Energy-aware Event-detection and Resolution through Decentralized Co-ordination of Intelligent Entities in Smartphone-based Remote Elderly Health Monitoring System

Deepak Uniyal, Vaskar Raychoudhury

Department of Computer Science and Engineering

Introduction

Remote Health Monitoring System for Elderly Patients (EHMS)

- ✓ To bridge the infrastructure gap and to provide round-the clock monitoring of the elderly patients
- ✓ Elderly healthcare is emerging as a very important and practical research area
- ✓ Existing infrastructure available to us is insufficient to cater to the needs of growing population.
- ✓ Multiple embedded sensors will monitor the vital signs and the surrounding environments.

Goals

The goals of the proposed research are

- ✓ To decide critical health situations of elderly patients through collaborative interaction of multiple embedded and wearable micro-sensors
- ✓ To inform patients about potential threats (pollen count, pollution, etc.) in indoor and outdoor environments based on their past health history
- ✓ To adopt smartphone based decision making approaches for emergency actions and to use simple multi-modal interfaces to facilitate interaction between patients and caregivers

Research Objectives

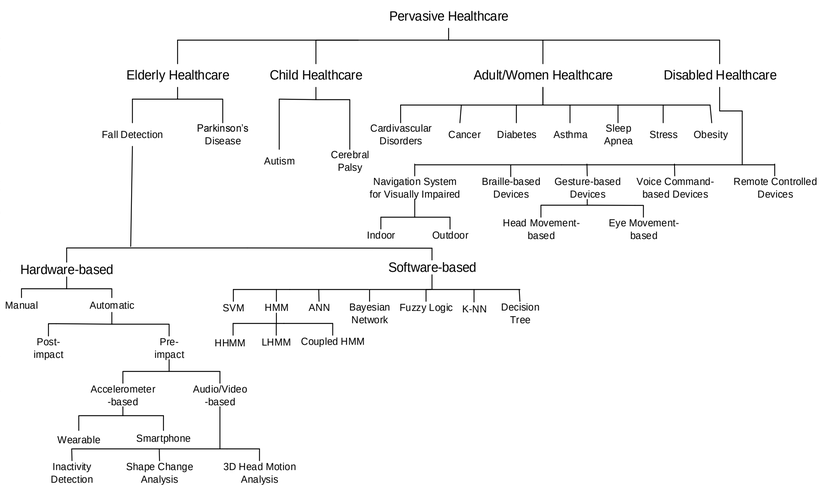
- ✓ Continuously monitoring the physiological status of high risk elderly patients to detect abnormal events.
- ✓ Premonition of ensuing health risks by monitoring vital and environmental signs in both indoor and outdoor locations.
- ✓ Automatically alerting the appropriate nearby caregivers to emergency situations regarding a patient's health.
- ✓ Providing smartphone based user friendly interface to facilitate communication between patient and care givers in emergency situations, and
- ✓ Ensuring proper security of sensitive healthcare information of individual patients

Research Plan

- ✓ Studying Application Requirement and Identifying Issues
- ✓ Developing a Multi-Sensor Intelligent Co-ordination Model
- ✓ Developing Data Analysis and Decision Making Algorithms

Pervasive Healthcare: The State of Art

- ✓ Extensive survey for studying application requirement and identifying issues
- ✓ Existing systems are loosely coupled
- ✓ Different sensor collect data but are not integrated into a single system
- ✓ So we have proposed a multi-sensor intelligent co-ordination model
- ✓ Different smart sensors can co-ordinate together to take a final decision



