System Architecture of Medical Expertise Pooling Concept in terms of Potential Applications

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ABSTRACT

Medical expertise pooling (MEP) is a concept to optimize the available physician resources and maximize the efficiency of the medical support system by matching the demand with the available expert physicians through a network of on-duty physician pool. The system to establish this concept, aims to utilize robotics, tele sensing and manipulation technologies to connect patients with physicians via network. The efficiency of this concept can be implemented in multiple potential applications. This paper describes enabling technologies and system architecture of the MEP concept in terms of possible applications.

Keywords

Telemedicine, Medical Expertise Pooling, Robotics, Network, Remote Healthcare, Remote Medical Devices.

1. INTRODUCTION

Medical expertise pooling (MEP) is a concept that proposes to utilize the total number of existing physicians and redistribute them all over the United States through network to overcome the physical limitation of the uneven ratio of physicians and patients across the nation [1]. The concept is to optimize the existing medical resources by matching the demand with the available physicians through a network of on-duty physician pool and to utilize robotics, tele sensing and manipulation technology to connect patients with physicians via internet.

Typical remote healthcare research applications are either focused on specific healthcare devices or systems with concentrated medical resources available in specific areas [2]–[7], whereas the proposed MEP focuses on distributing the medical expertise evenly across the nation on the basis of requirements [1].

For physicians to perform the first step toward treating a patient, they must start with some fundamental practices which are; checking vital signs, listening to the heart and body sounds with a stethoscope, and palpate to feel for any abnormalities. The most commonly used vital signs monitoring devices have the features of monitoring heart pulse rate, body temperature, and electrocardiography [2], [5], [6].

The proposed system can allow a physician to facilitate these fundamental steps as they would with an in-person patient at a long-distance for the fastest diagnosis. The enabling technologies include bioacoustics, haptics, and bi-directional control incorporated through robotics.

In this paper, we will discuss possible applications of MEP concept and related system design along with enabling technologies necessary to establish the concept.

2. POTENTIAL APPLICATIONS AND RELATED SYSTEM DESIGN

The proposed MEP [1] is vastly transformative and there are several cases where this paradigm can be implemented. Before going into the potential cases where this concept can be applied, let's look into the general system architecture which is designed to demonstrate the concept.

The system, divided into patient unit and provider unit as shown in Figure 1, involves three modules i.e. video and indicator module, bioacoustics module and haptic module. The patient unit and the provider unit will allow these modules to be used through a plug-and-play design simultaneously collecting medical data. The patient unit will be connected to the provider unit through network allowing virtual sensing capability to the physician. The provider unit is responsible for collecting, managing and demonstrating the tele sensing to the physicians so that physicians can diagnose the patient and provide necessary feedback.

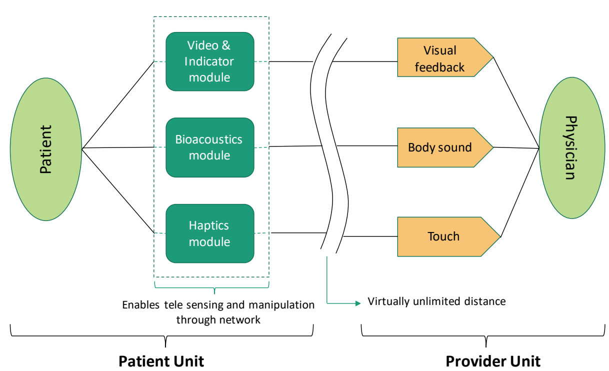

Figure 1. MEP concept: System Architecture [1]

The video and indicator module enables remotely and robotically controlled video camera and laser pointer for enhanced remote communication in which remote medical experts will be able to monitor the patients through video and point specific places on the patient body. The laser pointer mitigates the physical absence of medical experts as they can use it to explain and demonstrate the required action. The controllable laser pointer to localize a point of interest will be integrated with a small controllable camera attached to the ceiling of a transportation vehicle or a room. The system control will be attained by conventional visual servoing e.g. control joystick to move the pointer. In this system, a simple robotics technology is utilized in controlling video camera and pointer by enabling medical support using a bidirectional telemedicine unit that transmits critical medical information to the medical experts who can provide well-informed, life-saving decisions for the remote patients. Further, more complex robotics such as a robotic arm to provide physical support can easily be included to make it more automated.

In the bioacoustics module, a skin attached electronic stethoscope with multiple patches will be incorporated to process auscultation data from the body and provide continuous body sound monitoring. Electronic stethoscope technology enables sound magnification, noise canceling and data digitization. The feature of digital data processing helps to detect acoustic characteristics that human cannot hear.

The robotics enabled haptics module is to enable physical touch through the communication module directly to the physician to be able to feel for possible diseases like tumor or thyroid nodule in the patient's body. Enabling technologies i.e. haptics feedback, tactile technologies can be integrated to produce tactile imaging for palpation which is able to detect shape, size, and location [8], [9]. Further, to provide physician the actual texture, a surface can be created using soft robotics which will change its stiffness according to the input from the tactile image. As a result, when a physician sweeps his/her hand over the surface, he/she will be able to feel the stiffness to identify if there is any nodule.

