

DESCRIPTION

TITLE OF INVENTION: A CLEANING ROBOT

TECHNICAL FIELD

[0001] This invention relates to a cleaning device. More particularly, this invention relates to a cleaning robot for use in the cleaning of an environment.

BACKGROUND

[0002] The following discussion of the background to the invention is intended to facilitate an understanding of one or more inventions disclosed by the present disclosure only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general knowledge of the person skilled in the art in any jurisdiction as at the priority date of one or more inventions disclosed by the present disclosure.

[0003] An environment (for example a lavatory) may be cleaned by a cleaning robot that can be operated by a human operator or be programmed to automatically clean the environment. Cleaning robots may be developed for specific tasks such as cleaning floors, cleaning toilet bowls and cleaning walls, where such robots may be equipped with specific tools and/or functions that allow them to appropriately perform the tasks that they have been developed for.

[0004] By way of an example, the fixtures and fittings in a lavatory environment create areas that are difficult to access and clean, thereby allowing bacteria to thrive. Additionally, stubborn stains commonly occur in toilet bowls that are difficult to remove. Most cleaning robots can only perform floor cleaning which is a two-dimensional process. The cleaning of structures in a lavatory, such as a urinal, a toilet bowl, a basin and a mirror requires a robot that can perform three-dimensional cleaning with different tools. Additionally, using clean water alone to clean lavatory structures especially those with stubborn stains, which known cleaning robots do, is insufficient to achieve the sterilization and disinfection appropriate for the environment. Supplementing the clean water with cleaning chemicals is not eco-friendly. While there are cleaning robots that use a robotic arm to grip and hold a water gun for spraying water when cleaning, the cleaning process performed by such robots is typically long due to the constant need for robotic arm to swap between water gun and other cleaning tools.

[0005] Therefore, there exists a need to provide a cleaning device that addresses, alleviates or ameliorate, at least in part, one or more of the aforementioned problems.

SUMMARY

[0006] According to an aspect of the present disclosure, there is provided a cleaning robot comprising:

a body comprising:

a flushing liquid tank configured to contain a flushing liquid comprising water;

a first flushing outlet;

an ozone generator, and

a mobility mechanism configured to support the body and provide mobility to the cleaning robot along a surface,

wherein the ozone generator is configured to receive the flushing liquid from the flushing liquid tank to form aqueous ozone, and the cleaning robot is configured to provide aqueous ozone from the ozone generator to the first flushing outlet to clean an environment.

[0007] In some configurations, the ozone generator comprises an electrolytic ozone generator configured to provide an electrical discharge to a volume of flushing liquid received by the ozone generator from the flushing liquid tank to form the aqueous ozone.

[0008] In some configurations, the electrolytic ozone generator comprises

an active state wherein the electrical discharge is provided to the volume of flushing liquid, and

an inactive state wherein the electrical discharge is not provided to the volume of flushing liquid,

wherein the electrolytic ozone generator is configured to be in the active state when flushing liquid from the flushing liquid tank is provided to the electrolytic ozone generator, and wherein the electrolytic ozone generator is configured to be in the inactive state when the flushing liquid from the flushing liquid tank is not provided to the electrolytic ozone generator.

[0009] In some configurations, the electrical discharge comprises a voltage of about 24 V.

[0010] In some configurations, the electrolytic ozone generator comprises a chamber configured to hold the volume of flushing liquid received by the electrolytic ozone generator, wherein optionally, the chamber comprises a volume of about 500 mL to about 1000 mL, and optionally about 700 mL to about 800 mL.

[0011] In some configurations, the cleaning robot further comprises a flushing liquid pump configured to pump the flushing liquid from the flushing liquid tank to the ozone generator, wherein the ozone generator is configured to be in the active state when the flushing liquid pump is pumping the flushing liquid from the flushing liquid tank to the ozone generator.

[0012] In some configurations, the flushing liquid tank is fluidly connected to the first flushing outlet via only the ozone generator.

[0013] In some configurations, the cleaning robot further comprises a second flushing outlet configured to provide a fluid to clean one or more components of the cleaning robot. In some configurations, the fluid comprises aqueous ozone from the ozone generator, and wherein the cleaning robot is configured to provide a first portion of the aqueous ozone from the ozone generator to the first flushing outlet to clean the environment, and to provide a second portion of the aqueous ozone from the ozone generator to the second flushing outlet to clean the one or more components of the cleaning robot.

[0014] In some configurations, the cleaning robot further comprises a waste tank configured to collect and contain waste obtained from the cleaning of the one or more components of the cleaning robot.

[0015] In some configurations, the cleaning robot further comprises a cleaning liquid tank configured to contain a cleaning liquid comprising a cleaning chemical, and a cleaning liquid outlet, wherein the cleaning robot is configured to provide the cleaning liquid to the cleaning liquid outlet to clean the environment.

[0016] In some configurations, the cleaning robot further comprises a movable arm extending from the body, the movable arm comprising a first end portion connectable with the body and a second end portion movable in a plurality of directions.

[0017] In some configurations, the body comprises a tool dock configured to removably engage one or more cleaning tools and wherein the second end portion of the movable arm is configured to removably couple with the one or more cleaning tools to clean an environment.

[0018] In some configurations, the tool dock comprises the second flushing outlet to clean the one or more cleaning tools.

[0019] In some configurations, the second end portion of the movable arm is configured to mechanically and electrically couple with the one or more cleaning tools.

[0020] In some configurations, the second end portion of the movable arm is configured to limit torsional, axial and/or lateral movement of the one or more cleaning tools relative to the second end portion when coupled.

[0021] In some configurations, the cleaning robot further comprises an identification reader configured to identify the environment or a characteristic of the environment.

[0022] In some configurations, the first flushing outlet is provided to the second end portion of the movable arm.

[0023] In some configurations, the cleaning liquid outlet is provided to the second end portion of the movable arm.

[0024] In some configurations, the cleaning robot further comprises a power storage device configured to power one or more components of the cleaning robot, and to permit mobility of the cleaning robot without being tethered to a power supply, wherein optionally the power storage device comprises a rechargeable battery configured to be removably and electrically connected to a power supply.

[0025] According to another aspect of the present disclosure, there is provided a method of cleaning an environment with a cleaning robot comprising a mobility mechanism, a flushing liquid tank, an ozone generator and a first flushing outlet, the method comprising:

operating the mobility mechanism to move the cleaning robot to the environment;

providing a flushing liquid from a flushing liquid tank to the ozone generator;

forming aqueous ozone by the ozone generator; and

providing aqueous ozone from the ozone generator to the first flushing outlet to clean the environment.

[0026] In some configurations, the cleaning robot comprises a movable arm and the method further comprises operating the movable arm and coupling a second end portion of the movable arm with a cleaning tool.

[0027] In some configurations, the cleaning tool comprises a brush tool and the method further comprises operating the brush tool to rotate a brush head of the brush tool and urging the brush head against the environment.

[0028] In some configurations, the method further comprises decoupling the cleaning tool from the second end portion of the movable arm and coupling the cleaning tool with a tool dock to store the cleaning tool.

[0029] In some configurations, the method further comprises providing aqueous ozone from the ozone generator to a second flushing outlet of the cleaning robot to clean the stored cleaning tool.

[0030] In some configurations, the cleaning tool comprises a fan tool and the method further comprises operating the fan tool to rotate an impeller to direct an air flow to the environment to dry the environment.

[0031] In some configurations, the method further comprises providing a cleaning liquid to the environment via a cleaning liquid outlet.

[0032] Other aspects and advantages of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF DRAWINGS

[0033] The invention will be better understood with reference to the drawings, in which:

[0034] [Fig. 1] is a perspective view of an exemplary configuration of a cleaning robot of the present disclosure.

[0035] [Fig. 2] is a side view of the cleaning robot of [Fig. 1] when viewed from direction A.

[0036] [Fig. 3] is a side view of the body of the cleaning robot of [Fig. 1] when viewed from direction A, with a side portion of the body removed to show the internal components of the cleaning robot.

[0037] [Fig. 4] is a side view of the body of the cleaning robot of [Fig. 1] when viewed from direction B, with a side portion of the body removed to show the internal components of the cleaning robot.

[0038] [Fig. 5] is a schematic representation of the flushing liquid flow path of the cleaning robot of [Fig. 1].

[0039] [Fig. 6] is a schematic representation of the cleaning liquid flow path of the cleaning robot of [Fig. 1].

[0040] [Fig. 7] is a side view of an exemplary configuration of an ozone generator of the present disclosure.

[0041] [Fig. 8] is a front view of an exemplary configuration of an ozone generator of the present disclosure.

[0042] [Fig. 9] is a side view of the second end portion of the movable arm of the cleaning robot of [Fig. 1].

[0043] [Fig. 10] is a front view of the second end portion of the movable arm of the cleaning robot of [Fig. 1].

