US 20190091738A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2019/0091738 A1

(43) Pub. Date: Mar. 28, 2019

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(54) CLEANING SYSTEM FOR A VEHICLE

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(21) Appl. No.: **15/713,146**

(22) Filed: **Sep. 22, 2017**

Publication Classification

(51) **Int. Cl.**

B08B 7/00	(2006.01)
G01J 1/42	(2006.01)
A61L 2/10	(2006.01)
B60S 1/64	(2006.01)

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

CPC ***B08B 7/0057*** (2013.01); ***B60S 1/64*** (2013.01); ***A61L 2/10*** (2013.01); ***G01J 1/429*** (2013.01)

(57) **ABSTRACT**

A cleaning system for a vehicle is described and methods of using the system. The method may include: at a vehicle computer: receiving data from at least one environmental sensor; based on the data, determining an ultraviolet (UV) dosage for an interior surface of a cabin; and based on the determination, controlling UV light according to the dosage.

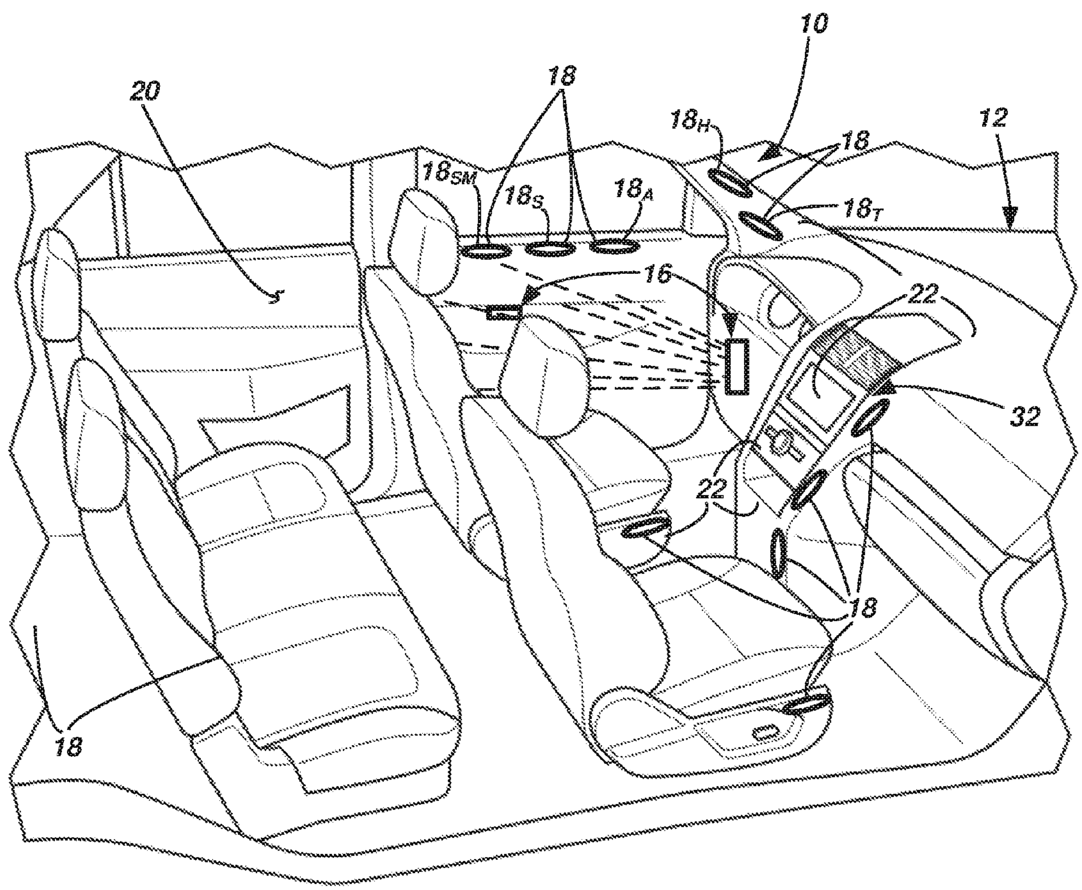


FIG. 1

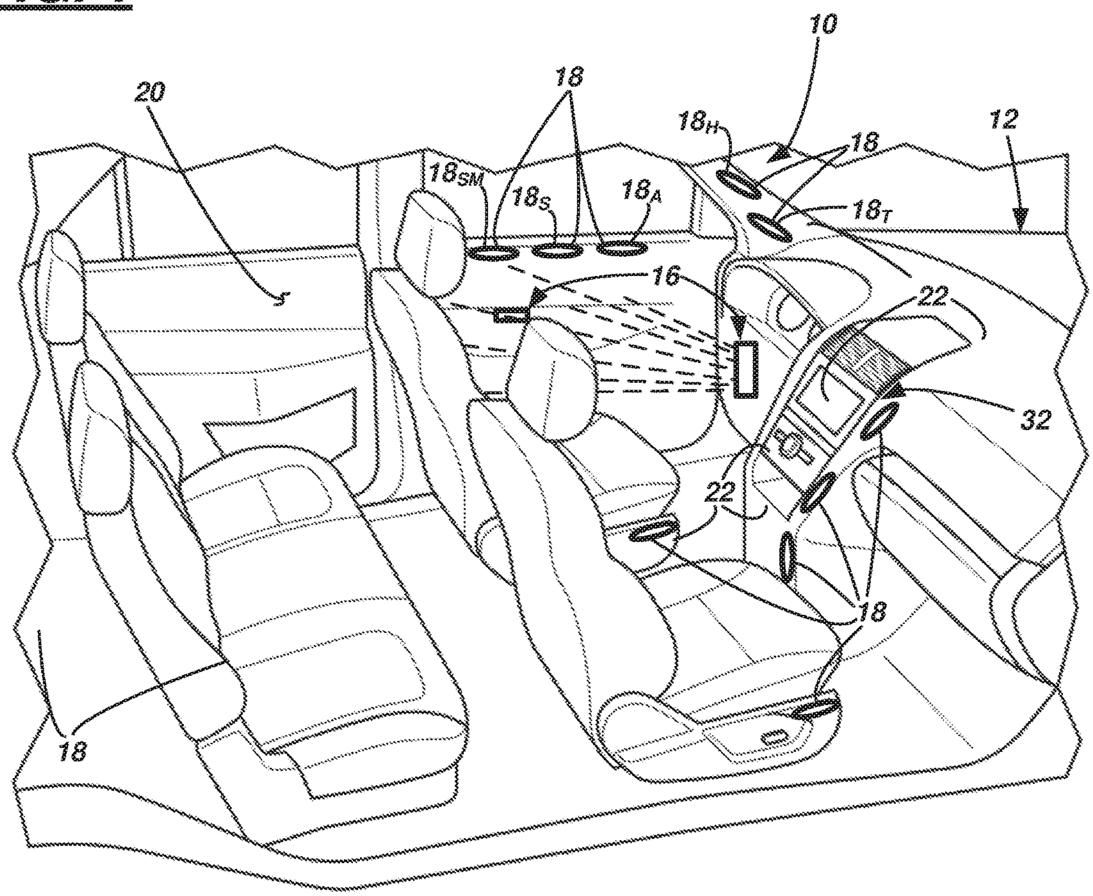

10
12
16
18
18SM
18S
18A
18H
18T
20
22
32

FIG. 3

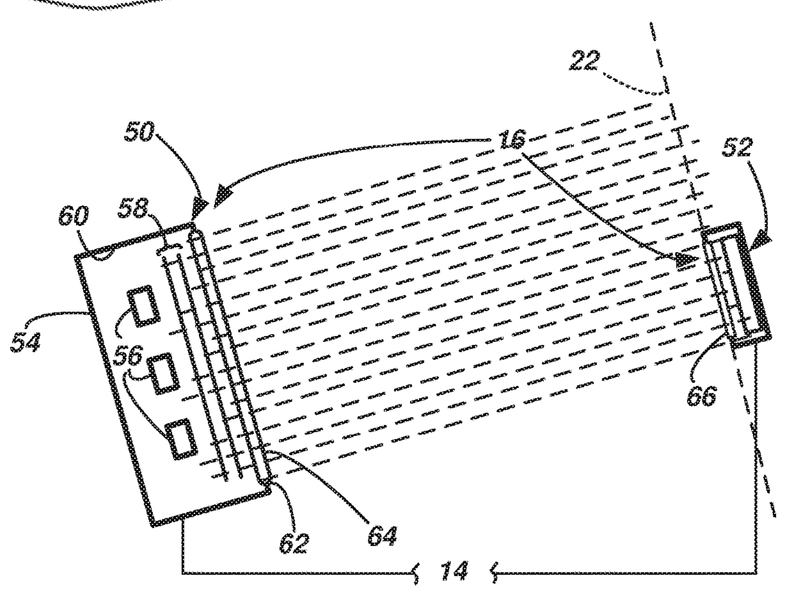
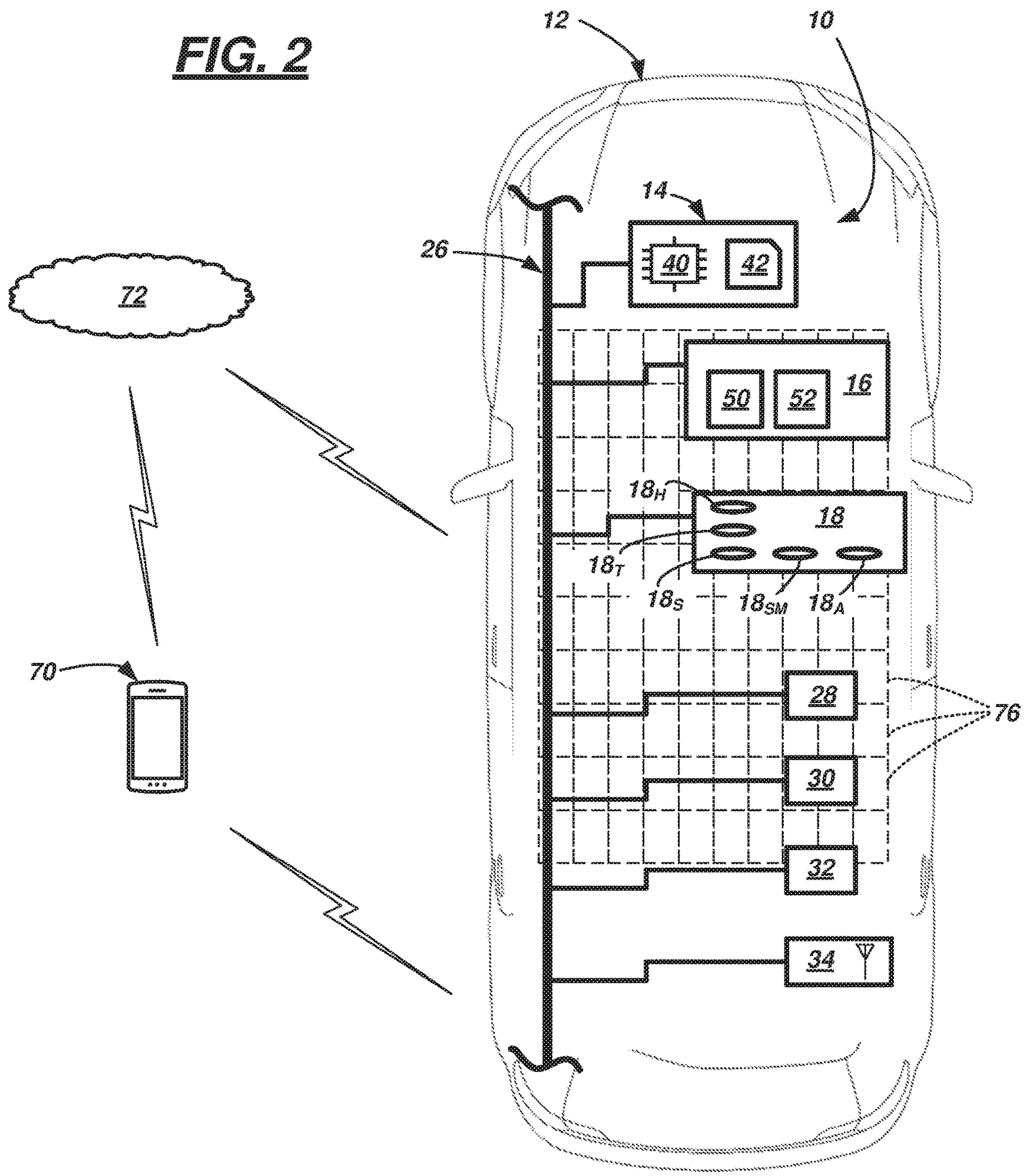

14
16
22
50
52
54
56
58
60
62
64
66

FIG. 2


12
10
14
40
42
26
72
16
50
52
18H
18
18T
18S
18SM
18A
70
28
76
30
32
34

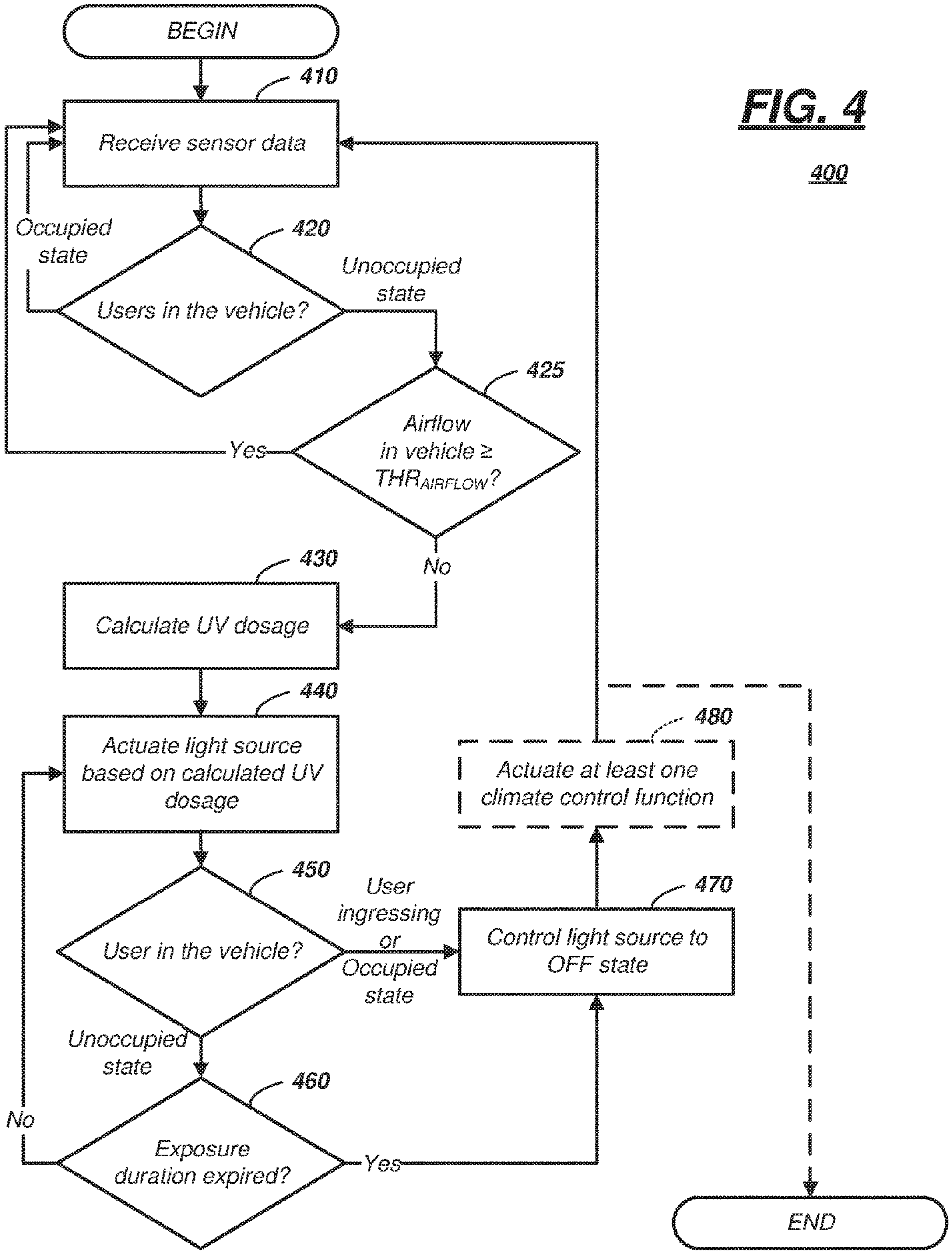
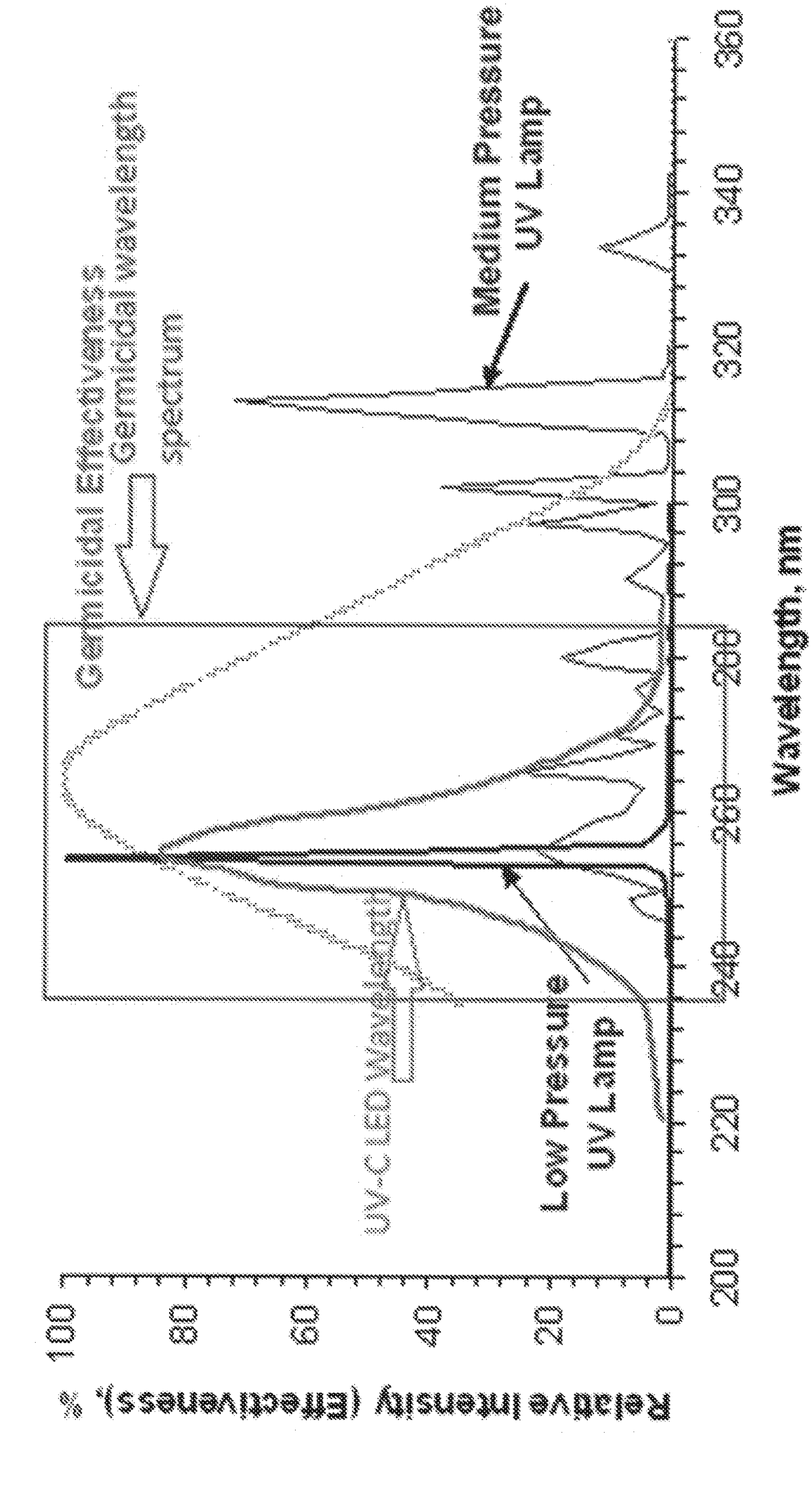

