

SPRAY DEVICE AND METHOD FOR CONTROLLING THE SAME

Technical Field

- 5 **[0001]** Various embodiments relate to a spray device and a method for controlling the spray device.

Background

- 10 **[0002]** There is a need to replace manual disinfecting methods with automatic systems. This need has been heightened following the COVID-19 pandemic. Known automatic disinfecting systems may be based on existing robot designs generally of humanoid shape. These inherently have intricate shapes and details to replicate humans. After a robot has been in an infected area, it itself has to be disinfected and wiped down. One disadvantage of the known robots and
15 especially the humanoid shapes is that they are not easy to clean/wipe due to the intricate details described above. Thus potentially there may be areas that still carry bacteria and viruses that can be harmful to the human operators.

[0003] There is therefore need to address the above-mentioned problems.

Summary

20 **[0004]** The invention is defined in the independent claims. Further embodiments of the invention are defined in the dependent claims.

- [0005]** According to an embodiment, a spray device for spraying fluid is provided. The spray
25 device may include a spray mechanism configured to spray a fog of droplets of the fluid into a space, a housing configured to house the spray mechanism, the housing having an external surface that is at least substantially smooth, and a drive mechanism configured to navigate the spray device through the space so that the fog of the droplets contacts the external surface and the contacted droplets drain over the external surface.

- 30 **[0006]** According to an embodiment, a method for controlling a spray device for spraying fluid is provided. The method may include spraying, by means of a spray mechanism of the spray

device, a fog of droplets of the fluid into a space, wherein the spray mechanism is housed by a housing of the spray device, the housing having an external surface that is at least substantially smooth, and navigating the spray device, by means of a drive mechanism of the spray device, through the space so that the fog of the droplets contacts the external surface and the contacted droplets drain over the external surface.

Brief Description of the Drawings

[0007] In the drawings, like reference characters generally refer to like parts throughout the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments of the invention are described with reference to the following drawings, in which:

[0008] FIG. 1 shows schematic views of a spray device, according to various embodiments.

[0009] FIG. 2A and 2B show schematic cross-sectional views of a spray device, according to various embodiments.

Detailed Description

[0010] The following detailed description refers to the accompanying drawings that show, by way of illustration, specific details and embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, and electrical changes may be made without departing from the scope of the invention. The various embodiments are not necessarily mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new embodiments.

[0011] Embodiments described in the context of one of the methods or devices are analogously valid for the other methods or devices. Similarly, embodiments described in the context of a method are analogously valid for a device, and vice versa.

[0012] In the context of various embodiments, the phrase “at least substantially” may include “exactly” and a reasonable variance.

[0013] In the context of various embodiments, the term “about” as applied to a numeric value encompasses the exact value and a reasonable variance.

[0014] As used herein, the phrase of the form of “at least one of A or B” may include A or B or both A and B. Correspondingly, the phrase of the form of “at least one of A or B or C”, or including further listed items, may include any and all combinations of one or more of the associated listed items.

[0015] Various embodiments may provide a self disinfecting spray device, e.g., a self disinfecting robot (SDR) or a self-cleansing disinfectant robot. The spray device may be an automated spraying device that has a smooth outer surface with minimal or without any protuberances, nooks and crannies. The device may clean itself as it is disinfecting.

[0016] Various embodiments may provide a disinfectant robot. The robot may be designed for use in affected areas and general disinfection. The robot may be operated by a human operator to reach every corner of the affected area with the aid of one or more cameras, e.g., two water resistant cameras. For general disinfection, the robot may be set on automatic navigation to apply the disinfectant.

[0017] According to the techniques disclosed herein, the outer shell of the device (e.g., robot) may be made of smooth streamlined surfaces with minimal or no protuberances, nooks and crannies where foreign matter may gather and reside. Inherent in the shape is the ability for any fluids to drain away. The device may easily and quickly be wiped to finish the cleaning process. The process may minimise the exposure of operators to harmful areas. The device may also offer accurate and, thus, efficient use of the disinfectant, maximising its impact to disinfect.