[0044] [Fig. 11] is a schematic drawing of a contacting face of the first jaw portion of the gripping mechanism that is provided at the second end portion of the movable arm of the cleaning robot of [Fig. 1].

[0045] [Fig. 12] is a front view of an exemplary configuration of a fan tool of the present disclosure.

[0046] [Fig. 13] is a side view of an exemplary configuration of a fan tool of the present disclosure.

[0047] [Fig. 14] is a front view of an exemplary configuration of a brush tool of the present disclosure.

[0048] [Fig. 15] is a side view of an exemplary configuration of a brush tool of the present disclosure.

DESCRIPTION OF THE EMBODIMENTS

[0049] As used herein, the term “(s)” following a noun means the plural and/or singular form of that noun.

[0050] As used herein, the term “and/or” means “and” or “or”, or where the context allows both.

[0051] Throughout this document, unless otherwise indicated to the contrary, the terms “comprising”, “consisting of”, “having” and the like, are to be construed as non-exhaustive, or in other words, as meaning “including, but not limited to.”

[0052] Furthermore, throughout the specification, unless the context requires otherwise, the word “include” or variations such as “includes” or “including” will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0053] It is intended that reference to any range of numbers disclosed herein (for example, 1 to 10) also incorporates reference to all rational numbers within that range (for example, 1, 1.1, 2, 3, 3.9, 4, 5, 6, 6.5, 7, 8, 9 and 10) and also any range of rational numbers within that range (for example, 2 to 8, 1.5 to 5.5 and 3.1 to 4.7) and, therefore, all sub-ranges of all ranges expressly disclosed herein are hereby expressly disclosed. These are only examples of what is specifically intended and all possible combinations of numerical values between the lowest value and the highest value enumerated are to be considered to be expressly stated in this application in a similar manner.

[0054] This disclosure may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more said parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which this disclosure relates, such known equivalents are deemed to be incorporated herein as if individually set forth.

[0055] Throughout the description, it is to be appreciated that the term “processor” and its plural form include controllers, microcontrollers, microprocessors, programmable integrated circuit chips such as application specific integrated circuit chip (ASIC), computer servers, electronic devices, and/or combination thereof capable of processing one or more input electronic signals to produce one or more output electronic signals. The processor includes one or more input modules and one or more output modules for processing of electronic signals.

[0056] “Coupled” – The following description refers to elements or nodes or features being “coupled” together. As used herein, unless expressly stated otherwise, “coupled” means that one element/node/feature/ is directly or indirectly joined to (or directly or indirectly communicates with) another element/node/feature, and does not necessarily connect a direct mechanical connection. Coupled elements/nodes/features are understood to exert mutual influence on one another. For example, although [Fig. 1] depicts one exemplary arrangement of elements, additional intervening elements, devices, features, or components may be present in an embodiment of the depicted subject matter.

[0057] In addition, certain terminology may also be used in the following description for the purpose of reference only, and thus are not intended to be limiting. For example, terms such as “upper”, “lower”, “above”, and “below” refer to directions in the drawings to which reference is made in a consistent but arbitrary frame of reference. Such terminology may include the words specifically mentioned above, derivatives thereof, and words of similar import. Similarly, the terms “first”, “second”, and other such numerical terms referring to structures do not imply a sequence or order unless clearly indicated by the context.

[0058] For the sake of brevity, conventional techniques related to robotic systems, devices and components, robotic system manufacture and operation and/or the like may not be described in detail herein. Furthermore, any connecting lines shown in various figures contained herein are intended to represent exemplary functional relationships and/or physical couplings between various elements. It should be noted that many alternative or additional functional relationships or physical connections may be present in exemplary cleaning robots and/or components thereof.

[0059] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by a skilled person to which the subject matter herein belongs.

[0060] The foregoing description of example embodiments includes example forms and configurations. Modifications may be made without departing from the scope of the disclosure and/or accompanying claims.

[0061] [Fig.1] shows a cleaning robot 1 according to an embodiment of the present disclosure. The cleaning robot 1 comprises a body 10, a mobility mechanism 20 and a movable arm 30. The cleaning robot 1 is configured to clean an environment. Unless specified, an “environment” used in the present disclosure includes an area (for example a lavatory, a lavatory stall, etc.) and/or a structure (for example a sink, toilet bowl, a floor, etc). The cleaning

robot 1 may be a non-autonomous, semi-autonomous or fully autonomous robot. A non-autonomous robot may also be known as a controlled robot where operation of the robot can be controlled by a user e.g. by using a remote controller. A semi-autonomous robot may be capable of performing certain functions autonomously but require a user input or supervision for certain other functions and/or in order to fully function, for example, a semi-autonomous cleaning robot may require a user to manually move it to a designated environment in order to autonomously perform the task of cleaning the environment. A fully autonomous robot may be capable of functioning independently for a task without a user input or supervision, for example a fully autonomous cleaning robot may be capable of navigating an environment, make decisions on how to act to achieve its task(s) and/or learn from its experience to improve its efficiency.

Body

[0062] As shown in [Fig. 3] and [Fig. 4], the body 10 comprises a cavity 101 defined by one or more walls. The cavity 101 houses one or more components of the body 10. The body 10 comprises an I/O (input/output) interface 102 for receiving user inputs to control one or more components of the cleaning robot 1 and/or providing an output, e.g. a display of information, related to the cleaning robot 1. The I/O interface 102 may be angled relative to a surface of the body 10, for example an upper surface of the body 10 from which the movable arm 30 extends. This permits ease of view of an output provided on the I/O interface 102 and/or ease of use for a user to provide an input to the I/O interface 102. The body 10 comprises a stop button 103 which allows a user to stop operation of the cleaning robot 1 when desired, e.g. in the event of an emergency. The stop button 103 is a manual button that requires actuation by a user. In some configurations, the stop button 103 may be a digital button displayed on the I/O interface 102.

[0063] The cleaning robot 1 comprises a power storage device configured to power one or more components of the cleaning robot 1 and to permit mobility of the cleaning robot 1 without being tethered to a power supply. The power storage device may be stored in the body 10, the mobility mechanism 20 and/or the movable arm 30. There may be a plurality of power storage devices. The power storage device may comprise a rechargeable battery configured to be removably and electrically connected to a power supply. The body 10 comprises one or more processors to control one or more components of the body 10. The one or more processors of the body 10 may communicate with one or more components of the cleaning robot 1, for example, a sensor (not shown), a user input/output (I/O) interface, etc. The body 10 may comprise one or more sensors configured to provide feedback to the cleaning robot 1 on an

environment, for example to allow the cleaning robot 1 to navigate to an environment to be cleaned.

[0064] The body 10 comprises a tool dock 151 comprising one or more compartments to store one or more cleaning tools 152. The tool dock 151 is configured to removably engage the one or more cleaning tools 152 and comprises a tool chamber in which a portion of the one or more cleaning tools 152 is positioned. The tool chamber is configured to prevent a stored cleaning tool 152, for example the portion that is used to clean the environment, from contacting anything external to the cleaning robot 1 so as to maintain sanitary conditions of the environment. The tool chamber additionally provides a zone for cleaning the cleaning tool 152 and the collection of any waste generated from such cleaning. The tool dock 151 may comprise one or more electrical contacts to power and/or control a cleaning tool 152 that is engaged with the tool dock 151.

[0065] The body 10 comprises a waste tank 141 configured to collect waste and contain waste obtained from the cleaning of one or more components of the cleaning robot 1, for example from cleaning the one or more cleaning tools 152. The waste may travel to the waste tank 141 under the effects of gravity or be suctioned by a pump into the waste tank 141. The waste may be stored for later removal and disposal.

[0066] The body 10 comprises a flushing liquid sub-assembly, components of which are housed, at least in part, within the cavity 101. The flushing liquid sub-assembly comprises a flushing liquid tank 121, flushing liquid conduits 122, a flushing liquid pump 123, an ozone generator 124, a manifold 125, a first flushing outlet 126 and a second flushing outlet 127. The flushing liquid sub-assembly is configured to provide a flushing liquid to an environment that is being cleaned by the cleaning robot 1. The term 'flushing' is not limited to a high flow rate and/or high velocity liquid and can include a liquid with any flow rate and/or velocity that can wash away an artefact from an environment. In some configurations, the flushing liquid may be provided at a substantially high flow rate and/or velocity to wash away an artefact from an environment, where the high flow rate and/or velocity is context dependent, for example whether a floor or a toilet bowl is being cleaned. The flushing liquid conduits 122 are configured to fluidly connect one or more components of the flushing liquid sub-assembly. The flushing liquid conduits 122 or portions thereof, may be arranged within the body 10 and/or the movable arm 30, external to the body 10 and/or the movable arm 30, or a combination of both.

