

AUTONOMOUS OPERATIONS SYSTEM

FIELD OF THE INVENTION

The disclosures made herein relate generally to the field of robotics and more
5 particularly to an autonomous operations system for handling a task.

BACKGROUND OF THE INVENTION

It is well known in prior art to control automated tools in an industrial
environment by programming each tool according to a task to be performed by
10 the corresponding tool. However, it is very expensive and tedious process to
program a tool according to each task, as actions to be performed by the tool
varies for each task. Further, even when programmed, a minimum manual
intervention is required for handling the tools. Also, it is not possible to program
simple hand tools like spray paint, paint roller, sanding tool, etc.

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Hence, there is a need for an autonomous operations system capable of
operating simple hand tools to perform a task without a need for manual
intervention.

20 SUMMARY OF THE INVENTION

The present invention relates to an autonomous operations system for operating
simple hand tools to perform a task without a need for manual intervention. The
system comprises one or more mobile units carrying tools, a scanning unit for
scanning an environment in which the task has to be performed, and a central

control unit for planning the task and route to be travelled by the mobile units. The scanning unit scans the environment and generates a scanning report to be sent to the central control unit. The central control unit receives the scanning report and a tool report from each mobile unit and plans the task and the route.

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In one embodiment of the present invention, the central control unit includes an image processing model for processing images captured by the scanning unit to determine one or more tasks to be performed in the environment. The central control unit plans the task and route on the determined tasks, the scanning report and the tool reports.

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The central control unit instructs the mobile units and scanning unit according to the planned task and route, such that the mobile units carry the corresponding tools to desired locations to perform the tasks without any manual intervention in handling the tools.

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BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The present invention will be fully understood from the detailed description given herein below and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, wherein:

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In the appended drawings:

FIGURE 1 shows a top view of a mobile unit of the autonomous operations system, in accordance with the first embodiment of the present invention.

FIGURE 2 shows a side view of a mobile unit of the autonomous operations system, in accordance with the first embodiment of the present invention.

FIGURE 3 shows a schematic representation of a scanning unit of the autonomous operations system, in accordance with the first embodiment of the present invention.

FIGURE 4 shows a top view of a mobile unit carrying a paint roller, in accordance with the first embodiment of the present invention.

FIGURE 5 shows a top view of a mobile unit carrying a sanding tool, in accordance with the first embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Detailed description of preferred embodiments of the present invention is disclosed herein. It should be understood, however, that the embodiments are merely exemplary of the present invention, which may be embodied in various forms. Therefore, the details disclosed herein are not to be interpreted as limiting, but merely as the basis for the claims and for teaching one skilled in the art of the invention. The numerical data or ranges used in the specification are not to be construed as limiting. The following detailed description of the preferred embodiments will now be described in accordance with the attached drawings, either individually or in combination.

Various terms as used herein are defined below. To the extent a term used in a claim is not defined below, it should be understood with the broadest definition given by persons in the pertinent art to that term as reflected in publications (e.g.

dictionaries, article or published patent applications) and issued patents at the time of filing.

Definitions:

- 5 The present invention relates to an autonomous operations system and an operating method thereof. The system comprises one or more mobile units for carrying tools to task locations, a scanning unit for scanning environment and a central control unit. Each mobile unit includes a communication unit for communicating with one or more nearby mobile units. The present invention is
- 10 capable of breaking down a task into multiple sub-tasks to be performed by the mobile units, planning one or more routes to be followed by each mobile unit and predict maintenance requirements of each mobile unit.

- Referring to the accompanying drawings, Figure 1 shows a top view of a mobile
- 15 unit of an autonomous operations system, in accordance with an exemplary embodiment of the present invention. The mobile unit (1) comprises a housing (2) coupled with one or more transport means (3a, 3b) and a tool bracket (4) and enclosing a control module (not shown) and a communication unit (not shown). The transport means (3a, 3b) is controlled by the control module for moving the
- 20 housing (2) from one place to another.

