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DETERMINING FUEL QUALITY

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ABSTRACT

The quality of gasoline and other fuel used in vehicles may vary with some gas stations selling higher quality fuels than other gas stations. This disclosure describes techniques for determining the quality of fuel sold by gas stations using existing vehicle sensors to monitor the fuel composition and combustion. The sensors may include harmonic and fuel sensors, such as water and ethanol sensors. The vehicle may determine the fuel quality by at least applying a machine learning algorithm to the collected combustion and fuel compensation information and/or may send the collected combustion and fuel compensation information to a remote computing system for analysis. After the quality of the fuel is determined, the fuel quality information along with the location at which the fuel was purchased may, after receiving explicit user permission, be automatically shared with other vehicles, a fuel quality monitoring system, or other systems. Other users may use the shared fuel quality information to select where to purchase fuel. In addition, navigation, assistant, or other similar systems may determine which gas stations to recommend based at least in part on the fuel quality information.

DESCRIPTION

Currently, it is very challenging for consumers to determine if a gas station is selling fuel that is same as the labelled octane and/or is contaminated with water, the incorrect blend of ethanol, or other impurities. Much of this challenge is due to the inability of consumers to easily test the fuel. For example, a typical consumer is not able to easily conduct a test to determine the true octane rating of the gasoline in the tank of their automobile. In addition, consumers are often

not able to recognize that the fuel in their automobile is problematic until noticeable issues occur, such as loud engine knocking or damage to the fuel injectors. Contaminated fuel can additionally cause problems and damage to combustion engines that is not immediately apparent to the driver of that vehicle.

In accordance with the techniques described herein, a computing system may use aggregated fuel and combustion information to determine the quality of fuel sold by gas stations. That is, using existing vehicle sensors to monitor the fuel composition and fuel combustion, vehicles may provide fuel station, fuel composition, and fuel combustion information to the computing system. The computing system may aggregate the information from a number of different vehicles and apply a machine learning model to the aggregated information. Based on the results of the machine learning algorithm, the computing system may determine if fuel stations are selling mislabeled, contaminated, or otherwise substandard fuel. In various instances, the computing system may provide information about the quality of fuel at the various fuel stations to applications, such as mapping applications, search applications, and fuel locator applications. When a driver uses such applications, the application may provide information about the quality of fuel at the various fuel stations.