BEGIN
410
Receive sensor data
420
Occupied state
Users in the vehicle?
Unoccupied state
425
Airflow in vehicle ≥ THR_AIRFLOW?
Yes
No
430
Calculate UV dosage
440
Actuate light source based on calculated UV dosage
450
User in the vehicle?
User ingressing or Occupied state
Unoccupied state
460
Exposure duration expired?
No
Yes
470
Control light source to OFF state
480
Actuate at least one climate control function
END

FIG. 4

400

FIG. 5



(Modified from Kowalski: Ultraviolet Germicidal Irradiation Handbook: UVGI for air and surface disinfection. 2009.)

CLEANING SYSTEM FOR A VEHICLE

BACKGROUND

[0001] Ultraviolet light (such as UV-B and UV-C) may be used as a germicidal agent. Disinfection may be achieved by killing or inactivating various microorganisms.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. **1** is a perspective view of a cleaning system for a cabin of a vehicle.

[0003] FIG. **2** is a schematic view of the cleaning system of the vehicle shown in FIG. **1**.

[0004] FIG. **3** is a schematic view of a light source and a light detector of the cleaning system.

[0005] FIG. **4** is a flow diagram illustrating a vehicle interior cleaning process executable by a computer of the cleaning system.

[0006] FIG. **5** is a graphical depiction of several bands of ultraviolet (UV) wavelength, each associated with a different type of UV light element.

DETAILED DESCRIPTION

[0007] A cleaning system is described and a method of using the system. According to one illustrative example, the method includes: at a vehicle computer: receiving data from at least one environmental sensor; based on the data, determining an ultraviolet (UV) dosage for an interior surface of a cabin; and based on the determination, controlling UV light according to the dosage.

[0008] According to the at least one example set forth above, controlling further comprises actuating a light source within the cabin which directs the light toward the surface.

[0009] According to the at least one example set forth above, the light comprises a band within 240-280 nanometers.

[0010] According to the at least one example set forth above, the dosage is based on a light intensity, an exposure duration, and at least one function based on the data.

[0011] According to the at least one example set forth above, the method further includes de-actuating a light source at an expiration of the duration.

[0012] According to the at least one example set forth above, the method further includes adjusting at least one climate control parameter based on the determination.

[0013] According to the at least one example set forth above, controlling further comprises changing an intensity of the light based on feedback from a detector at the surface.

[0014] According to the at least one example set forth above, the determination further comprises increasing an intensity of the light based on a relative humidity being greater than a threshold.

[0015] According to the at least one example set forth above, the determination further comprises decreasing an intensity of the light based on a relative temperature being less than a first threshold or greater than a second threshold.

[0016] According to the at least one example set forth above, the determination further comprises increasing an intensity of the light based on moisture at the surface being greater than a threshold.

[0017] According to the at least one example set forth above, the determination further comprises decreasing an intensity of the light based on a measurement of UV sunlight at the surface.

[0018] According to the at least one example set forth above, the method further includes inhibiting UV light emission based on an occupied state of the vehicle or a user ingres sing.

[0019] According to the at least one example set forth above, the method further includes inhibiting UV light emission based on relative airflow being greater than a threshold.

[0020] According to the at least one example set forth above, the method further includes inhibiting UV light emission based an open state of vehicle windows.

[0021] According to the at least one example set forth above, the dosage is based on a selected sterilization level.

[0022] According to another illustrative example, a system is disclosed. The system may include a computer, comprising processor and memory storing instructions executable by the processor, the instructions comprising, to: receive data from at least one environmental sensor; based on the data, determine an ultraviolet (UV) dosage for an interior surface of a cabin; and based on the determination, control UV light according to the dosage.

[0023] According to the at least one example set forth above, the system also may include: a lighting system coupled to the computer.

[0024] According to the at least one example set forth above, the lighting system comprises a light source and a detector which provides UV light intensity feedback.

[0025] According to the at least one example set forth above, the instructions further comprise, to: determine the dosage based on one of a relative humidity, a relative temperature, or a moisture at the surface.

[0026] According to the at least one example set forth above, the instructions further comprise, to: adjust the dosage based on a measurement of UV sunlight at the surface.

[0027] According to the at least one example, a computer is disclosed that is programmed to execute any combination of the examples set forth above.

[0028] According to the at least one example, a computer is disclosed that is programmed to execute any combination of the examples of the method(s) set forth above.

[0029] According to the at least one example, a computer program product is disclosed that includes a computer readable medium storing instructions executable by a computer processor, wherein the instructions include any combination of the instruction examples set forth above.

[0030] According to the at least one example, a computer program product is disclosed that includes a computer readable medium that stores instructions executable by a computer processor, wherein the instructions include any combination of the examples of the method(s) set forth above.

[0031] Now turning to the figures, wherein like numerals indicate like parts throughout the several views, there is shown a cleaning system **10** for a vehicle **12** that includes a computer **14**, a lighting system **16** (e.g., providing ultraviolet (UV) light), and one or more environmental sensors **18**. As will be described in detail below, the computer **14** may receive sensor data from sensor(s) **18**, determine a light emission dosage, and, when a cabin **20** of the vehicle **12** contains no users (e.g., human passengers or occupants), the computer **14** may control the lighting system **16** to emit light to impinge upon and clean an interior surface **22** of the cabin **20** (e.g., it may actuate the lighting system **16** to an ON state). More particularly, computer **14** may tailor a dosage (e.g., UV-C light exposure for a period of application time) to target one or more types of surface contaminants (e.g., bacteria, viruses, fungi, other pathogens, etc.). For example, using the environmental sensor data collected via sensors **18**, computer **14** in some instances may identify potential contaminants and, based on that identification, determine an appropriate dosage. Non-limiting examples of environmental sensor data include cabin humidity data, cabin temperature data, cabin surface sunlight data, surface moisture data, cabin airflow data, and the like. According to one example, in determining the dosage, computer **14** may determine a wavelength (or band), determine an intensity (of UV light), and/or determine an exposure duration (of the UV light) which may be suitable for eliminating, exterminating, or killing the identified contaminant while avoiding overdosing the surface **22**—as overdosing may result in deterioration of vehicle interior components (e.g., such as interior trim, moldings, etc. which may comprise rubber, plastic, or other materials which degrade in the presence of UV light). In addition, the computer **14** may actuate lighting system **16** to an OFF state following an expiration of the exposure duration or when, during the duration, the computer **14** determines that a user may be entering the vehicle **12**. In at least some instances, in order to inhibit or minimize the likelihood of contaminant growth within the cabin **20**, the computer **14** may control at least one climate control parameter following the UV dosage application (e.g., controlling cabin humidity, temperature, airflow, etc.). Computer **14** and other aspects of the cleaning system **10** are described in greater detail below.

[0032] FIGS. **1-2** illustrate an illustrative vehicle **12** that may comprise cleaning system **10**. Vehicle **12** is shown as a passenger car; however, vehicle **12** could also be a truck, sports utility vehicle (SUV), recreational vehicle, bus, train car, aircraft, or the like that includes the cleaning system **10**. Vehicle **12** may be operated in any one of a number of autonomous modes. In at least one example, vehicle **12** may operate as an autonomous taxi, autonomous school bus, or the like e.g., operating in a fully autonomous mode (e.g., a level 5), as defined by the Society of Automotive Engineers (SAE) (which has defined operation at levels 0-5). For example, at levels 0-2, a human driver monitors or controls the majority of the driving tasks, often with no help from the vehicle **12**. For example, at level 0 ("no automation"), a human driver is responsible for all vehicle operations. At level 1 ("driver assistance"), the vehicle **12** sometimes assists with steering, acceleration, or braking, but the driver is still responsible for the vast majority of the vehicle control. At level 2 ("partial automation"), the vehicle **12** can control steering, acceleration, and braking under certain circumstances without human interaction. At levels 3-5, the vehicle **12** assumes more driving-related tasks. At level 3 ("conditional automation"), the vehicle **12** can handle steering, acceleration, and braking under certain circumstances, as well as monitoring of the driving environment. Level 3 may require the driver to intervene occasionally, however. At level 4 ("high automation"), the vehicle **12** can handle the same tasks as at level 3 but without relying on the driver to intervene in certain driving modes. At level 5 ("full automation"), the vehicle **12** can handle all tasks without any driver intervention. In at least one example, vehicle **12** includes one or more autonomous driving systems, one or more autonomous driving computers, and the like to enable operation at level 5 and thus may operate in a fully autonomous mode. In this fully autonomous mode, the vehicle **12** may operate as an autonomous taxi or the like.

