Pervasive Healthcare for Elderly and Disabled Persons

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Abstract
Cardiovascular disease is one of the biggest threats to human life. Each and every year it takes thousands of people lives and also cost billions of dollars. Early detection and prevention of these diseases could save many lives and reduce the money spent considerably. Existing pervasive care systems constantly monitor sick and elderly patients and send alerts to healthcare providers when they detect abnormalities in heart rates. These systems are reactive as they take action only when abnormal heart condition, such as Tachycardia, has been detected, but it is observed that abnormality in heart rate could develop Tachycardia.
Using an advanced prediction model to estimate the heart rates of selected patients when calculated heart rates exceed a predefined threshold value then pervasive care system that would send message to a designated caregivers, It has the capability of predicting heart rate abnormality, and possibly Tachycardia, well in advance. Additionally send alerts information in a secured and reliable way.

Keywords
Cardiovascular, Pervasive Care Systems, Tachycardia

I. Introduction

Due to the declining fertility and life expectance the demand for the public health services is expected to increase rapidly, because of the increased life expectance the ageing population will lead to increased healthcare cost as care for the elderly is much more expensive than that of other aged group. Care for cardiovascular diseases in growing ageing population imposes one of the greatest challenges for the public healthcare services. An early detection of heart diseases is not only economically beneficial but also socially advantageous as this would reduce the burden of disease treatment. This requires a shift from expert driven crisis-care model to a more preventive type system which would monitor patients remotely and take actions when vital signs in monitored patients become obvious. Many heart patients are known to suffer from Tachycardia which
is a form of cardiac arrhythmia and refers to a rapid beating of the heart. By convention the term refers to heart rates greater than 100 beats per minute in the adult patient. In extreme cases, Tachycardia can be life threatening. Several pervasive health care systems have been proposed for Tachycardia patients these systems monitor the patients around the clock. However, these systems can notify doctors/medical centres only when the patient is in a very critical condition. Recently, it has been found that increase in heart rate precedes episodes of some deadly forms of Tachycardia in cardiovascular patients. If we observe the heart beat of a patient having symptoms of cardiovascular disease for some period of time then it is possible for us to identify how much the patient is prone to the disease. Based on this the proposed pervasive health care system is capable of predicting the future values (of heart rate) by comparing the current heart rate against a predefined threshold value. When the predicted value goes beyond the predefined threshold the system can trigger action by sending message (via SMS, internet) to caregivers .The caregiver could take appropriate action. Typical action could be an appointment with a doctor for medical checkups. Thus the system predicts abnormalities in advance and may prevent Tachycardia from attaining maturity. Pervasive healthcare is prone to most security and privacy attacks during information transmission .The attacker might modify the information and thus modified information makes the doctor to diagnose the condition wrongly resulting in life-threatening situations. Therefore it is mandatory to employ appropriate security mechanisms to protect the information in pervasive health care. These mechanisms include authentication, confidentiality. As the patient's health information is transmitted through the internet, the communication should be encrypted, so that it disables eaves droppers from accessing the channel and modifying or reading data without authorization. When the information is sent to the caregivers via email, it is necessary to secure the information by verifying confidentiality and authorship. Encrypting the data and using digital signatures before transmission of data enables to achieve this.

II. Literature Survey

1. The home system can display the bio signal data from sensor devices, which processes the sensed data according to the specified parameters. If any variation in the vital sign, it sends the information to the physician mobile devices.
2. This paper proposed the design and development of advanced prediction model to estimate the heart rates of selected patients in a pervasive health care system that would send alerts to a designated medical centre for appropriate action to be taken when estimated rates exceed a predefined threshold.
3. This paper provides interesting solution that further facilitates and enables the secure living of elderly people at their private homes under safe conditions - according to their own wishes through care-obot, which is a robot that monitors the vital sign of elderly person and sets alarm in critical situation.
4. This paper proposed Augmented Chart for nurse, a physical digital nurse sheet, used for showing a vital signs graph , by using that graph the nurse can able to evaluate the vital sign from any remote area.
5. The vital sign information is continuously transferred to the remote healthcare monitoring system, from where it is processed.
6. This paper proposed the design and development of healthcare systems that are secure, reliable, and truly accessible to users.
7. Telemedicine affords caregivers the ability to collect and transfer medicals data. The common methods used are ordinary telephone lines, the Internet, and satellites, although any means of transmission can be used.
8. Rather than using the network to connect computers that are being used directly by people, these appliances communicate over networks such that people do not directly monitor the communication between machines and programs. The majority of these communications will occur in an end-to-end structure that does not include a human at any point.

