

A DEVICE TO AUTOMATE MANUAL SURFACE MAINTENANCE MACHINES

FIELD OF INVENTION

[0001] The present invention relates to automated cleaning devices, and more particularly, automated surface maintenance machines and a method to automate manual surface maintenance machines.

BACKGROUND

[0002] Surface maintenance machines are used in open spaces to maintain the cleanliness or texture of the surface it is used on. They may comprise a plurality of maintenance apparatus such as rotating scrub brushes, a solution tank, vacuum systems, a squeegee, rakes or blades, attached to a power operated machine. The surface maintenance machines may receive power from an electric current source such as a battery unit or an internal combustion engine. Typical surface maintenance machines would incorporate a steering mechanism to provide a means to direct the machine's movement.

[0003] Surface maintenance machines may be manually controlled or autonomous. Manual surface maintenance machines require an operator to control the movements and cleaning operations of the surface maintenance machine. These machines are cost effective and easy to produce as the steering, movement and cleaning operations can be simple lever

mechanisms for the operator to control. Due to the simple mechanisms, the maintenance costs of the manual surface maintenance machines are also low. A major disadvantage of the manual surface maintenance machines, however, is that it is entirely dependent on an operator to function. Without an operator, the manual surface maintenance machine provides no benefit for the maintenance company. In addition, a new operator would need to be trained to operate the machine, which would incur further cost for the maintenance company. Further, the effectiveness of the manual surface maintenance machine relies entirely on the skill of the operator. Thus, cleanliness cannot be standardized on a broad scale as there is no quantitative way to standardize cleanliness standards between several operators.

[0004] Autonomous surface maintenance machines have been developed to reduce the dependence of surface maintenance machines on the human operator. The movement and cleaning functionality of autonomous surface maintenance machines are designed to be computer controlled. The autonomous surface maintenance machine may be configured to operate for extended periods of time or programmed to clean designated routes or areas on scheduled days. A major disadvantage of the autonomous surface maintenance machine is the high cost as the components in the autonomous surface maintenance machines require advanced circuitry for navigation, feedback and for performing cleaning operations. Additionally, repairs and

maintenance of these machines would need to be performed by a skilled serviceman, which would increase the costs even more. Further, in the event that a component not related to the cleaning or navigation function breaks down, an operator would be unable to utilize the malfunctioning autonomous surface maintenance machine for manual cleaning purposes.

[0005] Thus, what is needed is a surface maintenance machine that is able to incorporate the low cost advantages of the manual surface maintenance machines with the benefits of automation from the autonomous surface maintenance machines. Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

SUMMARY

[0006] Herein disclosed is a device for controlling a manual surface maintenance machine is presented. The device comprises at least one attachment means for coupling the device to at least one component of the manual surface maintenance machine, at least one control coupling means for electrically and mechanically coupling the device to a plurality of components of the manual surface maintenance machine, the plurality of components comprising at least one mechanical component and at least one electrical component, wherein the mechanical component includes apparatus control mechanisms, velocity control mechanisms and steering control mechanisms, wherein the at least one electrical component includes an energy storage device, velocity control means, and mechanical component on-off circuits, and a control means, the control means comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, provide control signals to the at least one mechanical component and the at least one electrical component of the manual surface maintenance machine, for controlling the manual surface maintenance machine to perform the steps of a first mode, the steps of the first mode comprising moving to a first location amongst a plurality of locations, performing at least one operation, while moving to the first location and at the first location, moving to a next location amongst a

plurality of locations, and performing at least one operation, while moving to the next location and at the next location.

[0006a] According to a first aspect, there is provided a detachable device for converting a manual surface maintenance machine to an automatic surface maintenance machine, the device comprising: at least one attachment means for mechanically attaching the device to the manual surface maintenance machine; at least one mechanical control coupling means for mechanically coupling the device to at least one mechanical component, the at least one mechanical component comprising apparatus control mechanisms, velocity control mechanisms and steering control mechanisms; at least one electrical control coupling means for electrically coupling the device to at least one electrical component, the at least one electrical component comprising an energy storage device, velocity control means, and mechanical component on-off circuits; and a control means, the control means comprising: at least one processor; and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, provide control signals to the at least one mechanical component and the at least one electrical component of the manual surface maintenance machine, for controlling the manual surface maintenance machine to at least move to one or more predetermined locations in response to location data stored in the at least one memory.

[0007] Herein disclosed is a network of one or more devices for controlling corresponding

manual surface maintenance machines is presented. The network comprises a central controller, a plurality of monitoring units, a plurality of manual surface maintenance machines and a plurality of devices coupled to a corresponding one of the plurality of manual surface maintenance machines.

[007a] According to a second aspect, there is provided a network of one or more devices in accordance with any of the above claims for controlling corresponding manual surface maintenance machines, the network comprising: a central controller; a plurality of monitoring units; a plurality of manual surface maintenance machines; and a plurality of devices coupled to a corresponding one of the plurality of manual surface maintenance machines.

