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Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

[Continued on next page]

(54) Title: TELEMATIC VEHICLE LEARNING SYSTEM AND METHOD

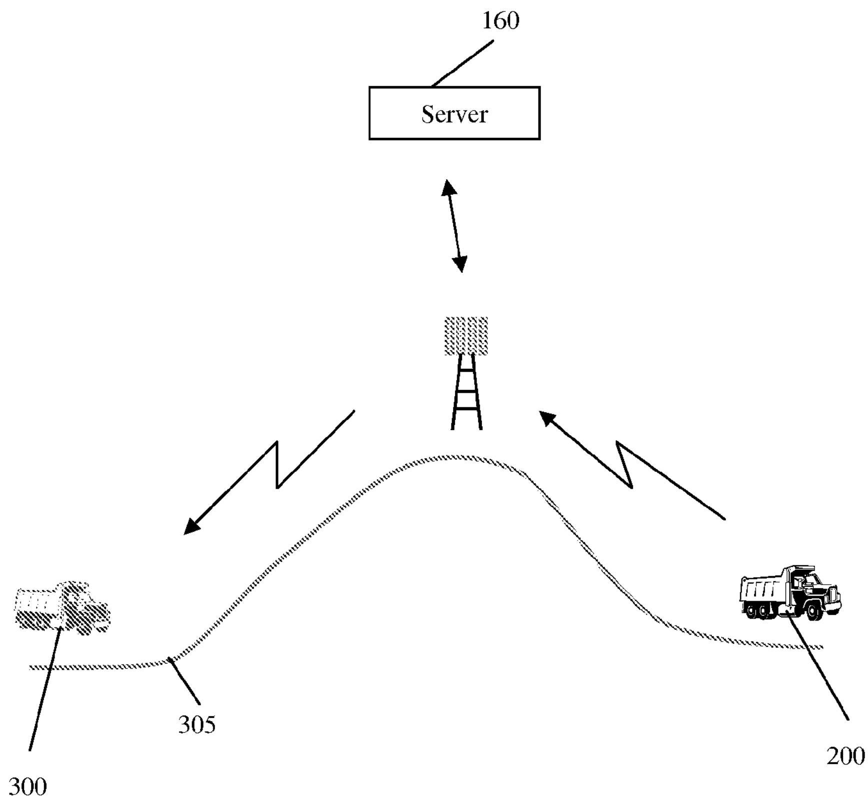

FIG. 3

(57) Abstract: A method of determining operational settings for a vehicle includes receiving data at inputs of the vehicle, storing the received data, computing an operational setting value of the vehicle by evaluating the received data, storing the computed operational setting value; and communicating the computed operational setting value.

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TELEMATIC VEHICLE LEARNING SYSTEM AND METHOD

BACKGROUND

[0001] Exemplary embodiments are directed to vehicles such as trucks and more particularly, to systems and methods for facilitating efficient operation of the trucks by determining and providing recommended operational settings to the trucks.

[0002] Trucks are typically programmed at the time of manufacture with standard operational settings. These settings may be programmed into an electronic control unit (ECU) in the form of data maps and relate to engine performance for example. The settings are generic and do not always take into account particular routes or conditions that the trucks may encounter during their operation.

[0003] Trucks encounter a wide range of driving conditions including varying road and environmental conditions. Road conditions may include, for example, inclines/declines, curves and quality of the road such as potholes, etc. Environmental conditions may include, for example, traffic congestion, road construction and weather related phenomena such as precipitation and temperature.

[0004] A particular combination of operational settings may be appropriate for a given set of driving and environmental conditions. A particular transmission gear (i.e. engine speed), engine braking strategy or coolant thermostat setting or a combination thereof may be appropriate while driving on an incline (such as on a hill ascent for example). Another engine speed, engine breaking strategy and coolant thermostat setting or a combination thereof may be more appropriate for driving on a decline (such as on a hill descent for example). Precipitation or extreme temperature may require additional adjustments. Fueling for fuel injection can also be adjusted according to load, driving conditions and environmental conditions.

