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Development Report:

Medical Round Robot – Terapio –

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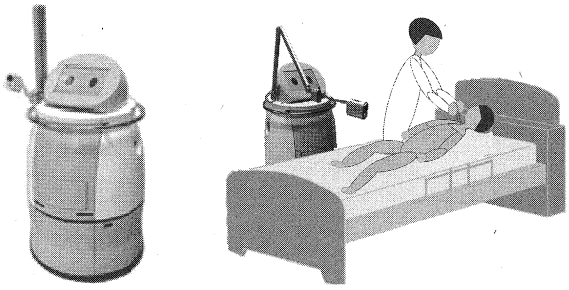
We have developed an innovative medical-personnel rounds-assistance robot called Terapio for use in hospital support, mainly in medical materials delivery and personnel rounds data recording. Terapio's omnidirectional mobility and personnel tracking control during doctors' rounds realize the smooth transfer of medical supplies from the nurses' station to a patient' bedside, for example. Vital information collected during medical personnel rounds is automatically recorded by a CCD camera and a voice recorder. This important information is then stored through the use of a touch panel.



(a) Terapio (b) Support during rounds (image)

Fig. 1. Terapio's work environment.

Keywords: support robot, omni-directional drive, human tracking, power assist control, H-R communication

1. Medical Rounds Support Robot Terapio

A declining birth rate in an aging society and the unequal geographical distribution of medical personnel are making labor shortages in the medical industry in Japan an increasingly critical problem. This underlies a growing demand for robots that are able to perform simple tasks that medical personnel would otherwise have to perform [1–4]. We have developed Terapio, a next-generation medical-rounds support robot. Terapio is shown in **Fig. 1**. This robot supports medical examinations by delivering medical supplies and recording medical data, for example, during the medical rounds made by doctors and other personnel.

The robot was developed in collaboration with the Fukushima Medical University, the Toyohashi University of Technology, and local companies. This work combined the medical needs, robot production technology, and other related production technology from the various organizations involved and, as a result, Terapio's prototype was developed in just 12 months.

2. Integrated System and Features

2.1. System Overview

The main purpose that Terapio has been designed is to support doctors and nurses in their work. Among the system's features are an omnidirectional drive, the tracking of specified personnel such as physicians, the avoidance of obstacles, and a power-assisted drive. Terapio delivers medical materials, for example, through the use of autonomous tracking. Medical supplies and waste materials are also stored within the compartments of the robot. Additional features include the storing of data on patients, the displaying of logs, and the recording of videos and sound, which are used for displaying and managing the data used in medical examinations. Facial "expression" functions are enabled during the delivery of medical and other supplies. An expandable arm is equipped with lights, a camera, and a microphone, which can be used to aid medical personnel during the examinations of patients. The robot is also equipped with a touch display that is used for controlling the camera.

Figure 2 shows an overview of the flow of the integrated system. Supervisory control enables smooth transition between modes.

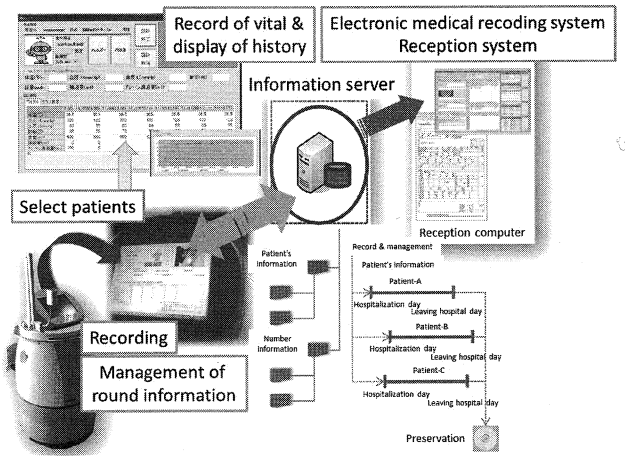


Fig. 6. Intercommunication between Terapio and an information server.

information from these rounds. The system can be used to record vital statistics such as body temperature, blood pressure, pulse, urine volume, fluid replacement volume, and drain volume for individual examinations. In rounds mode, Terapio starts recording visual and audio data. Images can also be taken using the touch panel. All media data are stored as information on individual patients. The information that is stored within Terapio is transferred to a data server at the nurses' station via wired connection (**Fig. 6**).

3. Conclusions

We have developed the prototype of a robot called Terapio that aids medical personnel during medical rounds at hospitals. We have demonstrated how using the robot may help decrease the task load on doctors and nurses. We are currently working on Terapio's practical application and commercialization.