[0008] Herein disclosed is a method for automating a manual surface maintenance machine is presented. The method comprises the steps of attaching a device to the manual surface maintenance machine, coupling the device to the manual surface maintenance machine mechanically and electronically and controlling the manual surface maintenance machine, through the device, to perform the steps of a first mode, the steps of the first mode comprising moving to a first location amongst a plurality of locations, performing at least one operation, while moving to the first location and at the first location, moving to a next location amongst a plurality of locations and performing at least one operation, while moving to the next location and at the next location.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views and which together with the detailed description below are incorporated in and form part of the specification, serve to illustrate various embodiments and to explain various principles and advantages in accordance with a present embodiment.

[0010] FIG. 1 depicts a flowchart of a broad method embodying operation in accordance with a present embodiment.

[0011] FIG. 2 depicts a block diagram of a device coupled to the manual surface maintenance machine in accordance with a present embodiment.

[0012] FIG. 3 comprising FIG. 3A and FIG. 3B illustrates front right top perspective drawings of a manual surface maintenance machine, wherein FIG. 3A illustrates the machine without the device attached and FIG. 3B illustrates the machine with the device attached, in accordance with a present embodiment.

[0013] FIG. 4 depicts a flowchart of a learning mode of the device of FIG. 2 in accordance with the present embodiment.

[0014] FIG. 5 depicts a flowchart of an autonomous mode of the device of FIG. 2 in accordance with the present embodiment.

[0015] FIG. 6 depicts a flowchart of an enforcement mode of the device of FIG. 2 in accordance with the present embodiment.

[0016] FIG. 7 depicts a flowchart of a standby mode of the device of FIG. 2 in accordance with the present embodiment.

[0017] FIG. 8 depicts a diagram of an example of a network of one or more devices of FIG. 2 for controlling corresponding manual surface maintenance machines for cooperative cleaning of a large surface in accordance with the present embodiment.

[0018] And FIG. 9 depicts a diagram of an example of a network of one or more devices of FIG. 2 for controlling corresponding manual surface maintenance machines for cooperative cleaning of multiple floors in accordance with the present embodiment.

[0019] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been depicted to scale. For example, the dimensions of some of the elements in the block diagrams or flowcharts may be exaggerated in respect to other elements to help to improve understanding of the present embodiments.

DETAILED DESCRIPTION

[0020] The following detailed description is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. Furthermore, there is no intention to be bound by any theory presented in the preceding background of the invention or the following detailed description. It is the intent of the present embodiment to present a device to automate a manual surface maintenance machine in order to reduce the manual surface maintenance machines' dependency on a human operator.

[0021] According to one embodiment of the invention, a device for controlling a manual surface maintenance machine is provided. The device attaches to a manual surface maintenance machine and controls the mechanical and electrical components of the manual surface maintenance machine to perform movements from a first location to a next location, while performing surface maintenance operations.

[0022] In one embodiment of the present invention, the at least one operation comprises surface maintenance operations, including one or more of cleaning, wiping, vacuuming, buffing, cutting and raking.

[0023] In one embodiment of the present invention, the at least one operation further comprises performing a non-maintenance operation including operating one or more of the apparatus control mechanisms to

raise an apparatus off the surface, reduce the rotation of the apparatus or divert power from the apparatus completely.

[0024] In one embodiment of the present invention, the computer program code is further configured to perform the steps of a second mode, the steps of the second mode comprising recording movement between a plurality of positions from a first location to a next location, recording the operations performed when at the first location and while moving to the next location, storing the movement between the plurality of positions and operations performed into the memory, and performing the steps of recording and storing as an operator uses the manual surface maintenance machine.

[0025] In one embodiment of the present invention, the computer program code is further configured to perform the first mode according to the movement and the operations recorded in the second mode.

[0026] In one embodiment of the present invention, the device further comprises a network coupling component to enable the device to couple to a network through network coupling, and to transmit and receive information through the network coupling to a central controller and/or at least one monitoring unit.

[0027] In one embodiment of the present invention, the computer program code is further configured to perform the steps of a third mode, the steps of the third mode comprising moving to a first position amongst a plurality of positions while performing an operation, recording a surface condition of the

first position, storing the surface condition of the first position into the memory and repeating the steps of moving, recording and storing for a plurality of positions.

[0028] In one embodiment of the present invention, the received information is a command to switch between two modes, the modes including the first mode, the second mode and the third mode.

[0029] In one embodiment of the present invention, the transmitted information is data stored in the memory of the device.

[0030] In one embodiment of the present invention, the data stored in the memory of the device includes battery life of the device, battery life of the manual surface maintenance machine, utilization status of the manual surface maintenance machine or device, apparatus control status, speed, direction, mileage, recorded video and still image data.

[0031] In one embodiment of the present invention, the network coupling comprises wired coupling includes USB and Firewire coupling.

[0032] In one embodiment of the present invention, the device further comprises a first plurality of sensors and a second plurality of sensors, the first plurality of sensors for determining the position and environment around the device including one or more of capacitive and photoelectric proximity sensors, laser and infrared scanners, GPS, accelerometers, bumper switches, electronic compasses, infrared range finders, ultrasonic

rangefinders, and the second plurality of sensors for determining the condition of the surface around the device including one or more of video recorders, cameras, infrared imaging, light scattering and detection devices.