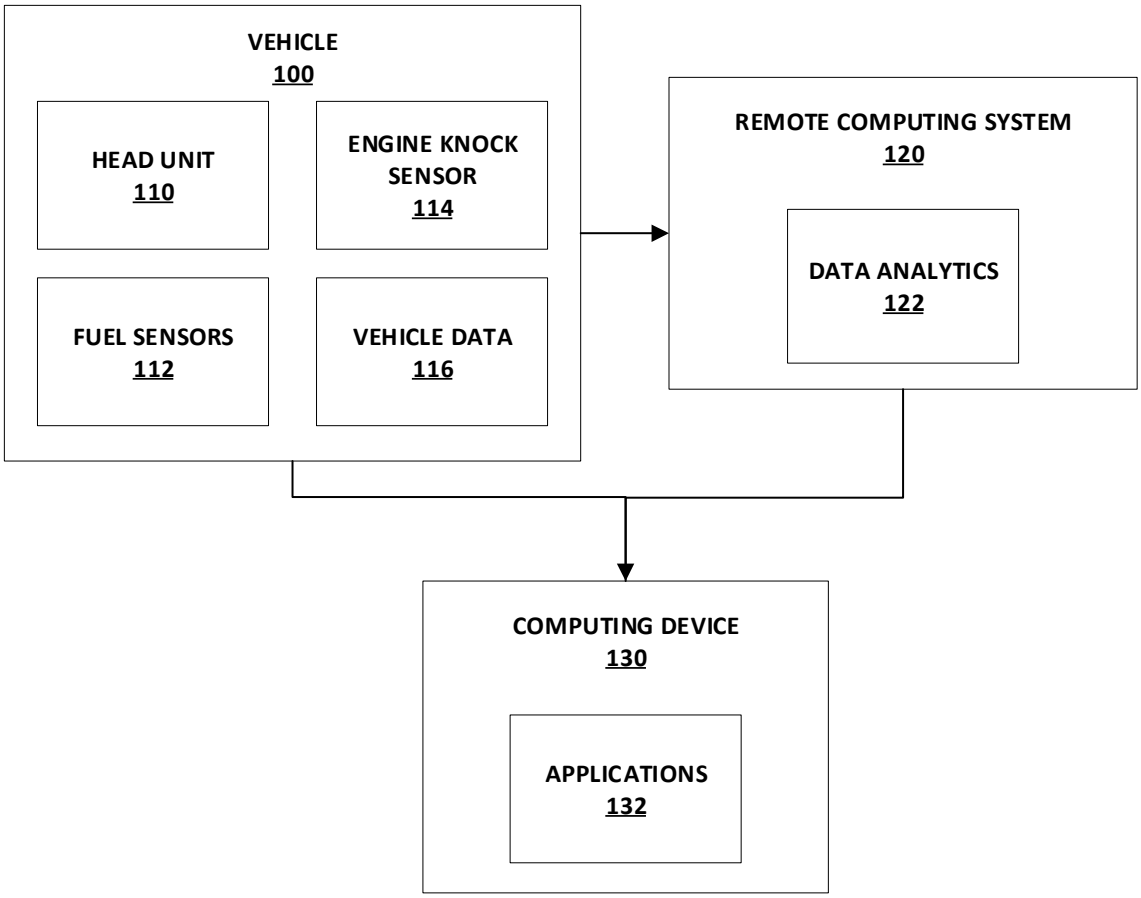

FIG. 1

FIG. 1 illustrates a fuel quality system that includes vehicle 100, remote computing system 120, and computing device 130. As shown in FIG.1, vehicle 100 includes head unit 110, fuel sensor(s) 112, engine knock sensor 114, and vehicle data 116. Head unit 110 may execute a head unit operation system or other software that maintains vehicle data 116 and collects and analyzes information generated or collected by other components of vehicle 100, such as fuels sensors 112 and engine knock sensor 114. Vehicle data 116 may include local environmental conditions (e.g., outside temperature), fuel purchase information (e.g., the type of fuel purchased, time and date of the fuel purchase, location of fuel purchase), vehicle specifications (e.g., what fuel octane is required by the vehicle manufacturer, whether the vehicle is diesel- or gasoline-

powered, etc.), and driving dynamics data (e.g., how hard the vehicle was driven, the length of the drive, etc.).

When a consumer refuels vehicle 100, head unit 110 may, if the consumer provides explicit permission, collect and store information about the refueling. For example, head unit 110 may store the location, time, and other information regarding the refueling of the vehicle. Based on the location, head unit 110 may determine an identity of the fueling station at which the vehicle was refueled. In some instances, head unit 110 may also receive information regarding the fuel purchase from the refueling station (e.g., the fuel pump), from the consumer, from computing device 130, etc. The fuel purchase information may include the type of fuel that was purchased, the octane rating of gasoline that was purchased, a name of the fuel station, etc.

As the consumer drives vehicle 100 after completing the refueling, various sensors of vehicle 100 may analyze fuel content and combustion events, such as fuel sensors 112 and knock sensors 114. Fuel sensors 112 may analyze the content of the fuel being provided to the engine for combustion. Fuel sensors 112 may include fuel composition sensors, such as a water sensor or an ethanol sensor. The fuel composition sensors may detect the presence of water in the fuel system of vehicle 100, determine the octane rating of the fuel, determine the ethanol content of the fuel, etc. Head unit 110 may collect information about the content of the fuel from the fuel composition sensors which may be used in determining the quality of the fuel.

In addition to analyzing the content of the fuel, vehicle 100 may use engine knock sensor 114 to monitor combustion of the fuel. Engine knock sensor 114 may include one or more specialized microphones and digital signal processing circuitry that detects knocking and other forms of irregular combustion occurring in the combustion chamber of the engine. If there is an irregular combustion even, engine knock sensor 114 may generate data regarding the event and

provide the data to head unit 110. Engine knock sensor 114 may provide the data regarding knocking and other events in the combustion chamber to the ECU of the vehicle 100. The ECU may then adjust engine timing, fuel flow, and other parameters to eliminate the knocking. Head unit 110 may receive data regarding combustion events from the ECU of the automobile through the OBDII port of the vehicle, through direct integration with the ECU, and/or directly from engine knock sensor 114.

Head unit 110 may also collect information about driving and environmental conditions represented by vehicle data 116. In many scenarios, a combustion system may be impacted by factors beyond fuel octane or fuel contamination. For example, the combustion system in a vehicle may not burn fuel as effectively during a startup in extreme cold as during operations in warmer temperatures, and experience engine symptoms similar to knocking. The symptoms of knocking may be the result of the cold weather and completely unrelated to the quality of the fuel. In an additional example, a combustion system in a vehicle operating in a high-altitude location (e.g., a mountain pass) may also experience issues with fuel combustion due to the lower density of the air. Various other sensors in the vehicle may monitor the environmental conditions of the vehicle and provide the environmental data regarding environmental conditions (e.g., outside temperature, altitude) and aggregate the data into vehicle data 116. Vehicle 100 may provide vehicle data to the ECU and/or directly to head unit 110 with the explicit permission of the user.