[0005] Recommended settings for operating the vehicle for each of a plurality of driving conditions reduce, *inter alia*, fuel consumption and brake wear for example. The life of the vehicle is prolonged and safety of the vehicle can also be enhanced while the need for repairs is reduced. As a result, the cost of operating the trucks is reduced. Such benefits are especially noticeable to owners or operators of a fleet of trucks since the benefits accumulate as each truck in the fleet operates in a more efficient manner with reduced costs, increased safety, etc. The benefits are further enhanced for fleets of trucks being driven repeatedly over the same routes.

[0006] It is desirable, therefore, to utilize mechanisms for facilitating such efficient utilization of vehicle such as trucks.

SUMMARY

[0007] In accordance with an exemplary embodiment, a method of determining operational settings for a vehicle is disclosed. The method comprises: receiving data at inputs of the vehicle; storing the received data; computing an operational setting value of the vehicle by evaluating the received data; storing the computed operational setting value; and communicating the computed operational setting value.

[0008] In accordance with another exemplary embodiment, a telematic vehicle learning system is disclosed. The telematic learning system comprises: a plurality of inputs for receiving data from a plurality of sensors and actuators corresponding to the vehicle; a processor for computing recommended operational settings for the vehicle based on the received data; a memory for storing the received data and the computed recommended operational settings; and a transmitter for transmitting contents of the memory.

[0009] In accordance with a further exemplary embodiment, a truck is disclosed. The truck comprises: a plurality of inputs for receiving data from a plurality of sensors and

actuators; a processor for computing recommended operational settings for the truck based on the received data; a memory for storing the received data and the computed recommended operational settings; a transmitter for transmitting contents of the memory; and a receiver for receiving recommended operational settings for the truck.

[0010] In accordance with yet another exemplary embodiment, a telematic feedback learning method for a truck is disclosed. The method comprises: receiving and storing recommended operational settings by a truck; setting the operational settings of the truck according to the recommended settings; monitoring performance of the truck; storing actual performance values of the truck; measuring the effectiveness of the recommended settings; and adjusting the recommended settings based on the measured effectiveness.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The several features, objects, and advantages of exemplary embodiments will be understood by reading this description in conjunction with the drawings. The same reference numbers in different drawings identify the same or similar elements. In the drawings:

[0012] FIG. 1 illustrates a system in accordance with exemplary embodiments; and

[0013] FIGs. 2A and 2B illustrate telematic performance learning in accordance with exemplary embodiments;

[0014] FIG. 3 illustrates telematic performance sharing in accordance with exemplary embodiments;

[0015] FIG. 4 illustrates a method in accordance with exemplary embodiments; and

[0016] FIG. 5 illustrates telematic predictive feedback learning method in accordance with exemplary embodiments.

DETAILED DESCRIPTION

[0017] The following description of the implementations consistent with the present invention refers to the accompanying drawings. The same reference numbers in different drawings identify the same or similar elements. The following detailed description does not limit the invention. Instead, the scope of the invention is defined by the appended claims.

[0018] According to exemplary embodiments, a telematic vehicle learning system is disclosed. The exemplary learning system monitors performance of a vehicle traveling (or being driven) over a particular route to determine or compute recommended operational settings for the vehicle. The monitoring of the vehicle can also be for performance or for diagnostics (e.g. OBD or preventative maintenance).

[0019] In some embodiments, this information (i.e. the recommended operational setting) may be shared with other similar vehicles. Both the monitoring vehicle and vehicles receiving the settings from the monitoring vehicle may be operating over the same route in similar conditions. Both vehicles may, but need not, be identical. As the similarity between the vehicles increases, the operational settings become more optimal.

[0020] An exemplary telematic vehicle learning system can be included in a vehicle such as in a truck. As illustrated in **FIG. 1**, telematic vehicle learning system 100 includes a plurality of inputs 110 for receiving data from sensors, actuators and other data sources. The sensors and actuators may monitor various performance parameters related to the truck.

[0021] The data received by the inputs may correspond, but is not limited, to: ABS, transmission gear selection, engine speed, intake manifold pressure, exhaust temperature, coolant temperature, thermostat settings, fueling (or fuel injection) and fuel consumption. Data may be obtained from one or more of the brake, accelerator, transmission range sensor, transmission gear split sensor, transmission gear position sensor, transmission gearing, rear axle ratio, etc. Data such as the weight of the truck may be known or calculated/computed.

