

A ROBOTIC APPARATUS FOR NAVIGATING AND INTERACTING WITH A USER

BACKGROUND

5 There has been a growing “manpower crunch” facing the nursing workforce in the public healthcare institutions. Healthcare demands are growing significantly due to factors including the rapidly ageing population and the rise of chronic disease. However, due to cost and resource constraint, the size of the nursing workforce cannot be scaled proportionally.

10 The routine tasks typically performed by nurses such as vital signs monitoring and administering medications, albeit important to the overall care of the patients, are processes that do not require higher-level thinking or value-add from the nurses and may therefore be automated. The challenge for automating these processes lies in the fact that they involve dynamic interactions with patients and nurses.

15 Thus far, robots have been used for the automation of straightforward tasks where minimal human interactions are required, for example back-end linen or meal transportation. It is observed that robots having capabilities of interacting and engaging with patients in the wards appear to be still out of reach, largely due to the gap in Human Robot Interaction (HRI) technologies where robots can recognize patients and their behaviors and speech and react appropriately.

20 Therefore, there is a need to provide automated apparatus (for example using robots) for carrying out routine tasks, while nurses may focus on practicing at the top of their license. Further, there is a need to design the capabilities required to adapt to the dynamic situations described above and react accordingly, around a set of workflows that allow the robotic apparatus to be deployed and used in a general ward of a hospital.

SUMMARY

25 The present disclosure provides a robotic apparatus for navigating and interacting with a user, the robotic apparatus comprising a processor; a data storage unit coupled to the processor; one or more sensors coupled to the processor for identification of a user; wherein the data storage

unit comprises a navigation module configured to autonomously move the robotic apparatus to a first location upon receiving a set of instructions; an identification module configured to autonomously scan a second location from the first location and identify the user at the second location; wherein upon identification of the user at the second location, the robotic apparatus is
5 configured to (a) autonomously move to the second location and adjust the second location corresponding to a position of the user; (b) assess if the second location is an optimal location to execute of a plurality of healthcare-related tasks; (c) adjust the second location to fit the optimal location; (d) execute the plurality of healthcare-related tasks, through an autonomous interaction with the user; and wherein the plurality of the healthcare-related tasks is selected from a group
10 consisting of measuring vital signs of the user and dispensing a plurality of medications to the user.

According to some embodiments, the data storage unit may further comprise a machine learning module.

According to some embodiments, the one or more sensors may be configured to identify the user at the second location from the first location using said machine learning module.

15 According to some embodiments, the identification of the user may comprise recognizing position or posture of the user or recognizing the presence of one or more subjects other than the user.

According to some embodiments, the one or more sensors may be configured to read a plurality of indicia associated with the user to confirm the identity of the user.

20 According to some embodiments, the identification of the user may comprise comparing data obtained from the reading of the plurality of indicia associated with the user with information of the user in the data storage unit. The plurality of indicia may comprise a barcode, a QR code, a facial recognition or a voice recognition.

25 According to some embodiments, the navigation module may comprise an additional sensor to allow the robotic apparatus avoiding an obstruction when moving to the first location.

10. According to some embodiments, the robotic apparatus may further comprise a vital signs measurement device, wherein the vital signs measurement device monitors or detects a heart rate,

a respiratory rate, a blood pressure, an oxygen saturation, a temperature of the user or its combination thereof.

According to some embodiments, the robotic apparatus may further comprise a storage compartment to store and dispense the plurality of medications to the user.

5 According to some embodiments, the plurality of the healthcare-related tasks may be executed the robotic apparatus without the intervention of a third party.

According to some embodiments, the robotic apparatus may be configured to autonomously navigate inside a ward of a hospital.

10 According to some embodiments, the robotic apparatus may be configured to execute the plurality of healthcare-related tasks in response to the interaction with the user.

According to some embodiments, the robotic apparatus may be configured to execute the plurality of healthcare-related tasks in response to the interaction with the user for up to six users.

There is provided a method of executing a plurality of healthcare-related tasks using a robotic apparatus disclosed herein, comprising:

15 (i) autonomously moving the robotic apparatus via a navigation module to a first location upon receiving a set of instructions;

 (ii) scanning a second location from the first location via an identification module and identifying the user at the second location;

20 (iii) autonomously moving the robotic apparatus to a second location near to the patient; and

 (iv) executing the plurality of healthcare-related tasks, through an autonomous interaction with the user.