[0033] In one embodiment of the present invention, the device further comprises a user interface for users to access the control means.

[0034] According another embodiment of the present invention, a network of one or more devices for controlling corresponding manual surface maintenance machines is presented.

[0035] In one embodiment of the present invention, the central controller is able to transmit information through a network coupling to at least one device, the information comprising commands for the at least one device to switch between two modes, the modes including the first mode, the second mode and the third mode and recorded data of the at least one device.

[0036] In one embodiment of the present invention, the central controller is able to receive information through a network coupling from at least one device, the information comprising battery life, utilization status, and recorded data of the at least one device.

[0037] In one embodiment of the present invention, the plurality of monitoring units are able to transmit information to, and receive information from, the at least one device through a network coupling to at least one device, the information comprising commands for the at least one device to

switch between two modes, the modes including the first mode, the second mode and the third mode, battery life, utilization status, and recorded data of the at least one device.

[0038] In one embodiment of the present invention, the plurality of monitoring units are able to transmit information to, and receive information from, the at least one device through a network coupling to the central controller, the information comprising commands for the at least one device to switch between two modes, the modes including the first mode, the second mode and the third mode, battery life, utilization status, and recorded data of the at least one device.

[0039] In one embodiment of the present invention, the network coupling comprises wireless coupling includes Wi-Fi, 3G, 4G, radiofrequency, microwave and infrared transceiving means.

[0040] In one embodiment of the present invention, the network coupling comprises wired coupling includes USB and Firewire coupling means.

[0041] According to another embodiment of the present invention, a method for automating a manual surface maintenance machine is presented.

[0042] In one embodiment of the present invention, the step of controlling the manual surface maintenance machine device comprises controlling the manual surface maintenance machine, through the device, to perform the steps of a second mode, the steps of the second mode comprising recording movement

between a plurality of positions from a first location to a next location, recording the operations performed when at the first location and while moving to the next location, storing the movement between the plurality of positions and operations performed into the memory and performing the steps of recording and storing as an operator uses the manual surface maintenance machine.

[0043] In one embodiment of the present invention, the step of controlling the manual surface maintenance machine device comprises controlling the manual surface maintenance machine, through the device, to perform the steps of moving to a first position amongst a plurality of positions while performing an operation, recording a surface condition of the first position, storing the surface condition of the first position into the memory and repeating the steps of moving, recording and storing for a plurality of positions.

[0044] In one embodiment of the present invention, the method for automating a manual surface maintenance machine further comprises the step of controlling the manual surface maintenance machine to perform the steps of any of the first mode, the second mode and the third mode at a scheduled time and for a determined period of time.

[0045] Referring to FIG. 1, a flowchart 100 of a broad method embodying operation in accordance with a present embodiment is depicted. At step 102, the device is attached to at least one component of the manual surface maintenance machine through an attachment means. At step 104, the device is electrically and mechanically coupled to a plurality of electrical and

mechanical components of the manual surface maintenance machine through a control means. At step 106, the device controls the movement and operation of the manual surface maintenance machine.

[0046] Referring to FIG. 2, a block diagram 200 of a device 202 coupled to the manual surface maintenance machine 204 in accordance with a present embodiment is depicted. The device 202 for controlling a manual surface maintenance machine 204, in accordance with the present embodiment, comprises at least one attachment means 206 for coupling the device 202 to at least one component of the manual surface maintenance machine 204.

[0047] The device 202 may further comprise at least one control coupling means 208 that provides electrical coupling 212 and mechanical coupling 210 to a plurality of components including mechanical components 214 and electrical components 216 of the manual surface maintenance machine 204. The mechanical components 214 may include apparatus control mechanisms 218, velocity control mechanisms 220 and steering control mechanisms 222. The electrical components 216 may include an energy storage device 224, velocity control means 226, and mechanical component on-off circuits 228.

[0048] The device may further comprise a control means 230 including a processor 232, a memory 234 with computer program code 236, and mechanical control components 238 configured with the control coupling means 208 to control at least one mechanical component 214 and at least

one electrical component 216 of the manual surface maintenance machine 204.

[0049] The components in the control means 230 of the device 202 may be configured to provide control signals to the mechanical components 214 and electrical components 216 of the manual surface maintenance machine 204 through the control coupling means 208. C, C++, Python, Java, Basic, Perl, Ruby, Scheme or similar programming language may be used as the means to configure processor 232, memory 234 and mechanical control components 238, together with the control coupling means 208 to provide control signals to the mechanical components 214 and electrical components 216 of the manual surface maintenance machine 204.

[0050] In some alternative embodiments of the present invention, sensors may include a proximity sensor 250 to detect the presence of nearby stationary or moving objects in the environment surrounding the device 202. The proximity sensor 250 may utilize capacitive or photoelectric sensors to detect plastic objects, or inductive sensors to detect metallic objects. Sensors 250 may also include laser or infrared scanners to sweep the area in the path of the manual surface maintenance machine 204 to detect potholes, steps or other depressions in the path of the manual surface maintenance machine 204. Data from the sensor 250 may be transmitted to the processor 232 in the device 202, and upon detection of objects or obstacles, the processor 232, together with the computer program code 236, may configure the

manual surface maintenance machine 204 to slow down, stop or circumvent the obstacle by using an alternative route to the predetermined location.

