Preliminary Development of Robotic Personal Aids for ECG Monitoring and Diagnosis Assistance

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***Abstract*—This paper presents a preliminary development of a robotic assistant system with its solutions for combining robotics and health-care devices. In our approach, the mobile robotic system acts as the sensing equipment for monitoring the heart rate from the continuous electrocardiographic (ECG) waveforms in real-world testing. In addition, with the aid by technical advancements in information and communication technology (ICT), the designed robot aims to provide the assistance in the remote symptom monitoring for end users susceptible to heart failure and to absorb the shortage of professional caregivers in the future. To present the planned features of the designed robotic system with ECG monitoring and diagnosis assistance, consider an end user at home, where the experimental environment is deployed.**

I. INTRODUCTION

The field of smart health care, supported by modern technology and methods, has resulted in significant growth in the global society. Several solutions to smart health-care devices have been proposed to promote health care in terms of speeding up treatment and diagnostic processes and reducing physician visit costs while maintaining caring quality [1, 2]. With the continuous advancements in information and communications technology (ICT), digital accessories for monitoring various aspects of biological functions are likely available. Such data obtained from these devices are expected to provide compliance status with health guidelines of an individual, that potentially contributes the diagnosis assistance of an ailment to the health-care provider.

It is desired to realize the smart health-care system with various functional devices under various environments and health conditions. However, as the system complexity increases, the user acceptability, operation reliability and safety, and the cost-effectiveness regarding acquisition and maintenance becomes difficult to attain. Besides, the other one of major obstacles raises in the development of smart health-care system at home is the obtrusiveness against social expectations and needs [3]. To alleviate these obstructions and achieve the design goals of smart health care, the involvements of robotics and home automation in this domain have become attractive [4].

In this paper, we propose a preliminary development of robotic assistant system which aims to provide the personalized health-care to the specific needs of individuals. The current robot system can act as the sensing equipment for monitoring health from electrocardiography (ECG) signal. The target of our system is to prolong the time spent living in a smart home and to pursue the higher acceptance and unobtrusiveness.

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Fig. 1. The demonstration scenairo for the developed robot with ECG monitoring task and data collection to the server.

II. DESIGN CONFIGURATION

A. ECG Collection

In medical centers, physiological data is collected daily to assist clinicians performing fast and accurate diagnosis, and to plan early therapeutic interventions for patient outcomes improvement. Electrocardiography (ECG or EKG) is one of the most useful tool that can support diagnosis and treatment of various cardiac and other related diseases [5]. It collects the electrical activity of the heart during the measure time by using electrodes placed on the skin. The electrodes will detect the tiny electrical changes on the skin causing from the electro-physiologic pattern of heart muscles during each heartbeat. The ECG waveforms carry a large amount of information of the heart and its function.

B. Example Scenario

The current robot platform also can offer domestic assistance in other tasks such as visual recognition for the end users, so that the robot can reach their sitting position. Then, the ECG monitoring task of the robot is triggered by the end user through user-friendly visual user interface. As shown in Fig. 1, the developed robotic assistant system can help to monitor the heart behavior of users by establishing the personal heart performance baseline through frequently ECG collections. Right after that, a quick analysis of the ECG waveform will then be performed to evaluate the physiologic state of the user during measure time. The collected data to the

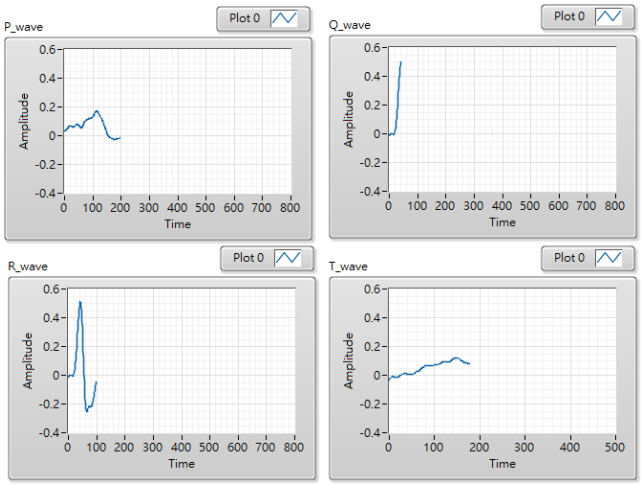

Fig. 2. The segmented 4 features of an exampled ECG sample.