[0022] Other types of received data may include environmental data such as temperature, humidity, light, precipitation, etc. Additional data can include geographic co-ordinates corresponding to the location of the vehicle (e.g. GPS). Some of the received data may be from a vehicle electronic control unit (ECU). The ECU is known and is not described.

[0023] Another source of data received by the inputs can include an incline or decline detector. Trucks are equipped with an electronic stability protection (ESP) system for maintaining stability of the cab portion. This system can detect a gradient of the truck to determine if it is driving on an ascent or on a descent. A GPS system can also be used to make such determination. The GPS may compare altitude of the vehicle at periodic intervals (such as every five seconds for example) to determine whether the vehicle is traveling uphill or downhill.

[0024] System 100 includes a processor 120 and memory 130. Processor 120 may process the data received by inputs 110 to determine recommended operational settings for the truck for example. Memory 130 can store the data received by the inputs and the (computed) recommended operational settings. A timestamp may also be associated with the data received by the inputs and can be stored in memory 130.

[0025] System 100 also includes a communication means 140 for communicating the data received by the inputs 110 and the computed recommended operational settings (both of which may be stored in memory 130 as described above). Communication means may include a transmitter and a receiver. The transmitter can transmit both the data received by the inputs 110 and the computed recommended operational settings. The receiver can receive the recommended operational settings. Communication means 140 may be a modem for facilitating communication via a cellular communication network for example. The communication may be between a truck and a remote server 160 for example. Other types of wireless communication links can also be used to for facilitating the communication.

[0026] System 100 further includes a data bus 150 for facilitating communication of data between 110, 120, 130 and 140. System 100 can also include a display 170 for displaying the data received by the inputs and the recommended operational settings for example.

[0027] In an exemplary embodiment, as illustrated in **FIG. 2A**, truck 200 on route 205 may operate according to the pre-programmed settings (from manufacture) as it approaches the crest of hill 210. In some embodiments, an operator of truck 200 may evaluate the approaching road conditions by detecting (manually observing), for example, curves, inclines, declines, road quality and the weather. In this example, the operator detects (or sees) a hill 210 ahead. Based on experience and/or knowledge, the operator may set the operational settings of the truck that seem appropriate for the approaching road. The settings can include engine speed, fueling for fuel injection, coolant temperature and alternator strategies for battery charging for example.

[0028] Referring to **FIG. 2B**, as the truck is driven over route 205 (i.e. climbs hill 210), telematic system 100 (as described above with respect to **FIG. 1**) associated with truck 200 monitors performance of truck 200 based on data obtained by the plurality of inputs 110. Monitoring can include recording the data received by the inputs along with an associated timestamp. The data received by the inputs can be used to determine recommended operational settings for a particular route.

[0029] In some embodiments, the data received by the inputs may be compared with the operational settings being used by the truck to determine whether the currently being used settings are appropriate for this particular route.

[0030] In an exemplary scenario, a truck may be operating below a particular engine speed (based on pre-set values) while being driven on an ascending slope (i.e. a hill). The temperature of the engine may exceed a recommended value (recommended by the manufacturer for example). This could indicate that the engine speed and coolant settings currently being used are not appropriate (or efficient) for this particular ascent or route. The engine speed could have been set higher in this case for more efficient operation.

[0031] The data received by the inputs 110 can be stored in memory 130 for future use. In some embodiments, the data can be used to determine the recommended operational settings which can also be stored. The recommended operational settings determined by system 100 of truck 200 can also be communicated to server 160 for storage.

[0032] In some embodiments, the data received by inputs 110 of truck 200 can also be provided to server 160 for determining the recommended operational settings - that is, the settings may be determined by processors associated with server 160.

[0033] In accordance with other exemplary embodiments, the recommended operational settings determined for a particular route may be provided to other vehicles driving along the same route. As illustrated in **FIG. 3**, truck 200 can provide data received by the inputs or recommended operational settings to a server 160. Another truck 300 following route 305 of truck 200 can receive the recommended operational settings from server 160. The operational settings of truck 300 can be set according to the recommended operational settings received by truck 300 from server 160. An operator of truck 300 can also evaluate the road conditions and rely on experience in determining whether to apply the received operational settings or adjust the settings.