[0067] [Fig. 5] provides a schematic representation of a flushing liquid flow path 120 in the cleaning robot 1. The flushing liquid tank 121 is configured to contain a flushing liquid that comprises water. The flushing liquid tank 121 may be configured to receive via an inlet, the

flushing liquid from an external liquid source. The flushing liquid tank 121 may therefore be replenished with flushing liquid. The flushing liquid may be water which includes but is not limited to distilled, tap and sterilized water. The flushing liquid need not be pure water such as distilled water, however water purity, pH and temperature can affect the solubility and/or stability of ozone in aqueous ozone as will be described further below. In some configurations, the flushing liquid is water with at least about 50% purity, at least about 60% purity, at least about 70% purity, at least about 80% purity, at least about 90% purity, at least about 95% purity or about 100% purity. In some configurations, the flushing liquid is tap water.

[0068] The flushing liquid pump 123 is configured to pump the flushing liquid from the flushing liquid tank 121 to ozone generator 124. The flushing liquid pump 123 may be configured to pump the flushing liquid through the ozone generator 124 at a flow rate of about 1 L/min. As depicted in [Fig. 5], the flushing liquid pump 123 is arranged between the flushing liquid tank 121 and the ozone generator 124. In some configurations, the flushing liquid pump 123 may be positioned elsewhere along the flushing liquid flow path 120, for example upstream before the flushing liquid tank 121. The flushing liquid pump 123 may be a part of one or more components of the flushing liquid sub-assembly, for example it may be a part of the flushing liquid tank 121 or the ozone generator 124. The flushing liquid pump 123 may be a pump that draws in the flushing liquid from an upstream component, a pump that drives the flushing liquid to a downstream component or a combination thereof.

[0069] The ozone generator 124 is configured to receive the flushing liquid from the flushing liquid tank 121 to form aqueous ozone, and the cleaning robot 1 is configured to provide the aqueous ozone from the ozone generator 124 to the first flushing outlet 126 to clean an environment 2. In particular, the ozone generator 124 receives the flushing liquid from the flushing liquid tank 121 (via the flushing liquid pump 123) to form aqueous ozone. When cleaning an environment, aqueous ozone can effectively decompose stains and improve cleaning efficiency. Sanitary ware can also be concurrently sterilized and disinfected. The ozone generator 124 may be an ozone generator that generates gaseous ozone which is dissolvable in the flushing liquid to form aqueous ozone or an ozone generator that generates aqueous ozone from the flushing liquid via an electrolytic process. In some configurations, the ozone generator comprises an electrolytic ozone generator that is configured to generate aqueous ozone from the flushing liquid. An electrolytic ozone generator is capable of generating aqueous ozone quickly and efficiently. An exemplary configuration of an electrolytic ozone generator is shown in [Fig. 7] and [Fig. 8]. The electrolytic ozone generator 124 comprises a generator inlet 124a that is configured to receive the flushing liquid from the flushing liquid tank 121, and a generator outlet 124b that is configured to provide the generated

aqueous ozone to downstream components, e.g. the first flushing outlet 126. The electrolytic ozone generator 124 comprises a chamber configured to hold a volume of flushing liquid received by the electrolytic ozone generator 124. The chamber of the electrolytic ozone generator 124 may comprise a volume of about 500 mL to about 1000 mL, or about 700 mL to about 800 mL. The electrolytic ozone generator 124 comprises electrodes to provide an electrical discharge to a volume of flushing liquid received by the electrolytic ozone generator 124. The electrolytic ozone generator 124 further comprises one or more electrical contacts to electrically couple the electrodes to one or more electrical components of the cleaning robot, e.g. a processor and a power supply (e.g. the power storage device). The electrolytic ozone generator may comprise one or more of a metal, glass, plastic and ceramic. The electrodes may be formed of a different material from a wall of the chamber.

[0070] The electrolytic ozone generator 124 is configured to provide an electrical discharge to a volume of flushing liquid that is received by the electrolytic ozone generator 124 to generate the aqueous ozone. The electrical discharge may be provided continuously or discontinuously. The amount and duration of the electrical discharge provided may vary depending on the desired concentration of ozone in the aqueous ozone. The electrical discharge may comprise a voltage of about 24 V. The electrolytic ozone generator 124 may comprise an active state where the electrical discharge is provided to the volume of flushing liquid, and an inactive state where the electrical discharge is not provided to the volume of flushing liquid.

[0071] The electrolytic ozone generator 124 may be configured to be in the active state when flushing liquid from the flushing liquid tank 121 is provided to the electrolytic ozone generator 124. The electrolytic ozone generator 124 may be configured to be in the active state when the flushing liquid pump 123 is pumping the flushing liquid from the flushing liquid tank 121 to the electrolytic ozone generator 124. In some configurations, the active state of the electrolytic ozone generator 124 occurs concurrently with the pumping of the flushing liquid by the flushing liquid pump 123. In some configurations, the active state of the electrolytic ozone generator 124 occurs for the same duration of time when the flushing liquid pump 123 is pumping the flushing liquid. In other configurations, the start of the active state of the electrolytic ozone generator 124 may occur at a different time from when the flushing liquid pump 123 is pumping the flushing liquid and/or the active state may occur for a different duration of time when the flushing liquid pump 123 is pumping the flushing liquid, however it is preferable for the period of time of the active state of the electrolytic ozone generator 124 to at least overlap with the period of time of pumping the flushing liquid by the flushing liquid pump 123.

[0072] The electrolytic ozone generator 124 may be configured to be in the inactive state when the flushing liquid from the flushing liquid tank 121 is not provided to the electrolytic ozone generator 124. The electrolytic ozone generator 124 may be configured to be in the inactive state when the flushing liquid pump 123 is not pumping the flushing liquid from the flushing liquid tank 121 to the electrolytic ozone generator 124. In some configurations, the inactive state of the electrolytic ozone generator 124 occurs concurrently with the time when the flushing liquid is not pumped to the electrolytic ozone generator 124 by the flushing liquid pump 123. In some configurations, the inactive state of the electrolytic ozone generator 124 occurs for the same duration of time when the flushing liquid pump 123 is not pumping the flushing liquid. In other configurations, the start of the inactive state of the electrolytic ozone generator 124 may occur at a different time from when the flushing liquid pump 123 is not pumping the flushing liquid and/or the inactive state may occur for a different duration of time when the flushing liquid pump 123 is not pumping the flushing liquid.

[0073] The aqueous ozone generated by the ozone generator 124 is provided from the ozone generator 124 to the first flushing outlet 126 and/or second flushing outlet via manifold 125 to clean an environment 2 or one or more components of the cleaning robot 1, e.g. cleaning tool 152 respectively. The manifold 125 receives the aqueous ozone from the ozone generator 124 via a manifold inlet. The manifold 125 comprises two or more manifold outlets. A first manifold outlet directs a first portion of the aqueous ozone to the first flushing outlet 126 via a first flow path, and a second manifold outlet directs a second portion of the aqueous ozone to the second flushing outlet 127 via a second flow path. The manifold 125 may comprise one or more valves to control the flow (for example stop a flow or change a flow rate) of the aqueous ozone to the first and/or second flushing outlets 126, 127. The one or more valves may be solenoid valves. The one or more valves may be controlled electronically by a processor of the cleaning robot 1. In some configurations, the manifold 125 comprises three manifold outlets, where one manifold outlet directs a portion of the aqueous ozone to the first flushing outlet 126 and the other two manifold outlets direct a portion of the aqueous ozone to a plurality of second flushing outlets 127. In the flushing liquid flow path 120, the liquids are considered to flow in a downstream direction from the flushing liquid tank 121 to the first flushing outlet 126 and/or second flushing outlet 127. The flushing liquid tank 121 is fluidly connected to the first flushing outlet 126 and/or the second flushing outlet 127 via only the ozone generator 124 (and manifold 125), i.e. liquid flow does not bypass the ozone generator 124. In some configurations, the flushing liquid tank 121 is fluidly connected to the first flushing outlet 126 via only the ozone generator 124, optionally via the manifold 125. One or more one-way valves

may be provided to the flushing liquid flow path 120 to prevent or minimize reverse flow of the flushing liquid in an upstream direction.

[0074] In some configurations, there is no manifold 125 and the aqueous ozone is divided into various flow paths to the first and/or second flushing outlets 126, 127 by the ozone generator outlet. In some configurations, there is no manifold 125 and the aqueous ozone from the ozone generator 124 is provided only to the first flushing outlet 126. In some configurations, the manifold 125 only provides the aqueous ozone to the first flushing outlet 126 and the manifold 125 does not provide aqueous ozone to the second flushing outlet 127. In some configurations, the second flushing outlet 127 may be provided with a liquid via a different flow path and/or source. For example, the second flushing outlet 127 may be provided with the flushing liquid from the flushing liquid tank 121, bypassing the ozone generator 124. In another example, the second flushing outlet 127 may be provided with a flushing fluid from another flushing liquid tank.

