Medical tele-tutoring and Data Summarization for Internet of Medical Things

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Abstract—Pervasive computing has become a vital part of the healthcare system. With population aging becoming a reality with an increase of the percentage of people above the age of 60 and lifestyle diseases skyrocketing. Medical care facility anytime anywhere is of foremost priority. The challenge of reaching remote places for healthcare, especially during an emergency is of great difficulty. Pervasive computing systems have become an integral part of such circumstances. This work will discuss further two such applications a) Through continuous monitoring of electro-physiological body data, the Internet of Medical Things (IoMT) enables early diagnosis and alarm of crucial disease situations. b) Operators involved in emergency interventions receive remote medical tutoring using a subsystem is yet another life-saving invention in the field of the medical healthcare system.

I. INTRODUCTION

SOCIETAL CHALLENGES AND POTENTIAL SOLUTION

The Emergency Service is based on first-aid interventions, in which ambulances with sanitary operators onboard may reach patients and give emergency care. A solution that allows the Operations Center to deliver remote medical assistance to the operators on the ground can improve the efficiency of emergency care while also supporting the operators and reassuring the patients. In the Emergency Department, telemedicine technologies have been implemented. Some technologies have been developed to monitor patients' health conditions from the Operations Center, however, they are only meant to work on ambulances. A system that can work before the patient boarded the ambulance, allowing medical telemonitoring to take place in places where ambulances cannot go (impervious places, buildings, etc.) but where operators can arrive is discussed in the following session.

Patients can now be monitored remotely thanks to wearable IoMT devices. There is only intermittent connectivity to data networks in most rural and isolated areas, as well as a paucity of capacity. The transmission of important parameters from IoMT devices to remote clinicians necessitates the development of bandwidth-conscious data reduction strategies. At the physician's end, there is a parallel challenge. The vast data being blasted from remote patients' sensors would overwhelm the physicians, who are already overburdened. This paper also discusses a technique for converting unwieldy multi-sensor time-series data into summarized patient/disease-specific trends in steps of progressive precision as demanded by the physician for the patients' personalized condition at hand, which can aid in identifying and then predictively alerting the onset of critical conditions.

II. THE MEDICAL TELE-TUTORING SYSTEM

a) The wearable subsystem: The sanitary operator's wearable subsystem consists of a helmet that houses all of the necessary components, including sensors (camera and Inertial Measurement Unit - IMU), elaboration, transmission, and power. In Figure 1, you can see a prototype of this subsystem as well as some helmets that were utilized in the experiment. Figure 1: Prototype helmets and system in action.[1]

Figure 1. REC-VISIO 118 helmet prototypes and system in action.

b) The application in the Operations Center: The encrypted data is transferred to a cloud server via a Virtual Private Network (VPN) over a 4G network. The dashboard of the application in the Operations Center communicates to the server via a VPN on the opposite side of the system. The application is built to handle several simultaneous calls from various helmets used in various emergency situations.[1]

Figure 2. Main screen with incoming calls[1]

Literature Review: The device has been extensively tested at the 118 Emergency Service of Pistoia (Italy), where twelve helmets are used on a daily basis and where it was part of a four-month testing effort in 2019. This experiment revealed that the system can assist in delivering a rapid pre-diagnosis during emergency triage, which is especially important in the event of time-dependent diseases such as heart attacks, heart failure, or stroke, which necessitate emergency detection and immediate assistance.[1]

Technical Challenges: The Logitech C920 camera utilized in the REC-VISIO 118 offers full HD video resolution in H.264 format, as well as stereo audio for better tele-tutoring interaction quality. The MPU-9150 IMU, which consists of a gyroscope and an accelerometer, is attached to the camera and creates inertial data about each video frame's relative position to the preceding one. For the synchronization of video frames with corresponding IMU data and the video stabilization process, the embedded elaboration unit is the Raspberry Pi 3 Single Board Computer (SBC).

The communication is based on the Web Real-Time Communication (WebRTC) protocol [3], which delivers Real-Time Communication via simple Application Programming Interfaces(APIs) to web browsers and mobile applications. Thus, in order to accept a call from the wearable system in the Operations Center, any browser can be used to navigate to the project site and then to the operator without the need to install any software. Moreover, using an encrypted connection protects the data's privacy.

IV. RAPID ACTIVE SUMMARIZATION FOR EFFECTIVE PROGNOSIS

The steps involved in RASPRO are:

Step 1: We extract N separate vital parameter series, V P S1, V P S2,.., V P SN, using sensor data. Step 2: For each vital parameter series, each sample value is converted to a disease-parameter-specific discrete value symbol for a quantized severity degree. Step 3: A multiplexer groups all parameters related to the disease being monitored into a two-dimensional Disease Severity Matrix (DSM) using quantized severity symbol series. The number of columns C in the DSM denotes the total number of samples in the monitoring interval, and each row R represents one parameter. There could be a series of DSMs for subsequent monitoring intervals separated by a quiescent time interval. Step 4: Using a disease parameter-specific formulation, all the quantized severity symbols in a parametric row of DSM are temporally summarized to one consensus symbol. The consensus symbol, in general, represents the prevalent tendency in the patient data.[2]

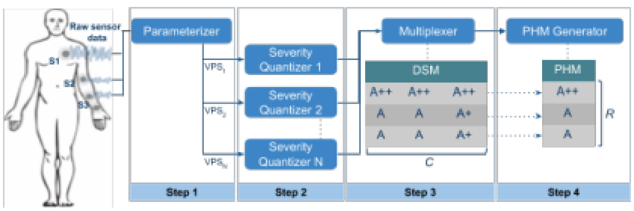

Fig. 1. The RASPRO Engine for converting raw sensor data from IoMT devices to severity summaries in the form of Disease Severity Matrices (DSMs) and Personalized Health Motifs (PHMs).

Literature Review: The RASPRO technique was clinically validated in two steps: (a) testing on 83 patients using the Physionet MIMIC II dataset [4] for detecting and warning of cardiac problems, and (b) comparison with another symbolic data reduction representation technique [5].

Over bandwidths ranging from 0.2-0.75 bits/unit-time, RASPRO outperforms domain agnostic approaches such as SAX, with a 20-90 percent gain in F1 score.[2]

Technical Challenges: Personalized Health Motifs: The RASPRO provides a framework for differentiating summaries for distinct clinical needs, a more thorough approach to identifying PHMs in order to capture disease-specific trends.[6]

Machine Learning Models with Motifs as Input: Unless trained on vast and reliable datasets, domain agnostic machine learning classifiers can lead to misclassification. The RASPRO motifs indicate the patient's significant patterns, and they might be utilized as an alternative dataset for developing machine learning models that could run on smaller datasets.

V. CONCLUSION AND FUTURE WORK

In the event of epidemics or pandemics, the REC-VISIO system can also be used to maintain a safe distance between doctors and patients. Currently, the REC-VISIO 118 system is used on a regular basis in Pistoia's 118 Emergency Service, where it is also used to aid patients suspected of COVID19.
RASPRO is a clinical severity identification and data summarization technique for IoMT devices that is medically aware. This technology can be used in edge devices to make pervasive computing more accessible in remote and underserved areas. Opportunities in other fields, including neurology and endocrinology, are among the research's future directions.
The integration of the aforementioned technology can emerge into the great potential in the field of healthcare using pervasive computing.

VI. REFERENCES

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