[0034] A system in accordance with exemplary embodiments may be a learning system that evolves over time. Initially, truck 200 may be different from truck 300 with respect to manufacturer, model, year, etc. As the system evolves, trucks 200 and 300 can be of the same brand, model, similar weight, engine type, age, etc. As the amount of data received increases with number of trucks monitoring and reporting their performance, the system provides that are more relevant to a receiving truck.

[0035] Truck 300 is, therefore, "learning" from truck 200. Truck 300 can, in addition to receiving the recommended operational setting values, monitor its performance based on received inputs. This process further contributes to the learning system.

[0036] A method 400 in accordance with exemplary embodiments may be described with reference to **FIG. 4**. A truck (such as truck 200 or 300) being driven on a particular route (such as route 205 or 305 for example) may record or receive data from various sources at the inputs at 410. The inputs may correspond to those described above with reference to **FIG. 1**. The data received from the inputs may be stored at 420. The data may be used to determine or compute recommended operational settings of the truck at 430.

[0037] The computation may include comparing the data received from a sensor associated with a particular function of the truck to a corresponding manufacturer specified (maximum/minimum) value or parameter for that function. The functions may include engine speed or coolant settings for example. The computed recommended operational settings may be stored at 440. The computed recommended operational settings may also be communicated (to a server for example) at 450.

[0038] Recommended operational setting computed in one vehicle may be communicated directly to other vehicles in some embodiments. Engine brake and coolant thermostat settings are known hence not described herein. Engine brake setting is more applicable or relevant during a descent. Coolant setting is more applicable or relevant during an ascent.

[0039] The remote location may be a server. Communication between the truck and the server may be over a wireless communication link such as a cellular communication network for example. The server may also be located at a network location or in the cloud and may be accessible over a public network such as the internet or over a private network.

[0040] In accordance with another exemplary embodiment, a telematic feedback learning method is disclosed. Feedback learning is a process by which performance (of a truck in this example) based on the recommended operational setting can be evaluated and utilized to evaluate the effectiveness of the recommended setting. The actual performance resulting from the recommended settings may, for example, be compared with manufacturer set performance parameters, thresholds, tolerances, etc.

[0041] In the context of a truck receiving recommended operational settings as described above, some examples of performance goals that can be evaluated may include, but are not limited to: (i) whether the truck reaches the crest of a hill without downshifting; (ii) whether the truck reaches the crest of a hill without exceeding the (set) coolant temperature limit; (iii) whether the truck reaches the bottom of a hill without using the wheel brakes; and (iv) whether the truck achieves a fuel economy target before the next highway exit.

[0042] A telematic feedback learning method in accordance with exemplary embodiments may be described with reference to **FIG. 5**. Recommended operational settings (such as those described above) can be received and stored by a truck at 510. The recommended settings may be applied to the truck at 520.

[0043] As the truck is driven over a route, performance of the truck may be monitored at 530. The actual performance value(s) may be stored at 540. The actual performance value(s) may be compared with the manufacturer recommended parameters (for example) to evaluate the effectiveness of the recommended settings at 550. The operational settings may be adjusted or modified (for future use) based on effectiveness of the recommended settings at 560.

[0044] The actual performance values (based on recommended settings) that are stored provide the feedback. The analysis (comparison) and adjustment (modification) form the feedback learning aspect of exemplary embodiments as described.

[0045] It will be appreciated that the methods or processes described above may be carried out repetitively as necessary to determine recommended operational settings and to evaluate the effectiveness of these settings. To facilitate understanding, many aspects of the invention are described in terms of sequences of actions that can be performed by, for example, elements of a programmable computer system. It will be recognized that the various actions could be performed by mechanical elements and/or specialized circuits (e.g., discrete logic gates interconnected to perform a specialized function or application-specific integrated circuits), by program instructions executed by one or more processors, or by a combination of both.

[0046] Moreover, the invention can additionally be considered to be embodied entirely within any form of non transitory computer-readable storage medium having stored therein an appropriate set of instructions for use by or in connection with an instruction-execution system, apparatus, or device, such as a computer-based system, processor-containing system, or other system that can fetch instructions from a medium and execute the instructions.

[0047] As used here, a "computer-readable medium" can be any means that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction-execution system, apparatus, or device. The computer-readable medium can be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or propagation medium. More specific examples (a non-exhaustive list) of the computer-readable medium include an electrical connection having one or more wires, a portable computer diskette, a random-access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM, EEPROM, or Flash memory), an optical fiber, and a portable compact disc read-only memory (CD-ROM).