25 According to some embodiments, the plurality of the healthcare-related tasks may be selected from a group consisting of measuring vital signs of the user and dispensing a plurality of medications to the user.

BRIEF DESCRIPTION OF THE DRAWINGS

In order for the present disclosure, to be better understood and for its practical applications to be appreciated, the following Figures are provided and referenced hereafter. It should be noted that the Figures are given as examples only and in no way limit the scope of the invention.

5 Fig. 1 is a schematic illustration of a workflow whereby the robotic nursing assistant, in accordance with some embodiments, is deployed for delivery of items to the patients;

 Fig. 2 is a schematic illustration of a workflow whereby the robotic nursing assistant, in accordance with some embodiments, is deployed for vital signs measurement and monitoring; and

10 Fig. 3 is a schematic illustration of a workflow whereby the robotic nursing assistant, in accordance with some embodiments, is deployed for last mile medication administration to the patients.

 Identical or duplicate or equivalent or similar structures, elements, or parts that appear in one or more drawings are generally labelled with the same reference numeral, optionally with an additional letter or letters to distinguish between similar entities or variants of entities and may not
15 be repeatedly labelled and/or described. References to previously presented elements are implied without necessarily further citing the drawing or description in which they appear.

DETAILED DESCRIPTION

20 In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those of ordinary skill in the art that the invention may be practiced without these specific details. In other instances, well-known methods, procedures, components, modules, units and/or circuits have not been described in detail so as not to obscure the invention.

25 Dimensions of components and features shown in the figures are chosen for convenience or clarity of presentation and are not necessarily shown to scale or true perspective. For convenience or clarity, some elements or structures are not shown or shown only partially and/or with different perspective or from different point of views.

Although embodiments of the invention are not limited in this regard, the terms “plurality” and “a plurality” as used herein may include, for example, “multiple” or “two or more”. The terms “plurality” or “a plurality” may be used throughout the specification to describe two or more components, devices, elements, units, parameters, or the like. Unless explicitly stated, the method
5 embodiments described herein are not constrained to a particular order or sequence. Additionally, some of the described method embodiments or elements thereof can occur or be performed simultaneously, at the same point in time, or concurrently. Unless otherwise indicated, use of the conjunction “or” as used herein is to be understood as inclusive (any or all of the stated options).

With specific reference now to the drawings in detail, it is stressed that the particulars
10 shown are by way of example and for purposes of illustrative discussion of embodiments of the disclosure. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the disclosure may be practiced.

The present disclosure provides a robotic apparatus or a robotic nursing assistant (RNA) for navigating and interacting with a user and its use thereof in a hospital setting. The objective of
15 present disclosure is to develop and integrate foundational technologies in Human Robotic Interaction (HRI) to enable the in-ward automation of a plurality of healthcare-related tasks by robots. Examples include the recognition or identification of patients including their behavior, posture and speech as well as the ability to react to patients (first users or simply users) and nurses or healthcare workers or professionals (second users) in a socially appropriate manner.

20 In some embodiments of the present disclosure, the robotic apparatus may interact with a user or first user. In some embodiments, the user or first user may be a patient in a hospital or a clinic. In some embodiments, the robotic apparatus may interact with a second user, wherein the second user may be healthcare worker or healthcare professional including nurse and doctor.

The present disclosure provides work processes required to operationalize the robotic
25 apparatus or the RNA meaningfully, in particular in the ward of public hospitals, which, in turn, allow nurses to focus on higher-value activities including care planning, patient and caregiver engagement and education. The robotic apparatus of the present disclosure may be configured to perform a plurality of healthcare-related tasks including answering nursing calls, medication processing and administration as well as vital signs monitoring.