[0051] In some alternative embodiments of the present invention, the device 202 may comprise the processor 232, memory 234, and mechanical control components 238 coupled to the user interface 248, sensors 250 and network coupling device 246. The user interface 248, sensors 250 and network coupling device 246 may be decoupled 252 from the device 202 if required. For example, if the device 202 is to be used in a remote location out of the range of the network, the network coupling device 248 may be decoupled 252 from the device to conserve battery life of the device. An operator may configure the device 202 to run a maintenance schedule through the user interface 248. Further, the sensors 250 may be decoupled 252 from the device 202 or interchangeable depending on the conditions that the manual surface maintenance machine 204 will be performing maintenance on. For example, in harsh outdoor conditions where heat or moisture is prevalent, delicate light detecting sensors utilizing expensive photomultiplier tubes may be substituted for more durable light detecting sensors utilizing photodiodes or phototransistors. In another example, daytime light detecting sensors may be substituted with light detecting sensors utilizing photomultiplier tubes configured for low light conditions. This is advantageous as the device 202 and corresponding manual surface maintenance machine 204 would be adaptable for operation in a wide variety of conditions and lightings.

[0052] In some alternative embodiments of the present invention, the mechanical control components 238 may be decoupled 252 from the device 202 in the event that the mechanical control components 238 requires maintenance. In this state, the device 202 would not be able to control the movement and operations of the manual surface maintenance machine 204 autonomously. However, an operator may still control the movement and operations of the manual surface maintenance machine 204 through the user interface 250 of the machine. The device would still be able to utilize the sensors 250 to determine the location, speed, direction and location of physical objects in the environment around the manual surface maintenance machine 204, and transmit this information to the central controller using the network coupling device 246.

[0053] The manual surface maintenance machine 204 may be controlled by the device 202, to move from a first location to a second location, while navigating over one or more positions between the first location to the next location. The device 202 may control the motion of the manual surface maintenance machine 204 by varying the power supplied to the electrical components 216 of the manual surface maintenance machine 204 that are electrically coupled 212 to the control means 230 of the device 202. For example, the device 202 may control power supplied to the motor of the manual surface maintenance machine 204, to control the torque delivered to the wheels 240. Additionally, the device 202 may also control the amount of power delivered to the electromagnetic brakes or frictional brake pads on the

wheels 240 of the manual surface maintenance machine 204 to provide deceleration. Further, the device 202 may control the directionality of motion by controlling the steering wheel 242, steering column, steering rack and pinion, tie rod or related components of the manual surface maintenance machine's 204 steering control mechanism 222 which is mechanically coupled 210 to the mechanical control components 238 of the control means 230 of the device 202 through the control coupling means 208.

[0054] In some alternative embodiments of the present invention, control coupling means 208 may include position rotation servo motors, continuous rotation servo motors, or linear servo motors that control the movement of the steering column or steering rack and pinion of the manual service maintenance machine 204. The servo motors 210 would be controlled by the processor 232 based on feedback from sensors 250 providing environmental and navigation data collected from gyroscopes, infrared sensors and GPS for example.

[0055] Operations may be performed while the manual surface maintenance machine 204 is stationary at a first location, or while moving towards the next location. The operations may comprise surface maintenance operations including cleaning, wiping, vacuuming, buffing, cutting and raking. The operations may also comprise non-surface maintenance operations including operating one or more of the apparatus control mechanisms 218 to raise an apparatus 244 off a surface, reduce the rotation of the apparatus 244 or divert power from the apparatus 244

completely. Further, operations may be activated, deactivated, simultaneously or sequentially while the manual surface maintenance machine 204 is stationary at a first location, while moving towards the next location, or when it is at an intermediate position between two locations.

[0056] The device 202 in accordance with the present embodiment may further comprise a network coupling device 246 to enable the device 202 to couple to a network through network coupling, to transmit and receive information or commands from the network.

[0057] The device 202 in accordance with the present embodiment may further comprise a user interface 248 for an operator to control the device 202 and the manual surface maintenance machine 204 through the device 202. The device 202 may also allow the operator to control the manual surface maintenance machine 204 through the manual surface maintenance machine's user interface 250 directly.

[0058] Referring to FIG. 3A, a front right top perspective drawing 300 of a manual surface maintenance machine 204 without the device 202 in accordance with a present embodiment is illustrated. The manual surface maintenance machine 204 comprises apparatus control mechanisms 218 to raise an apparatus 244 off the surface, reduce the rotation of the apparatus 244 or divert power from the apparatus 244 completely. The apparatus 244 may be used for surface maintenance operations include cleaning, wiping, vacuuming, buffing, cutting and raking. Without the device 202, the manual

surface maintenance machine 204 is still able to perform movement and operations under the manual control of an operator through its user interface 250.