[0033] When vehicle **12** is used as an autonomous taxi, bus, or the like, the cabin **20** typically will be used daily by a number of different users. As used herein, a cabin is a region of vehicle **12** adapted with passenger seating. The cleaning system **10** may facilitate some cleaning between at least some occupancies of these different users—e.g., during periods of less frequent vehicle use. The cleaning system **10** described herein may be particularly desirable in relatively small, enclosed environments: since smaller and enclosed regions often have temperatures suitable for human comfort (e.g., such as cabin **20**) but which also can harbor and/or promote the growth of infectious pathogens such as bacteria, viruses, and fungi; and since both infected and un-infected users regularly may utilize vehicle **12**—e.g., thus making the vehicle cabin **20**, without the cleaning system **10**, a more likely vessel for spreading infection. Thus, according to at least one example, cleaning system **10** may be used to minimize the spread of respiratory, gastrointestinal, and other illnesses (e.g., which can be spread by user contact with contaminated surfaces **22** within the vehicle **12**).

[0034] According to one example, cleaning system **10** comprises a wired or wireless communication network connection **26** which facilitates communication between one or more of: computer **14**, lighting system **16**, environmental sensor(s) **18**, an occupant detection system **28**, a climate control system **30**, a human-machine interface (HMI) module **32**, and a telematics module **34**. In at least one example, the connection **26** includes one or more of a controller area network (CAN) bus, Ethernet, Local Interconnect Network (LIN), a fiber optic connection, or the like. Other examples also exist. For example, alternatively or in combination with e.g., a CAN bus, connection **26** could comprise one or more discrete wired or wireless connections (e.g., between the sensors **18** and computer **14**, between the lighting system **16** and computer **14**, etc.).

[0035] Computer **14** may be a single computer (or multiple computing devices—e.g., shared with other vehicle systems and/or subsystems). Computer **14** may be a body control module (BCM); however, this is merely one non-limiting example. Computer **14** may comprise a processor **40** (e.g., or processing circuit) coupled to memory **42**. For example, processor **40** can be any type of device capable of processing electronic instructions, non-limiting examples including a microprocessor, a microcontroller or controller, an application specific integrated circuit (ASIC), etc.—just to name a few. In general, computer **14** may be programmed to execute digitally-stored instructions, which may be stored in memory **42**, which enable the computer **14**, among other things, to: receive sensor data from at least one environmental sensor **18**; determine at least one light source parameter based on the sensor data; determine a contaminant type based on the sensor data; actuate lighting system **16** based on the determined parameter and/or based on the contaminant type; execute a combination of these exemplary instructions; or the like. Other programmable instructions executable by processor **40** will be discussed in greater detail below.

[0036] Memory **42** may include any non-transitory computer usable or readable medium, which may include one or more storage devices or articles. Exemplary non-transitory computer usable storage devices include conventional hard disk, solid-state memory, random access memory (RAM), read-only memory (ROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), as well as any other volatile or non-volatile media. Non-volatile media include, for example, optical or magnetic disks and other persistent memory, and volatile media, for example, also may include dynamic random access memory (DRAM). These storage devices are non-limiting examples; e.g., other forms of computer-readable media exist and include magnetic media, compact disc ROM (CD-ROMs), digital video disc (DVDs), other optical media, any suitable memory chip or cartridge, or any other medium from which a computer can read. As discussed above, memory **42** may store one or more computer program products which may be embodied as software, firmware, or other programming instructions executable by the processor **40**.

[0037] Lighting system **16** (also illustrated in FIG. **3**) may comprise any suitable light emitting device which cleans a cabin interior surface **22** when directed thereat. As used herein, an interior surface is an interior surface of vehicle cabin **22** and should be broadly construed to include any surfaces within the vehicle **12**—including but not limited to any suitable surface of a vehicle instrument panel, any suitable touchscreen surface of the vehicle **12**, any suitable surface of vehicle seating, an interior surface of a vehicle door or vehicle door panel, a vehicle steering wheel (if available), an interior surface of a vehicle window or window pane, or the like.

[0038] According to one example, the lighting system **16** comprises a light source **50** and a light detector **52**. Light source **50** may comprise a housing **54**, one or more light elements **56**, and one or more filters **58**. Non-limiting examples of light elements **56** include UV-emitting gas discharge lamps, UV-emitting fluorescent bulbs, UV-emitting light emitting diodes (LEDs), UV-emitting organic light emitting diodes (OLEDs), and the like. According to at least one example, elements **56** comprise one or more UV-emitting gas discharge lamp(s)—e.g., as these types of elements may have suitable sterilization parameters (e.g., a narrow bandwidth of 4 nanometers (nm), typically centered at about 253.7 nm which is a suitable center frequency for killing bacteria, viruses, fungi, and other contaminants). As shown in FIG. **5**, UV-LEDs and UV-OLEDs and fluorescent bulbs may have bandwidths greater than 20 nm, require broader filtering, etc.

[0039] FIG. **3** illustrates several light elements **56** (e.g., LEDs) carried within a cavity **60** of the housing **54**; more or fewer elements **56** may be used in other examples. In this example, the filters **58** are positioned between the elements **56** and an opening **62** of the housing **54** so that emitted light from elements **56** is filtered. The filters **58** may block transmission of any suitable wavelengths of light from exiting housing **54**. The term filter should be construed broadly to include a film, screen, or other layer of light blocking material—e.g., which in some instances, include dyes and/or other polarizing apparatuses. In at least one example, the light source **50** comprises a lens and/or diffuser **64**—e.g., positioned within the opening **62** to control the directionality, focus, etc. of the emitted light.

[0040] According to one example, light source **50** may emit ultraviolet (UV) light having a peak wavelength within a band of 240-280 nanometers (nm); and according to at least one example, the UV center frequency is 253.7 nm (e.g., having a +/−2 nm bandwidth), as discussed above. As will be described below, computer **14** may control the emitted wavelength, intensity, and/or an exposure duration. For example, to control the wavelength, computer **14** may selectively actuate or move one or more filters **58** (e.g., mechanically positioning them (and/or displacing from) between the elements **56** and opening **62**). In another example of wavelength control, computer **14** may selectively actuate one or more of elements **56**, wherein at least one of the elements **56** emits light at a different wavelength than the others. These and other techniques may be used singly or in combination with one another (by computer **14**) to control wavelength output.

[0041] According to one example, the peak wavelength is selected to be between 240-280 nm because this light region of the spectrum may photo-catalyze the formation of deoxyribonucleic acid (DNA) pyrimidine dimers—which damages cellular DNA and triggers cell death (e.g., in a pathogen). Also, the use of filter(s) **58** (e.g., such as a high pass filter to inhibit light wavelengths less than 200 nm) desirably may minimize the formation of ozone (O_3) within cabin **20**.

[0042] With respect to controlling light emission intensity, computer **14** may control intensity by selectively controlling a voltage or current to at least some of the elements **56**—e.g., in instances where greater current or voltage results in a higher intensity output from the elements **56**. In other examples, which may be used alternatively or in combination herewith, computer **14** selectively may actuate elements **56**. For instance, in the illustrated example (FIG. **3**), computer **14** could minimize intensity by illuminating only one or two of the elements **56**. And to increase intensity, computer **14** could actuate all three elements **56**. Like the discussion of wavelength control, this also is merely an example. Other examples exist.

[0043] As will be discussed below, computer-selected intensity from light source **50** (e.g., as well as light emission duration) may depend on the targeted contaminant. For example, computer **14** may determine a likely contaminant based on sensor data from the environmental sensors **18**, and based on this determination, computer **14** may control the intensity—which intensities may differ for each of bacteria, fungi, bacterial endospores, etc. Also, computer **14** may adjust the intensity based on a desired cellular logarithmic kill ratio or so-called sterilization level (e.g., 90%, 99%, 99.99%, etc.)—e.g., higher levels having a greater likelihood of killing the contaminant. These will be discussed more below.

[0044] In at least one example, multiple light sources **50** may be positioned within vehicle cabin **20**, and at least some of these sources **50** may have different arrangements or quantities of light elements **56**. Further, multiple light sources **50** may correspond to a single detector **52**, or for example, each light source **50** may have a corresponding detector **52**.

[0045] Further, while FIG. **1** illustrates a light source **50** in an instrument panel, in other examples, a light source **50** may be located in a vehicle headliner, in a vehicle A-, B-, etc. pillar, in a vehicle center console, in a vehicle door panel, or the like. Intensity of each respective light source **50** may be controlled at least partially based on a relative distance between the source **50** and a targeted surface **22** (e.g., accounting for intensity received at the surface **22** being inversely proportional to the square of the distance between the source **50** and the targeted surface **22**). Other aspects and techniques for using the light source(s) **50** will be discussed below.

[0046] Light detector **52** may be any suitable electronic device for detecting and measuring an intensity of impinging light (e.g., power per unit area) at an interior surface **22**. For example, the detector **52** may be located at, on, or even at least partially within the interior surface **22**. According to one non-limiting example (FIG. **3**), detector **52** comprises a UV-sensitive window **66** which may be approximately flush with surface **22** (i.e., more particularly, window **66** may be an element which is electrically responsive to UV light). Using window **66**, detector **52** may provide as output an electrical signal, wherein the magnitude of the current or voltage of the signal may correspond with a magnitude of intensity impinging upon the window **66**.