In some embodiments, the robotic apparatus for navigating and interacting with the user may comprise a navigation module. In some embodiments, the navigation module may independently and autonomously mobilize the robotic apparatus of the present disclosure from its dock to a first location and subsequently to a second location for example to a location where the patient is found in the wards of a public hospital, upon receiving instructions by programmed command or from the second user (a healthcare worker for example a nurse). In some embodiments, the set of instructions is received via a dashboard. In some embodiments, the first location may refer to a neutral point defined at in each ward where the robotic apparatus may be responsible for and may have a good view of the users, bed and its surrounding. In some embodiments, the neutral point may be defined based on the reference positions of the hospital beds and the viewing angle of the camera mounted on the robot. Hence, it is to be understood that this neutral point may vary and may be adjusted depending on the configuration of the hospital beds, layout of the ward and other parameters. In some embodiments, the bed positions may be set to coincide with the field of view of the camera mounted on the robot following certain algorithm or calculation and is a function of the parameters mentioned above including configuration of the hospital beds, layout of the ward and viewing angle of the camera. In some embodiments, in the event that the neutral point is obstructed, the robot may be configured to move a second neutral point. In some embodiments, only either first neutral point or second neutral point may be used. In some embodiments, once the neutral point is identified, a bed foot zone may be generated. This zone is defined as an area whereby the bedside goals points are disallowed. At the first location or neutral point, the robotic apparatus may scan (or perform a scanning) of the second location where the patient or the patient's bed is located. In some embodiments, the second location may be located by the one or more sensors, wherein the one or more sensors comprises a sensor fusion of 3D point. In some embodiments, the one or more sensors may generate a map of the ward environment including the area surrounding the patient's bed.

In some embodiments, the navigation module may comprise a navigation algorithm, preferably an autonomous ward-ready navigation algorithm. The navigation algorithm may allow maneuvering of the robotic apparatus to a precise position or location and orientation with respect to the targeted patient's current posture. In some embodiments, the robotic apparatus, via its navigation module, may mobilize independently upon receiving a set of instructions from the

second user. Such navigation module may comprise one or more sensors for navigation and/ or identification of the patient (first user). The in-ward navigation module may be able to navigate the system autonomously so as to avoid obstacles within the ward environment. In some embodiments, the navigation module may comprise a sensor to allow the robotic apparatus
5 avoiding an obstruction when moving to the first location.

In some embodiments, the one or more sensors include motion sensors (accelerometers for measuring linear, gravitational as well as rotational accelerations), rotation sensors (or gyroscopes). In some embodiments, the one or more sensors may be infrared-based sensors. In some embodiments, the one or more sensors may be based on multisensory-fusion technologies.

10 The navigation module may be configured to allow the robotic apparatus to identify the identity of the patient for example by reading a plurality of indicia associated with the patient including a barcode or a QR code, a facial recognition, or a voice recognition. The plurality of indicia may be found in bed, room or ward, or on the patient (the indicia may be found on a wrist band). Once the correct patient has been identified, the navigation module may then recognize the posture of the
15 patient at pre-defined points for example sleeping, sitting on the bed, sitting at the side of bed and so forth. If incorrect identification or posture is found, the robotic apparatus may not proceed with the subsequent tasks and may return to the first location to perform the subsequent task. In some embodiments, the identification of the patient may involve comparing data obtained from the reading of the plurality of indicia associated with the user with information of the user in the data
20 storage unit.

In some embodiments, depending on the patient's posture at the neutral point, the robotic apparatus of the present disclosure may advantageously identify the second location after scanning the second location and orientation to approach the patient. The RNA may subsequently determine or identify whether subject is (i) sleeping, (ii) sitting on the bed, or (iii) sitting at the bedside. The
25 robotic apparatus may determine the optimal location (which may be different from the second location) to deliver the plurality of healthcare-related tasks. In some embodiments, the second location is the optimal location. In some embodiments, the robotic apparatus may make adjustment to distance and orientation from the second location to the optimal location for more comfortable interactions without the patient adjusting positions as much.

In some embodiments, the robotic apparatus further comprises an identification module for identifying the patients and/ or their current states. The identifying step may be similar to that of the navigation module whereby the identification is by reading a plurality of indicia associated with the patient including a barcode or a QR code, a facial recognition, or a voice recognition. The identification module may determine how the interaction with the subject will be carried out. The navigation module may be provided as a separate module or may be integrated with the navigation module. In some embodiments, the identification module, when used independently or when integrated with the navigation module may identify the state and responsiveness of the subject i.e. asleep, awake and lying down, awake and sitting-up etc. Similar to the navigation module, the identification module may comprise one or more sensors for identifying the state and responsiveness of the subject. The identification module may use multi-factor authentications to confirm the identity of the patient.

In some embodiments, the identification module of the robotic apparatus may comprise video analytics used to recognize the different positions or posture of the patient (sleeping, sitting and so forth). If the patient is currently asleep, the RNA may be configured to perform any of the following tasks: to make a return trip to the same patient later, to attempt to wake the patient up or to alert the nurse. The identification module of the robotic apparatus may be configured to determine the state and responsiveness of the patient. The robotic apparatus may be configured to carry out intended tasks only when the patient is awake.

