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User-centred Interface Design for a Robot Teleoperation System for General Medical Examination

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***Abstract*—Thailand, as well as many other countries worldwide, is facing a shortage of medical staff. We propose a solution to improve medical services in rural areas: a robot teleoperation system that allow patients to consult with doctors from public hospitals, and for doctors to examine and make decisions about their required care. To develop such a system, we are following a user-centred design (UCD) process. Two research questions have been addressed: how should an effective robot teleoperation system be designed to support medical diagnosis and patient communication? And does the use of a social robot improve the social interaction and examination quality in a remote consultation? This paper discusses the overall UCD process, starting from requirement analysis with Thai end-users (*finished*), system design and development on Pepper robot (*in-progress*), and user-centred evaluation (*future plan*).**

***Index Terms*—User-centred design, Robot teleoperation, Medical diagnosis, Remote consultation, Pepper robot**

I. Introduction

In Thailand, the shortages of healthcare workers are becoming more serious [1]. To overcome this challenge, a possible solution could be to use telemedicine systems to make medical expertise available in rural areas where healthcare facilities are inadequate. It has been proven that remote examinations increase accessibility to health services, and patients spend less time waiting for consultation [2]. The use case proposed here is that in a health centre (patient's site), healthcare assistants will help doctors from public hospitals examine patients remotely (doctor's site) using the information provided via a robot's telepresence interface (Fig. 1). At the same time, the robot will facilitate social interaction between doctors, assistants, and patients. This would reduce the number of patients at public hospitals, saving time and costs. Moreover, such a system would facilitate social distancing, necessary in the case of a pandemic such as COVID-19.

A range of research has been conducted on remote consultation. Fatehi et al. [3] showed that patients with diabetes who were seen remotely by endocrinologists were generally satisfied, despite the inability to perform physical examination. Nielson et al. [4] explored the use of a telepresence robot for rehabilitation and succeeded in performing a smooth and successful video-mediated consultation. However, both telepresence systems lack medical features to provide better diagnosis. Carranza et al. [5] developed Akibot, a telepresence robot with the integration of an otoscope, a stethoscope, and an ultrasound probe. The results indicated that the end-users were satisfied with the robot control, receiving a high SUS score. Despite the users' satisfaction in Akibot, there is no formalised requirements analysis conducted to understand what the end-users need. Hence, it is possible that users might take longer time to adapt, and increase the chances of misuse. Therefore, a user-centered design (UCD) process [6] is implemented in this study to design the effective robot teleoperation system that supports medical diagnosis and patient communication. UCD involves users throughout the design process, and hence creates highly usable and accessible products for them.

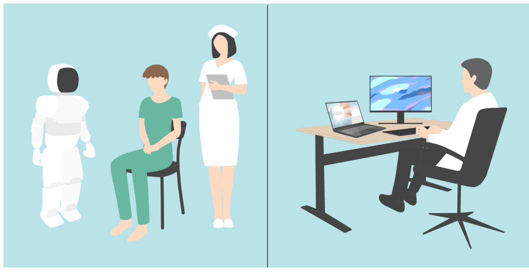

Fig. 1. Robot Teleoperation System: Patient's (left) and Doctor's (right) sites

Pepper, a humanoid robot, is employed because it is well-developed and has form and function suited to social interaction. Multiple sensors and software stacks in the Pepper robot enhance a safe human-robot interaction, and thus, it has been commonly used in medical research e.g. [7]. With these benefits, we would like to focus on software development that facilitates human-human-robot interaction (HHRI) between doctors, assistants, patients and the Pepper robot and build user-friendly interfaces for all user groups. Hence, two research questions have been addressed: 1) How should an effective robot teleoperation system be designed to support medical diagnosis and patient communication? 2) Does the use of a social robot improve the social interaction and examination quality in a remote consultation?

II. METHODOLOGY

The robot teleoperation system will be developed based on a UCD process. The UCD process consists of three main stages, namely 1) Requirement Analysis, 2) System Design and Development and 3) User-centred Evaluation. This section provides an overview on the progress for each of the stages.

A. Requirement Analysis

A requirement analysis has been completed by running a virtual focus group with four Thai GPs who are working at Banphaeo General Hospital via MS Teams. All participants are male, in the age range 18 - 35 years. As interns, they need to examine patients more than 10 times per day. Then, an online survey was conducted with 42 general people (66.7% male, 33.3% female) between the ages of 18 and 30 [8]. Miro[1], an online collaborative board, has been employed to help the main researcher gather information and avoid misinterpretation. It allows the participants to remotely collaborate with each other. The section started with an informal conversation to place the participants at ease before discussing the specific topics including the common ailments found in patients, information required for making decisions, opinion on different remote consultation technologies, and preferred features and interface of a teleoperation system.

After the focus group, a survey with general people was done via Qualtrics to validate the result from patient's perspective. The survey contained 12 items separated into the categories: demographic, medical issues, attitude and expectation towards technology, and system design. Lastly, all data were sorted and summarized into main themes, and interpreted using a framework analysis [9], a systematic and flexible way to analyze qualitative data. Detailed results are presented in [8] which discussed how the collected requirements can be transferred into technical specifications of the system.

B. System Design and Development

The system is currently being designed and developed to cover the user requirements. Medical sensors and tools will be integrated with the Pepper robot to provide medical information which will be overlayed on the video feed to aid diagnosis. A stereo camera and RGB-D sensors will also be integrated to enable social signal processing that will facilitate HHRI between doctors, assistants, patients, and the Pepper robot. To do so, ROS, a free, open-source middleware platform for robotics, will be required. It also allows the subprograms (nodes) to be written in any language, mainly Python and C++. The preferred interface paradigm for the robot teleoperation system is a desktop augmented reality (AR) display which will be designed in Unity, a cross-platform game engine for creating 2D and 3D interactive experiences. In this work, it will be used for designing the interfaces for the end-users. It supports scripting in C# and can be connected to ROS, by creating an endpoint to accept ROS messages sent from a Unity scene. During this stage, the end-users will be involved regularly to ensure that the user interface is user-friendly.

[1]https://miro.com

C. User-centred Evaluation

The overall usability of the system will be tested by conducting a series of experiments with participants which will be compared to traditional remote consultation. A pilot study will be run with naïve users, role-playing as doctors, to ensure that the system works properly. Then, in the main experiment, one doctor will operate a Pepper robot remotely from Thailand while another participant will be role-playing as a patient in the UK. The researcher will be role-playing as an assistant. After the experiments, users will be asked to complete short questionnaires on their demographics, system usability, and provide self-reported measures of performance. The results then will be used as a basis to revise the robot teleoperation system as parts of the UCD iterative process.

III. CONCLUSION

This work aims to develop a robot teleoperation system that allows examination and remote consultation between doctors and patients. The steps of the UCD process have been briefly discussed in this paper. It is worth to note some limitations. During the requirement analysis, only four GPs attended the focus group since it is difficult to arrange a date as they have a very tight schedule to attend to the COVID-19 patients. Another limitation is that only young Thai people participated in the survey as the results were collected via social media. Some adjustments could be changed in the future, depending on the time, the COVID-19 situation, and the budget.

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