[0048] Thus, the invention may be embodied in many different forms, not all of which are described above, and all such forms are contemplated to be within the scope of the invention. It is emphasized that the terms "comprises" and "comprising", when used in this application, specify the presence of stated features, integers, steps, or components and do not preclude the presence or addition of one or more other features, integers, steps, components, or groups thereof.

[0049] The particular embodiments described above are merely illustrative and should not be considered restrictive in any way. The scope of the invention is determined by the following claims, and all variations and equivalents that fall within the range of the claims are intended to be embraced therein.

What is claimed is:

1. A method of determining operational settings for a vehicle, the method comprising the steps of:

receiving data at inputs of the vehicle;

storing the received data;

computing an operational setting value of the vehicle by evaluating the received data;

storing the computed operational setting value; and

communicating the computed operational setting value.

2. The method of claim 1, further comprising:

receiving data from an engine control unit of the vehicle.

3. The method of claim 1, further comprising:

receiving data from a plurality of sensors and actuators.

4. The method of claim 3, further comprising:

receiving data from sensors and actuators associated with engine speed, transmission shift pattern, fuel consumption, intake manifold pressure, intake manifold temperature, brake actuation and coolant temperature.

5. The method of claim 1, wherein the storing of the received data further comprises:

associating a timestamp for the received data.

6. The method of claim 1, wherein the computation of the operational setting value comprises:

comparing the received data for a function of a truck to a manufacturer specified parameter for the function.

7. The method of claim 1, wherein the communicating of the computed operational setting value comprises:

transmitting the computed operational setting value to a server over a wireless communication link.

8. The method of claim 1, wherein the communicating of the computer operational setting value comprises:

transmitting the computed operational setting value to another vehicle over a wireless communication link.

9. A telematic vehicle learning system comprising:

a plurality of inputs for receiving data from a plurality of sensors and actuators corresponding to the vehicle;

a processor for computing recommended operational settings for the vehicle based on the received data;

a memory for storing the received data and the computed recommended operational settings; and

a transmitter for transmitting contents of the memory.

10. The telematic vehicle learning system of claim 9, further comprising:

a receiver for receiving recommended operational settings.

11. The telematic vehicle learning system of claim 9, wherein the processor is further for:

assigning a timestamp to the received data.

12. The telematic vehicle learning system of claim 9, wherein the transmitter is further for:

transmitting the computed recommended operational settings to a server.

13. The telematic vehicle learning system of claim 9, wherein the transmitter is further for:

transmitting the computed recommended operational settings to another truck.

14. A truck comprising:

a plurality of inputs for receiving data from a plurality of sensors and actuators;

a processor for computing recommended operational settings for the truck based on the received data;

a memory for storing the received data and the computed recommended operational settings;

a transmitter for transmitting contents of the memory; and

a receiver for receiving recommended operational settings for the truck.

15. The truck of claim 14, wherein the plurality of sensors and actuators are associated with coolant temperature, engine speed, gear shifts, fuel consumption, intake manifold pressure and intake manifold temperature.

16. The truck of claim 14, wherein the plurality of sensors and actuators are associated with ambient conditions including temperature, humidity and precipitation.

17. The truck of claim 14, wherein the plurality of sensors are associated with detecting road gradient and geographic location of the truck.

18. The truck of claim 14, further comprising:

a display for displaying the monitored readings.

19. A telematic feedback learning method for a truck comprises:

receiving and storing recommended operational settings by a truck;

setting the operational settings of the truck according to the recommended settings;

monitoring performance of the truck;

storing actual performance values of the truck;

measuring the effectiveness of the recommended settings; and

adjusting the recommended settings based on the measured effectiveness.

20. The telematic feedback learning method of claim 19, wherein the analyzing comprises comparing the actual performance values with the recommended settings.