It is to be understood that correct identification of the patient is necessary to ensure safety, particularly before the right medications are to be administered, or the vital signs measurements are taken. In identifying the patient, the robotic apparatus may use at least a two-factor authentication approach when it reaches the designated bed. In some embodiments, the RNA may use other suitable type of authentication step. Non-limiting examples of the following multi-sensor authentication method that may be used to verify the identification of the patient include facial recognition, voice recognition, iris recognition, QR code verification, and barcode verification.

In some embodiments, as the robotic apparatus may interact with the patient at appropriate proximity, the RNA may be equipped with additional sensors that are able to adjust its position depending on the location of the patient. In this regard, the navigation module of the RNA allows

navigation and prompt response to the dynamic environmental factors. The additional sensors may include a camera.

In some embodiments, the robotic apparatus disclosed in the present application may further comprise a communication module for allowing the RNA to understand and appropriately respond to the patient naturally in the context of the ward environment. Advantageously, the robotic apparatus may understand the patient in verbalizing relevant information such as pain score in a recognizable language, and respond accordingly. The robotic apparatus may recognize and understand multiple languages including English, Malay and Chinese.

In some embodiments, the robotic apparatus further comprises a collaboration module to establish a natural human-robot physical collaboration. In other words, the robotic apparatus may be able to deliver and complete the plurality of healthcare-related tasks intuitively including collaborating with the patient without any human assistance or a third-party intervention. In some embodiments, the plurality of healthcare-related tasks may be delivered or performed in response to the interaction with the user or first user. From these interactions, the robotic apparatus may be able to recognize whether the patient is ready for his or her vital signs to be measured or whether the patient is ready to receive medication. During the implementation of the robotic apparatus, it is anticipated that some of patients may be non-tech savvy, and thus unfamiliar to communicate or collaborate with the robotic apparatus. Further, some group of patients may not fully understand the signal from the robotic apparatus. Advantageously, the robotic apparatus may address the challenges or at least alleviate the challenges faced by typical robotic assistants that are not able to interact with humans in a dynamic environment.

As mentioned above, the robotic apparatus disclosed in the present disclosure may perform a plurality of healthcare-related tasks and may be automated to reduce the workload of the healthcare workers including nurses. Non-limiting examples of the healthcare-related tasks include last mile medicine delivery, item delivery, vital signs measurements and so forth. Other healthcare-related tasks not mentioned here may also be performed by the robotic apparatus disclosed.

In some embodiments, the robotic apparatus may comprise a storage compartment to store and dispense the plurality of medications. The RNA may therefore be programed to serve the right

medication from the storage compartment to the right patient. The robotic apparatus, through its one or more sensors, may be able to identify if the medication has been administered to the patient.

In some embodiments, the robotic apparatus may be automated and deployed to patient for items delivery tasks.

5 In some embodiments, the robotic apparatus further comprises a vital signs measurement device mounted on the apparatus to measure the patient's vital signs and collect the readings thereof. In some embodiments, the vital signs measurement device may monitor or detect a heart rate, a respiratory rate, a blood pressure, an oxygen saturation, a temperature of the patient or its combination thereof. In some embodiments, the robotic apparatus, via video analytics
10 technologies, may be able to monitor the motion and orientation of the patient's limbs, and use visual or audio instructions to guide and interact with the patients so they can place their limbs on a platform provided in the robotic apparatus in the correct position.

 In some embodiments, the robotic apparatus or the RNA may be sized and designed to be responsible for up to five to six patients, or one typical in-patient ward cubicle. It is to be
15 understood that the robotic apparatus of the present disclosure may be reconfigured so that it may be able to perform a plurality of tasks for a different size of patients. In some embodiments, a front-end system interfacing between the second user and the robotic apparatus may allow the second user to select the user or first user (a group of patients) and beds that the robotic apparatus is responsible for. In some embodiments, the robotic apparatus may be able to mobilize and serve
20 the patients accordingly and autonomously or with minimum or no intervention of a third party. The robotic apparatus may also be configured to autonomously seek the patients it is responsible for and capture their vital signs at the timings programmed via the front-end system.