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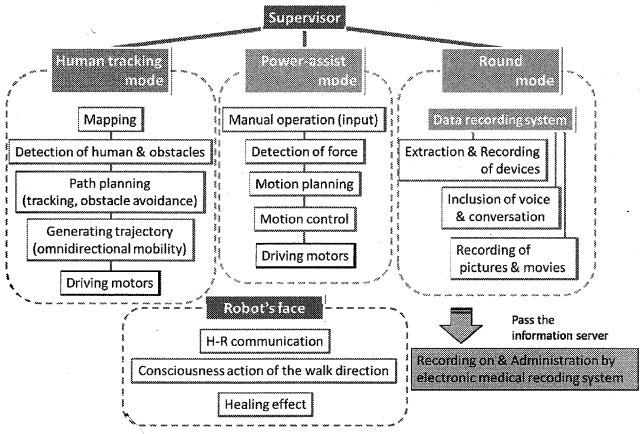

Fig. 2. Integrated system for robot actions.

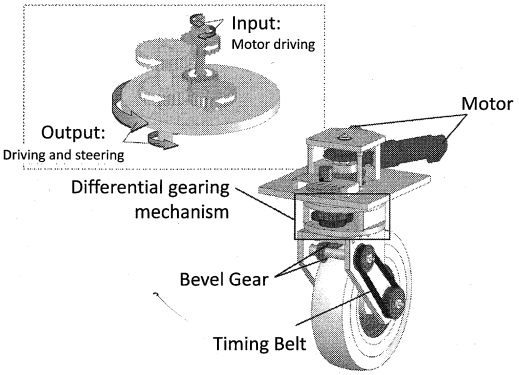

Fig. 3. New differential drive steering system for omnidirectional driving.

2.2. Omnidirectional Drive

2.2.1. Differential Drive Steering System

Terapio's drive system features an omnidirectional unit that is useful in places where space is limited. The differential drive steering system (DDSS), which is shown in **Fig. 3**, was developed previously [2]. The robot's wheels and spur gears are used to improve mobility. In order to increase operating efficiency and to make the motor more compact, the robot's two motors are used to control movement such as turning around and driving

2.2.2. Omnidirectional Power Assist

The ring-shaped power assist handle that encircles the top of Terapio below the touch panel can be used to operate the robot with minimal effort. The ring-shaped handle enables the robot to be operated to go in any direction. Force data obtained from the six-axis force sensor which is equipped on the handle is used to estimate the direction in which the operator intends to move. Owing to the minimal effort to operate the robot, power assist function can be useful for positioning Terapio towards the bed.

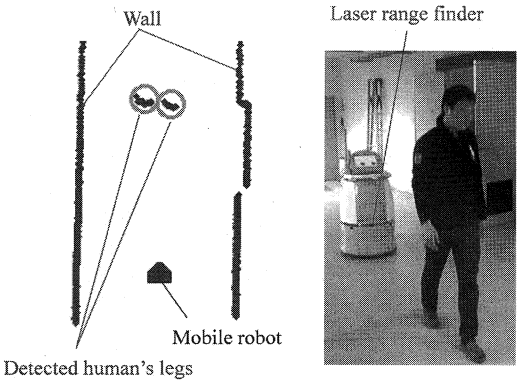

Fig. 4. Personnel tracking system.

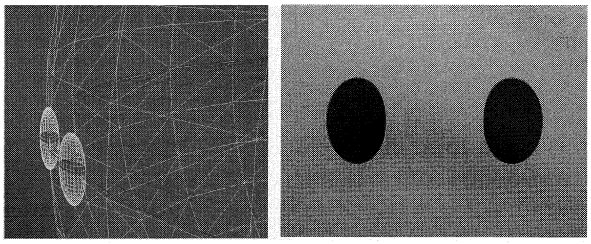

Fig. 5. Robot "face" display.

2.3. Tracking of Specified Personnel

In order to obtain data on specific personnel and 360° environment, the robot has three horizontal laser range finders around the base of the robot as shown in **Fig. 4** [3]. In order to detect ramps and stairs, two vertical laser range finders on the front of the robot are used for detecting ramps, stairs, and other changes in floor surfaces. From information obtained about specified personnel and obstacles, the Potential and the Rapidly-exploring Random Tree (RRT) were used to plan routes. A Kalman filter was used for prediction that enabled the tracking of specified personnel with a high success rate. An example plot obtained from distance sensors is shown at left in **Fig. 4**, and indicates how both of a targeted person's feet are detected.

2.4. Facial Expression

Terapio is equipped with a liquid crystal display for showing simple "facial" expressions. Two round figures designed using computer graphics are displayed as the robot's "eyes," as shown in **Fig. 5**. Gouraud shading is used to give the eyes roundness. Terapio's "eyes" are constantly focused on the operator, and if the robot loses sight of the operator, its "face" shows a "sad" expression. It also shows a "happy" expression when the operator is found [4].

2.5. Recording and Managing Information from Medical Rounds

In order to support medical rounds conducted by medical personnel, Terapio's facial display is used to input