In a preferred embodiment, the transport means (3a, 3b) includes a set of rubber tires (3a) or tracked wheels for moving the housing (1) on ground surface and/or one or more suction units (3b) such as electric ducted fans (EDF) and vacuum

suction cups, for moving the housing (1) over a wall surface. Alternatively, the transport means (3a, 3b) may also include one or more propeller. The tool bracket (4) carries one or more tools e.g. paint roller, paint spray, sanding tool, etc., for performing a corresponding task e.g. painting, sanding, etc. Even
 5 though the tool bracket (4) is shown to be attached to a top portion of the housing (2) in FIGURE 2, it may also be removably or rotatably coupled to other portions of the housing (2) as per requirement of the task.

The control module includes one or more inertial measurement unit (IMU)
 10 sensors, one or more actuators e.g. servomotor, coupled to the transport means (3a, 3b) and one or more microcontrollers for controlling the IMU sensors, actuators, tools and the communication unit. Additionally, the mobile unit (1) includes a location device such as global positioning system (GPS) sensor for capturing location of the mobile unit (1). Optionally, the housing (1) encloses a
 15 power source e.g. battery, for powering the control module, communication unit and the tool. Alternatively, the control module, communication unit and the tool are connected to an external power source e.g. mains or generator. The communication unit includes a wireless module e.g. Wi-Fi, Bluetooth, ZigBee, etc., for wireless communicating with a central control unit (100, as in FIGURE
 20 4), a scanning unit (10, as in FIGURE 3) and/or one more similar mobile units involved in the task. Alternatively, the communication unit may also be communicating with the central control unit (100), scanning unit (10) and/or similar mobile units through a wired connection.

FIGURE 3 shows a schematic representation of the scanning unit, in accordance with an exemplary embodiment of the present invention. The scanning unit (10) includes a support base (11) supporting a rotatable head (12) which carries an imaging device (13) and a range finder (not shown). The support base (11) includes but not limited to a tripod, monopod, pedestal or any other stable base capable of supporting the other components of the scanning unit (10). The rotatable head (12) includes an actuator (not shown) such as stepper motor, capable of rotating the head (12) around 360°.

10 The imaging device (13) captures still or video images of an environment of the scanning unit (10) as the head (12) rotates. In a preferred embodiment, the imaging device (13) includes one or more charge coupled device (CCD) sensors or complementary metal-oxide-semiconductor (CMOS) sensors capable of capturing visible light images. Alternatively, the imaging device (13) may include one or more sensors capable of capturing non-visible radiation images such as infrared images, ultrasound images, etc. For example, the imaging device (13) may capture non-visible light images of rough patches on a wall surface, and the mobile unit (1, shown in FIGURE 1) is moved to the rough patches for smoothening the patches using a sanding tool.

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The range finder is a laser-based or ultrasound-based range finder for measuring a distance between the scanning unit (10) and a task location. For example, once a rough patch on a wall surface is identified from an image, the range finder determines a distance between the scanning unit and the identified patch.

Optionally, a location device such as global positioning system (GPS) sensor is included in the scanning unit (10) for adding location data to each image captured by the imaging device (13). Additionally, the scanning unit (10) includes a communication unit (not shown) for communicating with the mobile
5 unit (1) and the central control unit (100), as shown in FIGURE 4.

The central control unit (100) is a desktop computer, portable computer, smartphone or server located near the environment or at a remote location. Alternatively, the central control unit (100) may also be a cloud server. The
10 central control unit (100) includes an image processing model for processing the images captured by the scanning unit (10). The image processing model is an artificial intelligence (AI)-based model, preferably a machine learning model.

Before loading the image processing model into the central control unit (100),
15 the image processing model is trained using a training dataset comprising a set of manually labeled images, wherein the images are manually analyzed and classified by one or more experts based on one or more tasks to be performed within a location captured in the corresponding image.