[0047] According to at least one example, the light source **50** and/or detector **52** may be positioned and oriented (relative to one another) so that window **66** receives incident light from source **50** (e.g., having an angle of incidence of approximately 0° (e.g., between +/−5° of normal); however, this is not required in all examples. As will be appreciated from the discussion below, smaller angles of incidence may result in light source **50** using less power in cleaning applications, as less UV light may be reflected from window **66** (and in some degree, surface **22**). Further, in some examples, if the angle of incidence is too great, all or most of the UV light may be reflected at the window **66**—e.g., resulting in the detector **52** being unable to measure UV light intensity from the source **50**.

[0048] According to one example, detector **42** may detect UV intensity between 0 and 2500 microWatts/centimeter^2 ($\mu W/cm^2$). As will be described more below, light source **50** may be configured to direct light at the surface **22** (and consequently at window **66**) having an intensity between 500-2000 $\mu W/cm^2$. Light detector **52** may be coupled to computer **14** (and/or light source **50**) in order to provide feedback data regarding how much UV light is actually being received at the surface **22**. Thus, for example, computer **14** may instruct light source **50** to emit light having a predetermined intensity, detector **52** may measure the UV light intensity at surface **22**, detector **52** may provide a measurement via a feedback loop to computer **14** (and/or to light source **50**), and, based on the measurement, light source **50** may increase or decrease its power output in accordance with the instruction from computer **14**. Further, based on the intensity of UV light received via the detector **52**, computer **14** may maintain the controlled application of UV light for an exposure duration so that a predetermined dosage (e.g., energy per unit area) may be received at surface **22**. Other aspects and examples of UV dosages will be described more below.

[0049] As discussed above, the cleaning system **10** may comprise one or more environmental sensors **18**. And in at least one example, the system **10** comprises a plurality of sensors **18**. At least some of these sensors **18** may be configured to receive different types of sensor data. For example, according to one example, system **10** comprises: a cabin humidity sensor $\mathbf{18}_H$, a cabin temperature sensor $\mathbf{18}_T$, a surface moisture sensor $\mathbf{18}_{SM}$, a sunlight sensor $\mathbf{18}_S$, an airflow sensor $\mathbf{18}_A$, or a combination thereof. Each of the sensors **18** may provide an electrical output to computer **14** which may be correlated thereby to an analog value (e.g., an analog temperature, an analog humidity, an analog moisture level, an analog UV sunlight level, an analog airflow level, etc.) and/or be compared with predetermined threshold values (e.g., which may be associated with contaminant growth, activity, etc.).

[0050] In FIG. **1**, locations of these and other sensors **18** are shown for purposes of illustration only (i.e., and are not intended to be limiting). For example, the system **10** may comprise more than one humidity sensor $\mathbf{18}_H$ and the plurality of humidity sensors $\mathbf{18}_H$ could be located on or near a vehicle A-pillar (as shown) and/or elsewhere in the cabin **20**. The same may be true for cabin temperature sensors $\mathbf{18}_T$, surface moisture sensors $\mathbf{18}_{SM}$, sunlight sensors $\mathbf{18}_S$, airflow sensors $\mathbf{18}_A$, etc. (i.e., there may be more than one of each and the respective locations may differ in other examples).

[0051] Turning now to the occupant detection system **28**, system **28** may comprise any number of electronic devices which may be at least partially within the cabin **20** and which are coupled to computer **14** and which thereby enable the computer **14** to determine whether a user (or animal, pet, etc.) is within the vehicle **12**. Non-limiting examples of such electronic devices include motion detection sensors within cabin **20**, infrared or thermal sensors within cabin **20**, pressure and/or proximity sensors (e.g., within vehicle seating, arm rests, etc.), imaging sensors within cabin **20** (e.g., such as complementary metal oxide semiconductor (CMOS) and charge-coupled device (CCD) cameras), and the like. The system **28** may comprise other cabin occupancy detection devices as well—e.g., including wireless signal (e.g., Bluetooth), door ajar signals, vehicle pitch and roll sensors, etc.). Thus, system **28** may comprise a computer processing device (not shown) which includes instructions enabling it to detect vehicle occupancy based on one or more inputs of the exemplary electronic devices discussed above. Furthermore, this computer processing device of system **28** may be programmed to increment a counter for vehicle occupants ingressing vehicle **12** and decrement the counter for occupants egressing the vehicle **12**. (In other examples, these or similar programming instructions may be stored in memory **42** and executed using processor **40** of computer **14**). Thus, in at least one example, occupant detection system **28** may determine an occupancy status and report this status to computer **14**, as will be described in greater detail below.

[0052] Climate control system **30** may comprise any suitable components for providing cabin comfort by controlling temperature, humidity, airflow, etc. For example, system **30** may include a heating unit, an air-conditioning (AC) unit, a humidifier, a blower or fan, a manifold and plurality of air ducts opening into cabin **20**—none of which are shown in the figures. Typically, climate control system **30** includes a computer processing device (e.g., having a processor and memory) which controls the heating and AC units, the blower, the humidifier, etc. In some instances, these components are programmable by the user or a vehicle or original equipment manufacturer. Further, in at least one example, the computer processing device may be adapted to receive (e.g., via network **26**) an instruction from computer **14** requesting it to adjust a climate control parameter. For example, as explained more below, controlling the parameter may include selectively (and respectively) increasing or decreasing one or more of vehicle cabin temperature, cabin humidity, or forced air pressure (e.g., airflow) within the cabin **20**.

[0053] Human-machine interface (HMI) module **32**—also shown in FIG. **2**—may include any suitable input and/or output devices such as switches, knobs, controls, etc.—e.g., on a vehicle instrument panel, steering wheel, etc. of vehicle **12**—which are coupled communicatively to computer **14**. In one non-limiting example, HMI module **32** may comprise an interactive touch screen or display which provides navigation information (e.g., including text, images, etc.) to the vehicle user and permits the user to enter a desired destination for the vehicle **12** in a fully autonomous mode to transport the user. Such interactive devices further may be used to notify the user that the vehicle interior surfaces **22** have been cleaned and/or to permit the user to suggest to the computer **14** that the cabin surfaces **22** should be purged once the user leaves the vehicle **12** (e.g., based on visual inspection by the respective user). In at least one example, a level of sterilization be selected via module **32**; this is discussed more below as well.

[0054] FIG. **2** also illustrates telematics module **34**. Module **34** may be any suitable telematics computing device configured to wirelessly communicate with other electronic devices—e.g., including a remote server (not shown) or even local devices such as a mobile device **70** (which may be carried by a user). Such wireless communication via telematics module **34** may include use of cellular technology (e.g., LTE, GSM, CDMA, and/or other cellular communication protocols), short range wireless communication technology (e.g., using Wi-Fi, Bluetooth, Bluetooth Low Energy (BLE), dedicated short range communication (DSRC), and/or other short range wireless communication protocols), or a combination thereof. Such communication includes so-called vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications as well of which will be appreciated by those skilled in the art.

[0055] Mobile device **70** may be any suitable portable, electronic communication device. It may be used by a user to communicate with computer **14** via telematics module **34**. For example, the user of the device **70** who desires to use vehicle **12** as an autonomous taxi may—via the device **70**—request a ride, provide a desired destination, instruct the computer **14** to clean the surfaces **22** of the vehicle **12** before the user ingresses, and even to select a sterilization level of the surfaces therein. Non-limiting examples of mobile device **70** include a cellular telephone, a personal digital assistant (PDA), a Smart phone, a laptop or tablet computer having two-way communication capabilities (e.g., via a land and/or wireless connection), a netbook computer, and the like.

[0056] Mobile device **70** may communicate with telematics module **34** directly (e.g., via any suitable wireless peer-to-peer connection) or it may communicate with module **34** indirectly—e.g., via a wired and/or wireless communication network **72**. This network **72** may comprise a land communication network, a wireless communication network, or a combination thereof, as will be appreciated by those skilled in the art. For example, a land communication network can enable connectivity to public switched telephone network (PSTN) such as that used to provide hardwired telephony, packet-switched data communications, internet infrastructure, and the like; further, the land communication network may facilitate V2I communication as well. A wireless communication network may include satellite communication architecture and/or may include cellular telephone communication over wide geographic region (s). Thus, in at least one example, network **72** includes any suitable cellular infrastructure that could include eNodeBs, serving gateways, base station transceivers, and the like. Further, network **72** may utilize any suitable existing or future cellular technology (e.g., including LTE, CDMA, GSM, etc.).

[0057] As will be discussed more below, one or more remote servers (not shown) may communicate with and/or instruct computer **14** via network **72**. For example, in at least one example, the server may be associated with or owned by a vehicle manufacturer or other original equipment manufacturer. Via the communication, an authorized service technician may control computer **14**, lighting system **16**, etc. Further, from time-to-time, such remote servers may provide software updates or so-called software patches which may be installed in computer memory **42** (so that thereafter, processor **40** may execute updated programming instructions to clean the interior surfaces **22** of vehicle **12**).