III. System Architecture

The system architecture is shown in fig. 1.
It comprises three modules:

1. Data transmission from biosensors to PC
2. Data Reception and signal processing at PC
3. Communicating Information to Care Givers and Health Personnel

It should be noted that the whole procedure is completely automated without the intervention of human operators.

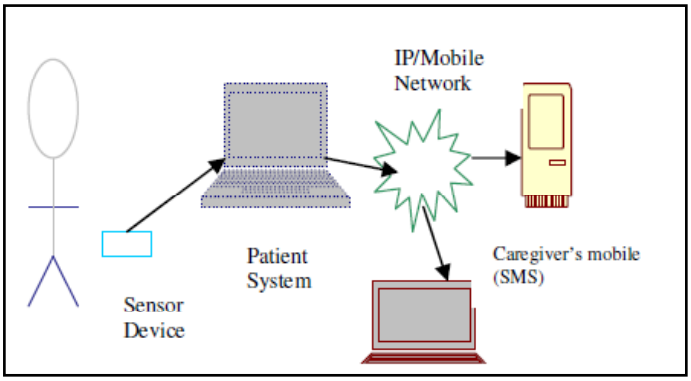

Fig. 1: Pervasive Healthcare Architecture

IV. System Description

The major functional components are briefly described below:

A. Data Transmission from Biosensors to PC

1. Sensor Inputs

The input to the monitor system is from human vital signals via biosensor. The sensor device consists of an infrared transmitter LED and an infrared sensor photo-transistor. The transmitter-sensor pair is clipped on one of the fingers of the subject. The LED emits infrared light to the finger of the subject. The photo-transistor detects this light beam and measures the change of blood volume through the finger artery. This signal is then sent to the ECG amplifier.

2. ECG Amplifier

The purpose of the ECG amplifier is to take the sensor inputs and produce a meaningful signal. The ECG amplifier removes noise from the signal as well as amplifies it and the amplified signal is fed to a low-cost microcontroller for analysis and display. The microcontroller counts the number of pulses over a fixed time interval and obtains the heart rate of the subject.

3. ECG Data Conversion

The Received data from ECG amplifier is sampled using Analog to Digital Converter (ADC). The ADC is interfaced with PC through USB to serial port converter.

B. Data Reception and Signal Processing at PC

1. Data Reception

The sensory data from biosensors are extracted from serial port using java serial forwarder program and the count of pulses over a fixed time interval is graphically displayed on the PC. Signal Processing is performed at PC from the extracted sensory data using Heart Rate Predictor method to calculate the future heart rate value.

The Heart Rate Predictor works on the principle of prediction model and has the following steps:

- Calculate the predicted future value
- Calculate the predefined threshold value
- Check whether the estimated future value is greater than the predefined threshold

Advanced Arrhythmias Prediction Model uses Holt's linear method to predict the future heart rate values and the working principle is explained below [2].

2. Advanced Arrhythmias Prediction Model

The main goal of the model is to detect in advance if there is any increase in heart rate and notifies the caregivers immediately. The Holt's linear method of time series analysis, forecast the future values of heart rate from the available data.