20 The trained model processes the images captured by the scanning unit (10) to determine one or more tasks to be performed. The central control unit (100) plans a task to be performed and route to be followed by each mobile unit (1) based on the tasks determined by the trained model, data received from the scanning unit (10) and data received from each mobile unit (1). In a preferred

embodiment, data received from the scanning unit (10) includes GPS data and range finder data. Similarly, data received from each mobile unit (1) includes GPS data and tool data of the corresponding mobile unit (1). The tool data may be data regarding type of tool(s) carried, available lifetime of the tools and the like. Alternatively, the data received from the scanning unit (10) and mobile unit(s) (1) may also include but not limited to power requirements for performing an assigned task and power availability, which enable the central control unit (100) to optimize the plan accordingly, so that the tasks are completed without any interruption due to power failure in any of the mobile units (1) or scanning unit (10).

FIGURE 5 shows a top view of the mobile unit (1) carrying a paint roller (5a) connected to a hose (5b) for supplying paint to the roller (5a). FIGURE 6 shows a top view of the mobile unit (1) carrying a sanding tool comprising a pair of sanding heads (6a) coupled to a handle bar (6b) which is in turn coupled to the tool bracket (4). In an alternate embodiment, the tool bracket (4) may include provisions to coupled two or more tools, one which is selected by the control module according to the task to be performed.

Referring back to FIGURE 4, the complete functioning of the present invention is explained based on a painting task to be performed in a room. The central control unit (100) receives an input from a user regarding a paint color to be applied to each wall surface in the room. Further, the central control unit (100) instructs the scanning unit (10) and the mobile units (1) to transmit a scanning

report and a tool report, respectively. The scanning unit (10) scans each wall, generates a scanning report and transmits the scanning report to the central control unit (100), wherein the scanning report includes data regarding location of the scanning unit (10), distance between the scanning unit (10) and each wall and, length and height of each wall and images of each wall. Each mobile unit (1) generates a tool report regarding one or more spray paint carried by the corresponding mobile unit (1). Each tool report includes data regarding paint color and volume carried by the corresponding mobile unit (1).

10 The image processing model processes the images and determines an amount and color of painting needed for each wall based on the user input. The central control unit (100) plans a task to be performed and route to be followed by each mobile unit (1) based on the an amount and color of painting needed for each wall as determined by the image processing model, the scanning report and the tool reports. Further, the mobile units (1) and the scanning unit (1) may co-operate with one another to guide each mobile unit (1) according to the corresponding plan received from the central control unit. Additionally, based on the processing of actual images, the image processing model is fine-tuned for improving accuracy of processing the images.

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Alternatively, one of the mobile units (1) may function as a master mobile unit, while the remaining mobile units (1) may function as slave mobile units. The master mobile unit also functions as an intermediate device between the central control unit (100) and the slave mobile units. The master mobile unit receives

the tool reports from the corresponding slave mobile units and compiles and transmits a master tool report to the central control unit (100). Further, the master mobile unit receives task plan from the central control unit (100), breaks down the plan into multiple sub-plans based on the number of slave mobile units (1) and transmits the sub-plans to the corresponding slave mobile units. By this way, a number of high quality communication units can be minimized as the master mobile unit only requires communicating with the central control unit (100). Further, processing load is shared between the central control unit (100) and the master mobile unit.

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Even though the tool carried by the mobile units is shown as paint roller, spray paint and sanding tool in above embodiment, it may also include lawn mower, vacuum cleaner and the like. Similarly, the present invention may also be applied for cleaning, putty application, lawn mowing, sports arena ground marking and the like.

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The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a", "an" and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises", "comprising", "including" and "having" are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements and/or components, but do not preclude the presence or addition of one or more other

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features, integers, steps, operations, elements, components and/or groups thereof.

The method steps, processes and operations described herein are not to be
5 construed as necessarily requiring their performance in the particular order
discussed or illustrated, unless specifically identified as an order of
performance. It is also to be understood that additional or alternative steps may
be employed. The use of the expression “at least” or “at least one” suggests the
use of one or more elements, as the use may be in one of the embodiments to
10 achieve one or more of the desired objects or results.