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An IOT-Based Framework for Elderly Remote Monitoring

[1]Balamurugan V, [2]Shibhani.T, [3]Rajesh.G, [4]Remesh.M
Assistant Professor, Department of CSE, Sri Eshwar College of Engineering, Coimbatore, India[1]
UG Scholars, Department of CSE, Sri Eshwar College of Engineering, Coimbatore, India [2 3 4]

ABSTRACT: This Paper presents an Internet of Things(IoT) based framework to look at ECG for biometric recognition and acceleration for fall detection to the present end, an IoT based RemoteElderly Monitoring System (REMS) platform is described. REMS consists of a Shimmer 3TM device transmitting physiological signal wirelessly to a close-by gateway which routes the knowledge to a remote IoT-platform, able to accommodate dynamically changing configurations. The Shimmer firm ware has been modified to send data supported the compressive sensing theory so as to ameliorate energy consumption additionally of real data, and the analysis and processing are done locally on a heterogeneous multicore edge device so on unravel latency issues associated with cloud reliance. Subsequently the framework has been designed to handle the various parameter settings and multiple scenarios in a user friendly way. Furthermore, it allows the user to look at physiological data and acquire some feedback associated with their analysis. Looking forward to a scenario (energy save, secure communication) the system is configured manually or automatically to monitor ECG or acceleration data and displays them, it can also identify the topic supported ECG recognition and detect fall if it occurs.

KEYWORDS*:* Compressive Sensing; Hetrogeneous Multicore Platforms, Internet of Things, Remote Elderly Monitoring.

I. INTRODUCTION

Due to the outstanding advances the stylish technologies seen during the last decades, the earth life time has been increasing for the last decades and is predicted to further rise within the longer term [1].As a results of this, the quantity of senior adults is continuously growing and thus, the need for enhanced tools for real time monitoring and efficient data analysis is highly required.

Remote health monitoring is also applied to identify serious illnesses and act to forestall some irreversible consequences; it should also reduce injuries intervention time. Two events that are of interest during this framework are fall detection and ECG biometric.

In 1987 the Kellogg international working group to prevent the falls of elderly defined fall as coming to ground without any intention, or as a consequence of sustaining a violent blow, or consciousness loss, or sudden onset of stroke or an epileptic seizure' [2]. Also, ECG based biometrics is another important tool used for subject identification. Tremendous interest has been dedicated to the event of Internet of Things (IoT)-based systems. They're described as several wearable sensors recording essential physiological data for a serious period of some time, the gathered information is then sent to a cloud host through the online. At the cloud level, processing and analysis is completed to produce medical assistance.

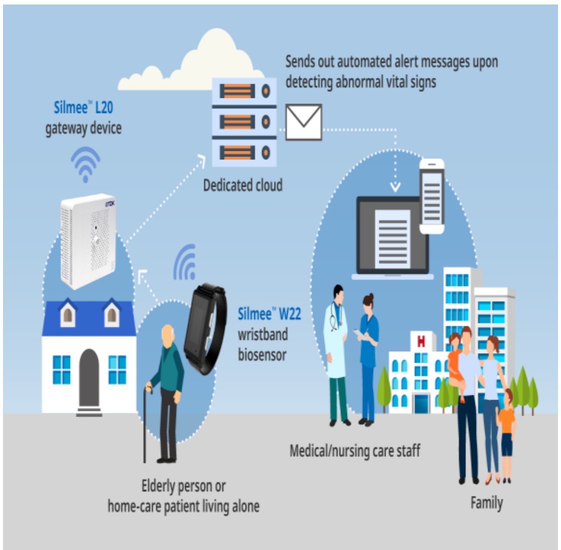
Under the high standard requirements of medical systems this solution isn't accepted. Wearable medical devices are battery driven so have power consumption issues. Additionally the system relies on communication with cloud and hence gives latency issues. During this work we address an edge computing-based Remote Elderly Monitoring System (REMS) platform using the Compressive Sensing (CS) theory.CS aims to merge the acquisition and compression to optimize power consumption [3]. To beat the latency problems in our REMS we developed a heterogeneous multi core edge device based gateway [4], handling the processing and analysis of information .

The proposed platform is allotted to enable automatic fall detection for elderly people and biometric ECG recognition. The data analysis and monitoring are easily accessed through a user friendly interactive tool.

II. PROPOSED ELDERLY MONITORING SYSTEM

The monitoring system comprised of three parts as in regular IoT designs and is shown in Fig. 1. Wearable medical sensors transmit physical and physiological information to a close-by gateway. The gateway is the primary part of this framework. It is a heterogeneous multi core platform (HMP) that is in charge of the data processing, which incorporates signal reconstruction and other information covered in our system.