[0059] Referring to FIG. 3B, a front right top perspective drawing 350 of a manual surface maintenance machine 204 with the device 202, in accordance with a present embodiment, is illustrated. The device 202 may be attached to a component of the manual surface maintenance machine 204 as depicted in the illustration. The device 202 is electronically and mechanically coupled to the manual surface maintenance machine 204 through a control coupling means 208. With the device 202, the manual surface maintenance machine 204 may be controlled remotely to perform movement and operations without the need for an operator to be physically present. The device 202 may be detachable from the manual surface maintenance machine 204 when necessary.

[0060] An operator may configure the device 202 to control the manual surface maintenance machine 204 to perform the steps of a plurality of modes. The plurality of modes may comprise a learning mode, autonomous mode, enforcement mode and standby mode, for example.

[0061] Referring to FIG. 4, a flowchart 400 of a learning mode of the device 202 in accordance with a present embodiment is depicted. At step 406, the device 202 may enter a learning mode, based on a command received from the central controller, monitoring unit or manual input from an

operator. The device 202 may control the manual surface maintenance machine 204 to perform the steps of a learning mode 408, 410. At step 408, the device 202 records the movement of the manual surface maintenance machine 204 between a plurality of positions from a first location to a next location and the operations performed when at the first location and while moving to the next location as a human operator uses it. At step 410, the device 202 stores the movement of the manual surface maintenance machine 204 between the plurality of positions and operations the manual surface maintenance machine 204 has performed into the memory 234. The device 202 may perform the steps of recording 408 and storing 410 as an operator uses the manual surface maintenance machine 204. At step 412, the device 202 may transmit the recorded data to a central controller and/or at least one monitoring unit coupled to the device 202.

[0062] Referring to FIG. 5, a flowchart 500 of an autonomous mode of the device 202 in accordance with the present embodiment is depicted. At step 506, the device 202 may enter an autonomous mode, based on a command received from the central controller, monitoring unit or manual input from an operator. The device 202 may control the manual surface maintenance machine 204 to perform the steps of an autonomous mode 508, 510, 512. At step 508, the device controls the manual surface maintenance machine 204 to move to a first location amongst a plurality of locations, performing at least one operation, while moving to the first location and at the first location, moving to a next location amongst a plurality of locations, and performing at

least one operation, while moving to the next location and at the next location. These movements and operations performed by the manual surface maintenance machine 204 in step 508 may have been recorded and stored previously when an operator had used the manual surface maintenance machine 204 in learning mode. The device 202 may stop movements and operations after this step 508. At step 510, the device 202 may record surface conditions while controlling the movement and operations of the manual surface maintenance machine 204 while in autonomous mode. At step 512, the device 202 may store the surface conditions into its memory 234. At step 514, the device 202 may transmit the recorded data to a central controller and/or at least one monitoring unit coupled to the device 202.

[0063] Referring to FIG. 6, a flowchart 600 of an enforcement mode of the device 202 in accordance with the present embodiment is depicted. The device 202 may enter an enforcement mode, based on a command received from the central controller, monitoring unit or manual input from an operator. The device 202 may control the manual surface maintenance machine 204 to perform the steps of an enforcement mode 608, 610, 612. At step 608, 610 and 612, the device 202 controls the manual surface maintenance machine 204 to move to a first position amongst a plurality of positions while performing an operation, recording a surface condition of the first position, storing the surface condition of the first position into the memory, and repeating the steps of moving, recording and storing for a plurality of positions. At step 614, the device 202 may transmit the recorded data to a

central controller and/or at least one monitoring unit coupled to the device 202. The device 202 may use the enforcement mode to retrace a route learned in the learning mode and assess the surface condition along the route. The assessment may be performed in the processor 232 of the device 202 or raw data may be uploaded to a central controller or monitoring unit for processing.

[0064] Referring to FIG. 7, a flowchart 700 of a standby mode of the device 202 in accordance with the present embodiment is depicted. At step 706, the device 202 may enter a standby mode based on a command received from the central controller, monitoring unit or manual input from an operator. In step 708, the device 202 may send information about the battery life of the device 202, battery life of the manual surface maintenance machine 204, utilization status of the manual surface maintenance machine 204 or device 202, apparatus control status, speed, direction, mileage, recorded video or still image data or similar information to a central controller and/or at least one monitoring unit coupled to the device 202.

[0065] Referring to FIG. 8, a diagram 800 of an example of a network 802 of one or more devices 202 coupled to corresponding manual surface maintenance machines 204 in accordance with the present embodiment for cooperative cleaning of a large surface 804 is depicted. The network 802 comprises a central controller 806, a plurality of monitoring units 808, a plurality of manual surface maintenance machines 204, and a plurality of devices 202 coupled to a corresponding one of the plurality of manual

surface maintenance machines 204. The central controller 806 and monitoring units 808 are able to transceive information through the network 802 through a plurality of network couplings 810, 812 to the at least one device 202. The information may comprise commands for the devices 202 to switch between the learning mode, autonomous mode, enforcement mode or standby mode. The information may also comprise recorded data that is stored in the memory 234 of the at least one device 202, such as battery life of the device 202, battery life of the manual surface maintenance machine 204, utilization status of the manual surface maintenance machine 204 or device 202, apparatus control status, speed, direction, mileage, recorded video or still image data or similar information. The network coupling 810, 812 between the central controller 806, monitoring unit 808 and the device 202 may be a wired coupling 812 or a wireless coupling 810.