[0075] The first flushing outlet 126 is provided at the second end portion 302 of the movable arm 30. The second end portion 302 is configured to direct a flow of the aqueous ozone discharged by the first flushing outlet 126 to the environment 2 that is being cleaned by the cleaning robot 1. In some configurations, the aqueous ozone may be directed by the second end portion 302 towards a cleaning tool 152 that is stored in the tool dock 151 to clean said cleaning tool 152. The first flushing outlet 126 may discharge the flow of aqueous ozone alongside a cleaning tool 152 that is coupled with the second end portion 302. The discharged flow of aqueous ozone may be directed in a direction that is substantially parallel to a length of a cleaning tool 152 coupled to the second end portion 302. In some configurations, the first flushing outlet 126 is configured to fluidly couple with a tool flushing liquid inlet of a cleaning tool 152 that is coupled with the second end portion 302 such that the aqueous ozone is delivered through a flow path within the cleaning tool 152 to a tool flushing liquid outlet to discharge the aqueous ozone. For example, the tool flushing liquid outlet may comprise one or more apertures in the brush head 152b3 of a brush tool 152b, at the base of the bristles. In some configurations, the first flushing outlet 126 may be provided on another portion of the body 10 such that the direction of the aqueous ozone towards an environment being cleaned by the cleaning robot 1, is different from a direction of a cleaning tool 152 (that is coupled to the movable arm 30) that engages the same environment. In some configurations, there is a plurality of first flushing outlets 126. Each of the plurality of first flushing outlets 126 may be provided to different portions of the body 10.

[0076] The second flushing outlet 127 may be provided to one or more components (for example, a tool dock, a tank, a conduit, etc) of the cleaning robot 1 so as to provide the aqueous ozone to clean the one or more components of the cleaning robot 1. The tool dock 151 may comprise one or more second flushing outlet 127 to provide the aqueous ozone to clean a cleaning tool 152 stored in the tool dock 151. Aqueous ozone is useful to clean any stains on the cleaning tool 152 and also sterilize and disinfect the cleaning tool 152. In configurations where the tool dock 151 comprises a plurality of compartments to separately store cleaning tools 152, there may be a plurality of second flushing outlets 127, each second flushing outlet 127 provided to each compartment. There may be one or more second flushing outlets 127 provided to each compartment. The second flushing outlet 127 is configured to direct a flow of aqueous ozone towards a portion of a stored cleaning tool 152 to clean the cleaning tool 152. Said flow of aqueous ozone may be directed in a direction substantially normal to a length of the stored cleaning tool 152, or towards the stored cleaning tool 152 at an angle such that the aqueous ozone is directed substantially towards the base of the tool dock 151 so as to avoid unintentional escape of the aqueous ozone out of the tool dock 151.

[0077] The first and/or second flushing outlets 126, 127 may discharge the aqueous ozone in one or more forms, e.g. a liquid column or liquid droplets. In some configurations, the first and/or second flushing outlets 126, 127 discharge the aqueous ozone in the form of a liquid column. The first and/or second flushing outlets 126, 127 may comprise a nozzle.

[0078] The body 10 may comprise a cleaning liquid sub-assembly, components of which are housed, at least in part, within the cavity 101. The cleaning liquid sub-assembly comprises a cleaning liquid tank 131, a cleaning liquid pump 133 and a cleaning liquid outlet 136. The cleaning liquid sub-assembly is configured to provide a cleaning liquid to an environment 2 that is being cleaned by the cleaning robot 1. The cleaning liquid sub-assembly also comprises cleaning liquid conduits (not shown) to fluidly connect one or more components of the cleaning liquid sub-assembly. The cleaning liquid conduits or portions thereof, may be arranged within the body 10 and/or the movable arm 30, external to the body 10 and/or the movable arm 30, or a combination of both.

[0079] [Fig. 6] provides a schematic representation of a cleaning liquid flow path 130 in the cleaning robot 1. The cleaning liquid tank 131 is configured to contain a flushing liquid that comprises water. The cleaning liquid tank 131 may be configured to receive via an inlet, the cleaning liquid from an external liquid source. The cleaning liquid tank 131 may therefore be replenished with cleaning liquid. The cleaning liquid comprises one or more cleaning chemicals. The one or more cleaning chemicals may be used to for example, decontaminate

and/or deodorize an environment, degrease a surface and/or remove stains. The cleaning liquid may comprise water which is used as a solvent for the one or more cleaning chemicals. In some configurations, the cleaning liquid comprises an organic solvent. The flushing liquid is different from the cleaning liquid in that the flushing liquid would at least comprise water which is of a higher purity compared to the cleaning liquid. In some configurations, the flushing liquid does not comprise a cleaning chemical. In some configurations, the cleaning liquid comprises one or more cleaning chemicals and the flushing liquid comprises tap water. In the cleaning liquid flow path 130, liquids are considered to flow in a downstream direction from the cleaning liquid tank 131 to the cleaning liquid outlet 136. One or more valves may be provided to the cleaning liquid flow path 130 to for example, control the flow of the cleaning liquid to the cleaning outlet 136 and/or to prevent or minimize any reverse flow of the cleaning liquid in an upstream direction.

[0080] The cleaning liquid pump 133 is configured to pump the cleaning liquid from the cleaning liquid tank 131 to the cleaning liquid outlet 136 to clean an environment 2. As depicted in [Fig. 6], the cleaning liquid pump 133 is arranged between the cleaning liquid tank 131 and the cleaning liquid outlet 136. In some configurations, the cleaning liquid pump 133 may be positioned upstream before the cleaning liquid tank 131. The cleaning liquid pump 133 may be part of one or more components of the cleaning liquid sub-assembly, for example it may be a part of the cleaning liquid tank 131. The cleaning liquid pump 133 may be a pump that draws in the cleaning liquid from an upstream component, a pump that drives the cleaning liquid to a downstream component or a combination thereof.

[0081] The cleaning liquid outlet 136 is provided at the second end portion 302 of the movable arm 30. The cleaning liquid outlet 136 may be arranged adjacent to the first flushing outlet 126 as shown in [Fig. 9]. The terminal end of the first flushing outlet 126 may be positioned proximal to the second end portion 302 relative to the terminal end of the cleaning liquid outlet 136 (i.e. the flushing liquid outlet 126 is closer to the second end portion 302). In some configurations, cleaning liquid diverges as it exits cleaning liquid outlet 136. Having the first flushing outlet 126 positioned closer to the second end portion 302 prevent or minimizes the first flushing outlet 126 from being blocked up by the cleaning liquid. Further, having the cleaning liquid outlet 136 arranged distal relative to the first flushing outlet 126 creates a pivotal point of contact for the second end portion 302. This is advantageous for example when the second end portion 302 is actuating a toilet bowl flush button where a pivot point will make it easier to press the flush button compared to a larger area of contact if the terminal ends of the first flushing outlet 126 and the cleaning liquid outlet 136 terminate along the same plane. The flow rate of the aqueous ozone from the first flushing outlet 126 may be the same or different

from the flow rate of the cleaning liquid from the cleaning outlet 136. The second end portion 302 is configured to direct a flow of the cleaning liquid discharged by the cleaning liquid outlet 136 to an environment 2 that is being cleaned by the cleaning robot 1. In some configurations, the cleaning liquid may be directed by the second end portion 302 towards a cleaning tool 152 that is stored in the tool dock 151 to clean said cleaning tool 152. The cleaning liquid outlet 136 may discharge the flow of cleaning liquid alongside a cleaning tool 152 that is coupled with the second end portion 302. The discharged flow of cleaning liquid may be directed in a direction that is substantially parallel to a length of a cleaning tool 152 coupled to the second end portion 302. In some configurations, the cleaning liquid outlet 136 is configured to fluidly couple with a tool cleaning liquid inlet of a cleaning tool 152 that is coupled with the second end portion 302 such that the cleaning liquid is delivered through a flow path within the cleaning tool 152 to a tool cleaning liquid outlet to discharge the cleaning liquid. In some configurations, a portion of said flow path may merge with the flow path for the flushing liquid, and the tool flushing liquid outlet is the same as the tool cleaning liquid outlet. In some configurations, the flow paths are separate, and the tool cleaning liquid outlet is different from the tool flushing liquid outlet. For example, the tool cleaning liquid outlet may comprise one or more apertures in the brush head 152b3 of a brush tool 152b, at the base of the bristles. In some configurations, the cleaning liquid outlet 136 may be provided on another portion of the body 10 such that the direction of the cleaning liquid towards an environment being cleaned by the cleaning robot 1, is different from a direction of a cleaning tool 152 (that is coupled to the movable arm 30) that engages the same environment. In some configurations, there is a plurality of cleaning liquid outlets 136. Each of the plurality of cleaning liquid outlets 136 may be provided to different portions of the body 10. One or more cleaning liquid outlets 136 may be provided to the tool dock 151 (e.g. one or more compartments if there are a plurality of compartments) to clean one or more cleaning tools 152 stored at the tool dock 151. The flow of cleaning liquid provided by the cleaning liquid outlet 136 may be directed in a direction substantially normal to a length of the stored cleaning tool 152, or towards the stored cleaning tool 152 at an angle such that the cleaning liquid is directed substantially towards the base of the tool dock 151 so as to avoid unintentional escape of the cleaning liquid out of the tool dock 151.