As per the remote part of the system, the gateway stores daily activities and transmits reports periodically or at the end user need. This takes into consideration patterns of the different physical or potentially physiological observed parameters to be investigated over time. Moreover, through its emergency classifications, it informs care givers of any potentially hazardous event and after that transmits physiological information continuously for early diagnosis. As stated before, this methodology reduces the system latency and addresses stability concerns associated with cloud-computing and internet connectivity dependence [5] and hence, there is no extra burden onto the cloud. Furthermore, HMPs give plenty of computational setups and configurations, empowering adaptability and improvements on a case to case basis.



A.COMPRESSION

Shimmer3TM ECG/EMG unit is a state-of-the-art wearable device able to simultaneously stream ECG and acceleration data [6]. On a hardware level, it uses a 16 bit - 24 MHz- 16 Kb RAM micro controller, supplied by Texas Instruments. Software-wise, the device is provided with a firmware called Log And Stream written in C language. The firmware was modified in order to send both compressed and raw data. To do so, a digital CS is implemented on the shimmer by buffering acceleration and ECG to a desired window length, then matrix multiplication is carried out on the resulting registers to decrease the length before transmission. To speed up the process, the Sensing Matrix (SM) is chosen to contain only binary elements so that multiplication becomes addition. Authors in [8] proved that to achieve good compression results, a sparse binary matrix with arbitrary 1s in each column could be used.

B. RECONSTRUCTION ON THE GATE WAY PLATFORM.

Hardkernel's ODROID-XU4 Board [9] Features ARMs big. LITTLE heterogeneous octacore solution which uses 8 Cores (4 big A-15 cores and 4 little A-7). This device has been chosen because it is found on most of todays smartphones. All the processing is done on the ODROID-XU4, reconstruction of data is done using two different algorithms Orthogonal Matching Pursuit and Subspace Pursuit. Additionally, other algorithms were implemented to process data namely ECG patient identification and fall detection.

III. FRAMEWORK SOFTWARE IMPLEMENTATION

An important stage of project development is
making the system easy to use providing a user friendly access to the configuration and monitoring. This is why a large parts of the code were dedicated to implement an easy to use framework. Our application has been developed using Pythons Tkinter module, which comes ready to use with Python and is a cross platform interface. Tkinter is a wrapper around Tk and is used to create windows, frames and buttons also known as widgets. For easy and efficient programming Tk module has been used in object oriented programming, for quick call backs. It contains three applications:

- REMS
- Smart Ambulance System
- Robotic Surgery

REMS has been successfully implemented and tested on the ODROID-XU4. The user will be able to access the Shimmer devices around, connect to them and configure them for the chosen scenario (e.g. Activate ECG sensor, 1 sec window CS, high quality reconstruction, 4 CPUs for processing, etc.). To do so, two operating modes have been developed:

- Analysis mode
- Operational mode

A. ANALYSIS MODE

The user will have full control over the application by manually selecting the parameters to display data. The parameters are divided into two categories:

- Acquisition: Parameters related to the Shimmer, and cover the CS process and security
- Processing: Parameters related to the reconstruction and the processing of the data done on the ODROID-XU4.

Analysis mode interface contains three buttons which will select the corresponding sensor to activate mainly: ECG monitoring, fall detection and ECG biometrics following the approach taken in [10].Depending on which sensor is activated (ECG or acceleration) the Shimmer will acquire the data and send the compressed values resulting from the CS applied on the modified firmware. The compressed data are then sent to the platform (ODROID-XU4) and the original signal is reconstructed. The steps to use REMS in analysis mode are:

- Chose which application to use namely ECG monitoring, fall detection, ECG based biometrics.
- Select the configuration parameters
- Click on plot, and the application will start streaming and plotting.
- ECG biometrics also output in a Label the patient number to whom the ECG belongs.

B. OPERATIONAL MODE

In the Operational Mode, the user must choose a desired system configuration that must fulfil her needs; here, criticalities represent the needs, and thus the user is given the selection to select a configuration that satisfies most (if not all) the related criticalities. During this work, we show this process, starting from a higher-level approach, e.g., model-based. Particularly, we employ the Systems Modelling Language(SysML)[11], [12] a daily modelling language. Use a model-based design approach to:
(a) effectively illustrate the REMS structure , in terms of its individual components,
(b) define the criticalities of REMS subsystems, in the form of manageable SysML requirements, and
(c) enable the user to choose alternative design configurations,depending on different scenarios, and configure the system accordingly.

Within the subsequent, the REMS Home subsystem, where the elderly patient resides and operates the medical devices is described. Only this subsystem and its components are shown here for brevity; the logic behind the illustration is similar for all the REMS subsystems. The afore mentioned components are illustrated, forming the REM Shierarchy and comprising its structure; Shimmer3-ECG [6] is the wearable medical device, the ODROID-XU4 represents the aggregator that collects all device-generated data, and the Elderly Patient Home acts because the centre layer. The device and the aggregate or are connected with the layer via directed compositions, indicating that they are parts of it. Note that each component holds operational properties that describe them. For example, the aggregator holds its core Type, number OF Cores reconstruction Algorithm, etc.