server analysis can inform the doctor on the end user's heart condition that help the doctor diagnose symptoms early and take timely remedial action if necessary.

III. SYSTEMS

A. ECG Waveform Analysis

A normal ECG rhythm including four components, a P wave, a QRS complex, a T wave, and a U wave. The P wave is the first upward movement of the ECG, which represents atrial depolarization, where the QRS complex represents ventricular depolarization, the T wave represents ventricular re-polarization, and the U wave, that is not typically seen and can be ignored, represents papillary muscle repolarization.

To analysis ECG waveform, we need to identify PQRST wave for each ECG sample at first. A high-pass filter and low-pass filter are applied to remove noise and artifacts. After that, four features derived from these waves as in Fig. 2, including PR interval, QRS interval, QT interval, and ST interval, are used to determine the ECG abnormalities. Moreover, the heart rate variability (HRV) can be calculated to evaluate one's health where the higher HRV is associated with good health and low HRV is indicated illness.

B. Robot Platform

The model of the robot is based on a 4WD vectoring robot with Mecanum wheels, and equipped with the processing platform (Mini PC) and Arduino-based motor control boards. Due to the fact that the robot is a mobile device, the prime design objective for safety and reliability should feature sensors for odometric measurements, motion control, perception, and localization. During the first operation of the robot, the new environment will be transformed to a digital representation for robot automatic localization and mapping. The information received from the internal sensors, such as the laser scanner, stereoscopic camera, and encoders, can be transmitted to the server if required. Besides, the robot can acquire data from other sensors within the environment which assist the robot to recognize the moving objects like end users. With the support by footage from the static cameras in the

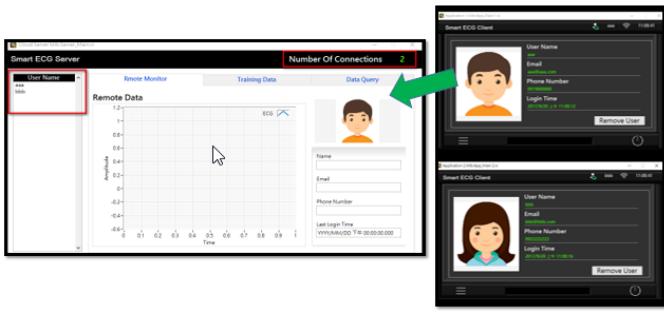

Fig. 3. The user interface design in to the server (left) and the robot display (right).

home environment, the task of navigation and tracking movement can be more effective especially when the target object moves out of the sensing field of robot.

C. Customizability

The health indications to heart rate associated with ECG signals are user dependent. In our system, the ECG monitoring program in the robot is designed through the development of user-specific machine-learning models which are incorporated into the analysis stage according to individual user's ECG training pattern. Figure 3 illustrates the login interface as different user, and the personalized parameters to a particular user can be utilized to yield more accurate evaluation performance. To effective carry out the ECG monitoring task, the robot can also track a scheduled routine of monitoring task following a doctor-defined schedule. This can be easily done through the user interface on the robot. The delay or cancel option for monitoring task is also allowable in the user interface if the end user request.

IV. CONCLUSION

In this paper, a robotic assistant system with ECG monitoring is presented to promote potential wellness by diagnosing disease and enabling proactive prevention strategies. More capabilities and functions of smart health care, in the future, will be integrated into the robot platform with the connection to smart home environment.

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