[0058] Turning now to FIG. **4**, a process **400** is shown for cleaning the interior surfaces **22** of vehicle **12**. The process begins with instructional block **410** which includes computer **14** receiving sensor data from one or more environmental sensors **18** in vehicle **12**. Thus, for example, one or more cabin humidity sensors 18_H may receive data pertaining to a humidity measurement within vehicle cabin **20**; one or more cabin temperature sensors 18_T may receive data pertaining to a temperature measurement within vehicle cabin **20**; one or more surface moisture sensors 18_{SM} may receive data pertaining to a surface moisture measurement of a respective surface **22** within vehicle cabin **20**; one or more UV sunlight sensors 18_S may receive data pertaining to a measurement of UV light upon a respective surface **22** within vehicle cabin **20**; one or more airflow sensors 18_A may receive data pertaining to an airflow measurement within vehicle cabin **20**; etc. When multiple sensor data is received from a same type of environmental sensor **18**, computer **14** may average the values. Or in some instances, computer **14** may evaluate environmental conditions for one or more sub-regions **76** of cabin **20**. The size and quantity of sub-regions **76** shown in FIG. **2** is merely an example (other quantities and/or sizes may be used). According to one example, computer **14** may determine to average multiple sensor data received regarding cabin humidity, cabin temperature, and cabin airflow; however, for an identified sub-region **76**, it may determine an independent UV sunlight measurement, an independent surface moisture measurement, or the like. Other examples also exist. It should be appreciated that while block **410** is illustrated as a single block, in some examples, computer **14** may continue to receive sensor data throughout the process **400**.

[0059] In block **420** which follows, computer **14** may determine whether any users are in the cabin **20** of vehicle **12**. For example, computer **14** may receive an indication from occupant detection system **28**—which may employ one or more sensing apparatuses discussed above and provide an electrical output received by processor **40** indicating an occupied state or an unoccupied state of vehicle **12**. As discussed above, this determination may be based on motion sensing, proximity sensing, pressure sensing, infrared or thermal sensing, imaging sensing, or the like. When computer **14** determines an occupied state, the process loops back to block **410** and the computer **14** continues to receive additional environmental sensor data. And when computer **14** determines an unoccupied state, the process **400** proceeds to block **425**.

[0060] In block **425**, using sensor data from sensor(s) 18_A, the computer **14** may determine whether a relative airflow within the vehicle cabin **20** is greater than or equal to a threshold ($THR_{AIRFLOW}$). As used herein, a relative airflow is a movement of air within the cabin **20** of vehicle **12**. According to one non-limiting example, threshold ($THR_{AIRFLOW}$) may be 1 meter per second (m/s); however, other examples exist. According to one example, the threshold ($THR_{AIRFLOW}$) corresponds to a value in which contaminants (e.g., the cells of bacteria or fungi, endospores, etc.) typically do not adhere and/or bind to one another—e.g., thus, mitigating a need for sterilization. Further, relative airflow greater than or equal to the threshold ($THR_{AIRFLOW}$) may suggest that a user is within or ingres sing the vehicle cabin **20**, that a window of vehicle **12** is open, etc. In either instance, according to one example, no application of UV dosage occurs if sensed airflow is greater than or equal to threshold ($THR_{AIRFLOW}$). For example, when computer **14** determines that relative airflow $THR_{AIRFLOW}$, then the process may loop back to block **410**, and the computer **14** may continue to receive additional environmental sensor data. And when computer **14** determines relative airflow<$THR_{AIRFLOW}$, the process **400** may proceed to block **430**. (According to at least one example, process **400** loops back to block **410** at any time computer **14** determines (during block **440**) that airflow within cabin **20** greater than or equal to threshold ($THR_{AIRFLOW}$). For example, if any light source **50** is actuated at the time of this determination, computer **14** immediately may change the source(s) **50** to a de-actuated state.)

[0061] In block **430**, computer **14** may calculate a UV dosage for a light source **50** to be applied at a targeted interior surface **22** (e.g., which corresponds to an emission beam from respective source **50**). The targeted interior surface **22** may comprise an entire object (e.g., such as an instrument panel, a center console, an arm rest, etc.)—or it may be for one or more sub-regions **76** of the cabin **20** (as discussed above). In some instances, block **430** may include determining a plurality of light emission parameters—e.g., such as a narrow emission band and/or center wavelength (λ), an emission intensity or flux (Φ), and an exposure duration (t_{EXPOS}). Each will be discussed in turn.

[0062] According to one example, computer **14** may to select one of a plurality of UV wavelengths (or center frequencies) as part of block **430**. For example, different wavelengths could be determined by computer **14** by selectively actuating one or more light elements **56** of the light source **50** (e.g., wherein the elements **56** emit different UV wavelengths), by selectively actuating one or more of the filters **58** of the light source **50**, or a combination thereof. Of course, in at least one example, the UV band and/or center frequency (λ) is predetermined and not selectable by computer **14**.

[0063] As discussed above, block **430** comprises determining a UV dosage to be applied to the targeted interior surface **22**—e.g., regardless of the UV band and center frequency (λ). As used herein, a dosage (also called fluence) is a quantity of UV light energy received at a unit area of interior surface **22** (e.g., micro-Joules per square centimeter or $\mu J/cm^2$). In general, dosage (D) can be expressed according to Equation 1.

$D=\Phi * t_{EXPOS}$, where Φ (e.g., having units of micro-Watts per square centimeter or $\mu W/cm^2$) is an intensity or radiant flux of UV light at surface 22 and t_{EXPOS} (having units of seconds (s)) is an exposure duration of the UV light. Equation 1:

[0064] As discussed above, computer **14** may calculate the dosage based on sensor data from one or more of the environmental sensors **18**, as well as other factors (e.g., beam divergence, attenuation, etc.). More particularly, computer **14** may determine a dosage (D_{ENV}) based on environmental sensors data within the cabin **20**, as illustrated in the non-limiting example shown as Equation 2. Stated differently, dosage (D) of Equation 1 may be modified as dosage (D_{ENV}), which also depends on environmental factors of cabin **20** such as temperature, humidity, surface moisture, UV sunlight, etc.

$D_{ENV}=(\Phi * t_{EXPOS}) * r(h) * D_T * M)-D_{SUN}$, where $r(h)$ is a function of the relative humidity within cabin 20, where D_T is a function of temperature within cabin 20, where M is a function of moisture at the target surface 22, and where D_{SUN} is a correction factor based on the amount of ambient UV light (e.g., from the sun) which is impinging upon the targeted surface 22. Each will be explained in greater detail. Equation 2

[0065] The r(h) function may be defined accordingly: when sensor data from environmental sensor(s) $\mathbf{18}_H$ indicates a relative humidity that is less than a threshold THR_{REL_HUM} (e.g., such as 60%), then r(h)=1; and when sensor data from sensor(s) $\mathbf{18}_H$ indicates a relative humidity that is greater than or equal to threshold THR_{REL_HUM}, then $1<r(h)\leq 5$. As used herein, relative humidity is a humidity within the air of the cabin **20** of vehicle **12**. Thus, for example, the r(h) function may scale linearly, exponentially, or the like between 1 and 5 when threshold THR_{REL_HUM} is greater than 60% and less than 100%. Of course, the threshold THR_{REL_HUM} value of 60% and function values of $1<r(h)\leq 5$ are merely examples; and other examples also exist.

[0066] The D_T function may be defined accordingly: when sensor data from environmental sensor(s) $\mathbf{18}_T$ indicates a relative temperature that is less than or equal to a first temperature threshold THR_{TEMP_LOW} (e.g., such as 0° Celsius (° C.)), then $D_T=[1+D_{T\_LOW}(t)]$, where $-1<D_{T\_LOW}(t)<0$; and when sensor data from environmental sensor(s) $\mathbf{18}_T$ indicates a relative temperature that is greater than or equal to a second temperature threshold THR_{TEMP_HIGH} (e.g., such as 30° C.), then $D_T=[1+D_{T\_HIGH}(t)]$, where $-1<D_{T\_HIGH}(t)<0$. As used herein, relative temperature is a temperature of the air within cabin **20** of vehicle **12**. Thus, according to one example, when sensor $\mathbf{18}_T$ indicates 0° C.≤relative temperature 30° C., then $D_{T\ LOW}(t)=D_{T\ HIGH}(t)=0$ and $D_T=1$.

[0067] When sensor $\mathbf{18}_T$ indicates a relative temperature between 0° C. and a maximum low temperature (e.g., such as −20° C.), then $D_{T\_LOW}(t)$ is scaled between 0 and −1 (according to any suitable scaling). Similarly, when sensor $\mathbf{18}_T$ indicates a relative temperature between 30° C. and a maximum high temperature (e.g., such as 50° C.), then $D_{T\_HIGH}(t)$ is scaled between 0 and −1 (according to any suitable scaling).

[0068] The M function may be defined accordingly: when sensor data from sensor(s) $\mathbf{18}_{SM}$ indicates any moisture on the targeted interior surface **22**, the value of M may be between a predetermined range (e.g., such as 2-10); and where no moisture exists on the targeted interior surface **22** (or when the moisture on surface **22** is less than a threshold THR_{MOIST}), then the value of M may be 1. The predetermined range (e.g., of 2-10) may be scaled in any suitable manner (e.g., linearly, exponentially, etc.), as already described above. Of course, these values also are merely examples, and other values may be used instead.

[0069] The value of D_{SUN} may be based on a measured value at the light detector **52** when the light source **50** is in the un-actuated state. For example, some surfaces **22** in cabin **20** may receive direct (or even reflected) sunlight comprising UV rays. Prior to actuation of the light source **50**, detector **52** may measure this UV value and provide it to computer **14**. Using this value, computer **14** may extrapolate the dosage attributable from the sunlight based on a surface area of target surface **22**, and this extrapolated value may be assigned as D_{SUN}.