[0018] In various embodiments, the shape of the spray device (e.g., a robot) may provide water resistant and self-disinfecting capabilities. The device may have one or more nozzles that may point and spray outwards while the device moves and the (disinfectant) fluid may cover the entire robot body surface. The body or housing may be made with fiberglass, ABS (acrylonitrile butadiene styrene), resin or nylon. The spray device may include one or more cameras and a lidar system to aid navigation of the spray device. The camera(s) and lidar may be IP65 rating. The shape of the device and spray vaporization may enable the disinfectant fluid to settle on the outer surface of the housing and drain away. The housing of the device may have a smooth streamlined surface with minimal or no protuberances, nooks and crannies where foreign matter can otherwise gather and reside.

[0019] In terms of coverage of the disinfectant, the droplets may float to cover more surfaces, and reach out to nooks and crannies for deep penetration disinfection. The self-cleansing capability of the spray device may reduce the risk of infection as exposure to human is reduced. The automation, ability to cover large area and combination of using human operator to
5 disinfect reduces the time versus doing the disinfection process manually. Further, using self-navigation to cover a large area may reduce operation and labour cost.

[0020] Various embodiments may provide a spray device for spraying fluid. The spray device includes a spray mechanism configured to spray a fog of droplets of the fluid into a space, a housing configured to house the spray mechanism, the housing having an external surface that
10 is at least substantially smooth, and a drive mechanism configured to navigate the spray device through the space so that the fog of the droplets contacts the external surface and the contacted droplets drain over the external surface.

[0021] In other words, a spray device having a spray mechanism for spraying a fluid (e.g., a disinfectant fluid) in a fog of droplets of the fluid into a space may be provided. The fog may be
15 sprayed, for example, outwardly and/or upwardly. The fog of droplets may mean an aerosol of the droplets of the fluid. The droplets may hang in the air, at least temporarily. The droplets may float in the air and/or may be carried with air movement (wind).

[0022] The spray device may further include a housing to house the spray mechanism. The housing may support the spray mechanism, and in this way, the housing may act as a
20 supporting structure. The housing may have an external or exterior surface that is at least substantially smooth (e.g., a smooth streamlined surface). The external surface or at least part of the external surface, e.g., a lower section of the housing, may be at least substantially flat or planar.

[0023] The spray device may further include a drive mechanism for driving or navigating the
25 spray device through the space, as well as into and out of the space. Accordingly, the spray device may be movable, driven by the drive mechanism. The drive mechanism may be coupled to the housing. The drive mechanism may include a chassis with wheels, motors, gears, etc.

[0024] The external surface may be covered by or may come into contact with the fog of the droplets that is sprayed, for example, as the spray device is navigated through the space. The
30 droplets that contact the external surface may drain over the external surface, for example, drain downwards or flow down the external surface. Due to the smooth external surface, the fluid

may be drained away with minimal or without resistance. There is generally no pooling of the fluid on the external surface due to the smooth nature of the surface. Movement of the spray device, while it is being navigated through the space, may also aid draining of the contacted droplets over the external surface. By contacting the external surface with the fog of the droplets and draining, there may be self-cleaning (e.g., self-disinfecting) of the housing or the spray device.

[0025] The housing includes an external surface that may contact the fluid that is sprayed, and the housing may have a shape adapted to allow or aid draining of the contacted fluid over the external surface, where the external surface is at least substantially smooth.

[0026] In various embodiments, the spray mechanism may include a nozzle arrangement. The nozzle arrangement may include a first nozzle arranged towards an upper part of the spray device, and a second nozzle arranged towards a lower part of the spray device. At least one of the first nozzle or the second nozzle may be movable. At least one of the first nozzle or the second nozzle may be orientated to spray the fog in any direction, including, for example, upwardly, horizontally and downwardly. It should be appreciated that one or more additional nozzles may further be provided, depending on the applications.

[0027] In various embodiments, the housing may include an upper section to support the first nozzle, and a lower section to support the second nozzle. The spray device may be arranged to allow relative movement between the upper section and the lower section. This may mean that at least one of the upper section or the lower section may be movable, e.g., rotatable.

[0028] The spray mechanism may further include a pressurisation device (or an atomisation device) to atomise the fluid for spraying the fog into the space. The pressurisation (or atomisation) device may include a compressor or a (high pressure) pump.

