Telemedicine Mobile Robot - Robots to Assist in Remote Medical

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***Abstract*—This paper presents a design of medical helping robot and interaction between human and robot (HRI) in health care for robot called Telemedicine - a robotic system for remote diagnosis based on real-time videoconference and saved in electronic medical record. We would love to show our research to reach the design of the first prototype of Telemedicine system and some first successful experiment such as two-side medical teleconference for connecting between a doctor and a patient, helping an assistance provides drugs for patients, finally supporting doctor determines patient's condition with medical record and remote moving platform. Robot system has own network includes individual patient-doctor and assistant-doctor communicate channels, these channels is capability as well as separately. This robot can also automatically move to recharge dock to make sure battery always in the best condition.**

***Index Terms*— Tele-health care, Telemedicine, HRI, elderly, electronic medical record, teleconference.**

I. Introduction

Following newest robotics trends 2019 updated by the ROBO Global Robotics & Automation Index, today, healthcare accounts for 10% of the ROBO Index, with a focus on robotics guidance and surgery, laboratory automation, genomics, and AI healthcare applications. The sector returned more than 21% in the first 11 months of 2018 [1]-[3]. This means Robots for health examination which supported to healing up patients has appeared more than ever, it plays a certain role in human life. In almost countries nowadays, specifically developed countries such as Japan and European, Robots began replacing humans even do better than human have done. Many robots are generally used in manufacturing processes, dangerous environments which harmful for humans. In health environment, this is easily affected by infectious diseases, fatal diseases, these diseases could increases the risk of diseases transmission human through human. Especially, from World Health Organization(WHO) regarding the current outbreak of novel coronavirus (2019-nCoV) that was first reported from Wuhan, China, the acceleration of modern technologies in isolation, diagnostics, medical examination and treatment has never been more and more focused on the world, it is worth noting that the entry of robots supporting remote medical examination and treatment. Otherwise, nurse, assistance and doctor working in hospital and the nursing house are not qualified enough due to training knowledge or many hospitals lack serious medical staff. Especially, Vietnam has a huge problem of lacking medical equipment and specialized doctors are not enough for apportioning to all provinces of Vietnam, the most important is not having any doctor or medical care are being supplied in time to emergency problem, or area often affected by natural disaster which had become more difficult than ever. Moreover, due to, there are increasing of violence cases that patients attacking doctors, its make many doctor working in Vietnam as well as foreign doctors worried this could be the reason why doctors have quit their jobs to ensure their own safety. Following these necessary purposes above, we would like to research and design Telemedicine robot. This robot is some spectacular results in taking care for the elderly and patient, helping observe children when their parents not being home and supporting doctor to take care patients around hospital with only sitting on one location. Medical care by robot help in Vietnam is still quite new and strange so that to make and applied this robot field in Vietnam need to spend a lot of time and money for manufacturing, this robot could not only save time and budget for medical care but also reduce cross-species transmission, (CST) or spillover.

II. Technical Requirements and User Requirements

A. Select Affordable Appearance for Robot

First, this robot is designed for medical care purpose, it means robot have to be slight and easy to move indoor[4], not only as small as it can but also helping patient communicate with doctor oversea as easier as possible. Otherwide, our object in this experiment is elderly, children from three to fourteen years old and patient who are in course of doctor observation which suffering from trauma or infectious disease requires isolation, need long-term medical care, for all reason above, this telemedicine need to be light, smooth moving and easiest to use;With 4 functions and 4 ideas for each function (in Table I) we can combine into 4^4 design options. However, with the weights set in the design which requirements set out in the above, section to meet the low cost, small size -

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compact, flexible, independent operation, we choose the plan with these ideas: The idea is as follows: Pedestal moves with 2 degrees of freedom with 2-wheel drive and 1 self-selected gear (concept 1st in moving platform), screen with 2 rotary joints, screen rotation to ensure the view of the person appropriate for human - robot interaction and cluster-oriented direction in order to change height with simple and inexpensive structure but as strong as it can to help to hold touch screen for stability requirements (like concept 4th for Screen Justify).