 In some embodiments of the present disclosure, the data storage unit further comprises a machine learning module. In some embodiments, the one or more sensors is configured to identify
25 the user at the second location from the first location using said machine learning module. The identification of the user may be recognizing position or posture of the user. In some embodiments, the identification of the user comprises recognizing the presence of one or more subjects other than the first user. In other words, if the robotic apparatus identifies another subject in addition to the patient or in the absence of the patient as scanning is being performed.

In some embodiments, as previously described, once the neutral point position has been identified, machine learning may be used to determine user's position for e.g. at the second location. In an exemplary embodiment, when the apparatus detects the presence of a second person or a plurality of subjects, the apparatus may be configured to request the non-patient subjects to move away. The apparatus may be configured to wait till all visitors are cleared before continuing to determine the distance and angle of the user with respect to the robot. Point cloud identified by the one or more sensors may generate a map of the area surrounding the patient or the patient's bed. Criteria-based search engine may then be implemented to determine appropriate engagement goals based on the inputs entered. In some embodiments, as previously described, in addition to the user's or patient's position, the apparatus may also obtain details of the surrounding of the bed by scanning. These details, in some embodiments, may be depth information of the 3D surrounding around the bed and may be converted into point cloud data. These data may be feed into robot navigation module, which generates a cost map that can be used to determine the appropriate engagement points. The information obtained from point cloud may be significant for the navigation of the apparatus. In some embodiments, without such information from the point cloud, the apparatus may not be able to see the far end of the bed and may not be able to determine if the far end of the bed is suitable engagement position with the patient or the user.

Following the identification of the patient's position and generation of the cost map of the bed surrounding, a criteria-based search engine may be implemented to determine the appropriate engagement goal points. In some embodiments, all possible goal points may be calculated first. The goal points may be a set of data related to the patient's coordinates. Output of the search, which may be presented as the "best" goal, may be selected from a pool of goal candidates by a non-linear activation function. Any suitable mathematical equations to perform the non-linear activation algorithm may be used.

In some embodiments, as described herein the apparatus disclosed may comprise a plurality of sensors and may implement deep learning algorithms. Advantageously, a precise arrival at the navigation goal point may be achieved. In addition, machine learning may also enable enhanced navigation path planning and decision-making capabilities. Yet advantageously, the robot or apparatus disclosed herein may comprise "humanized" design feature and may provide user-friendly workflow implementation and thus a better or improved human-robot interaction. In some

embodiments, the apparatus disclosed may allow interaction with the patients without the need for the patients to make any body adjustments as the robot is able to identify where the patient is and to move towards the patient for an interaction. This may allow the patient to be engaged directly with the robot for the intended tasks or applications. Accordingly, work productivity of the healthcare workers, particularly nurses will be increased in consideration that the required tasks can now be assisted by the robot.

In some embodiments, the present disclosure provides a server device comprising a second data storage and a communication interface to communicate via a communications network with one or more robotic apparatus of the present disclosure. In some embodiments, a plurality of wireless network access points may be deployed throughout the ward. In some embodiments, it is essential to ensure the access points cover all corners of the ward where the RNA is expected to roam. The RNA unit will communicate with the server through wireless connectivity afforded by the access points. In some embodiments, the wireless network access points may be linked up by wired or wireless backhaul to the server in the equipment room. Every bed position where the RNA is to approach and serve patient may be mapped into the system. In some embodiments, the mapping may be done in advance, to facilitate the navigation and may be updated as changes occur.

In some embodiments, for more integrated deployments, the RNA dashboard may be incorporated with that of the electronic medical record system. This may facilitate automatic transmission of information, alerts for follow-up, scheduling of RNA activity with patient based on clinical need, among others. In some embodiments, when deployed, the RNA may be configured to obtain patient demographic and bed data through integration with the electronic medical record system. This will include, among others, patient name, ID, bed number, current location and status, attending team, clinical baselines, and facial biometric data. In some embodiments, the RNA may be designed to perform facial recognition and verification as part of its identity verification process. Ward orientation will incorporate an introduction of the RNA to the patient, and how it will be serving the patient. In some embodiments, the identification process may require the subject to align his posture and face towards the camera in the robot, and capture the patient's different facial profiles into the RNA's system using the onboarding process. Alternatively, these details may be manually populated into RNA via dashboard.