[0070] In accordance with Equation 2, it should be appreciated that computer **14** is not required to collect sensor data from each of a relative humidity sensor **18**$_H$, a relative temperature sensor **18**$_T$, a surface moisture sensor **18**$_{SM}$, and a UV sunlight sensor **18**$_S$. For example, where sensor data is not collected for relative humidity, r(h) may be assumed to equal one (e.g., 1). And for example, where sensor data is not collected for relative temperature, D_T may be assumed to equal one (e.g., 1). And for example, where sensor data is not collected for surface moisture, M may be assumed to equal one (e.g., 1). And for example, where sensor data is not collected for UV sunlight, D_{SUN} may be assumed to equal zero (e.g., 0).

[0071] Other factors may be used alternatively, or in addition to, those illustrated in Equation 2. For example, as discussed above, the computer **14**, an authorized service technician, or even a user (e.g., via mobile device **70**) may select a sterilization level. For example, the sterilization level may be based on a logarithmic kill ratio (e.g., how much of the contaminant is likely to be killed or destroyed); non-limiting examples include kill ratios of 90% (e.g., 90% of bacteria, viruses, fungi, etc. are killed), 99% (e.g., 99% of bacteria, viruses, fungi, etc. are killed), 99.99% (e.g., 99.99% of bacteria, viruses, fungi, etc. are killed), etc. Accordingly, dosage (D_{ENV}) may be modified based on the selected sterilization level—e.g., modified as dosage (D_{ENV-90}), dosage (D_{ENV-99}), dosage ($D_{ENV-99.99}$), etc. Accordingly, in many instances, dosage ($D_{ENV-99.99}$) may be larger than dosage (D_{ENV-90}) and dosage (D_{ENV-99}), and, in many instances, dosage (D_{ENV-99}) may be larger than dosage (D_{ENV-90}). The scaling factors may be based on testing or other empirical values. Tables I, II, and III below are merely illustrative examples illustrating UV intensity values, exposure durations (t_{EXPOS}), and dosages (D_{ENV-90}, D_{ENV-99}) for a few illustrative contaminants.

[0072] For purposes of illustration only, Table I below shows two different dosage examples based on different sterilization levels (e.g., in this particular instance, r(h) $=D_T$=M=1 and D_{SUN}=0).

Contaminant	UV Intensity (μW/cm^2)	t_{EXPOS} [for 90% kill ratio] (s)	t_{EXPOS} [for 99% kill ratio] (s)	D_{ENV-90} (μJ/cm^2)	D_{ENV-99} (μJ/cm^2)
BACTERIA	1000	3	6.6	3000	6600
ENDOSPORE	1000	4.5	8.7	4500	8700
FUNGI	1000	44	88	44000	88000
YEAST	1000	3.3	6.6	3300	6600

[0073] For purposes of illustration only, Table II below shows an example of the higher relative humidity (e.g., in this particular instance, r(h)=5, D_T=M=1, and D_{SUN}=0).

Contaminant	UV Intensity (μW/cm^2)	r(h) * t_{EXPOS} [for 90% kill ratio] (s)	r(h) * t_{EXPOS} [for 99% kill ratio] (s)	r(h) * D_{ENV-90} (μJ/cm^2)	r(h) * D_{ENV-99} (μJ/cm^2)
BACTERIA	1000	15	33	15000	33000
ENDOSPORE	1000	22.5	43.5	22500	43500
FUNGI	1000	220	440	220000	440000
YEAST	1000	16.5	33	16500	33000

[0074] For purposes of illustration only, Table III below shows an example of the relatively high surface moisture (e.g., in this particular instance, M=10, r(h)=D_T=1, and D_{SUN}=0).

Contaminant	UV Intensity (μW/cm^2)	M * t_{EXPOS} [for 90% kill ratio] (s)	M * t_{EXPOS} [for 99% kill ratio] (s)	M * D_{ENV-90} (μJ/cm^2)	M * D_{ENV-90} (μJ/cm^2)
BACTERIA	1000	30	66	30000	66000
ENDOSPORE	1000	45	87	45000	87000
FUNGI	1000	440	880	440000	880000
YEAST	1000	33	66	33000	66000

[0075] In at least one example of block **430**, sensor data from multiple environmental sensors **18** are used to determine the UV dosage. Further, in at least one example, computer **14**—in its dosage calculation—uses sensor data from each of sensor **18**$_T$, sensor **18**$_H$, sensor **18**$_S$, and sensor **18**$_{SM}$.

[0076] While not required, computer **14** may identify a type of contaminant by determining a likelihood (e.g., a statistical probability) of the type of contaminant using measurement values of the environmental sensors **18**, as well as other geographic data, calendar data, etc. For example, computer **14** may predict the presence of endospores and fungi by determining a relatively high humidity (e.g., about 90%), temperatures between 20-30° C., and a relatively high surface moisture (e.g., wherein M is between 8-10). Computer **14** via telematics module **34** may receive an indication of geographic location (e.g., Tampa, Fla., USA) and time of year (e.g., September), and based on this additional information, further may narrow a likely contaminant (e.g., to be a fungi or particular strain of fungi). In at least one example, the UV dosage is based on a contaminant type prediction using such a predictive algorithm; however, this is not required.

[0077] Returning to FIG. **4**, following block **430**, computer **14** may execute instructional block **440**. In block **440**, computer **14** controls and actuates a light source **50** based on UV dosage calculated in block **430**. Thus, the light source **50** emits UV light according to the center wavelength (λ) and bandwidth and according to the calculated intensity (Φ). According to one non-limiting example, the intensity (Φ) may be between 500-2000 μW/cm^2. Due to beam divergence, attenuation, and other losses, computer **14** may emit UV light at an intensity (e.g., at the light source **50**) that is greater than is expected to be received at the targeted surface **22** (and detector **52**); these higher values may be determined empirically (at the vehicle manufacturer) or using the feedback loop discussed above. Further, according to at least one example, the total dosage (D_{ENV}) delivered to the respective surface **22** for any application period may be less than a maximum dosage (D_{MAX}) (e.g., one non-limiting example of maximum dosage (D_{MAX}) may be 1,000,000 μJ/cm^2 or 1 J/cm^2), and this maximum dosage may be associated with minimizing interior component deterioration.

[0078] In block **440**, computer **14** also may actuate a timer (e.g., via processor **40**) to track the exposure time. This timer may be executed in software via processor **40** (or via an electrical timing circuit coupled to processor **40**). Regardless, as discussed above, this UV light may be directed at the targeted interior surface **22** of cabin **20**—which also may include a corresponding light detector **52**. As the computer **14** may attempt to deliver UV light to the surface **22** according to the dosage, block **440** may include adjusting a magnitude of the emission intensity (Φ) based on the feedback data provided by detector **52** (as discussed above).

[0079] Following block **440**, computer **14** may re-determine whether a user is in the vehicle **12** (block **450**). This instruction may be similar or identical to block **420**; therefore, it will not be re-described herein. Using this block, computer **14** may repeatedly check the cabin **20** for a user ingressing vehicle **12** (e.g., during the transmission of UV light). In at least some examples, block **450** may include determining that a user is approaching vehicle **12**, a user is opening a vehicle door, or the like. When computer **14** determines in block **450** that vehicle **12** remains in the unoccupied state, then process **400** may proceed to block **460**. And when computer **14** determines that the vehicle is in an occupied state or about to be occupied, then process **400** proceeds to block **470** (discussed below).

[0080] In block **460**, computer **14** determines whether the exposure duration (t_{EXPOS}) has expired by comparing the current run time of the timer (previously initiated) with the exposure duration (t_{EXPOS}). When computer **14** determines that vehicle **12** the exposure duration (t_{EXPOS}) has not expired, then process **400** may loop back to block **440**. And when computer **14** determines that the exposure duration (t_{EXPOS}) has expired, then process **400** proceeds to block **470**. Thus, computer **14** may execute blocks **440**, **450**, and **460** repeatedly—e.g., checking the occupancy state of the vehicle **12** and whether the exposure duration (t_{EXPOS}) has expired. In the latter case (as discussed above), de-actuating the light source **50** at the expiration of the exposure duration (t_{EXPOS}) inhibits overdosing of targeted surface **22**—e.g., and mitigating premature deterioration of the vehicle interior components.

[0081] In block **470**, computer **14** actuates the light source **50** to an OFF state. As discussed above, this may occur following a user ingress attempt or a user ingressing the vehicle **12** (e.g., block **450**) or following the expiration of an exposure duration (e.g., block **460**). During instances when multiple light sources **50** are dosing one or more interior surfaces **22**, and when a user ingress is detected (block **450**), computer **14** may de-actuate all light sources **50** via instructional block **470**.

[0082] Following block **470**, process **400** may proceed to block **480**, to block **410**, or end. For example, optional instructional block **480** may comprise computer **14** actuating at least one climate control parameter based on the sensor data collected in block **410** and/or based on the calculated UV dosage of block **430**. As used herein, actuating a climate control parameter is a computer-actuated operation of the climate control system **30**: that, when the parameter is adjusted, changes a temperature of the vehicle cabin **20**; that, when the parameter is adjusted, changes a humidity within the cabin **20**; and/or that, when the parameter is adjusted, changes a volume of forced air into the cabin **20**. Non-limiting examples include increasing the temperature of the cabin **20**, decreasing the humidity within the cabin **20**, and increasing the amount of forced air (e.g., through HVAC vents into the cabin **20**).

[0083] According to at least one example, one or more climate control parameters are actuated by computer **14** in response to a determined contamination type. In this manner, when the light source(s) **50** are in the OFF state, additional contaminant growth is minimized.