[0082] The cleaning liquid outlet 136 may discharge the cleaning liquid in one or more forms, e.g. a liquid column or liquid droplets. In some configurations, the cleaning liquid outlet 136 discharges the cleaning liquid in the form of liquid droplets. The cleaning liquid outlet 136 may comprise a nozzle.

Mobility Mechanism

[0083] The mobility mechanism 20 is configured to support the body 10 and provide mobility to the cleaning robot 1 along a surface, e.g. a floor. Accordingly, cleaning robot 1 comprises a mobile cleaning robot 1. The mobility mechanism 20 may permit manual movement (e.g. user operated) or provided automated movement of the cleaning robot 1. As depicted in [Fig. 1], the body 10 is arranged on top of the mobility mechanism 20, where the mobility mechanism 20 acts as a base of the cleaning robot 1. However, it will be appreciated that a cleaning robot is not limited to such an arrangement and in some configurations, the mobility mechanism 20 may be arranged on a lateral side of the body 10, such that the mobility mechanism 20 permits mobility of the cleaning robot 1 along a substantially vertical surface, such as a wall. The body 10 may be removably coupled with the mobility mechanism 20 to permit for example independent repair and/or maintenance of the body 10 and the mobility mechanism 20.

[0084] The mobility mechanism 20 comprises four wheels 210. It will be appreciated that the number of wheels is not limiting and in some configurations the mobility mechanism 20 may comprise one, two, three or five or more wheels. The one or more wheels 210 may be a caster wheel that permit movement in a plurality of directions. The mobility mechanism 20 may comprise other forms of propulsion mechanisms, for example continuous tracks. The mobility mechanism 20 may comprise actuators (e.g. gears) that are configured to actuate movement of one or more components of the mobility mechanism 20. The mobility mechanism 20 comprises one or more processors to control one or more components of the mobility mechanism 20. The one or more processors of the mobility mechanism 20 may communicate with one or more components of the cleaning robot 1, for example, a sensor (not shown), a user input/output (I/O) interface, etc. The mobility mechanism 20 may comprise a power storage device to power one or more components of the cleaning robot 1. The mobility mechanism 20 permits movement of the cleaning robot 1 in one or more directions, for example in the x and/or y directions.

Movable Arm

[0085] The movable arm 30 extends from the body 10. In particular, the movable arm 30 extends from an upper surface of the body 10, where the upper surface is opposite to the surface of the body 10 that engages the mobility mechanism 20. It will be appreciated that the arrangement of the movable arm 30 with respect to the body 10 is not limiting and in some configurations, the movable arm 30 may extend from another surface, e.g. a lateral side surface, of the body 10. In some configurations, the movable arm 30 may be positioned proximate to the mobility mechanism 20. In some configurations, the movable arm 30 may

extend from the mobility mechanism 20. The movable arm 30 may be removably coupled with the body 10 to permit for example independent repair and/or maintenance of the movable arm 30 and body 10.

[0086] The movable arm 30 comprises a first end portion 301 and a second end portion 302. The first end portion 301 is connectable to the body 10 and the second end portion 302 is movable in a plurality of directions, i.e. in the x, y and/or z directions. The ability of the movable arm 30 and/or second end portion 302 to move allows the cleaning robot 1 to perform cleaning actions in a three-dimensional space, expanding its capability of cleaning complex environments, such as sanitary appliances (e.g. toilet bowls, urinals, water basins, etc.) in a bathroom. The first end portion 301 is rotatably (includes pivotably) connected to the body 10. The first end portion 301 may be rotatable about one or more axes relative to the body 10. The movable arm 30 further comprises joints 303 and segments 304. The joints 303 connect the segments 304 and/or one or more parts of the movable arm 30 together. The joints 303 are configured to permit rotational movement of the segments 304 and/or one or more parts of the movable arm 30 relative to one another. The one or more joints 303 accordingly permit mobility of the movable arm 30 and/or the second end portion 302. In some configurations, the movable arm 30 comprises one joint 303. In some configurations, the movable arm 30 comprises a plurality of joints 303. In some configurations, the movable arm 30 comprises one segment 304. In some configurations, the movable arm 30 comprises a plurality of segments 304. The segments 304 may be elongate segments 304 as shown in [Fig. 1] to [Fig. 4]. The movable arm 30 comprises actuators (e.g. gears) that are configured to actuate movement in one or more components of the movable arm 30. The movable arm 30 may comprise one or more electrical and/or fluidic connections, for example electrical wiring and flexible conduits. The one or more electrical and/or fluidic connections (e.g. liquid conduits) may be arranged internally within the movable arm 30, mounted externally to the movable arm 30, or a combination of both. The electrical and fluidic connections allow communication of for example electrical signals (includes power) and liquids between the body 10 and the second end portion 302 and/or one or more cleaning tools 152.

[0087] The second end portion 302 is configured to removably couple with one or more cleaning tools 152 to clean an environment. The second end portion 302 is configured to mechanically and electrically couple with the one or more cleaning tools 152 to clean an environment. [Fig. 9] and [Fig. 10] show the second end portion 302 of the movable arm 30. The second end portion 302 comprises a tool coupling mechanism in the form of gripping mechanism 310, and an identification reader 320. The first flushing outlet 126 and cleaning

liquid outlet 136 are provided to the second end portion 302 as described elsewhere in the present disclosure.

[0088] The second end portion 302 of the movable arm 30 is configured to limit torsional, axial and/or lateral movement of a cleaning tool 152 relative to the second end portion 302 when coupled. In the configuration shown in [Fig. 9] and [Fig. 10], the gripping mechanism 310 comprises a first jaw portion 311 and a second jaw portion 312. In some configurations, the gripping mechanism 310 comprises more than two jaw portions. The gripping mechanism 310 is configured to actuate the first and second jaw portions 311, 312 towards each other to clamp a grip portion (for example a fan tool grip portion 152a5 and brush tool grip portion 152b5) of a cleaning tool 152. The first jaw portion 311 comprises a contact surface that faces and is opposite a contact surface of the second jaw portion 312. The contact surfaces of the first and second jaw portions 311, 312 may comprise a shape, texture and/or material that facilitates the coupling of a cleaning tool 152 with the second end portion 302. As shown in [Fig. 11], the contact surface of the first jaw portion 311 comprises two elongate recesses 311a, 311b that are arranged transverse to one another, in the shape of a cross. The contact surface of the second jaw portion 312 may comprise the same recesses (312a, 312b not shown) in mirror image. The two elongate recesses 311a, 311b are arranged to correspond with complimentary projections on the grip portion of the cleaning tool 152. The recesses 311a, 311b are configured to receive at least a portion of the complimentary projections of the grip portion of the cleaning tool 152. When the first and second jaw portions 311, 312 are engaged with the grip portion of the cleaning tool 152 and the complimentary projections are received by the recesses 311a, 311b, 312a, 312b, the cleaning tool 152 is prevented or restricted from torsional, axial and/or lateral movement relative to the second end portion 302. The provides stability of the engaged cleaning tool 152 relative to the second end portion 302 during operation of the cleaning tool 152. It will be appreciated that in the alternative, the recesses may be provided on the grip portion of the cleaning tool 152 and the contact surfaces of the first and second jaw portions 311, 312 comprise the complimentary projections. In some configurations, the contact surfaces comprise a combination of recesses and projections. Other configurations of the recesses and/or projections are envisaged in the present disclosure and are not limited to the configuration shown in [Fig. 11], for example the two recesses may form an "X" shape. The contact surface of the second jaw portion 312 may have the same or different shape, texture and/or material from the contact surface of the first jaw portion 311.

[0089] The second end portion 302 comprises one or more electrical contacts to electrically couple with one or more electrical contacts on the one or more cleaning tools 152 when a cleaning tool 152 is coupled with the second end portion 302. Electrically coupling the second

end portion 302 and the cleaning tool 152 allows the cleaning robot 1 to power and/or control the cleaning tool 152 to clean an environment 2. An electrical coupling is however optional and the cleaning tool 152 may not require electrical power. In such a configuration, the second end portion 302 of the movable arm 30 is only mechanically coupled with the cleaning tool 152. Other forms of coupling to couple movement of a component (e.g. second end portion 302) with another (e.g. cleaning tool 152) are also envisaged in the present disclosure, whether in addition to or as an alternative of mechanical coupling, for example, magnetic coupling. Therefore, any reference to a mechanical coupling in the present disclosure may include other such forms of coupling as an alternative or in addition to mechanical coupling.