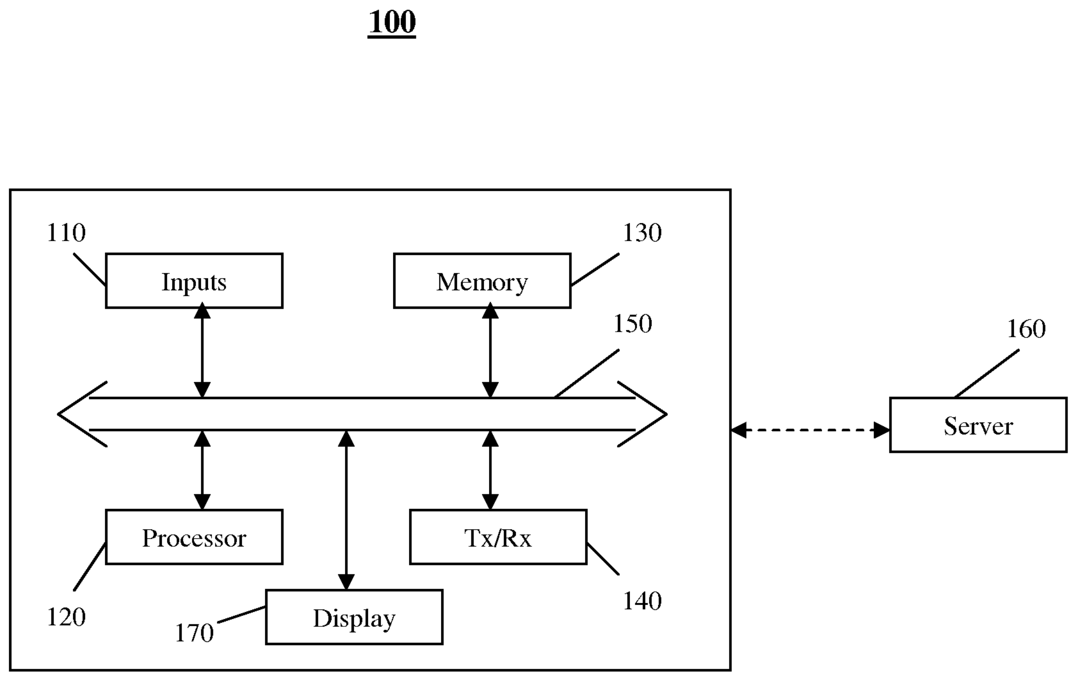
100
110
Inputs
130
Memory
150
160
Server
Processor
Tx/Rx
120
170
Display
140