[0084] Following block **480**, the process **400** either ends or loops back and repeats (at least a portion thereof) beginning with block **410**. Similarly, when optional block **480** is omitted, the process proceeds from block **470** to either block **410** or simply ends.

[0085] Other examples exist. For example, block **470** may be executed when computer **14** determines that light source **50** is actuated but light detector **52** is receiving less than a threshold (e.g., less than **100** μJ/cm^2) amount of UV light—e.g., indicating a misalignment of source **50** and detector **52**. As a result, computer **14** may execute a shut-off instruction and may generate a diagnostic trouble code and not actuate the light source **50** until the vehicle **12** has been serviced by an authorized service technician.

[0086] Similarly, according to at least one example, block **470** may be executed when computer **14** determines that light source **50** is actuated but light detector **52** is receiving UV light within a threshold range (e.g., 100-500 μJ/cm^2)—e.g., indicating a potential fault at source **50** and/or detector **52**. Similarly, computer **14** may execute a shut-off instruction and may generate a diagnostic trouble code and not actuate the light source **50** until the vehicle **12** has been serviced by an authorized service technician.

[0087] Similarly, according to at least one example, block **470** may be executed when computer **14** determines that light source **50** is actuated but light detector **52** is receiving UV light greater than a threshold (e.g., 2000 μJ/cm^2)—e.g., indicating a potential fault at source **50**. Similarly, computer **14** may execute a shut-off instruction and may generate a diagnostic trouble code and not actuate the light source **50** until the vehicle **12** has been serviced by an authorized service technician.

[0088] According to at least one example, in block **420**, computer **14** also may determine window state data and/or controls the state of the vehicle windows (e.g., from an open state to a closed state)—e.g., prior to actuating the light source **50**. In this manner, UV light from the source **50** may be contained within the vehicle **12**—e.g., particularly if the windows are manufactured with a protective UV-blocking film, polarizing glazing, or the like.

[0089] Tables I, II, and III illustrated a constant intensity value (e.g., 1000 μW/cm^2) of UV light received at the surface **22**, and the exposure duration (t_{EXPOS}) was increased in some instances (e.g., by a multiplier) to vary UV dosage. According to another example, UV dosage may be varied by changing the UV intensity (Φ), changing the exposure duration (t_{EXPOS}), or a combination thereof. Of course, when computer **14** increases the UV intensity, the intensity still may be bounded by a threshold range or maximum (e.g., between 500-2000 μW/cm^2).

[0090] Thus, there has been described a cleaning system for a vehicle. The system includes a computer and a lighting system. The computer is programmed to receive sensor data from one or more environmental sensors in the vehicle cabin, and then, based on the data, determine a light dosage to emit from the lighting system toward an interior surface of the cabin.

[0091] In general, the computing systems and/or devices described may employ any of a number of computer operating systems, including, but by no means limited to, versions and/or varieties of the Ford SYNC® application, AppLink/Smart Device Link middleware, the Microsoft® Automotive operating system, the Microsoft Windows® operating system, the Unix operating system (e.g., the Solaris® operating system distributed by Oracle Corporation of Redwood Shores, Calif.), the AIX UNIX operating system distributed by International Business Machines of Armonk, N.Y., the Linux operating system, the Mac OSX and iOS operating systems distributed by Apple Inc. of Cupertino, California, the BlackBerry OS distributed by Blackberry, Ltd. of Waterloo, Canada, and the Android operating system developed by Google, Inc. and the Open Handset Alliance, or the QNX® CAR Platform for Infotainment offered by QNX Software Systems. Examples of computing devices include, without limitation, an on-board vehicle computer, a computer workstation, a server, a desktop, notebook, laptop, or handheld computer, or some other computing system and/or device.

[0092] Computing devices generally include computer-executable instructions, where the instructions may be executable by one or more computing devices such as those listed above. Computer-executable instructions may be compiled or interpreted from computer programs created using a variety of programming languages and/or technologies, including, without limitation, and either alone or in combination, Java™, C, C++, Visual Basic, Java Script, Perl, etc. Some of these applications may be compiled and executed on a virtual machine, such as the Java Virtual Machine, the Dalvik virtual machine, or the like. In general, a processor (e.g., a microprocessor) receives instructions, e.g., from a memory, a computer-readable medium, etc., and executes these instructions, thereby performing one or more processes, including one or more of the processes described herein. Such instructions and other data may be stored and transmitted using a variety of computer-readable media.

[0093] A computer-readable medium (also referred to as a processor-readable medium) includes any non-transitory (e.g., tangible) medium that participates in providing data (e.g., instructions) that may be read by a computer (e.g., by a processor of a computer). Such a medium may take many forms, including, but not limited to, non-volatile media and volatile media. Non-volatile media may include, for example, optical or magnetic disks and other persistent memory. Volatile media may include, for example, dynamic random access memory (DRAM), which typically constitutes a main memory. Such instructions may be transmitted by one or more transmission media, including coaxial cables, copper wire and fiber optics, including the wires that comprise a system bus coupled to a processor of a computer. Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, DVD, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, a RAM, a PROM, an EPROM, a FLASH-EEPROM, any other memory chip or cartridge, or any other medium from which a computer can read.

[0094] Databases, data repositories or other data stores described herein may include various kinds of mechanisms for storing, accessing, and retrieving various kinds of data, including a hierarchical database, a set of files in a file system, an application database in a proprietary format, a relational database management system (RDBMS), etc. Each such data store is generally included within a computing device employing a computer operating system such as one of those mentioned above, and are accessed via a network in any one or more of a variety of manners. A file system may be accessible from a computer operating system, and may include files stored in various formats. An RDBMS generally employs the Structured Query Language (SQL) in addition to a language for creating, storing, editing, and executing stored procedures, such as the PL/SQL language mentioned above.

[0095] In some examples, system elements may be implemented as computer-readable instructions (e.g., software) on one or more computing devices (e.g., servers, personal computers, etc.), stored on computer readable media associated therewith (e.g., disks, memories, etc.). A computer program product may comprise such instructions stored on computer readable media for carrying out the functions described herein.

[0096] The processor is implemented via circuits, chips, or other electronic component and may include one or more microcontrollers, one or more field programmable gate arrays (FPGAs), one or more application specific circuits ASICs), one or more digital signal processors (DSPs), one or more customer integrated circuits, etc. The processor may be programmed to process the sensor data. Processing the data may include processing the video feed or other data stream captured by the sensors to determine the roadway lane of the host vehicle and the presence of any target vehicles. As described below, the processor instructs vehicle components to actuate in accordance with the sensor data. The processor may be incorporated into a controller, e.g., an autonomous mode controller.

[0097] The memory (or data storage device) is implemented via circuits, chips or other electronic components and can include one or more of read only memory (ROM), random access memory (RAM), flash memory, electrically programmable memory (EPROM), electrically programmable and erasable memory (EEPROM), embedded MultiMediaCard (eMMC), a hard drive, or any volatile or non-volatile media etc. The memory may store data collected from sensors.

[0098] The disclosure has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Many modifications and variations of the present disclosure are possible in light of the above teachings, and the disclosure may be practiced otherwise than as specifically described.

1. A method, comprising:

at a vehicle computer:

receiving data from at least one environmental sensor;

based on the data, determining an ultraviolet (UV) dosage for an interior surface of a cabin; and

based on the determination, controlling UV light according to the dosage.

2. The method of claim **1**, wherein controlling further comprises actuating a light source within the cabin which directs the light toward the surface.

3. The method of claim **1**, wherein the light comprises a band within **240-280** nanometers.

4. The method of claim **1**, wherein the dosage is based on a light intensity, an exposure duration, and at least one function based on the data.

5. The method of claim **4**, further comprising de-actuating a light source at an expiration of the duration.

6. The method of claim **1**, further comprising adjusting at least one climate control parameter based on the determination.

7. The method of claim **1**, wherein controlling further comprises changing an intensity of the light based on feedback from a detector at the surface.

8. The method of claim **1**, wherein the determination further comprises increasing an intensity of the light based on a relative humidity being greater than a threshold.

9. The method of claim **1**, wherein the determination further comprises decreasing an intensity of the light based on a relative temperature being less than a first threshold or greater than a second threshold.

10. The method of claim **1**, wherein the determination further comprises increasing an intensity of the light based on moisture at the surface being greater than a threshold.

11. The method of claim **1**, wherein the determination further comprises decreasing an intensity of the light based on a measurement of UV sunlight at the surface.

12. The method of claim **1**, further comprising inhibiting UV light emission based on an occupied state of the vehicle or a user ingres sing.

13. The method of claim **1**, further comprising inhibiting UV light emission based on relative airflow being greater than a threshold.

14. The method of claim **1**, further comprising inhibiting UV light emission based an open state of vehicle windows.

15. The method of claim **1**, wherein the dosage is based on a selected sterilization level.

16. A system, comprising:

a computer, comprising processor and memory storing instructions executable by the processor, the instructions comprising, to:

receive data from at least one environmental sensor;

based on the data, determine an ultraviolet (UV) dosage for an interior surface of a cabin; and

based on the determination, control UV light according to the dosage.

17. The system of claim **16**, further comprising a lighting system coupled to the computer.

18. The system of claim **17**, wherein the lighting system comprises a light source and a detector which provides UV light intensity feedback.

19. The system of claim **15**, wherein the instructions further comprise, to: determine the dosage based on one of a relative humidity, a relative temperature, or a moisture at the surface.

20. The system of claim **15**, wherein the instructions further comprise, to: adjust the dosage based on a measurement of UV sunlight at the surface.

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