Head unit 110 and/or computing system 120 may analyze the data collected from vehicle 100 and determine the quality of the fuel. Head unit 110 may determine the quality of the fuel each time that a user drives the vehicle. In various instances, head unit 110 may determine if there is an issue with the quality of the fuel by comparing the determined fuel quality and/or the

composition of the fuel to a baseline or minimal fuel quality and/or composition. If either or both of the determined fuel quality and fuel composition do not satisfy the baseline requirements, head unit 110 determines that there is an issue with the fuel. Head unit 110 may provide the indication of fuel quality and/or indication of issues with fuel quality to remote computing system 120. In addition, head unit 110 may provide the data received from the vehicle sensors to remote computing system 120 with the explicit permission of the user. Remote computing system 120, responsive to the receipt of data from head unit 110, may analyze the data.

Remote computing system 120 may receive and analyze data received from head unit 110. Remote computing system 120 may include servers, desktops, virtualized computing environments, computing cloud(s), and/or other connected computing devices. Remote computing system 120 may crowd-source fuel purchase, quality, and other information from a plurality of vehicles. For example, remote computing system 120 may receive fuel purchase data from hundreds of vehicles a day for a particular fueling station or for multiple different fueling stations. In addition, remote computing system 120 may receive data regarding driving conditions from thousands of vehicles. Remote computing system 120 may use the crowd-sourced data to determine whether there are any fuel quality issues with the fuel provided by the associated fuel stations. In some examples, remote computing system 120 may also receive indications of fuel quality and/or indications of issues of fuel quality from the vehicles.

Remote computing system 120 may associate sets of vehicle data with the fuel station at which those vehicles most recently refueled. For example, remote computing system 120 may segment the data and indications of fuel quality based on the date of refueling, the location the fuel station, the type of fuel purchased, etc.

Data analytics 122 of remote computing system 120 may utilize the aggregated data to determine whether a fuel station is experiencing issues with fuel quality. Data analytics 122 may include one or more machine learning models that take fuel quality data as an input and provide an indication of where there is a fuel issue at the various fuel stations. As one example, data analytics 122 applies the machine learning model to the data and determines that a substantive percentage of vehicles that most recently received fuel from a particular fuel station have experienced irregular combustion events. Based on the data regarding combustion events, data analytics 122 determines that the particular fuel station is experiencing issues with fuel quality. As another example, data analytics 122 applies the machine learning model to the data and determines that gasoline labeled with a 91-octane rating at a gas station is in fact not 91-octane gasoline at least based in part on engine knocking information included in the data. Remote computing system 120 may provide information about the fuel quality issues to applications 132 and head unit 110 for use in informing consumers about possible fuel quality issues at particular fuel stations.

Computing device 130 may include mobile computing devices, desktop computing devices, tablet computing devices, wearable computing devices, or any other mobile or non-mobile computing device. Computing device 130 include applications 132 executable by one or more processors of computing device 130. Applications 132 may include a variety of types of applications including mapping applications, social network applications, messaging applications, shopping applications, etc. One or more of applications 132 may provide graphical user interface that includes an indication of the received fuel quality and fuel station information. The user interface may include a warning about particular fuel stations, particular fuels being sold at the fuel stations, etc. as well as specific details about the fuel issues identified at the

particular fuel stations. The specific details may include incorrect octane ratings, water-contaminated diesel, gasoline with the incorrect blend of ethanol, etc. Applications 132 may provide the fuel quality information in response to a consumer searching for gas stations, in response to a fuel station being located in proximity to the consumer's current location, etc.

In addition, applications 132 may act as a record-keeping service to record the time and place of fuel stations that are suspected to have sold problematic fuel. The consumers that purchased the problematic fuel and suffered engine damage as a result may access the records generated by applications 132 to demonstrate that the problematic fuel was the cause of their engine damage. Lastly, with explicit permission from the consumers, fuel station owners and operators may access the fuel quality information to more easily determine if shipments of fuel that received by the fuel station have quality issues, or if there are issues with the fuel storage and dispensing systems of the fuel stations.

The fuel quality reporting by head unit 110 may assist in the securing of an information chain regarding fuel purchases. The information regarding the quality of the fuel is obtained by head unit 110, reported to remote computing system 120, and connected to fuel purchases recorded by head unit 110. Consumers may use this information to prevent the fuel station from shifting blame by claiming that the issues with the fuel are errors committed by the consumer. The automated process may ensure the integrity of the information chain regarding the quality of the fuel and may assist consumers recovering costs from gas stations in the event of contaminated or low-quality fuel causing damage to a vehicle. In addition, vehicle manufacturers may use this information to recover the costs of repairs under warranty that were caused by contaminated fuel instead of defective components within the automobile. Finally, fuel station

operators may use the data regarding fuel quality to recover from suppliers that do not deliver fuel of the correct type or deliver contaminated fuel.

It is noted that the techniques of this disclosure may be combined with any other suitable technique or combination of techniques. As one example, the techniques of this disclosure may be combined with the techniques described in U.S. Patent Publication No. US20190293016A1. In another example, the techniques of this disclosure may be combined with the techniques described in E.P.O. Patent Application No. EP14802650.3A.