In our model-driven approach, SysML requirements are accustomed illustrate the corresponding criticalities of the REMS. Object Management Group(OMG)[13], a requirement specific capability or a condition that possesses to be satisfied, or a function that a system must perform or a performance condition that a system must achieve. In SysML, a requirement includes two basic properties: a unique identifier (id) and an overview

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of itself written in textual form (text). Here, a replacement property has been added, namely the extent, depicting the quantitative criticality gradation. Moreover, the criticality is characterized by a particular criticality type, e.g., Time, Security,Swap(Size,Weight and Power), etc. as an example, a Time Real Time Transmission criticality is depicted; it is a novel id(4), a text that describes the requirement for the real-time transmission of the patients medical data, and thus the real-time value in its level property. A requirement is assigned to a model element through the SysML satisfy relationship. The REMS model illustrates the assignment of -blue-coloured-criticality requirements to -white-coloured-REMS components.

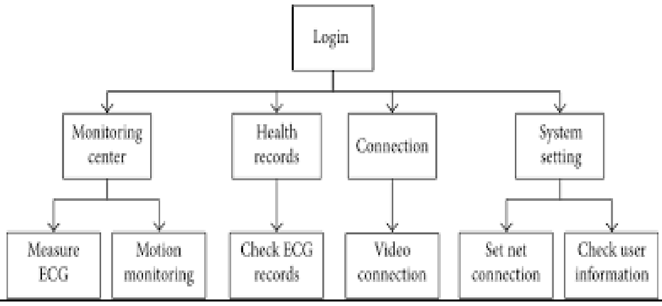
In this the Real Time Transmission criticality is connected to the Elderly Patient Home layer, the Aggregator Battery Life time to the ODROIDXU4 aggregator and thus the Secure Transmission and Portability criticality Requirements to the Shimmer3-ECGdevice. It's worth mentioning that this step is significant since we connect the criticalities with the system, applying the generated criticality requirements to the REMS structure; this way we've a consistent REMS component-criticality model. Supported reasonable system-wide abstractions, it can be quite useful for designers and system engineers, assisting the design and management of complex criticality healthcare systems. This is necessary to understand systems (via comprehensive models), before implementing and deploying them within the globe.

Following the REMS modelling and explicitly mapping its components with respective criticalities, the designer can configure the system .As an example, a REMS configuration, regarding the foremost performance of the system components, is taken into consideration, i.e. maximizing the performance of each component, to return up with data(see Shimmer device), transmit them from the device to the aggregator(see Home layer), and process and analyze the data (see ODROID aggregator), in real-time When the designer chooses it among others, via a menu provided within the modelling environment specific properties of the component are automatically populated with pre-defined values i.e. reconstruction accuracy of the transmitted data= HQ (high quality), the signal Transmission Mode = RT, i.e. real-time, or the aggregators number of Cores = 4, indicating its high-power to process the data, etc. Note that the grey-coloured elements, depicted are accustomed check whether a criticality is satisfied by the desired configuration; here, supported the chosen configuration –and the related properties values the VRD Real Time Transmission receives a calculated output from the Real Time Transmission ver. This is compared to the criticality level value, i.e. real-time, and since they're the identical, the criticality is satisfied. Via the modelling environment, automatically generated xml and csv files are extracted, comprising the values of every component, According to the chosen configuration. Therefore, so as to use REMS in operational mode, the user selects the scenario from the drop menu, and clicks on plot for the data to start streaming.

IV. RESULTS AND DISCUSSION

The system has been tested, so as to plot ECG and acceleration, Matplotlib module for Python has been used Draw now function (Interactive function to plot live data) from Matplotlib was investigated initially for this task. Unfortunately, due to its slow displaying of knowledge (It couldn't display more than 150 a Second [14] since ECG data are 360 Hz the plotting will create latency and that we lose the live streaming aspect, another approach was taken to hurry up this process where we store the constructed data during a computer file for every time Streaming window and when the last value of the info is received we draw the entire period. In ECG biometrics the ECG were acquired and then added to a matrix. This matrix will there fore contain the training data to which, the sensed ECG data are compared when biometric recognition is required [15].set. The info are acquired using the Shimmer device, the compressed signal was then sent via Bluetooth to the ODROID-XU4 which reconstructs the compressed data.

In ECG biometrics the ECG sample were acquired and then added to a matrix. This matrix will therefore contain the training data to which, the sensed ECG data are compared when biometric recognition is required [16].Furthermore a 7-inch multi-touch screen was also used, which allows our application to run.



V. CONCLUSION

IoT based remote health monitoring systems can revolutionize healthcare and improve patient's quality of life, if their limitations are addressed. This study described an IoT based tool where CS was implemented on the sensing node to scale back power consumption and a HMP gateway to unravel latency issues associated with cloud reliance. For a straight forward access to the configuration of the system a framework was introduced with two possible modes:

An analysis mode where parameters are set manually and an operational mode where different configurations are generated depending on different scenarios and criticalities. The work presented here may well be extended to incorporate two other applications that are Smart Ambulance Systems and Robotic Surgery.

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