resistance experienced by the vehicle, each impacting the fuel efficiency of the vehicle.

23. A vehicle, comprising:
a display device; and
a controller communicably and operatively coupled to the display device, the controller structured to:
receive vehicle data indicative of at least one attribute of the vehicle;
receive vehicle operation data indicative of at least one operating characteristic of the vehicle;
determine an amount of fuel loss due to one or more driving inputs made by an operator of the vehicle based on the vehicle data and the vehicle operation data; and
provide an indication of the amount of fuel loss on the display device in response to the one or more driving inputs.

24. The vehicle of claim 23, further comprising at least one sensor structured to acquire the vehicle operation data, wherein the at least one sensor is communicably coupled to the controller, and wherein the at least one operating characteristic of the vehicle includes at least one of an engine speed, an engine torque, a vehicle speed, a current gear selection, a braking intensity, and an amount of aerodynamic drag.

25. The vehicle of claim 23, further comprising an input device structured to receive at least a portion of the vehicle data, wherein the input device is communicably coupled to the controller, and wherein the at least one attribute of the vehicle includes at least one of an axle ratio, a tire size, a transmission ratio at each gear, a fuel efficiency map, a coefficient of aerodynamic drag, a vehicle aerodynamic drag area, and a vehicle weight.

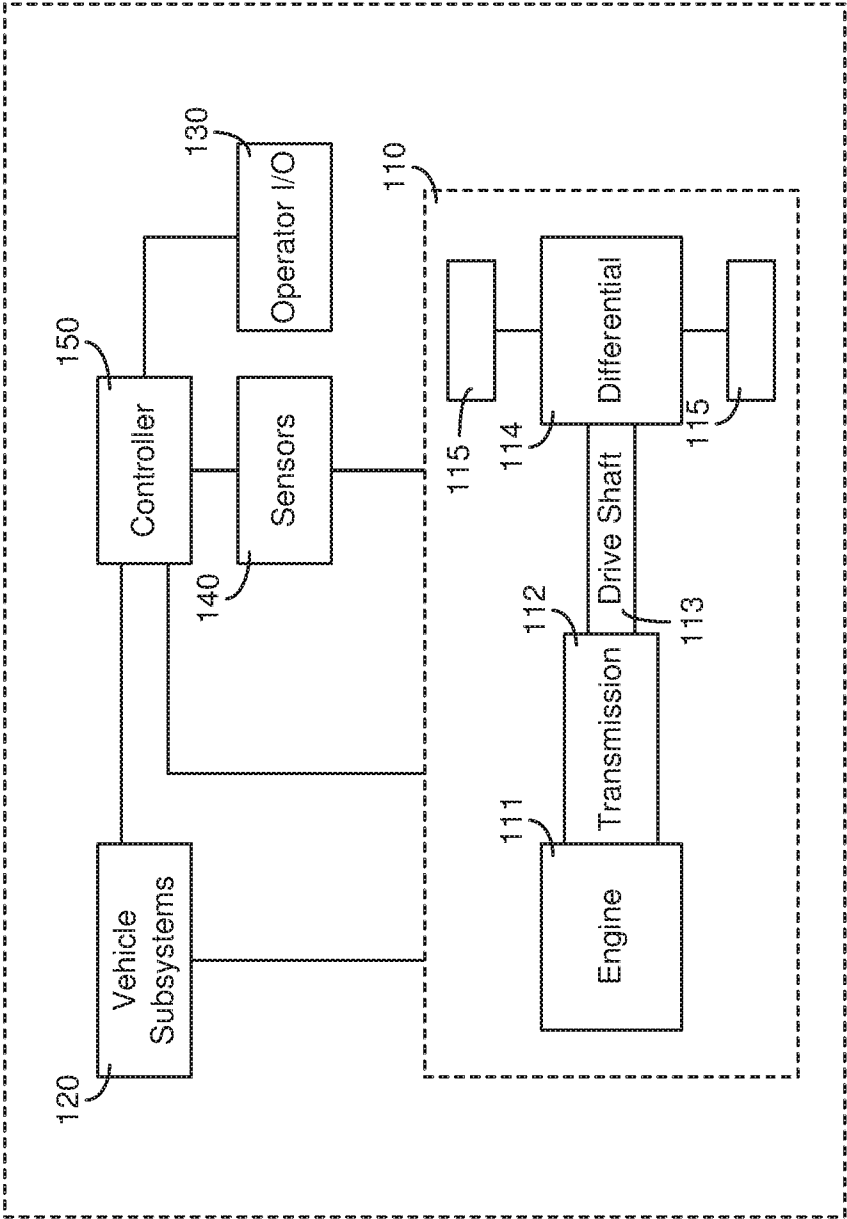


FIG. 1

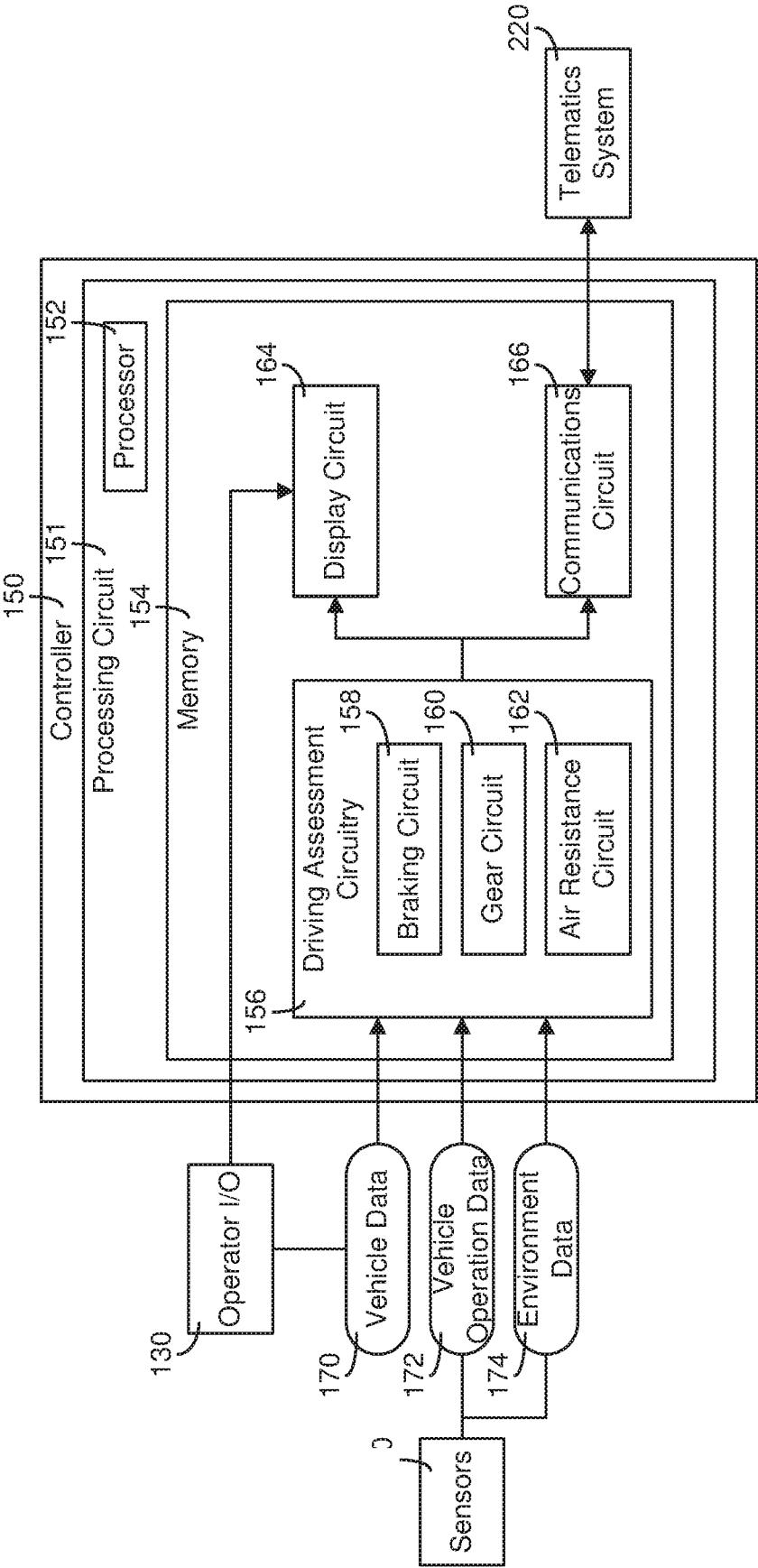


FIG. 2

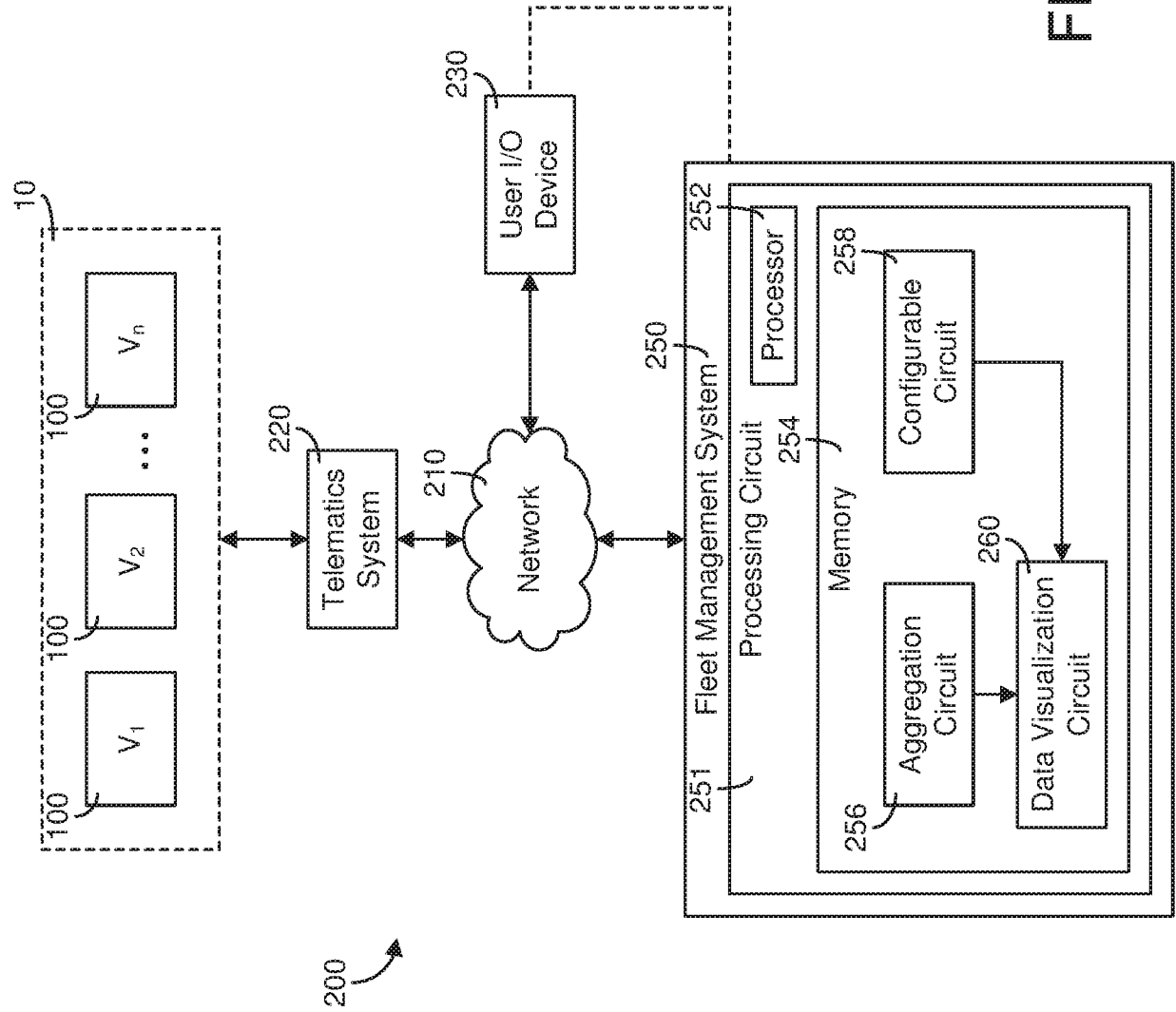