[0029] At least one opening may be defined in the housing, and the spray device may further include a cover for sealing the at least one opening, the cover being arranged flushed with the external surface of the housing. The at least one opening may allow access into an internal part of the housing or the spray device.

[0030] In various embodiments, a top portion of the housing may be dome-shaped.

[0031] In various embodiments, the housing may be conical-shaped.

[0032] In various embodiments, the spray device may further include a camera arrangement. The camera arrangement may allow remote viewing of the space, and/or imaging of the space, including video recording. This may aid navigation of the spray device through the space.

[0033] In various embodiments, the spray device may further include an optical sensing mechanism (e.g., Lidar mechanism or system) to aid navigation of the spray device through the space.

[0034] In various embodiments, the spray device may further include a power source. The power source may include a battery, e.g., a rechargeable battery.

[0035] In various embodiments, the external surface may be free of protuberance, nook and cranny.

[0036] In various embodiments, the external surface may include a glossy surface, e.g., a (high) gloss finish.

[0037] In various embodiments, the housing may be made of fiberglass, ABS, resin or nylon.

[0038] In the context of various embodiments, the spray device may be a robot or a robotic device, e.g., a portable or movable robot.

[0039] Various embodiments may also provide a method for controlling a spray device for spraying fluid. The method includes spraying, by means of a spray mechanism of the spray device, a fog of droplets of the fluid into a space, wherein the spray mechanism is housed by (or within, at least partially) a housing of the spray device, the housing having an external surface that is at least substantially smooth, and navigating the spray device, by means of a drive mechanism of the spray device, through the space so that the fog of the droplets contacts the external surface and the contacted droplets drain over the external surface.

[0040] The method may further include, prior to spraying the fog of the droplets, atomising the fluid.

[0041] Various embodiments or techniques will now be further described in detail, by way of non-limiting examples and with reference to FIGS. 1, 2A and 2B.

[0042] FIG. 1 shows schematic views of a spray device 1, according to various embodiments. The spray device 1 may be a self disinfecting or self cleaning robot. The spray device 1 may have a shape with a smooth outer surface with minimal or no protuberances, nooks and crannies.

[0043] The spray device 1 may include a top domed part (e.g., upper section) 2 and a body part (e.g., lower section) 3. The top part 2 and the body part 3 may define a housing 7 for the spray device 1. There may be relative movement between the sections 2, 3. At least one of the upper section 2 or the lower section 3 may be movable, e.g., rotatable.

5 **[0044]** The bottom end 4 may be designed to interface with a chassis 5 that has wheels 8, drive and navigation systems (not shown). The chassis 5 may define a drive mechanism for the spray device 1. The bottom part 4 may form part of the housing 7. The exterior or external surface 6 of the housing 7 has a smooth surface with minimal or no protuberances. The surface 6 may optionally be painted to a high gloss finish.

10 **[0045]** The housing (or shell) 7 of the spray device 1 may have access openings 10 and 11, illustrated as examples. Removable covers 12, 13 may be provided for the openings 10, 11. The covers 12, 13 may be designed to be of a minimum thickness or may be inset and fixed to make them flush with the outer surface 6.

[0046] The spray device 1 may include a spray mechanism for spraying fluid (e.g., disinfectant fluid), e.g., in the form of a fog of droplets of the fluid. The spray mechanism may include a nozzle arrangement of one or more nozzles. By way of example, two nozzles 20, 21 are shown in FIG. 1, with the positions of these disinfectant application nozzles 20, 21 illustrated as a non-limiting example. The nozzle 20 may be provided at an upper region of the spray device 1, e.g., at the upper section 2, and the nozzle 21 may be provided at the bottom region of the spray device 1, e.g., at the lower section 3. One or more further nozzles may be added, if required. There may be a number of shelves or sections (e.g., sections 2, 3) of the housing 7 to mount the spraying mechanism.

25 **[0047]** The nozzle 20 may be employed to create a cone of fog of the fluid for treating the bulk of the volume of a space or chamber being disinfected. The nozzle 20 may be mounted at a wide range of heights on a side wall of the housing 7. The orientation may be determined by the end use applications, for example, high roof warehouses or low ceiling medical rooms. The nozzle 20 may be used for spraying fluid in any direction, including upwardly, downwardly, horizontally, etc. The nozzle 20 may be movable.