TABLE I. TABLE OF EQUIPMENTS USING INSIDE TELEMEDICINE

Functions	Design Concepts			
	Concept 1	Concept 2	Concept 3	Concept 4
Moving platform	Differential, a passive wheel	2 x Chain slides	4 x Omni wheels	Differential and active wheel
Screen Justify	Translation motion	Rotate	Translation and rotate	Tilt and Pan
Carrying Medical and Specimens	MEDICAL BOX / PLATFORM Removable	MEDICAL BOX / PLATFORM Freeze	PLATFORM / MEDICAL BOX Following	MEDICAL BOX / FLATFORM Slide from platform
Charging	FLATFORM Station	FLATFORM Wireless	FLATFORM Using wire	FLATFORM Exchange

The power supply will be independent and located on this platform with a volume not too large, so use a battery instead of a battery with a charging station fixed because this robot is self-propelled capable of self-positioning so the positioning determination. It is possible to position correctly to the point *(as concept 1st for charging)*. Because of wireless charging plans are too expensive and pulling wires while moving is not suitable for operating in a large environment, or replacing batteries when they are finished makes it difficult and requires a technician. Finally, medical and drugs box can be removable that doctor can efficiently change for using robot to transport patient's specimens easily and immediately in a second (like concept *1st for carrying medical equips and specimens).*

B. Determine Robot Function in Use

- ***Function 1*** *(in Fig. 1)*: This robot has the ability to move self-propelled on a flat background such as in hospitals, families, nursing homes..., these floors are flat without any jerks. Therefore, this self-propelled device features a self-propelled mobile robot, capable of moving on a plane.
- ***Function 2*** *(in Fig. 1):* The robot supports remote medical treatment by interacting via the touch screen by video call. The small right interactive screen at the same interactive touch screen can allow patients - doctors or role as users to easily observe and communicate with activities such as: delivery between doctors - patients, support for direct translation (online), explanation of professional terminology for patients, health counseling for patients, psychotherapy based on interactive features based on natural language processing and remind patients to follow the right regimen. Treatment and transportation of specimens should be necessary.

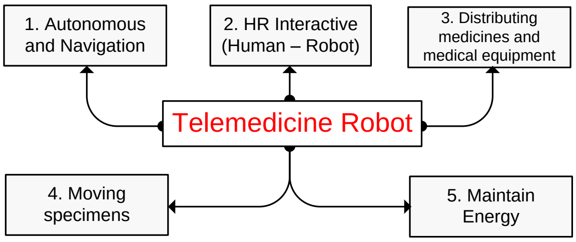

Figure 1. Analysis Robot Functions

- ***Function 3, 4*** *(in Fig. 1)*: The mobile robot is capable, transporting - supplying drugs, moving specimens to the required place so the robot must have a compartment or container of tools, medicines or specimens to keep correct request;
- ***Function 5*** *(in Fig. 1)*: Robot must ensure independent operation with the energy source managed and supervised.

III. MECHANISM DESIGN

A. Autonomous Platform Design

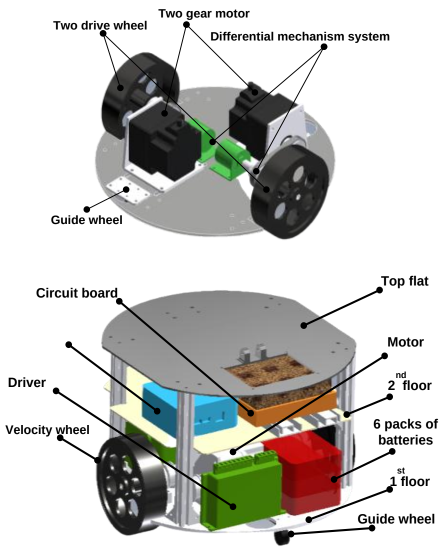

Figure 2. Telemedicine is using differential gear for autonomous platform with two floors design that contained all complex control system.