Developing a Multi-Sensor Intelligent Co-ordination Model

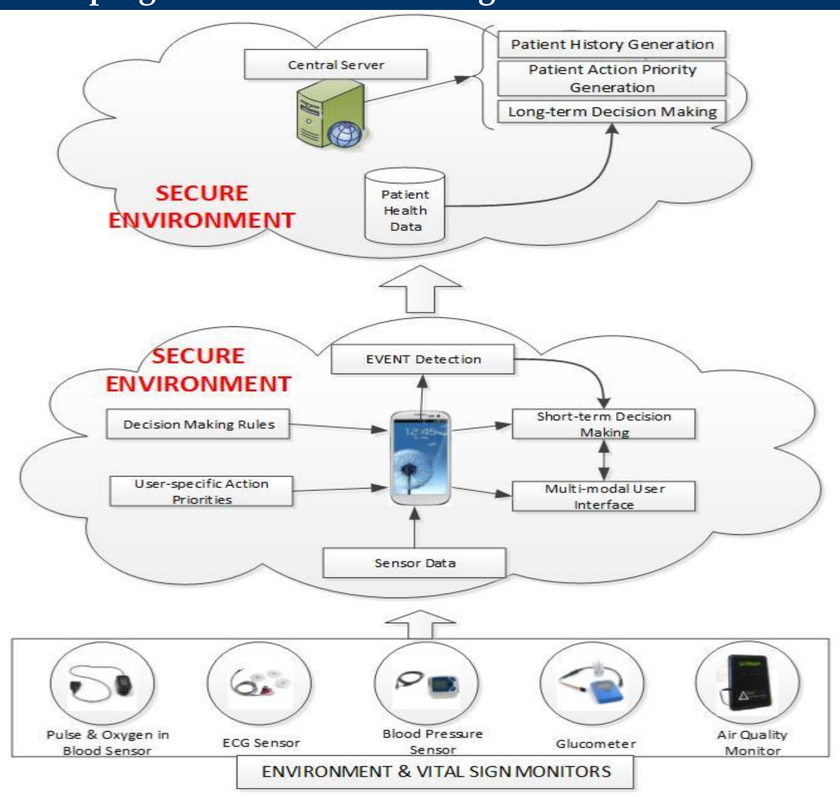


Figure-1: Architecture of EHMS

1) Data Collection

- ✓ Multiple embedded sensors will monitor the vital signs and the surrounding environments.
- ✓ All Sensor attached to e-health sensor shield which in turn transfer the data to Pc through Arduino UNO board.
- ✓ Data could be directly send to mobile wirelessly.

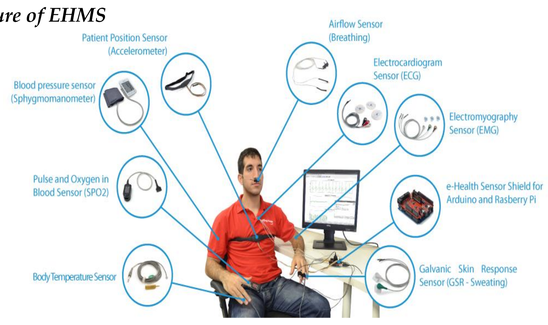


Figure-2: Health Sensor connected to body

2) Event Detection

- ✓ Several smart sensors deployed into the physical environment of a patient to form a network.
- ✓ All sensors work together in a coordinated fashion to detect a event.
- ✓ The sensed data is initially sent to the user's smartphone, which, based on the past health history of the patients, looks for abnormal sensor data readings.
- ✓ Events are detected in real-time and by the smartphone carried by patients.
- ✓ The smartphone then takes proper decision regarding future actions and asks for feedback from the user through convenient user interface.
- ✓ User responses are recorded for self-learning purposes and for future use.

Hardware

Arduino UNO

- ✓ Arduino can sense the environment by receiving input from a variety of sensors
- ✓ Can affect surroundings by controlling lights, motors and other actuators
- ✓ Microcontroller on the board is programmed using Arduino programming language
- ✓ Microcontroller board based on Atmega328
- ✓ 8-bit microcontroller with 32K Bytes in-system programmable flash
- ✓ 14 digital input/output pins (6 provide PWM output)
- ✓ SRAM 2KB and EEPROM 1 KB
- ✓ Clock speed 16 MHz

Figure-3: Arduino UNO Board

E-Health Sensor Shield

- ✓ Allows Arduino and Raspberry Pi users to perform biometric and medical applications using 9 different sensors
- ✓ Data can be wirelessly sent using any of the 6 connectivity options: Wi-Fi, 3G, GPRS, Bluetooth, 802.15.4 and ZigBee
- ✓ Privacy of data is important issue
  - ➢ In the communication link layer: AES for ZigBee and WPA2 for Wi-Fi
  - ➢ In the application layer: HTTPS for point to point security tunnel between each node and web server
- ✓ 9 sensors that can be connected to e-health sensor shield are as follows
  - ➢ Accelerometer, Glucometer, Airflow Sensor
  - ➢ ECG Sensor, EMG Sensor
  - ➢ Body temperature sensor, Sphygmomanometer
  - ➢ Pulse and oxygen in blood sensor
  - ➢ Galvanic skin response