According to some embodiments of the present disclosure, the server device provides responsive computing elements, such as software elements, code, hyper text markup language, computer styling elements, and the like, in response to requests received by the server device from various computing devices including robotic apparatus of the present disclosure in connection with the communications network.

In some embodiments, the robotic nursing assistant disclosed in the present disclosure may be deployed in the oncology ambulatory setting. For example, the use of robotic solutions to inspect toxic human output and perform automatic disposal in an oncology care setting not only improves the productivity of the nursing team, advantageously, it also improves their safety by minimizing cytotoxic exposure.

In some embodiments, an interface may be provided, through which instructions may be transmitted from the healthcare workers (for example) nurse to the RNA, and for information and/or alerts from the RNA may be received by the nurse. In its simplest form, this interface may be provided through a notebook computer running a standalone dashboard software for the RNA.

In some embodiments, the RNA dashboard may be incorporated with that of the electronic medical record system as described above.

EXAMPLES

Example 1

In an exemplary embodiment, the apparatus described in the present disclosure is used for delivery of items based upon patient's request.

As described in Fig. 1, a user or a healthcare worker (typically a nurse) is interfacing with the apparatus to input instructions and to store information on dashboard. Such information may include bed number, items to be delivered, list of tasks to be performed, patient's ID and so forth. Once the instructions are stored, the robotic nurse assistant will begin to deliver items by navigating the apparatus to a specific ward. Subsequently, the apparatus will perform a scan followed by approaching the patient, once identified correctly and perform a further scan to study the posture of the patient. Once the ideal posture is identified, the apparatus will greet the patient and communicate the intent. The apparatus will allow the patient to retrieve the items from the

storage compartment. The apparatus will communicate with the patient based on the delivered items. The robotic nurse assistant will end the conversation with the patient and communicate its intent to leave. Depending on the tasks entered into the dashboard, the apparatus will either execute subsequent tasks or it will go back to the charging dock. This example clearly demonstrates the benefit of the apparatus when deployed in the hospital setting.

Example 2

In an exemplary embodiment, the apparatus described in the present disclosure is used for vital sign measurement.

As described in Fig. 2, a user or a healthcare worker (typically a nurse) is interfacing with the apparatus to input instructions and to store information on dashboard. Such information may include bed number, list of tasks to be performed, patient's ID and so forth. Once the instructions are stored, the robotic nurse assistant will begin to perform the tasks. The robot will begin to navigate to a designated ward. Subsequently, the apparatus will perform a scan followed by approaching the patient, once identified correctly and perform a further scan to study the posture of the patient. Once the ideal posture is identified, the apparatus will greet the patient and communicate the intent. Next, the apparatus will perform a further identification of the patient via facial recognition. Such identification may be provided in the form of barcode or QR code found on the wristband of the patient. Once the correct patient is identified, the robot will measure the body temperature of the patient via contactless temperature measurement. The robot will next identify the patient via barcode once again and evaluate pain score of the patient. If the robot recorded a high pain score, then the robot will react accordingly. The robot may optionally perform the additional tasks including measurement of the heart rate, blood pressure, respiratory rate (RR) and saturated oxygen. Once the measurement is completed, the robotic nurse assistant will end the conversation with the patient and communicate its intent to leave. Before executing the subsequent tasks, the robot may display the measurement results to the patient as well as to the healthcare worker. Depending on the tasks entered into the dashboard, the apparatus will either execute subsequent tasks or it will go back to the charging dock. This example clearly demonstrates the benefit of the apparatus when deployed in the hospital setting.

In this example, the RNA can be configured to measure SpO2 and perform heart rate measurements in addition to temperature and respiratory rate. Alternatively, the RNA can monitor blood pressure in addition to the former four vitals.

5 In its deployment, the patient will be shown a short instructional video clip to guide him/her on how SpO2 (Pulse reading) and heart rate measurement is done, while at the same time, the measurement will be attempted by the robot till a valid reading is obtained. Before the actual SpO2 and heart rate measurement process, the robot will attempt to be nearer to the patient till the required distance and direction is achieved for the SpO2 and heart rate measurement. The robot will then stretch out the arm rest. Following the instructions, the patient will be required to place
10 his/her finger onto the Pulse Oximeter in the robot. Indications lights will help to indicate if the patient's fingers have been correctly placed.