The platform shown in Fig. 2 was designed and made of aluminum to minimize the weight of robot while still ensuring firm rigidity for entire structure. Telemedicine robot is using a differential mechanism system (2 drive wheels are controlled velocity by 2 motors and 2 drivers.

Guide wheel helps balance robot and let robot more go smoothly) which is divided into two floors follows: in the first floor, the robot platform contains engine and the entire power source of robot so its center will be lowered and first floor will also bear the full weight of robot. In the second floor, there are medicine containers or medical equipment and can be specimens as well as containing the central controller and the entire control circuit separated. The traction for robot is provided by two 30W - 24 DC motors integrated with gearbox sealed against dust, so that the platform can also availably used also in outdoor conditions such as disaster area required medical help.

Figure 3. The appearance of Telemedicine robot when designed and practical.

The platform mass is approximate 30 kilograms, reach maximum speed of 1.3 meters per second and carry on with maximum 20 kilograms. The platform contains enough power for entire system (22Ah x 6 batteries, DC/DC converters providing energy to a CPU, 4 ultrasonic sensors, motors and a touchscreen), sensors to avoid humans and objects walking in hospital, emergency cases user can stop robot by pressing emergency button. Robot system independently works with safety navigation algorithms and contributes preserve patient's treatment. This platform was designed to operate indoor environment, therefore the size 430 mm of length, 330 mm of width (not included with cover) with the height can be scaled base on user's height, maximum 940 mm in total like Fig. 3

B. Telemedicine Upper Body – Design for Easiest Interaction

This section describes the design and development of interactive screen systems of remote support medical with examination and treatment by robots. This work aims to create robot body easily adjusted for interaction doctor-patient through Telemedicine more naturally. With performing operational tasks and ensuring anthropological structures in general and specifically with Vietnamese, who has taken part in this experiment and giving greatfull feedbacks for this paper in the result. Screen holding part with the hanging frame, designed and made by 3D printing technology for 26 hours, it has two joints which can be rotated, in addition, a slide coupling allow to lift touch screen up (down) and foldable when using in custom controller. For user interaction environment , in this section the highest component is an interactive screen of 15.6 inches for patients or doctors to monitor and interact with each others. Besides, on the top of screen, there is a camera integrated to capture and save patient's condition, interactive images for the next therapy, several days or weeks. These picture placed above the screen. Monitor and navigate camera placed standing still on shaft-shaped body called slide coupling in Fig. 4

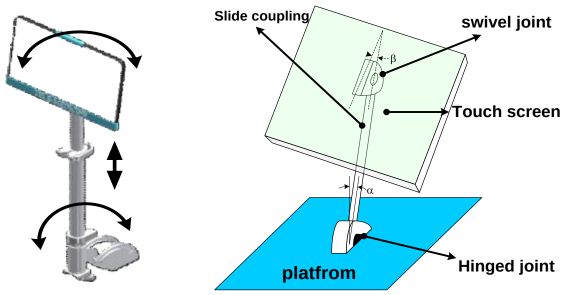

Figure 4. Designed for pan and tilt, holding touch screen and navigation camera

IV. COMMUNICATION SYSTEM

Two differential motors system of the robot are controlled by a microcontroller as a Slave, it links by I2C standard with a microcontroller that acts as a Master. The Master controller communicates with the computer via I2C standard. Image processing algorithms allowed robot determine user's face to adjust touch screen at the same user's vision, audio processing to enhance user identification to improve the efficiency of interacting with robot (HRI), guiding people for indoor environment to find specific room in hospital or nursing house. Depending on the location of the robot in the area, the location of the interaction, the robot can provide information on the screen and at the same time the user can interact with the robot via the touch screen.