[0090] The identification reader 320 is configured to identify the environment 2 or a characteristic of the environment 2, for example the type of toilet fixtures such as toilet bowl, mirror, basin and urinal. The identification reader may be a camera.

Cleaning Tool

[0091] Examples of cleaning tools 152 are shown in [Fig. 12] to [Fig. 15], where [Fig. 12] and [Fig. 13] show a fan tool 152a, and [Fig. 14] and [Fig. 15] show a brush tool 152b.

[0092] With reference to [Fig. 12] and [Fig. 13], the fan tool 152a comprises a fan tool body 152a1, an air inlet 152a2, an impeller 152a3, an air outlet 152a4, a fan tool grip portion 152a5, fan tool electrical contacts 152a6 and a fan tool dock engagement portions 152a7. The fan tool 152a is configured to provide an air flow to dry an environment. The fan tool body 152a1 houses one or more electronic and mechanical components of the fan tool 152a. When in operation, the impeller 152a3 is configured to draw in a flow of air from ambient via the air inlet 152a2 and direct the flow of air out through the air outlet 152a4. The fan tool grip portion 152a5 is configured to be clamped by the first and second jaw portions 311, 312 of the gripping mechanism 310, to couple with the second end portion 302. The fan tool electrical contacts 152a6 are configured to electrically couple with electrical contacts on the second end portion 302. When the fan tool 152a is electrically coupled with the cleaning robot 1 via the second end portion 302, the cleaning robot 1 is configured to power and/or control the operation of the fan tool 152a, for example driving the rotation of the impeller 152a3 to generate an air flow and controlling the angular velocity of the impeller 152a3 to control the air flow rate. The fan tool electrical contacts 152a6 are configured to electrically couple with electrical contacts on the second end portion 302 when the fan tool 152a is mechanically coupled with the second end portion 302. The fan tool electrical contacts 152a6 and the fan tool grip portion 152a5 are arranged to allow substantially simultaneous electrical and mechanical coupling when the gripping mechanism 310 engages the fan tool 152a. In the alternative, the electrical coupling

and mechanical coupling occur sequentially. The electrical coupling may occur after the mechanical coupling occurs. The fan tool electrical contacts 152a6 are arranged proximate to the fan tool grip portion 152a5. The fan tool dock engagement portions 152a7 are configured to removably engage the fan tool 152a with the tool dock 151 for storage of the fan tool 152a when it is not in use. There may be two or more fan tool dock engagement portions 152a7 to provide secure engagement of the fan tool 152a with the tool dock 151, which can be useful so that the fan tool 152a does not become disengaged from the tool dock 151 or become dislodged from its predetermined configuration in the tool dock 151 (which the cleaning robot 1 uses to determine where to manoeuvre the second end portion 302 in order to engage with the correct cleaning tool 152), when the cleaning robot 1 moves. Having upper and lower fan tool dock engagement portions 152a7 as shown in [Fig. 13] may also prevent or minimize lateral movement of the fan tool 152a when it is engaged with the tool dock 151, particularly during movement of the cleaning robot 1. When the fan tool 152a is engaged with the tool dock 151, a portion of the fan tool 152a (e.g. the impeller 152a3 and air outlet 152a4) are positioned in the tool chamber of the tool dock 151 which keeps said portion from contacting anything external to the cleaning robot 1 so as to maintain sanitary conditions of the environment 2. The fan tool dock engagement portions 152a7 may comprise electrical contacts to electrically couple with electrical contacts at the tool dock 151 when the fan tool 152a is engaged with the tool dock 151. When the fan tool 152a is electrically coupled with the cleaning robot 1 via the electrical contacts of the fan tool dock engagement portions 152a7 and the tool dock 151, the cleaning robot 1 may be configured to power and/or control the operation of the fan tool 152b, which may be useful to for example rotate the impeller 152a3 when a liquid is directed to the impeller 152a3 to clean it. As the fan tool 152a relies on the cleaning robot 1 to power and/or control its operation and has an inbuilt impeller which will likely be positioned proximate the environment being cleaned when in operation (i.e. when the fan tool 152a is coupled with the second end portion 302), the fan tool 152a avoids the need for complicated wiring and air ducts.

[0093] With reference to [Fig. 14] and [Fig. 15], the brush tool 152b comprises a brush tool body 152b1, a rotor shaft 152b2, a brush head 152b3, a brush tool grip portion 152b5, brush tool electrical contacts 152b6 and brush tool dock engagement portions 152b7. The brush tool 152b is configured to clean stains in an environment, which can be done effectively because of the rotation of the brush head 152b3. The brush tool body 152b1 houses one or more electronic and mechanical components of the brush tool 152b. When in operation, a motor in the brush tool body 152b1 is configured to drive the rotation of the rotor shaft 152b which in turn drives the rotation of the brush head 152b3. The brush tool grip portion 152b5 is

configured to be clamped by the first and second jaw portions 311, 312 of the gripping mechanism 310, to couple with the second end portion 302. The brush tool electrical contacts 152b6 are configured to electrically couple with electrical contacts on the second end portion 302. When the brush tool 152b is electrically coupled with the cleaning robot 1 via the brush tool electrical contacts 152b6 and the second end portion 302, the cleaning robot 1 is configured to power and/or control the operation of the brush tool 152b, for example driving the rotation and/or controlling the angular velocity of rotation of the rotor shaft 152b2 and brush head 152b3, to clean an environment 2. The brush tool electrical contacts 152b6 are configured to electrically couple with electrical contacts on the second end portion 302 when the brush tool 152b is mechanically coupled with the second end portion 302. The brush tool electrical contacts 152b6 and the brush tool grip portion 152b5 are arranged to allow substantially simultaneous electrical and mechanical coupling when the gripping mechanism 310 engages the brush tool 152b. In the alternative, the electrical coupling and mechanical coupling occur sequentially. The electrical coupling may occur after the mechanical coupling occurs. The brush tool electrical contacts 152b6 are arranged proximate to the brush tool grip portion 152b5.

[0094] The brush tool dock engagement portions 152b7 are configured to removably engage with the tool dock 151 for storage of the brush tool 152b when it is not in use and/or when cleaning of the brush tool 152b is required. There may be two or more brush tool dock engagement portions 152b7 to provide secure engagement of the brush tool 152b with the tool dock 151, which can be useful so that the brush tool 152b does not become disengaged from the tool dock 151 or become dislodged from its predetermined configuration in the tool dock 151 (which the cleaning robot 1 uses to determine where to manoeuvre the second end portion 302 in order to engage with the correct cleaning tool 152), when the cleaning robot 1 moves. Having upper and lower brush tool dock engagement portions 152b7 as shown in [Fig. 15] may also prevent or minimize lateral movement of the brush tool 152b when it is engaged with the tool dock 151, particularly during movement of the cleaning robot 1. When the brush tool 152b is engaged with the tool dock 151, a portion of the brush tool 152b (e.g. the rotor shaft 152b2 and brush head 152b3) are positioned in the tool chamber of the tool dock 151 which keeps said portion from contacting anything external to the cleaning robot 1 so as to maintain sanitary conditions of the environment 2. The brush tool dock engagement portions 152b7 may comprise electrical contacts to electrically couple with electrical contacts at the tool dock 151 when the brush tool 152b is engaged with the tool dock 151. When the brush tool 152b is electrically coupled with the cleaning robot 1 via the electrical contacts of the brush tool dock engagement portions 152b7 and the tool dock 151, the cleaning robot 1 may be configured to

power and/or control the operation of the brush tool 152b, for example driving the rotation and/or controlling the angular velocity of rotation of the rotor shaft 152b2 and brush head 152b3, to clean the brush tool 152b when a liquid is directed to the brush head 152b3.

[0095] As the brush tool 152b relies on the cleaning robot 1 to power and/or control its operation, it does not require complicated wiring and can rotate independently, which can clean stubborn stains and enhance the cleaning effect on stubborn stains in an environment 2.