[0066] Referring to FIG. 9, a diagram of an example of a network 802 of one or more devices 202 in accordance with the present embodiment for controlling corresponding manual surface maintenance machines 204 for cooperative cleaning of multiple floors 902, 904, 906, is depicted. Through the network 802, cooperative cleaning of multiple floors 902, 904, 906, may be managed by the central controller 806 and/or monitoring units 808. Surface conditions and recorded data of multiple floors 902, 904, 906, may be transmitted between the device 202 and central controller 806 periodically, for monitoring of the surface conditions and efficiency of the maintenance process. Devices 202 with corresponding manual surface maintenance

machines 204 may be redeployed to other floors 902, 904, 906 to increase productivity.

[0067] In some alternative embodiments of the present invention, commands may be sent to the devices 202 to switch between a first mode and a next mode after a predetermined period of time. A device 202 in standby mode initially may be commanded to switch into an autonomous mode, perform the cleaning route learned previously, return to a location and re-enter standby mode. Commands may also be sent to the devices 202 to perform the steps of any of the learning mode, the autonomous mode and the enforcement mode at a scheduled time and for a determined period of time. Surface conditions and recorded data of multiple floors 902, 904, 906 may be transmitted between the device 202 and central controller 806 periodically, while the device 202 is in autonomous mode for example, for monitoring of the surface conditions and cleaning efficiency of the process.

[0068] In some alternative embodiments of the present invention, the surface conditions may be recorded and analyzed in the processor 232 of the device 202, in the central controller 806, or in the monitoring units 808. If the surface condition is determined to be unsatisfactory, the device 202 with corresponding manual surface maintenance machines 204 on that floor 902, 904, 906 can be instructed to repeat movements and operations recorded for that floor 902, 904, 906 during the learning mode, or within the area that has been determined to have unsatisfactory surface conditions. Video recording, photographic imaging, infrared imaging, light scattering, attenuation,

absorption or reflection data may be used to assess the surface condition along the route.

[0069] In some alternative embodiments of the present invention, video analytics software may be used to determine if an area requires maintenance. Video recordings or still images may be processed by the video analytics software to detect particles, stains, water bodies, objects or surface roughness in the video or image data. If a parameter exceeds a predetermined threshold, the video analytics software flags the position as one that “requires maintenance”. Device 202 may be configured to respond immediately to this flagged position, store the flagged position in its memory 234 or transmit information on the flagged position to the central controller 806. The central controller 806 may compile a list of flagged positions and instruct the device 202 to execute a maintenance route in autonomous mode based on the list of flagged positions.

[0070] In some alternative embodiments of the present invention, network coupling 810, 812 between the device 202, the central controller 806 and the monitoring units 808 may exist as wireless coupling 810 including Wi-Fi, 3G, 4G, radiofrequency (VHF, UHF or ultra-wideband), microwave and infrared transceiving means, and wired coupling 812 including USB and Firewire coupling means.

[0071] In some alternative embodiments of the present invention, the commands transmitted and received between the device 202, the central

controller 806 and the monitoring units 808 may use binary encoding, unique identifiers or encryption to associate a particular command to a particular device 202.

[0072] In some alternative embodiments of the present invention, the position and location of the device 202 and corresponding manual surface maintenance machine 204 may be determined by the processor 232 of the device 202 by using data from GPS receivers, photoelectric proximity sensors, accelerometers, bumper switches, electronic compasses, infrared range finders, ultrasonic rangefinders, a combination of rotary encoders, linear variable differential transformers, laser doppler vibrometers, or by measuring the signal strength of Wi-Fi, 3G, 4G, radiofrequency, microwave and infrared transceiving means.

[0073] In some alternative embodiments of the present invention, the central controller 806 or monitoring unit 808 may check the battery life and utilization status of the devices 202 or other information in the memory 234 of the device 202 before scheduling a list of modes for that particular device to execute at a determined time. The central controller 806 or monitoring unit 808 may further query the device to determine if a particular maintenance route is present in the memory 234 of the device 202. If the maintenance route is not present in the memory 234 of the device 202, the central controller 806 or monitoring unit 808 may transmit the maintenance route to the device 202, along with a command to activate the autonomous mode based on the new maintenance route. Alternatively, if the maintenance route

is already present, the central controller 806 or monitoring unit 808 may check that the maintenance route is up to date, and if so, transmit a command to activate the autonomous mode based on the updated maintenance route.

[0074] In some alternative embodiments of the present invention, the device 202 may be programmed to transmit the information stored in the memory 234 of the device 202 including battery life of the device 202, battery life of the manual surface maintenance machine 204, utilization status of the manual surface maintenance machine 204 or device 202, apparatus control status, speed, direction, mileage, recorded video or still image data or similar information to the central controller 806 and monitoring units 808 irrespective of the mode that the device 202 is currently engaged in.