Alternatively, the robot can be configured to take measurement for blood pressure concurrently when measuring for SpO2 and Heart Rate in addition to the parameters listed above. When a reliable and consistent reading has been obtained, the robot will then instruct the patient
15 to remove his/her finger from the sensor in the robot. The robot will then inform the patient that task has been completed. The patient will be instructed to lay in bed freely. The acquired readings (result) will be displayed on the robot display and on the dashboard, while abnormalities will be displayed prominently only at the dashboard. Integrated developments will see the information and alerts for action pushed into the electronic medical record system. Next, the RNA robot will
20 await its next task assignment. After a certain predefined waiting time, if no tasks have been assigned, the RNA will proceed autonomously back to the charging station to recharge and wait. The nurse will then be given the cue to perform their routine VSM with the same patient at the same bedside as was previously performed by the RNA.

As for the Respiratory Rate Measurement, the patient will be shown a short instructional
25 video clip to guide him/her on how Respiratory Rate measurements are done, while at the same time, the measurement will be attempted by the RNA till it obtains a valid reading. The robot will obtain the patient's RR reading through its Lidar, capitalizing on the moments when patient would be still during oxygen saturation, heart rate, and blood pressure measurement to observe his or her chest and shoulder rises. The robot will read the sensor data directly and store within the robot's

memory systems. There is no need for the patient to enter any data. The RNA will repeat instructions to the patient to retry if there is no response from the patient, while checking for valid measurements, for up to three times, before it stops trying and will get a nurse to come over to assist.

5 *Example 3*

In an exemplary embodiment, the apparatus described in the present disclosure is used for last mile medication administration.

As shown in Fig. 3, a user or a healthcare worker (typically a nurse) is interfacing with the apparatus to input instructions and to store information on dashboard. Such information may
10 include bed number, medications to be delivered and administered, list of tasks to be performed, patient's ID and so forth. Once the instructions are stored, the robotic nurse assistant will begin to deliver the medications by navigating the apparatus to a specific ward. Subsequently, the apparatus will perform a scan followed by approaching the patient, once identified correctly and perform a further scan to study the posture of the patient. Once the ideal posture is identified, the apparatus
15 will greet the patient and communicate the intent. A further identification may be requested including facial recognition and barcode or QR code found on the wristband of the patient. Once the identification steps are completed, the apparatus may provide instructions to the patients (audio and/ or video) regarding the medications and their dose, administrations thereof. The apparatus will then dispense the medications from the storage compartment, after which the patient will
20 retrieve the dispensed medications. The robot will give an indication that the medications have been retrieved. The robot will also provide an indication that the medications have been administered accordingly. The apparatus will communicate with the patient based on the medications administered. The robotic nurse assistant will end the conversation with the patient and communicate its intent to leave. Depending on the tasks entered into the dashboard, the
25 apparatus will either execute subsequent tasks or it will go back to the charging dock. This example clearly demonstrates the benefit of the apparatus when deployed in the hospital setting.

In this example, the nurse will authenticate his/her identity via the dashboard to assign this task to the RNA. The nurse will then open the medicine dispenser door mechanism to load the medicine compartment with the medicines. Only tablets and capsules will be administered. There

will not be liquids nor injectable medications. Once the nurse has completed loading the medicine compartment, the robot will then lock down the medicine compartment after the door. The nurse will enter the respective identity of the patient and bed location for the robot to navigate. The nurse will dispatch the robot to the patient bed to deliver the medicines. The robot will navigate its way to the patient bed assigned. The nurse will also accompany the robot to the patient's bedside. The robot will then communicate to the patient that it is there to deliver medicines and will perform the patient ID verification. Upon complete verification, the robot will unlock the medicine dispenser door mechanism. The robot will operate alongside the nurse to serve medication at the bedside together. The robot will interact with the patient to guide him/her to retrieve his/her medicine from the medicine dispenser with the nurse's supervision. During this process, the nurse will observe the medicine delivery by the robot as well as the medicine retrieval and consumption by the patient. This observation process is to adhere to current practice in the inpatient wards to ensure correct medications are delivered to the correct patient. Once the patient has retrieved all items from the medicine dispenser, the medicine compartment door will attempt to close.