Method of Operating the Cleaning Robot

[0096] The cleaning robot 1 may be configured with preset cleaning programmes and/or may receive user set cleaning programmes via the I/O interface 102. For example, the cleaning robot 1 may be pre-programmed with details of an environment 2 to be cleaned, and a user may input into the I/O interface 102 when the cleaning robot 1 should commence the cleaning of the environment 2. For example, the process of cleaning a toilet bowl is pre-programmed in the cleaning robot 1, where which tool to use and the sequence of cleaning (e.g. use of brush tool 152b before use of fan tool 152a) is predetermined. When the cleaning robot 1 identifies the toilet bowl, it will commence cleaning the toilet bowl based on the pre-programmed sequence. The cleaning robot 2 may assess the condition of the environment 2 before commencing cleaning. When a cleaning process commences, the cleaning robot may autonomously navigate the environment 2 to clean said environment 2. In some configurations, the user may move the cleaning robot 1 to the environment 2 to be cleaned. For example, the environment 2 may be a toilet bowl and the user may position the cleaning robot 1 proximal the toilet bowl, and the user may commence the cleaning of the toilet bowl by the cleaning robot 1 by selecting a start function on the I/O interface 102. The I/O interface 102 may provide information to a user on one or more of the cleaning progress, amount of liquids remaining in the flushing liquid and/or cleaning liquid tanks 121, 131, and amount of waste in the waste tank 141.

[0097] A method of cleaning of an environment 2 by the cleaning robot 1 is provided as a non-limiting example below. Other types of cleaning operations by the cleaning robot 1 are also possible and should not be limited by the steps and/or their sequences provided in this non-limiting example.

[0098] The method of cleaning an environment comprises operating the mobility mechanism 20 to move the cleaning robot 1 to an environment 2 for cleaning. Operating the mobility mechanism 20 includes a manual operation by a user (the mobility mechanism 20 may be set to a 'manual' mode) and an autonomous movement by the cleaning robot 1. The

environment 2 may comprise an area and/or a structure. Where the environment comprises an area, the method comprises moving the cleaning robot 1 within the area.

[0099] The method further comprises performing a cleaning process of the environment 2 by the cleaning robot 1. The step of performing a cleaning process of the environment 2 may comprise the cleaning robot 1 receiving a user input via the I/O interface 102 to begin the cleaning process or may comprise commencing the cleaning process based on a timed trigger based on a preset cleaning programme. The user input may include details regarding the environment 2, for example where the environment 2 comprises a toilet bowl, dimensions and shape of the toilet bowl. The cleaning robot 1 may perform steps of a pre-programmed cleaning process sequence or may perform steps set by a user providing user inputs via the I/O interface 102.

[00100] The cleaning robot 1 may operate the identification system 320 to identify the environment 2 or a characteristic of the environment 2, before commencing the cleaning process. Once the cleaning process commences, the cleaning process may comprise an optional step of pre-flushing the environment 2 with a flow of aqueous ozone by pointing the first flushing outlet 126 provided on the second end portion 302 of the movable arm 30 towards the environment 2 and directing the flow of aqueous ozone towards the environment 2. During the pre-flushing of the environment 2, the flushing liquid pump 123 is pumping the flushing liquid from the flushing liquid tank 121 to the ozone generator 124 to generate aqueous ozone, and providing the aqueous ozone from the ozone generator 124 to the flushing liquid outlet 126 at the second end portion 302. Where the ozone generator 124 comprises an electrolytic ozone generator and as the flushing liquid is being pumped to the ozone generator 124, the electrolytic ozone generator 124 is in an active state and is providing an electrical discharge to a volume of the flushing liquid to generate the aqueous ozone.

[00101] The cleaning process comprises operating the movable arm 30 and coupling the second end portion 302 of the movable arm 30 with a brush tool 152b that is stored at the tool dock 151. The cleaning tools 152 are arranged in a predetermined configuration in the tool dock 151 so that cleaning robot 1 will know where to control the second end portion 302 to move to so as to couple with the correct cleaning tool 152. After engaging the brush tool 152b, the cleaning robot 1 moves the brush tool 152b and engages the brush tool 152b with a surface of the environment 2. The cleaning robot 1 may be configured to detect stained areas on the environment 2 and the cleaning robot 1 may be configured to engage the brush tool 152 with the stained areas of the environment 2. The cleaning process further comprises operating the brush tool 152b by rotating the brush head 152b3 and urging the brush head 152b3 against the

environment 2. While the brush tool 152b is being operated to clean the environment 2, the cleaning process may comprise providing a flow of aqueous ozone from the first flushing outlet 126 to the environment 2 to flush away dislodged artefacts. During this time, the flushing liquid pump 123 is operating to provide the flushing liquid from the flushing liquid tank 121 to the ozone generator 124 which is operating in the active state to form the aqueous ozone and is providing the aqueous ozone to the first flushing liquid outlet 126 to clean the environment 2. In some configurations, the cleaning process comprises stopping operation of the brush tool 152b and flushing the environment 2 with the aqueous ozone after the brush tool 152b has stopped operating.

[00102] The cleaning process may comprise directing a flow of cleaning liquid to the environment 2 by pointing the cleaning liquid outlet 136 provided on the second end portion 302 of the movable arm 30 towards the environment 2 and directing a flow of cleaning liquid towards the environment 2. During provision of the cleaning liquid to the environment 2, the cleaning liquid pump 133 is pumping cleaning liquid from the cleaning liquid tank 131 to the cleaning liquid outlet 136. In some configurations, the cleaning liquid is provided to the environment 2 during the operation of the brush tool 152b. In some configurations, the cleaning liquid is provided to the environment 2 after the brush tool 152b has stopped operating. In some configurations, the cleaning liquid is provided to the environment 2 while aqueous ozone is provided to the environment 2. In some configurations, the cleaning liquid is provided to the environment 2 when the aqueous ozone is not being provided to the environment 2, i.e. the provision of the aqueous ozone and cleaning liquid to the environment 2 are in a consecutive manner.

[00103] After the environment 2 is considered to be adequately cleaned, for example by determining whether there are still any stained areas present in the environment 2 by the cleaning robot 1, or after a series of cleaning steps have been completed by the cleaning robot 1, the cleaning process comprises decoupling the brush tool 152b from the second end portion 302 of the movable arm 30 and coupling the brush tool 152b with the tool dock 151 to store the brush tool 152b. The cleaning process may further comprises coupling the second end portion 302 of the movable arm 30 with the fan tool 152a that is stored in the tool dock 151. The fan tool 152a is thereafter moved to the environment 2 by the movable arm 30 and the cleaning process comprises operating the fan tool 152a to rotate the impeller 152a3 to direct an air flow to the environment 2 to dry the environment 2. When the environment 2 is being dried by the fan tool 152a, the cleaning robot 1 may concurrently clean the brush tool 152b stored in the tool dock 151 by providing a flow of aqueous ozone from the ozone generator 124 to the brush tool 152b, e.g. the brush head 152b3, via the second flushing outlet 127. The cleaning robot 1 may

operate the brush tool 152b to rotate the brush head 152b3 being cleaned while the flow of aqueous ozone is directed to the brush head 152b3. In some configurations, the cleaning of the brush tool 152b3 in the tool dock 151 occurs after the environment 2 has been dried and the fan tool 152a is returned to the tool dock 151 for storage.

[00104] After the cleaning process has completed, the cleaning robot 1 may be moved or may move to a storage zone for storing the cleaning robot 1 until it is needed. The storage zone may include a base station to which the cleaning robot 1 is configured to removably couple. When the cleaning robot 1 is coupled with the base station, the cleaning robot 1 may electrically couple with a power supply to charge the power storage device of the cleaning robot 1, the flushing liquid tank 121 and/or the cleaning liquid tank 131 may be replenished with flushing liquid and cleaning liquid respectively, and/or the waste tank 141 may be emptied of waste for disposal. The cleaning robot 1 and the base station may accordingly comprise one or more of electrical contacts, mechanical couplings and pneumatic couplings.

[00105] Although the present invention is described as implemented in the above described embodiment[s], it is not to be construed to be limited as such. It is to be appreciated that modifications and improvements may be made without departing from the scope of the present invention.

[00106] For example, the cleaning robot 1 may comprise a metal, a plastic or a combination thereof.

[00107] As yet another example, the cleaning robot 1 may comprise one or more sensors. The one or more sensors may be one or more of an image sensor, a line sensor, a proximity sensor, flow sensor, pressure sensor and temperature sensor. One or more of the sensors of the cleaning robot 1 may be configured to provide feedback to the cleaning robot 1 regarding an environment 2, e.g. the distance between the cleaning robot 1 and the environment 2 to be cleaned. One or more of the sensors of the cleaning robot 1 may be configured to receive information of a flow along one or more flow paths of the cleaning robot 1, for example the flow rate of flushing liquid through the flushing liquid flow path 120. Information provided by sensors relating to a flow along one or more flow paths of the cleaning robot 1 may be used to control one or more components of the cleaning robot 1, for example a flow sensor may detect a flow entering the ozone generator 124 and may provide a signal to a processor which controls the electrical discharge to the volume of flushing liquid in the ozone generator 124. Therefore, the trigger to place the ozone generator 124 in the active state may be the detection of one or more characteristics of a flow through the flushing liquid flow path 120 rather than the detection of operation of the flushing liquid pump 123.