Reliable and real-time delivery of medical data of patients to a distant medical facility is very important for the MEP system. In the system, the data will be sent wirelessly over long distances through the proposed advanced in wireless communication system [1]. In order to make the system efficient, as little information as possible will be transmitted on the basis of importance without losing the accuracy of data. Since, wireless networks are likely to suffer from packet losses, a form of forward error correction (FEC mechanism) i.e. rateless coding [10] will be applied to recover the lost data and to ensure a fast and reliable communication over wireless networks.

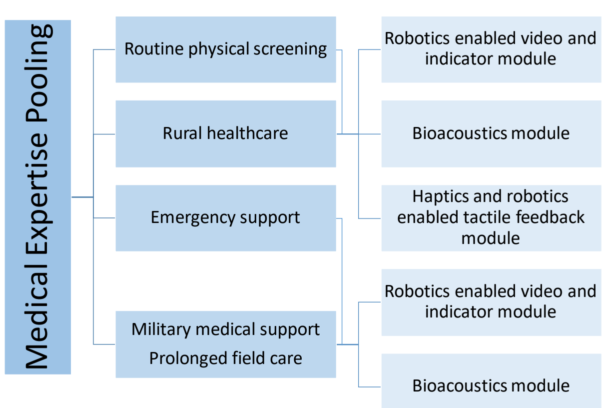

Figure 2. Potential applications of MEP concept

Since, the MEP system has the features of providing robotically enabled visual, audio and tactile feedback remotely, it is vastly transformative, and it can have many potential applications in terms of remote healthcare. Possible applications include, general healthcare like routine physical screening, rural healthcare, emergency medical support, also this paradigm could be implemented for combat casualty care in military medicine (Figure 2).

In case of routine physical screening, the proposed MEP system could enhance quality of life and save time for both patient and physician. Patients will be able to maintain their routine physical screening staying at home.

With the use of MEP system in rural healthcare, people from rural areas will be able to get proper treatment since there will be no constraints of limited expert physicians. They will be able to get treatment from expert physicians through a network of on-duty physician pool regardless of their location.

In both cases i.e., routine physical screening and rural healthcare, three modules i.e., robotics enabled video and indicator module, bioacoustics module, haptics and robotics enabled tactile feedback module will be incorporated to provide diagnostics and treatment facilities using visual, audio and tactile feedback.

Now, if we consider mass casualty events or emergency medical situations, with the use of this MEP paradigm, early diagnosis is possible before hospital arrival, so patients do not have to undergo typical diagnostic procedures that need to be performed in the hospital. Once diagnosed using our proposed system, medical experts can provide assistance whether the patient needs to be admitted to a hospital or simple treatment can be done by local providers. Hence, the proposed system can save time and resources at hospital, which can be critical, especially in mass casualty events.

During combat casualty or prolonged field care (PFC), there is often a possibility that due to limited medical experts and lack of bidirectional communication, many soldiers cannot be survived. In such cases, MEP paradigm can be transformed in order to enable real-time remote medical support by off-site medical experts from

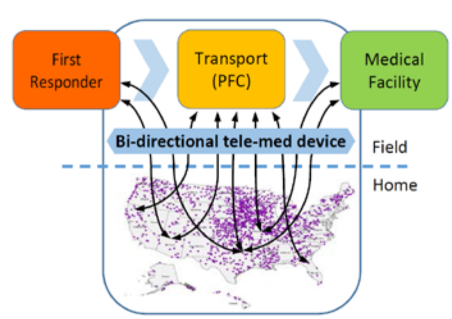

Figure 3. MEP concept: prolonged field care case

homeland who can provide critical support through secure network (Figure 3). The proposed system could provide advanced monitoring capability and deliver critical decisions during PFC, which can eventually increase survival rate.

Since, haptics enabled tactile feedback will not be necessary for mass casualty events, for such cases the system can be designed incorporating robotics enabled video and indicator module and bioacoustics module to maximize medical data acquisition and real-time communication for emergency situations.

3. DISCUSSION

The utilization of medical expertise pooling (MEP) saves hospital time and resources required during dire times. The system is critical to the enhancement of both hospitals and a patient's quality of life. MEP is able to distribute the medical experts throughout the nation regardless of their physical presence onsite. In the case of a mass casualty event, the use of the MEP will increase the hospital's efficiency and speed before the patient arrives at the hospital. This efficiency and speed will be possible due to the early diagnosis MEP will deliver to the physicians. The earlier a diagnosis can be determined, the quicker a patient can be treated. This would result in the decrease in total amount of examinations the patient has to typically undergo.

Development of MEP paradigm can revolutionize the medical support system by using physician resources all over the nation. This research can also be implemented for combat casualty care in military medicine, as well as the rural medical support in civilian healthcare. There are little to no alternative technologies that compares to this technology for both hospitals and the military. This research is important because implementing a MEP paradigm can lead to significant advancements in patient care.

4. REFERENCES

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