Autonomous robot with computer monitor via wireless signal. The operation diagram of the computer monitor is shown in Fig. 4. Robots interact with monitor via computers mounted on mobile platforms via wireless communication. The computer attached to the robot which communicates with the Master microcontroller via RS232 communication by I2C standard. Then all signals processed on the computer and the control signal will be sent to the master microcontroller to distribute control commands to the motor drivers of the motors. Every movement of the robot platform will be performed which controls by drivers in the second floor.

The main decision concluding interface shown in touchscreen, moving algorithm that comes from CPU mounted inside platform, which controls the hardware on the robot via wireless communication as shown in Fig. 5. The control signals are analyzed, processed and feedback to the central computer in every 100 ms. Robot is operated by its own software which written on computers in C# language, runs with Microsoft Window operating system. This system is an open system that can allow connecting other devices through the LAN.

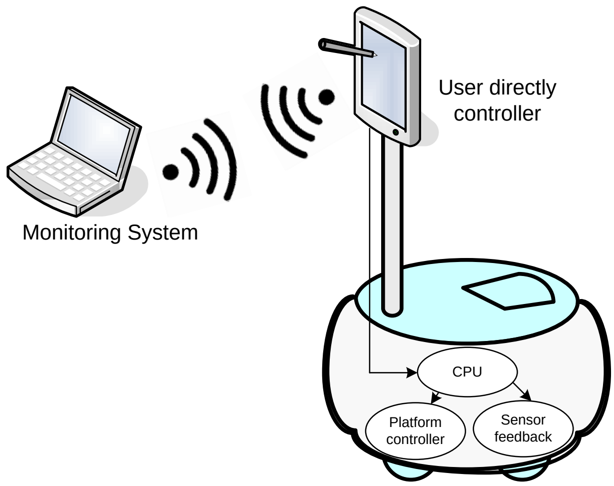

Figure 5. Monitor system (Personal Computer) control robot via wireless connection

V. HUMAN – ROBOT INTERACTIVE

Following the design of mechanism and communication system have been presented in previous section, we would like to present the design for a two-side medical teleconference system for communication between a doctor and a patient. This user interface is displayed on 15.6 inches touch screen mounted in front of the robot. The aim of this work shows reaction of people when being served by robot in public, to determine human robot interaction – HRI. In this task, we concentrate on these question of how Telemedicine robot needs to be made in order to meet the needs for three side user include doctor, patient and assistance (distant doctors do examine for patients by using real-time video-conference, patients getting examined by the help of assistance, moving patient's specimens, providing drugs, medical equipment and remind patient, elderly have medical treatment in time).

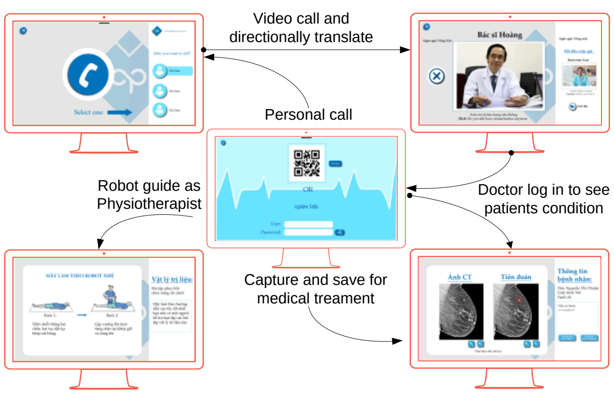

Figure 6. By sign in personal account doctor is able to see patients's health and patient will call to oversea doctor

For supporting distant doctors examine for patients by using real-time video-conference [5]. Telemedicine is connected to server designed specifically for examination purposes. Users have to log in by typing account they have or scan QR code appeared in the screen to enter multi medical function. For user mode, after logged in record, patient can see their medical care process, could call to relatives, doctor for treatment, received doctor's recommendation and following physical therapy recently updated by assistant every single day, the most important is patient just being in one place, doctor will communicate with patient by real-time video call which directionally translate dual two languages with less delay under 2 seconds, shown as Fig. 6.