[0075] In some alternative embodiments of the present invention, the device 202 may be configured to execute an exploration mode. In the exploration mode, device 202 may configure the manual surface maintenance machine 204 to perform randomized movements, without maintenance operations, to simulate a random walk in the environment it is exploring, and collect data of the environment around it through the plurality of sensors 250. In this mode, the location of the walls, obstacles, potholes and steps may be recorded without the need for a human operator. The device 202 may transmit this information to the central controller 806 and/or to monitoring units 808. Devices 202 engaged in this mode would provide a

virtual map of a new location that the operator wishes to perform surface maintenance on.

[0076] In some alternative embodiments of the present invention, the device 202 may be configured to execute a homing mode. In the homing mode, device 202, while *executing a maintenance route*, may respond to a command from a user or operator to interrupt the maintenance process in favor of executing a movement towards a desired location. After arriving at the desired location, the device 202 may notify the user of the arrival at the desired location.

[0077] In some alternative embodiments of the present invention, the device 202 may be configured to execute a security mode. In the security mode, device 202 may configure the manual surface maintenance machine 204 to perform movements from one location to another, while the infrared sensors 250 are configured to sense human presence. In the event that a human presence is detected by the device 202, the device 202 transmits an alert to the central controller and monitoring units to alert them of the human presence. It is understood that other modes may be made possible without departing from the scope of the invention as set forth in the appended claims.

[0078] In some alternative embodiments of the present invention, the central controller 806 may be a cloud shared server or a locally hosted server *within the vicinity*. The monitoring unit 808 may be a laptop, mobile phone, or remote control unit for the device 202.

[0079] In some alternative embodiments of the present invention, the device 202 may be removed from the manual surface maintenance machine 204, if an operator wishes to use the manual surface maintenance machine 204 manually. Alternatively, the device 202 may be configured to release control of the manual surface maintenance machine 204 to the operator while recording surface conditions or sending information to the central controller 806 or monitoring units 808 while the manual surface maintenance machine 204 is under manual control of the operator. In the event that the device 202 malfunctions, a manual override switch may be activated to configure the device 202 to release control of the manual surface maintenance machine 204 to the operator for manual operation.

[0080] Thus, in accordance with the present embodiment, a novel, advantageous and cost effect device 202, method and network 802 to automate manual surface maintenance machines 204, has been presented which overcomes the drawback of the prior art.

[0081] Some portions of the description which follows are explicitly or implicitly presented in terms of algorithms and functional or symbolic representations of operations on data within a computer memory. These algorithmic descriptions and functional or symbolic representations are the means used by those skilled in the data processing arts to convey most effectively the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical

manipulations of physical quantities, such as electrical, magnetic or optical signals capable of being stored, transferred, combined, compared, and otherwise manipulated.

[0082] Unless specifically stated otherwise, and as apparent from the following, it will be appreciated that throughout the present specification, discussions utilizing terms such as “recording”, “storing”, “determining”, “raising”, “detecting”, “releasing”, “transmitting”, or the like, refer to the action and processes of a computer system, or similar electronic device, that manipulates and transforms data represented as physical quantities within the computer system into other data similarly represented as physical quantities within the computer system or other information storage, transmission or display devices.

[0083] In addition, the present specification also implicitly discloses a computer program, in that it would be apparent to the person skilled in the art that the individual steps of the method described above may be put into effect by computer code. The computer program is not intended to be limited to any particular programming language and implementation thereof. It will be appreciated that a variety of programming languages and coding thereof may be used to implement the teachings of the disclosure contained herein. Moreover, the computer program is not intended to be limited to any particular control flow. There are many other variants of the computer program, which can use different control flows without departing from the spirit or scope of the invention.

[0084] Furthermore, one or more of the steps of the computer program may be performed in parallel rather than sequentially. Such a computer program may be stored on any computer readable medium. The computer readable medium may include storage devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a general purpose computer. The computer program when loaded and executed on such a computer effectively results in an apparatus that implements the steps of the preferred method.

[0085] While exemplary embodiments have been presented in the foregoing detailed description of the invention, it should be appreciated that a vast number of variations exist. For example, those skilled in the art will realize from the teachings herein that the present technology may also be applied to any manual surface maintenance device including floor polishers, road sweepers, and ice resurfacers.

[0086] It should further be appreciated that the exemplary embodiments are only examples, and are not intended to limit the scope, applicability, operation, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention, it being understood that various changes may be made in the function and arrangement of elements and method of operation described in an exemplary embodiment without departing from the scope of the invention as set forth in the appended claims.

CLAIMS

1. A detachable device for converting a manual surface maintenance machine to an automatic surface maintenance machine, the device comprising:

5 at least one attachment means for mechanically attaching the device to the manual surface maintenance machine;

at least one mechanical control coupling means for mechanically coupling the device to at least one mechanical component, the at least one mechanical component comprising apparatus control mechanisms, velocity
10 control mechanisms and steering control mechanisms;

at least one electrical control coupling means for electrically coupling the device to at least one electrical component, the at least one electrical component comprising an energy storage device, velocity control means, and mechanical component on-off circuits; and

15 a control means, the control means comprising:

at least one processor; and

at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, provide control signals to the at least one
20 mechanical component and the at least one electrical component of the manual surface maintenance machine, for controlling the manual surface maintenance machine to at least move to one or more

predetermined locations in response to location data stored in the at least one memory.