30 **[0048]** The nozzle 21 may be employed to produce a flat cone of fog of the fluid to disinfect under fixtures such as beds and tables. The nozzle 20 may be used for spraying fluid in any direction, including upwardly, downwardly, horizontally, etc. The nozzle 21 may be movable.

[0049] The spray device 1 may include a power source (not shown), such as a rechargeable battery, for example, a lithium battery.

[0050] The spray device 1 may operate within an atmosphere of disinfectant fog in the chamber/space, and, as a result, the device 1 may itself be disinfected while the device 1 is carrying out disinfection of the space. Any fog condensate on the housing 7 may drain down the smooth surface 6 without pooling.

[0051] Water-based disinfectant fluids may be used for the spray device 1, for example, chlorine or hydro peroxide disinfectant. Alcohol-based fluids may be used although this is less preferable as these fluids are volatile or flammable.

[0052] As a non-limiting example, a conical housing 7 is shown in FIG. 1. Alternative shapes are possible within the context of a smooth surface with minimal or without any protuberances, nooks and crannies. For example, the lower section 3 may be of a cylindrical shape.

[0053] As a non-limiting example, the total height of the spray device 1 may be around 1.2 m.

[0054] FIG. 2A and 2B show schematic cross-sectional views of a spray device 1a to illustrate at least some of the internal structures of the spray device 1a. Dimensions for the spray device 1a are shown in FIG. 2A, in unit mm. Also shown in FIGS. 2A and 2B is the chassis (or wheelbase) 5 with motor(s), motor driver(s) and wheels 8. The spray device 1a may be similar to the spray device 1, and description for like features are omitted for brevity. It should be appreciated that description in the context of the spray device 1 may be applicable to the spray device 1a, and vice versa.

[0055] The spray device 1a may include two nozzles 20, 21. The spray device 1a may include a (in-built) tank 50 to receive or contain the fluid (e.g., disinfectant fluid) 51 to be sprayed. There is an opening 52 to allow refilling of the tank 50. A connector 53 is provided for fluid communication between the tank 50 and the nozzles 20, 21 to allow the fluid 51 to be provided to the nozzles 20, 21.

[0056] The spray device 1a may include a camera arrangement to allow a human operator of the spray device 1a to remotely view the space or chamber to be disinfected. For example, a first camera 40 may be provided proximate to the upper nozzle 20, and a second camera 41 may be provided proximate to the lower nozzle 21. The cameras 40, 41 may be water resistant. The cameras 40, 41 may be used by a human operator to view the space the spray device 1a is in and to aid navigation of the spray device 1a through the space.

[0057] Referring to FIG. 2B, the spray device 1a may further include an optical sensing mechanism 60, for example, a Lidar (Light Detection and Ranging) system, to aid navigation of the spray device 1a through the space that is to be disinfected. The Lidar system 60 is a remote sensing device that uses light (e.g., in the form of a pulsed laser) to measure ranges or distance.

5 The Lidar system 60 may include an optical source (e.g., a laser) for emitting an optical signal and an optical sensor for receiving the optical signal that is reflected by a target for measuring the distance to the target. The system 60 may be used for navigation purposes by the spray device 1a.

[0058] A pressurisation device 70, e.g., an air compressor, may be provided. The air
10 compressor 70 may atomise the fluid to be sprayed through the top nozzle 20 and the bottom nozzle 21 to create a fog of droplets of the fluid. For atomisation purpose, the air in the tank of the compressor may be charged. The pressurisation device 70 may be coupled to the tank 50 and the nozzles 20, 21. Different sizes of droplets may be produced at different pressures. As a non-limiting example, the droplet size may range from about 7.5 micron at a pressure of 4 bar
15 to about 20 micron at 1 bar.

[0059] The spray device 1a may further include a power source arrangement, for example, having a plurality of batteries (e.g., six batteries) 76 (e.g., lithium batteries), and a corresponding plurality of battery chargers (e.g., six chargers) 78.

[0060] The spray device 1a may further include a fan louvre 80 and a DC-AC inverter 82.