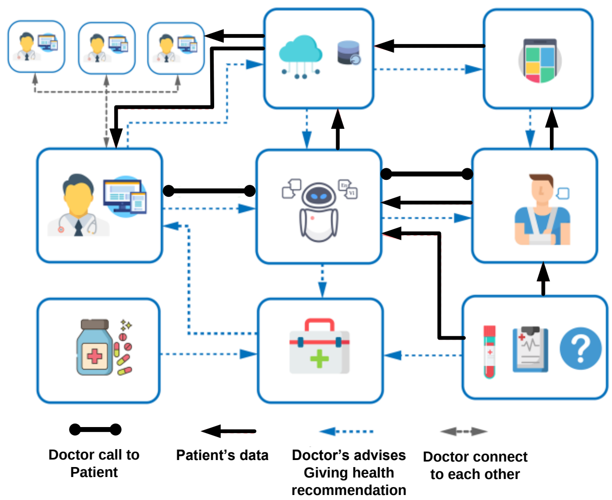

Figure 7. Diagram of Human – Robot interactive between three party, a doctor, an asisstance and the patient

Robot is also controlled through monitor system to navigate in determined area or hardly control by doctor. For doctor mode, assistant and doctor connect with each other in individualization network, assistant will input annual schedule for doctor, remind patient to have drugs in time, arrange medical devices into robot storage passing them to patient in a convenient way. Doctor can check their patient's condition anytime by electronic health record (EHR) which system collecting patient's condition by electronically-stored health information in floppy disc and digital format [6]. Potentially, these records can be shared across different health document among hospital in the world which using the same network like Fig. 7

Instead of transporting specimens manually (delivery - receive samples between faculty members with Laboratory staff). This robot also has the function to guide patients to take samples according to the instructions on the screen and transport patient's specimens from the patient's room to the laboratory. Under the operating, the robot will guide patients to place specimens in an insulated container to avoid contamination and the effect of moisture on the specimen. The robot will move according to the map to the laboratory. Specimen will be placed on storage box mounted in robot's platform, after all user press the start button to help transport to laboratory in map.

VI. Results and Discussions

This robot has function to supply medicine to patients instead of directly assistances and nurses. The robot will be equipped medical separated box on platform. Telemedicine as role as move drugs with the lid open automatically and exactly deliver to patients, when going to the numbered hospital bed, the robot will invite the patient from bed x to get medicine. Besides this function, the robot will remain may require patients to obtain medical equipment such as thermometers, heart rate and blood pressure devices to measure simple medical parameters according to the instructions displayed on the robot screen, patient gets used to interacting with robot and doctor really quick shown as Fig. 8 and Fig. 9.

In addition, Telemedicine robot also has provided with medical devices carrying for monitoring patient's conditions such as giving devices for measuring blood pressure and heart rate. The designed robot with specific features describe in Table II, which also has a medical box placed on the robot's platform, the robot's system is integrated with a temperature measure device and wireless transceiver module for measuring heart rate and remote measure patient's temperature. These modules are connected to monitor placed on doctor's office, receive user's data to contain in Cloud. These measuring devices are following MEMS-based, wireless measuring devices with configurations that can communicate wirelessly to the computer mounted on the robot. With this function, remote medical examination, robot has a huge potential to be used well for patients in separated area by infectious disease and area where there is lack of nurse. Robot data can be transmitted online in real time to doctors and health care station for support in diagnosis and treatment.