FIG. 3

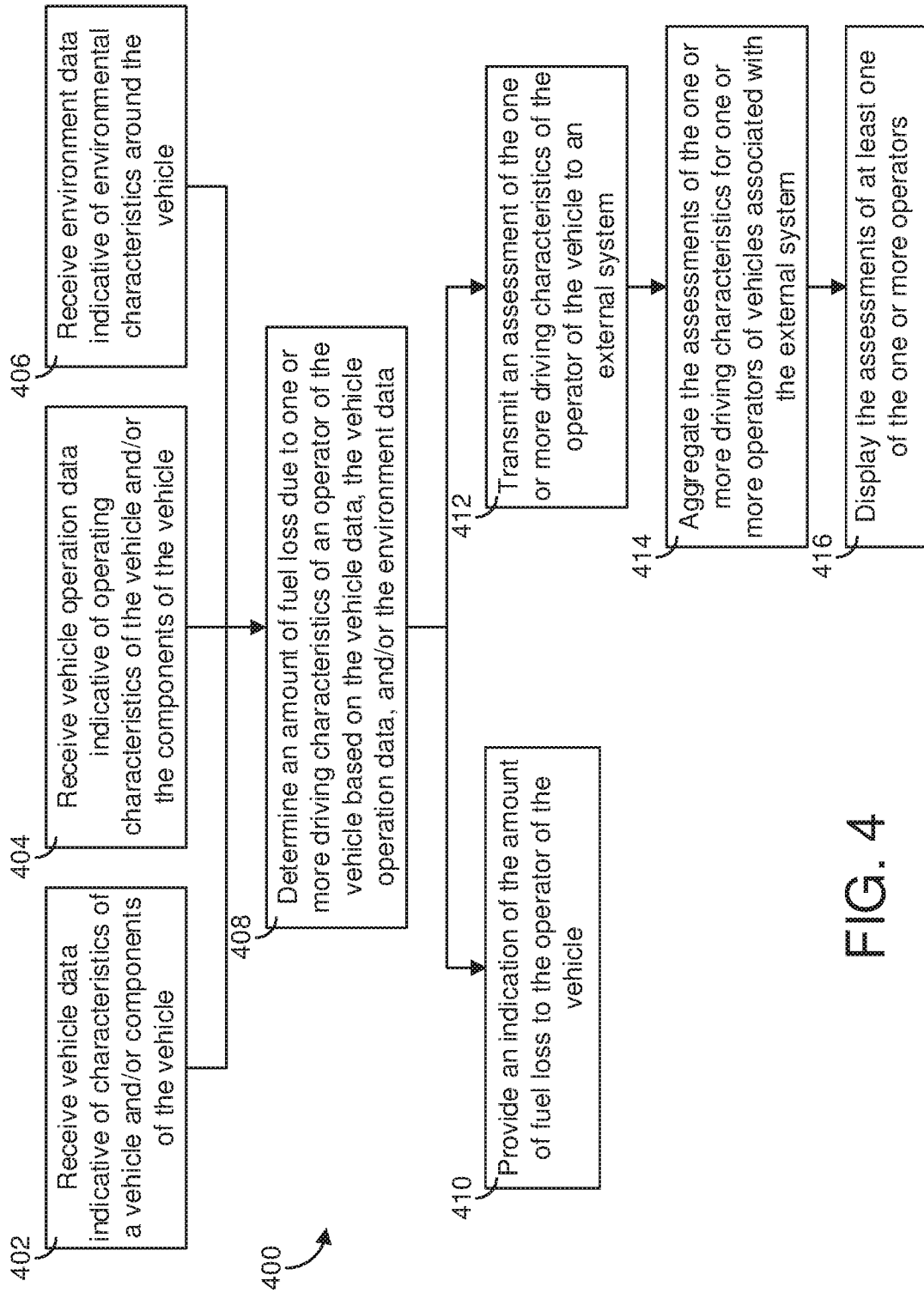


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2016/073790

A. CLASSIFICATION OF SUBJECT MATTER

B60W 50/14(2012.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60W; B60Q; F02D; H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI,EPODOC,CNPAT,CNKI:vehicle, car, fuel, loss, consum+, oil, display, attribute, character+, brak+, speed+, gear+, suggest+, indicat+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011205044 A1 (HONDA MOTOR CO., LTD.) 25 August 2011 (2011-08-25) description, paragraphs [0246]-[0250]	21,22
Y	US 2011205044 A1 (HONDA MOTOR CO., LTD.) 25 August 2011 (2011-08-25) descriptio, paragraphs [0085]-[0133], [0143]-[0172], [0197]-[0250], claim 1	1-20,23-25
Y	US 7233855 B1 (GM GLOBAL TECHONOLGY OPERATIONS, INC.) 19 June 2007 (2007-06-19) description, column 2 line 65-clomun 4 line 30, claim 1 and figures 1-2	1-20,23-25
A	CN 104085398 A (ZHEJIANG GEELY HOLODING GROUP CO., LTD. ET AL.) 08 October 2014 (2014-10-08) the whole document	1-25
A	US 2012139922 A1 (KIA MOTORS CORPORATION ET AL.) 07 June 2012 (2012-06-07) the whole document	1-25
A	US 2013041621 A1 (SMITH, DAVID B. ET AL.) 14 February 2013 (2013-02-14) the whole document	1-25



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

13 October 2016

Date of mailing of the international search report

07 November 2016

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2016/073790

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2016/073790

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				KR	20120062535	A	14 June 2012
				CN	102486387	A	06 June 2012
US	2013041621	A1	14 February 2013	None			
JP	2014177187	A	25 September 2014	None			