FIG. 1

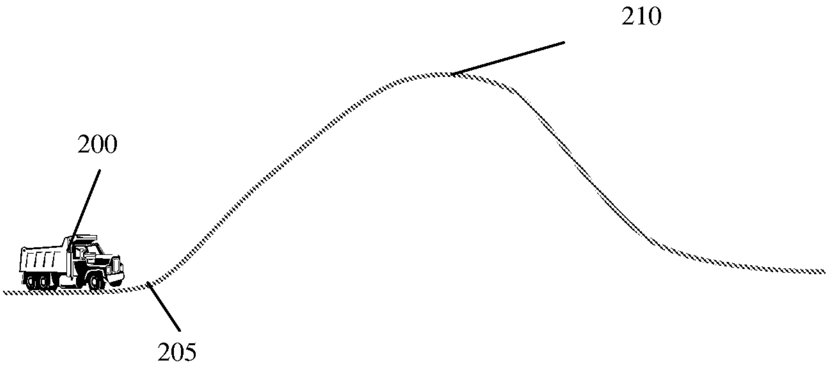

FIG. 2A

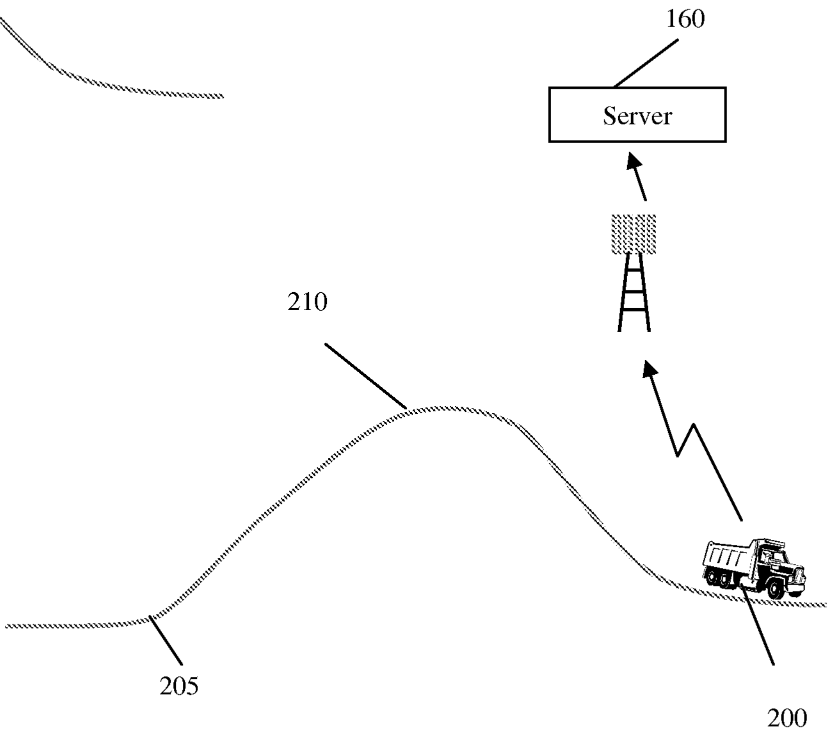

FIG. 2B

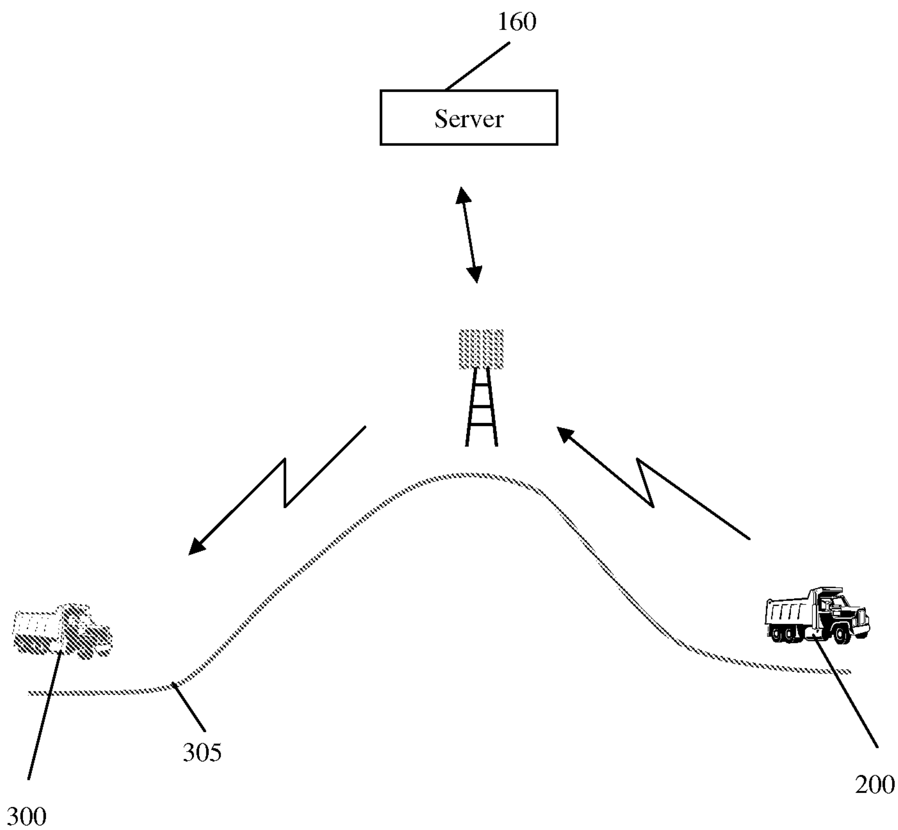

FIG. 3

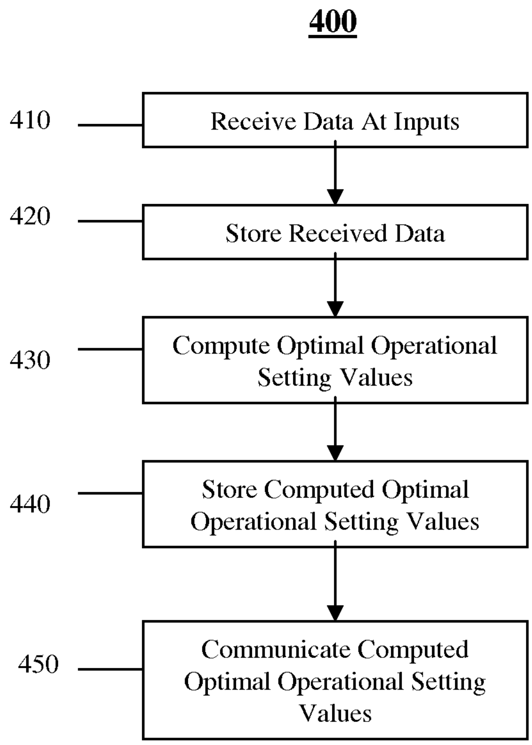
400
410
Receive Data At Inputs
420
Store Received Data
430
Compute Optimal Operational Setting Values
440
Store Computed Optimal Operational Setting Values
450
Communicate Computed Optimal Operational Setting Values

FIG. 4

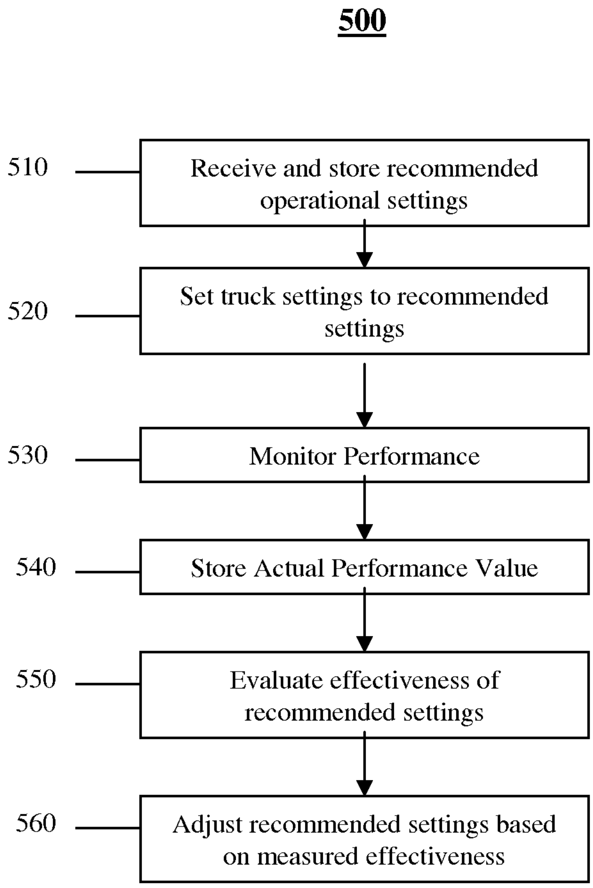
500
510
Receive and store recommended operational settings
520
Set truck settings to recommended settings
530
Monitor Performance
540
Store Actual Performance Value
550
Evaluate effectiveness of recommended settings
560
Adjust recommended settings based on measured effectiveness

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 12/71361

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G01M 17/00 (2013.01)
USPC - 701/31.5
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)
USPC-701/31.5; IPC (8)-G01M17/00.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC-701/29.1, 29.3, 32.7, 32.8, 33.1, 33.4, 33.7, 34.2, 34.3; 123
IPC (8)-G06F 7/00; G06F 19/00.

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Patbase, Google Patents/Scholar: terms-vehicle automobile truck car van bus taxi compute determine operational driving setting mode recommend optimal efficient learning feedback telemetry ambient environment data information temperature pressure sensor actuator

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y	US 2012/0203424 A1 (Filev et al.) 09 August 2012 (09.08.2012), para [0015]-[0043]; Figs. 1-3.	1,2, 3, 4, 6 ---- 5, 7, 8
X ---- Y	US 8,155,867 B2 (Krause) 10 April 2012 (10.04.2012), col. 3, ln 15 to col. 13, ln 67; Figs. 1-4.	9, 10, 12-20 ---- 7-8, 11
Y	US 8,155,868 B1 (Xing et al.) 10 April 2012 (10.04.2012), col. 7, ln 4-50.	5, 11
A	US 6,026,784 A (Weisman et al.) 22 February 2000 (22.02.2000), entire document.	1-20

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"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	Date of mailing of the international search report
24 March 2013 (24.03.2013)	19 APR 2013

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774