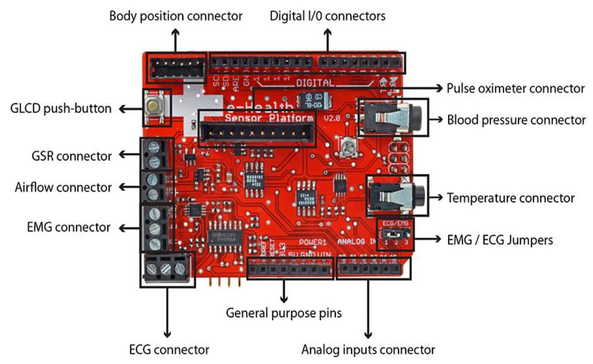


Figure-4: E-Health Sensor Shield

Results

Airflow Sensor

- ✓ Graph shows the respiratory rates and changes in respiratory rates
- ✓ Abnormal breathing rate is broad indicator of major physiological instability
- ✓ Normal adult has a respiratory rate of 15-30 breaths/min

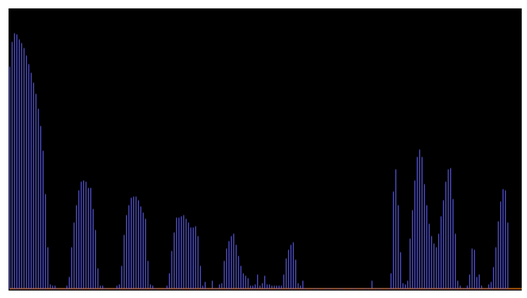


Figure-5: Airflow Sensor

Electrocardiogram (ECG) Sensor

- ✓ ECG is a tool to assess the electrical and muscular functions of the heart.
- ✓ Graph shows the ECG of data collected in lab which indicates the electrical activity of heart.
- ✓ ECG is one of the commonly used medical tests in the diagnosis of a myriad of cardiac pathologies.
- ✓ A heart problem may not always show up on the ECG.
- ✓ Some heart conditions never produce any ECG changes.
- ✓ ECG leads are attached to the body while patient lies flat.

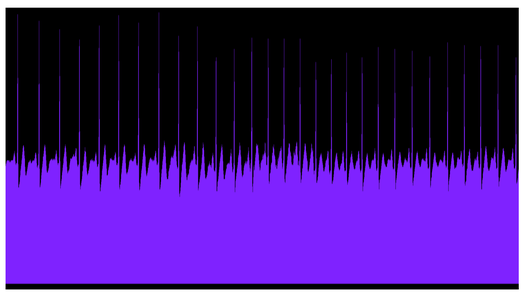


Figure-6: ECG Sensor

Electromyography (EMG) Sensor

- ✓ EMG measures the electrical activity of muscles at rest and during contraction.
- ✓ EMG detects the electrical potential generated by muscle cells when these cells are electrically activated.
- ✓ The signals can be analysed to detect medical abnormalities, activation level or the biomechanics of human or animal movement.
- ✓ EMG is used as a tool for identifying neuromuscular diseases, assessing low-back pain and disorder of motor control.
- ✓ Graph shows the EMG of data collected in lab which indicates the electrical activity of muscles depending on the amount of activity in the selected muscle.

Figure-7: EMG Sensor

Pulse and Oxygen in Blood (SPO2) Sensor

Figure-4: Blood Oxygen

- ✓ Graph shows the blood oxygen i.e. the amount of oxygen dissolved in blood based on the detection of Haemoglobin and Deoxyhaemoglobin.
- ✓ Acceptable normal ranges for patients are from 95-99%, for hypoxic drive problem it's between 84-99% and values of 100% indicate carbon monoxide poisoning.

Figure-5: Pulse Rate

- ✓ Graph shows the pulse rate (beats per minute).
- ✓ Normal range of pulse rate for adults is between 60-100.

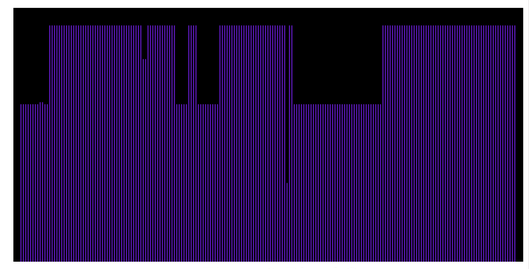


Figure-8: Blood Oxygen

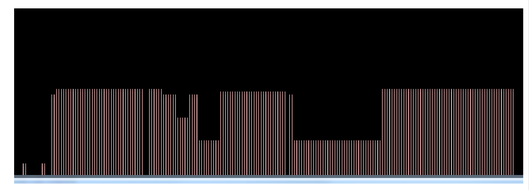


Figure-9: Pulse Rate

Future Work

To implement a prototype of the proposed EHMS framework with the following objectives:

- ✓ Connect different health sensors with a smartphone to facilitate mobile healthcare by local processing of critical vital signs.
- ✓ Build a rule-based decision making engine for the smartphone environment which will take real-time decision based on collected sensor data.
- ✓ Long term data storage and patient health case study and analysis to be done at the server side.