2. The device in accordance with claim 1 wherein the computer program code is further configured to perform the steps of a first mode, the steps of the first mode comprising:

moving to a first location amongst a plurality of locations,

performing at least one operation, while moving to the first location and at the first location;

10 moving to a next location amongst a plurality of locations; and

performing at least one operation, while moving to the next location and at the next location.

3. The device in accordance with claim 2 wherein the at least one operation comprises surface maintenance operations, including one or more of cleaning, wiping, vacuuming, buffing, cutting and raking.

4. The device in accordance with claim 2 wherein the at least one operation further comprises performing a non-maintenance operation including operating one or more of the apparatus control mechanisms to raise an apparatus off the surface, reduce the rotation of the apparatus or divert power from the apparatus completely.

5. The device in accordance with any of the preceding claims wherein the computer program code is further configured to perform the steps of a second mode, the steps of the second mode comprising:

recording movement between a plurality of positions from a first

5 location to a next location;

recording the operations performed when at the first location and while moving to the next location;

storing the movement between the plurality of positions and operations performed into the memory; and

10 performing the steps of recording and storing as an operator uses the manual surface maintenance machine.

6. The device in accordance with claim 5 wherein the computer program code is further configured to perform the first mode according to the movement
15 and the operations recorded in the second mode.

7. The device in accordance with any of the preceding claims wherein the computer program code is further configured to perform the steps of a third mode, the steps of the third mode comprising:

20 moving to a first position amongst a plurality of positions while performing an operation;

recording a surface condition of the first position;

storing the surface condition of the first position into the memory; and

repeating the steps of moving, recording and storing for a plurality of positions.

8. The device in accordance with any of the preceding claims wherein the device further comprises a network coupling component to enable the device to couple to a network through network coupling, and to transmit and receive information through the network coupling to a central controller and/or at least one monitoring unit.

9. The device in accordance with claim 8 wherein the received information is a command to switch between two modes, the modes including the first mode, the second mode and the third mode.

10. The device in accordance with claim 8 wherein the transmitted information is data stored in the memory of the device.

11. The device in accordance with claim 10 wherein the data stored in the memory of the device includes battery life of the device, battery life of the manual surface maintenance machine, utilization status of the manual surface maintenance machine or device, apparatus control status, speed, direction, mileage, recorded video and still image data.

12. The device in accordance with claims 8 to 11 wherein the network coupling comprises wired coupling includes USB and Firewire coupling.

13. The device in accordance with any of the above claims wherein the
5 device further comprises a first plurality of sensors and a second plurality of sensors, the first plurality of sensors for determining the position and environment around the device including one or more of capacitive and photoelectric proximity sensors, laser and infrared scanners, GPS, accelerometers, bumper switches, electronic compasses, infrared range finders, ultrasonic rangefinders, and the
10 second plurality of sensors for determining the condition of the surface around the device including one or more of video recorders, cameras, infrared imaging, light scattering and detection devices.

14. The device in accordance with any of the above claims wherein the
15 device further comprises a user interface for users to access the control means.

15. A network of one or more devices in accordance with any of the above claims for controlling corresponding manual surface maintenance machines, the network comprising:

- 20 a central controller;
 a plurality of monitoring units;
 a plurality of manual surface maintenance machines; and

a plurality of devices coupled to a corresponding one of the plurality of manual surface maintenance machines.

16. The network in accordance with claim 15 wherein the central controller is able to transmit information through a network coupling to at least one device, the information comprising:
commands for the at least one device to switch between two modes, the modes including the first mode, the second mode and the third mode; and
recorded data of the at least one device.

17. The network in accordance with claim 15 wherein the central controller is able to receive information through a network coupling from at least one device, the information comprising battery life, utilization status, and recorded data of the at least one device.

18. The network in accordance with claim 15 to 17 wherein the plurality of monitoring units are able to transmit information to, and receive information from, the at least one device through a network coupling to at least one device, the information comprising commands for the at least one device to switch between two modes, the modes including the first mode, the second mode and the third mode, battery life, utilization status, and recorded data of the at least one device.

19. The network in accordance with claim 15 to 18 wherein the plurality of monitoring units are able to transmit information to, and receive information from, the at least one device through a network coupling to the central controller, the information comprising commands for the at least one device to switch between
5 two modes, the modes including the first mode, the second mode and the third mode, battery life, utilization status, and recorded data of the at least one device.

20. The network in accordance with claim 15 to 19 wherein the network
10 coupling comprises wireless coupling includes Wi-Fi, 3G, 4G, radiofrequency, microwave and infrared transceiving means.

21. The device in accordance with claim 15 to 20 wherein the network coupling comprises wired coupling includes USB and Firewire coupling means.

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