The robot will sense if the dispenser compartment is empty. If the dispenser compartment is empty, it will acknowledge that the medicines have been retrieved and close the door. It will thank the patient and report the status of successful medicine delivery. If the robot senses that there are some remaining medications in the compartment which the patient has not yet retrieved, it will prompt the patient to retrieve them. If there are still some remaining tablets or medications, an alert will be sent to the patient and/or nurse. The nurse will then ensure that the medications are retrieved and consumed by the patient as required. The robot will move on to the next task assigned, or if it is assigned for medication delivery to another patient, it will proceed to that patient's bedside and the nurse will accompany the robot to repeat this process.

It should be appreciated that the above-described methods and apparatus may be varied in many ways, including omitting or adding steps, changing the order of steps and the type of devices or apparatus used. It should be appreciated that different features may be combined in different ways. In particular, not all the features shown above in a particular embodiment are necessary in every embodiment of the disclosure. Further combinations of the above features are also considered to be within the scope of some embodiments of the disclosure.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims, which follow.

CLAIMS

1. A robotic apparatus for navigating and interacting with a user, the robotic apparatus comprising:

a processor;

5 a data storage unit coupled to the processor;

one or more sensors coupled to the processor for identification of a user;

wherein the data storage unit comprises:

a navigation module configured to autonomously move the robotic apparatus to a first location upon receiving a set of instructions;

10 an identification module configured to autonomously scan a second location from the first location and identify the user at the second location;

wherein upon identification of the user at the second location, the robotic apparatus is configured to:

15 (a) autonomously move to the second location and adjust the second location corresponding to a position of the user,

(b) assess if the second location is an optimal location to execute of a plurality of healthcare-related tasks,

(c) adjust the second location to fit the optimal location,

20 (d) execute the plurality of healthcare-related tasks, through an autonomous interaction with the user; and

wherein the plurality of the healthcare-related tasks is selected from a group consisting of measuring vital signs of the user and dispensing a plurality of medications to the user.

2. The robotic apparatus of claim 1, wherein the data storage unit further comprises a machine learning module.

25 3. The robotic apparatus of claim 2, wherein the one or more sensors is configured to identify the user at the second location from the first location using said machine learning module.

4. The robotic apparatus of claim 3, wherein the identification of the user comprises recognizing position or posture of the user.
5. The robotic apparatus of claim 3, wherein the identification of the user comprises recognizing the presence of one or more subjects other than the user.
- 5 6. The robotic apparatus of claim 1, wherein the one or more sensors is configured to read a plurality of indicia associated with the user to confirm the identity of the user.
7. The robotic apparatus of claim 6, wherein the identification of the user comprises comparing data obtained from the reading of the plurality of indicia associated with the user with information of the user in the data storage unit.
- 10 8. The robotic apparatus of claim 6, wherein the plurality of indicia comprises a barcode, a QR code, a facial recognition or a voice recognition.
9. The robotic apparatus of claim 1, wherein the navigation module comprises an additional sensor to allow the robotic apparatus avoiding an obstruction when moving to the first location.
10. The robotic apparatus of claim 1, further comprising a vital signs measurement device.
- 15 11. The robotic apparatus of claim 10, wherein the vital signs measurement device monitors or detects a heart rate, a respiratory rate, a blood pressure, an oxygen saturation, a temperature of the user or its combination thereof.
12. The robotic apparatus of claim 1, further comprising a storage compartment to store and dispense the plurality of medications to the user.
- 20 13. The robotic apparatus of claim 1, wherein the plurality of the healthcare-related tasks is executed without the intervention of a third party.
14. The robotic apparatus of claim 1, wherein the robotic apparatus is configured to autonomously navigate inside a ward of a hospital.
15. The robotic apparatus of claim 1, wherein the robotic apparatus is configured to execute
25 the plurality of healthcare-related tasks in response to the interaction with the user.

16. The robotic apparatus of claim 15, wherein the robotic apparatus is configured to execute the plurality of healthcare-related tasks in response to the interaction with the user for up to six users.

17. A method of executing a plurality of healthcare-related tasks using a robotic apparatus as
5 claimed in claim 1, comprising:

(i) autonomously moving the robotic apparatus via a navigation module to a first location upon receiving a set of instructions;

(ii) scanning a second location from the first location via an identification module and identifying the user at the second location;

10 (iii) autonomously moving the robotic apparatus to a second location near to the patient; and

(iv) executing the plurality of healthcare-related tasks, through an autonomous interaction with the user.

18. The method of claim 17, wherein the plurality of the healthcare-related tasks is selected
15 from a group consisting of measuring vital signs of the user and dispensing a plurality of medications to the user.