Figure 8. Robot is carrying specimems of patient (left) – robot annual checking patient and report to doctor about patient's condition (right)

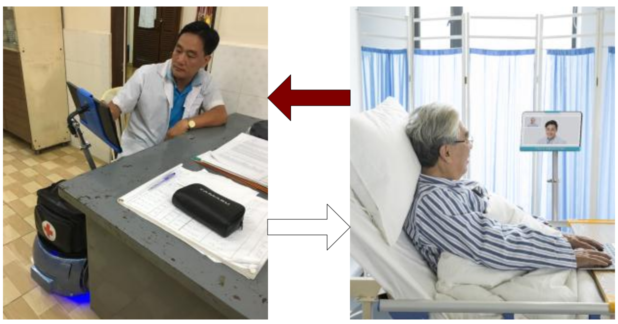

Figure 9. Robot is connecting doctor and patient in different places by video conferencing in real-time

TABLE II. Equipments Using Inside Telemedicine

ITEM	CONTENTS
SIZE	940 (Height) x 450 (length) x 340 (width) in millimeters
Weight	30 kilograms (not including medical equipment)
Material	Platform base : Aluminum, cover robot : Composite
Maximum Moving Speed	0.8 meter per second
CPU	NIVIDIA Core I5
Operating System	Win 10 professional
RAM	HDD 4GB
WEBCAM	12.0 Megapixel
CAMERA	360^0 View
LAN	Wireless LAN 70 Mbps/second
Sensor	Ultrasonic, Lidar sensor
Audio	4W Speaker
Interactive support	Full HD 15.6 inches touch screen
Holder	3D printing technology

VII. Conclusion

In control of moving robots for many orbits, by picking random starting points and ending points in many different positions, velocity and direction of the robot as well as the two wheels of the platform are tested giving less chattering as shown in Fig. 10 and Fig. 11 with the regulator Fuzzy controls for moving algorithms.

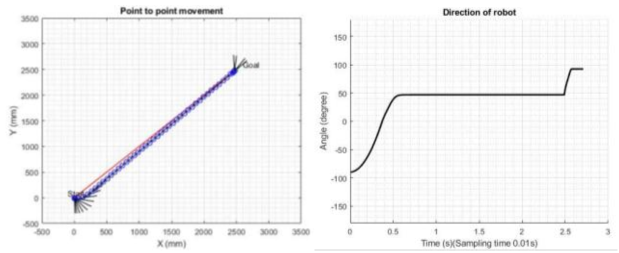

Figure 10. Satisfied the position, satisfied the rotation angle and 2-wheel robot of the specific case.

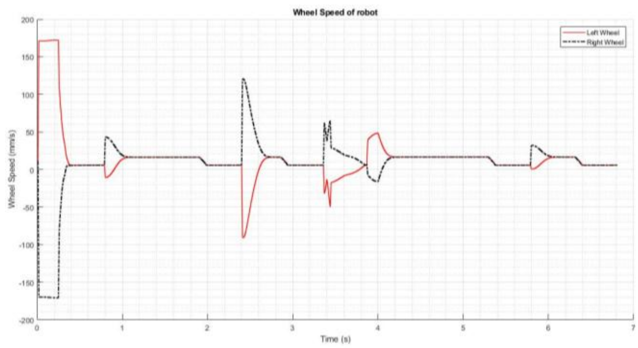

Figure 11. Fuzzy controller for moving algorithms.

In general, tele-medicine robot has offered so many benefits, following these are:

- Improve the expertise and save time for doctors;
- Network connection for exchange and share the information of patients for diagnosis and the best treatment regimen for patients;
- Minimal costs of moving and organizing seminars;

- Quickly store and access medical record and allow to accessing data anywhere and at any time;
- Convenient care, easier access to patients
- Save time and health care costs to travelling
- Patient health care at home allows patients to have better care conditions.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Nguyen Dao Xuan Hai contributed to the analysis and implementation of the research, to the analysis of the results and to the writing of the manuscript. All authors discussed the results and contributed to the final manuscript. Besides, Nguyen Truong Thinh conceived the study and were in charge of overall direction and planning. Nguyen Truong Thinh is a corresponding author.

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