Holt's linear method can be expressed by following equations:

$$L_t = (alpha)Y_t + (1 - alpha)(L_{t-1} + b_{t-1}) \quad (1)$$

$$b_t = (Beta)(L_t - L_{t-1}) + (1-Beta^{-})b_{t-1} \quad (2)$$

$$F_{t+m} = L_t + b_t{}^{*}m \quad (3)$$

In the above set of equations (1)-(3),

L_t is an estimation of the level of the series (i.e. available heart monitoring data) at time t.b_t denotes an estimate of the slope of the series at time t.F_t denotes an estimated forecast of heart rate.

The Algorithm for Holt's Linear Method

Step1: Get the initial heart rate.

Step2: Initial heart rate is stored as Y_t and L_t.

Step3: Initialize alpha and beta value as 0.5

Step4:

Do

L_t = (alpha)Y_t + (1 - alpha)(L_{t-1} + b_{t-1}) b_t = (Beta)(L_t – L_{t-1}) + (1-Beta^{-})b_{t-1}

calculate the future estimated value

F_{t+m} = L_t + b_{t*m}

//Calculate the maximum heart rate

hr_max= (220-age)*0.7 If(F_{t+m} > hr_max)

Go to step 5; Else

Go to step 4; While (true)

Step5: Send message

Step6: End

Smoothing parameters alpha = 0.5 and beta = 0.5 were chosen to forecast future values of heart rate to predict the possibility of Tachycardia [2]. It is also capable of extracting heart rate data over a period of time to calculate the mean heart rate.

C. Communicating Information to Care Givers and Health Personnel

The computed heart rate data is send to the prediction model for further decision to be made. If the decision is to send an alert message, the patient's system sends a message along with heart rate data to caregivers. The receiver (caregivers) receives an alert message via SMS or E-mail.

By using Way2sms web service to send SMS and any Mail Server can be used to send an E-mail automatically to caregivers. Even if one method of transmission fails, still the caregivers can receive the information by other mode. Thus the message is transmitted in reliable way.

Encryption ensures that an e-mail could be read only by the desired recipient. A digital signature proves that an e-mail has truly originated from the authenticated sender and the content is not modified. A digital signature allows e-mails to be treated as legally valid correspondence.

The RSA algorithm is used for both public key encryption and digital signatures. Hence the pervasive healthcare system ensures the data to be transmitted in secured way.

The algorithm for sending SMS to the Caregivers Mobile:
Steps for sending SMS to multiple Recipients
Step 1: Begin
Step 2: Register way2sms
Step 3: Get the login URL using URL and Http URL Connection.
Step 4: Enter username, Password, Message,
Receiver's Mobile number
Step 5: Set username and password into the login page through program
Step 6: Compose the message and send the message
Step 7: End.

V. Implementation

The proposed solution is implemented in Java using Mail server. The pulses and age are entered by user, and then check whether the predicted heart rate is greater than maximum heart rate, if yes send E-Mail and SMS to the caregivers.Fig1 shows the mail is sent to the caregivers. Fig. 2 shows the caregivers receive the E-Mail. fig. 3 and fig. 4 show the caregivers receive information through SMS.

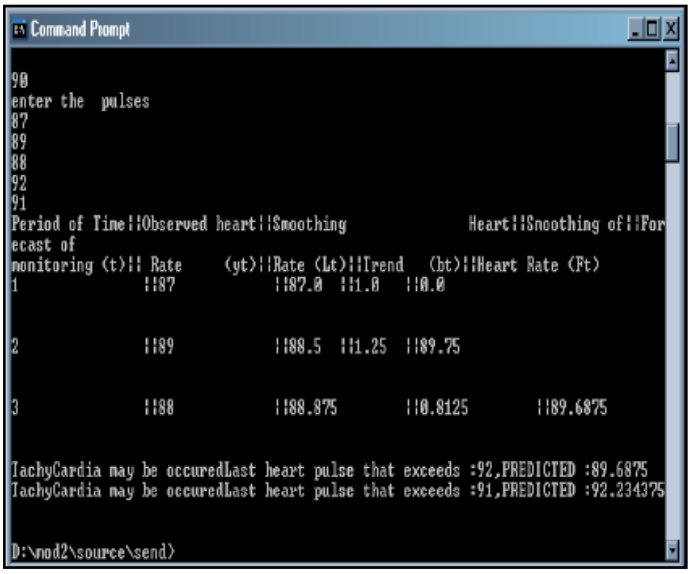

Fig. 1:

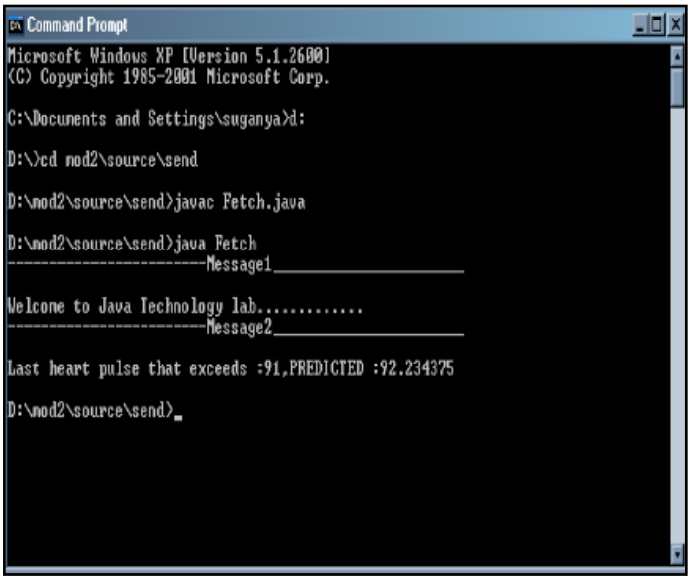

Fig. 2:

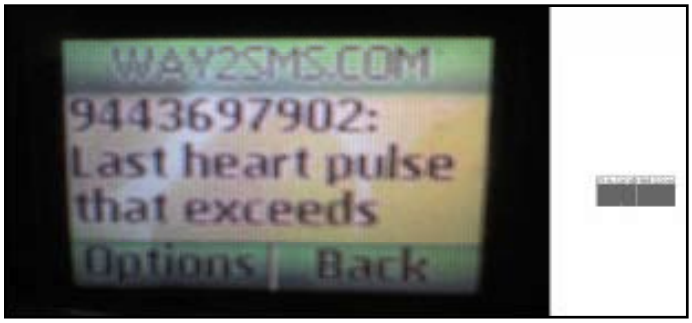

Fig. 3:

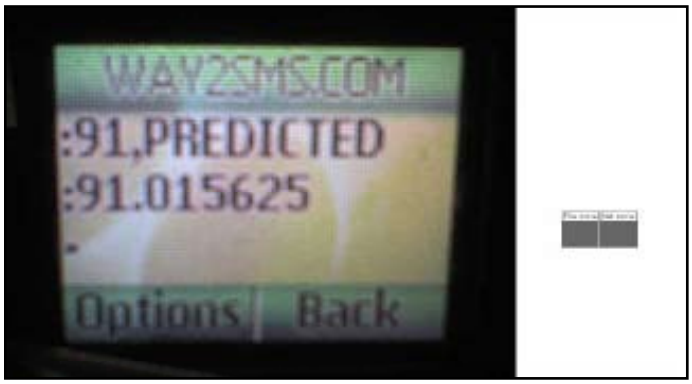

Fig. 4:

V. Conclusion and Future Work

In this paper, we have presented a pervasive healthcare system involving desktop and wearable monitoring devices that enables to predict heart disease (Tachycardia) in earlier stage before the patient get affected and informs the caregivers in a reliable and secured manner.
In future more biosensors which can measure various vital signals can be incorporated to the patient body and the information can be transmitted to remote system (Hospital) where it is updated hospital database. This helps the physician to monitor the unattended or remote patient where face-to-face consultation is impossible also get medical service regularly.

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