20 [0061] As non-limiting examples, the techniques disclosed herein may provide a disinfectant robot that is a 1.2 m tall robot that may utilize a vaporization and spray technique to spray 8.5 sqm of coverage per minute. The robot may have 2 nozzles. The top nozzle may be able to achieve a spray distance of about 2 m and provide various droplet sizes that may be achieved at pressures of between 1 - 4 bar. The droplet size may range from about 7.5 micron at 4 bar to
25 about 20 micron at 1 bar. The work hour of the robot may be about 3 hours continuously due to the capacity of a lithium battery. Nevertheless, increasing the capacity of the battery may provide a longer working time. Together with the lower nozzle (e.g., nozzle 21), the design is to cover deep penetration cleansing into cavities. The use case is either autonomous navigation or by remote control by an operator for affected area or general disinfection. There may be two
30 cameras for remote control operator to view the front of the robot or video recording can be done via the cameras to a portal where the footage may be stored.

[0062] The spray devices of various embodiments are designed to enable disinfection effectively and quickly to reduce human manpower and safety. The devices may provide safety for the operator and a lower cost of operation with automation.

[0063] As described above, the spray device may be self-disinfecting and by using remote control for disinfection against virus or bacteria, the spray device reduces the human risk of catching infection in the affected area. The spray device disclosed herein may enable a faster speed of operation as it is faster to disinfect using a robot than using human. The spray device disclosed herein may achieve a 3-metre distance coverage minimally with the nozzle arrangement and air technique (i.e., creation of fog of fluid droplets who sizes may be varied with pressures) disclosed herein.

[0064] While the invention has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

CLAIMS

1. A spray device for spraying fluid, the spray device comprising:
a spray mechanism configured to spray a fog of droplets of the fluid into a space;
5 a housing configured to house the spray mechanism, the housing comprising an external surface that is at least substantially smooth; and
a drive mechanism configured to navigate the spray device through the space so that the fog of the droplets contacts the external surface and the contacted droplets drain over the external surface.
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2. The spray device as claimed in claim 1, wherein the spray mechanism comprises a nozzle arrangement.
3. The spray device as claimed in claim 2, wherein the nozzle arrangement comprises:
15 a first nozzle arranged towards an upper part of the spray device; and
a second nozzle arranged towards a lower part of the spray device.
4. The spray device as claimed in claim 3, wherein the housing comprises:
an upper section configured to support the first nozzle; and
20 a lower section configured to support the second nozzle.
5. The spray device as claimed in claim 4, wherein the spray device is arranged to allow relative movement between the upper section and the lower section.
- 25 6. The spray device as claimed in any one of claims 1 to 5, wherein the spray mechanism comprises a pressurisation device configured to atomise the fluid for spraying the fog into the space.
7. The spray device as claimed in any one of claims 1 to 6, wherein at least one opening is
30 defined in the housing, and the spray device further comprises a cover for sealing the at least one opening, the cover being arranged flushed with the external surface of the housing.

8. The spray device as claimed in any one of claims 1 to 7, wherein a top portion of the housing is dome-shaped.

9. The spray device as claimed in any one of claims 1 to 8, wherein the housing is conical-shaped.

10. The spray device as claimed in any one of claims 1 to 9, further comprising a camera arrangement.

11. The spray device as claimed in any one of claims 1 to 10, further comprising an optical sensing mechanism to aid navigation of the spray device through the space.

12. The spray device as claimed in any one of claims 1 to 11, further comprising a power source.

13. The spray device as claimed in any one of claims 1 to 12, wherein the external surface is free of protuberance, nook and cranny.

14. The spray device as claimed in any one of claims 1 to 13, wherein the external surface comprises a glossy surface.

15. The spray device as claimed in any one of claims 1 to 14, wherein the housing is made of fiberglass, acrylonitrile butadiene styrene, resin or nylon.

16. A method for controlling a spray device for spraying fluid, the method comprising:
spraying, by means of a spray mechanism of the spray device, a fog of droplets of the fluid into a space, wherein the spray mechanism is housed by a housing of the spray device, the housing comprising an external surface that is at least substantially smooth; and
navigating the spray device, by means of a drive mechanism of the spray device, through the space so that the fog of the droplets contacts the external surface and the contacted droplets drain over the external surface.

17. The method as claimed in claim 16, further comprising, prior to spraying the fog of the droplets, atomising the fluid.