[00108] As yet another example, the flushing liquid tank 121, cleaning liquid tank 131 and/or waste tank may comprise one or more level sensors to detect a level of content in the respective tank. The one or more level sensors may comprise a liquid level sensor. The one or more level sensors may comprise a maximum level sensor and a minimum level sensor.

[00109] As yet another example, the cleaning robot 1 may be configured to output one or more audible and visual (e.g. via the I/O interface 102) signals, for example to indicate the commencement and/or end of a cleaning process.

[00110] As yet another example, the tool dock 151 is optional and the second end portion 302 of the movable arm 30 is configured to couple with cleaning tools 152 stored elsewhere, for example in a storage at the base station.

[00111] It should be further appreciated by the person skilled in the art that variations and combinations of features described above, not being alternatives or substitutes, may be combined to form yet further embodiments falling within the intended scope of the disclosure. As would be understood by a person skilled in the art, each embodiment, may be used in combination with other embodiment or several embodiments.

REFERENCE SIGNS LIST

Cleaning robot	1
Body	10
Cavity	101
I/O interface	102
Stop button	103
Flushing liquid flow path	120
Flushing liquid tank	121
Flushing liquid conduit	122
Flushing liquid pump	123
Ozone generator	124

Manifold	125
First flushing outlet	126
Second flushing outlet	127
Cleaning liquid flow path	130
Cleaning liquid tank	131
Cleaning liquid pump	133
Cleaning liquid outlet	136
Waste tank	141
Tool dock	151
Fan tool	152a
Fan tool body	152a1
Air inlet	152a2
Impeller	152a3
Air outlet	152a4
Fan tool grip portion	152a5
Fan tool electrical contacts	152a6
Fan tool dock engagement portion	152a7
Brush tool	152b
Brush tool body	152b1
Rotor shaft	152b2
Brush head	152b3
Brush tool grip portion	152b5

Brush tool electrical contacts	152b6
Brush tool dock engagement portion	152b7
Mobility mechanism	20
Wheel	210
Movable Arm	30
First end portion	301
Second end portion	302
Joint	303
Gripping mechanism	310
First jaw portion	311
Second jaw portion	312
Identification reader	320

CLAIMS

- [Claim 1] A cleaning robot comprising:
- a body comprising:
- a flushing liquid tank configured to contain a flushing liquid comprising water;
 - a first flushing outlet;
 - an ozone generator, and
- a mobility mechanism configured to support the body and provide mobility to the cleaning robot along a surface,
- wherein the ozone generator is configured to receive the flushing liquid from the flushing liquid tank to form aqueous ozone, and the cleaning robot is configured to provide aqueous ozone from the ozone generator to the first flushing outlet to clean an environment.
- [Claim 2] The cleaning robot according to claim 1, wherein the ozone generator comprises an electrolytic ozone generator configured to provide an electrical discharge to a volume of flushing liquid received by the ozone generator from the flushing liquid tank to form the aqueous ozone.
- [Claim 3] The cleaning robot according to claim 2, wherein the electrolytic ozone generator comprises
- an active state wherein the electrical discharge is provided to the volume of flushing liquid, and
 - an inactive state wherein the electrical discharge is not provided to the volume of flushing liquid,
- wherein the electrolytic ozone generator is configured to be in the active state when flushing liquid from the flushing liquid tank is provided to the electrolytic ozone generator, and wherein the electrolytic ozone generator is configured to be

in the inactive state when the flushing liquid from the flushing liquid tank is not provided to the electrolytic ozone generator.

- [Claim 4] The cleaning robot according to claim 2 or claim 3, wherein the electrical discharge comprises a voltage of about 24 V.
- [Claim 5] The cleaning robot according to any one of claims 2 to 4, wherein the electrolytic ozone generator comprises a chamber configured to hold the volume of flushing liquid received by the electrolytic ozone generator, wherein optionally, the chamber comprises a volume of about 500 mL to about 1000 mL, and optionally about 700 mL to about 800 mL.
- [Claim 6] The cleaning robot according to claim 3 or any one of claims 4 to 5 when dependent on claim 3, further comprising a flushing liquid pump configured to pump the flushing liquid from the flushing liquid tank to the ozone generator, wherein the ozone generator is configured to be in the active state when the flushing liquid pump is pumping the flushing liquid from the flushing liquid tank to the ozone generator.
- [Claim 7] The cleaning robot according to any one of the preceding claims, wherein the flushing liquid tank is fluidly connected to the first flushing outlet via only the ozone generator.
- [Claim 8] The cleaning robot according to any one of the preceding claims, further comprising a second flushing outlet configured to provide a fluid to clean one or more components of the cleaning robot.
- [Claim 9] The cleaning robot according to claim 8, wherein the fluid comprises aqueous ozone from the ozone generator, and wherein the cleaning robot is configured to provide a first portion of the aqueous ozone from the ozone generator to the first flushing outlet to clean the environment, and to provide a second portion of the aqueous ozone from the ozone generator to the second flushing outlet to clean the one or more components of the cleaning robot.
- [Claim 10] The cleaning robot according to claim 8 or 9, further comprising a waste tank configured to collect and contain waste obtained from the cleaning of the one or more components of the cleaning robot.

- [Claim 11] The cleaning robot according to any one of the preceding claims, further comprising a cleaning liquid tank configured to contain a cleaning liquid comprising a cleaning chemical, and a cleaning liquid outlet, wherein the cleaning robot is configured to provide the cleaning liquid to the cleaning liquid outlet to clean the environment.
- [Claim 12] The cleaning robot according to any one of the preceding claims, further comprising a movable arm extending from the body, the movable arm comprising a first end portion connectable with the body and a second end portion movable in a plurality of directions.
- [Claim 13] The cleaning robot according to claim 12, wherein the body comprises a tool dock configured to removably engage one or more cleaning tools and wherein the second end portion of the movable arm is configured to removably couple with the one or more cleaning tools to clean an environment.
- [Claim 14] The cleaning robot according to claim 13 when dependent on claim 8, wherein the tool dock comprises the second flushing outlet to clean the one or more cleaning tools.
- [Claim 15] The cleaning robot according to claim 13 or 14, wherein the second end portion of the movable arm is configured to mechanically and electrically couple with the one or more cleaning tools.
- [Claim 16] The cleaning robot according to any one of claims 13 to 15, wherein the second end portion of the movable arm is configured to limit torsional, axial and/or lateral movement of the one or more cleaning tools relative to the second end portion when coupled.
- [Claim 17] The cleaning robot according to any one claims 13 to 16, further comprising an identification reader configured to identify the environment or a characteristic of the environment.
- [Claim 18] The cleaning robot according to any one of the preceding claims, wherein the first flushing outlet is provided to the second end portion of the movable arm.
- [Claim 19] The cleaning robot according to any one of claims 12 to 18 when dependent on claim 11, wherein the cleaning liquid outlet is provided to the second end portion of the movable arm.

- [Claim 20] The cleaning robot according to any one of the preceding claims, further comprising a power storage device configured to power one or more components of the cleaning robot, and to permit mobility of the cleaning robot without being tethered to a power supply, wherein optionally the power storage device comprises a rechargeable battery configured to be removably and electrically connected to a power supply.
- [Claim 21] A method of cleaning an environment with a cleaning robot comprising a mobility mechanism, a flushing liquid tank, an ozone generator and a first flushing outlet, the method comprising:
- operating the mobility mechanism to move the cleaning robot to the environment;
- providing a flushing liquid from a flushing liquid tank to the ozone generator;
- forming aqueous ozone by the ozone generator; and
- providing aqueous ozone from the ozone generator to the first flushing outlet to clean the environment.
- [Claim 22] The method according to claim 21, wherein the cleaning robot comprises a movable arm and the method further comprises operating the movable arm and coupling a second end portion of the movable arm with a cleaning tool.
- [Claim 23] The method according to claim 22, wherein the cleaning tool comprises a brush tool and the method further comprises operating the brush tool to rotate a brush head of the brush tool and urging the brush head against the environment.
- [Claim 24] The method according to claim 22 or claim 23, the method further comprises decoupling the cleaning tool from the second end portion of the movable arm and coupling the cleaning tool with a tool dock to store the cleaning tool.
- [Claim 25] The method according to claim 24, the method further comprises providing aqueous ozone from the ozone generator to a second flushing outlet of the cleaning robot to clean the stored cleaning tool.
- [Claim 26] The method according to claim 22, wherein the cleaning tool comprises a fan tool and the method further comprises operating the fan tool to rotate an impeller to direct an air flow to the environment to dry the environment.

[Claim 27] The method according to any one of claims 21 to 26, the method further comprises providing a cleaning liquid to the environment via a cleaning liquid outlet.