Design and Development of Prognosis Based Body Monitoring and Reporting System Using Time Series Analysis

Pari Patel, D. Sagar, and Nithin Rao

Abstract In today's increasingly busy world, people hardly have any time to look after their health conditions which leads to ignoring routine checkups which help in diagnosing the health conditions and keeping updates on current condition of the body. Day by day, death ratio is at a high pace because of delay in treatment due to lack of infra-structure in science and technology to identify and take corrective action for any disease, one of the paradigms that can use the IoT to improve the human lifestyle. This proposed work presents that IoT-based system is able to collect the sensors data of user's heart rate and from that it will help in predicting the value for prognosis using ARMA model time series analysis. Based on prognosis, condition, abnormality and criticality rates are calculated and notified through E-mail to personnel health consultant.

Keywords Body monitoring and reporting system · IoT · Time series analysis · Prediction · Embedded system · Cloud

1 Introduction

Health monitoring plays an important role in e-health care system [1]. Body monitoring system deals with the body parameter and vital signs of patients with the help of biomedical sensor. Sensor-based embedded system measures different body parameters like heart rate (HR), blood glucose, blood pressure (BP), temperature, etc. Body diagnosis is the method of understanding diseases, disorders, or problems by detailed analysis of the background history with the currently achieved results [2]. Prognosis in the system comprises the situation where the patient's vital signs are monitored and based on the reading acquired, predictions are done on whether the patients is going to continue to be in healthy condition or detroit to critical condition within the predicted duration of time. The data collected through the experiment can

P. Patel · D. Sagar (✉) · N. Rao
M. S. Ramaiah University of Applied Sciences, Bengaluru, India
e-mail: sagar.cs.et@msruas.ac.in

G. R. Kadambi et al. (eds.), *Emerging Trends in Photonics, Signal Processing and Communication Engineering*, Lecture Notes in Electrical Engineering 649,
https://doi.org/10.1007/978-981-15-3477-5_22

be used for better analytical accuracy, prior notification or detection, and reducing cost in overall health care.

2 Background Theory

2.1 Internet of Thing (IoT)

Internet of Things is a concept in which various devices are connected with each other by different available resources and techniques to exchange the real-time data [3]. Internet of things integrates hardware and software platforms to allow full communication between M2M (machine to machine) and M2C (Machine to Cloud) for transferring the data which improves health care for patients. Health monitoring system based on IoT enhances the performance of biomedical instrument by allowing real-time sensor data which leads the system to reduce the error in the process of diagnosis and prognosis treatment of a patient.

2.2 Cloud Storage

Cloud storage service is mainly used to effectively manage huge real-time data and decide upon the ownership of data, real-time response, stored large amount of structured and unstructured physiological medical history data of the patient with a precise database concerning each patient [4]. Data storage and analysis will be a challenge when the whole world will be connected with Internet of Things technology [5].

2.3 Embedded System

System integrated with software to control the hardware to perform specific objectives is term as embedded system. In healthcare center, embedded system helps in accurate diagnosis of disease symptoms. Smart, trivial, and powerful monitoring devices ambitious by embedded technology and connected with the help of IoT are helping these people monitor and treat their health conditions. Embedded systems have managed to revolutionize the healthcare industry.

2.4 Time Series Analysis

Time series analysis is collection of huge number of data within a uniform time interval and analyses of the same to predict the change that will happen in future condition. It is used in copious field such as economics, pattern recognition, biometrics, etc. This process is applied in a wide range of spheres where the predicted value is helpful in many ways to take future decision.

In this proposed developed prognosis based body monitoring and reporting system, choose Autoregressive–moving-average (ARMA) model for analysis and prediction to get accurate predicted data [6].

The data series of patient's concentration over a time is considered as a random time series.

$$X_t = \sum_{j=1}^{p} a_j X_{t-j} + \sum_{j=1}^{q} b_j \epsilon_{t-j} + \epsilon_t$$

Current and future reading of pulse rate can be expressed as a previous pulse rate data with ARMA model [1].

X_t indicates the pulse rate at current time instant t, X_{t-k} is the previous reading of k time-units before current time t, a_1, a_2, a_3,…, a_p are the p order of autoregressive coefficient and b_1, b_2, b_3,…, b_q are the q order of moving average coefficient, and ε_t is the white noise.

3 System Design and Architecture

Figure. 1a, b represents the system level block diagram and flow chart of the system which measure the data from user's body with different biomedical sensors attached as an input stage. Furthermore, the data will get fetched and sent over cloud to create a history of data. If the user is encompassed in Wi-Fi range of raspberry pi connectivity, it will transmit the data directly to Raspberry Pi board through NodeMCU v0.9. In the next stage, ECU as a Raspberry Pi board is configured using LINX toolkit with IP address with LabVIEW. Control unit of the system fetches data and feeds it to LabVIEW for further analysis and predicts the future condition of users. All history of the patient data will be stored over a cloud. From the predicted value and prognosis condition of the patient, we can identify the abnormality of the disease and calculate the criticality data rate and notify the user and their relatives and also alert the medical health care consultant for the criticality issue through E-mail.

Important tools required for Software Simulation Setup are as follows:-

- Python Language
- Embedded C with Arduino IDE
- LabVIEW (Laboratory Virtual Instrument Engineering Workbench).

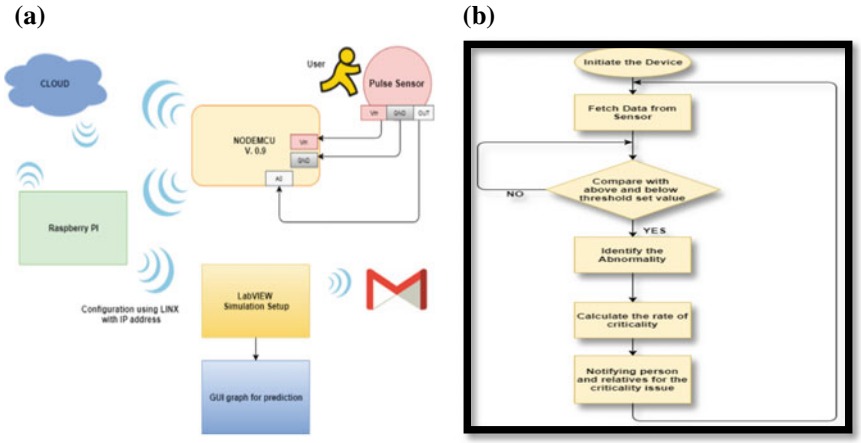

Fig. 1 **a** System block diagram. **b** Flowchart of system design

4 System Implementation

4.1 Hardware and Software Implementation Setup

Figure 2a, b shows the overall physical model of the system that the user will be working within this experiment.

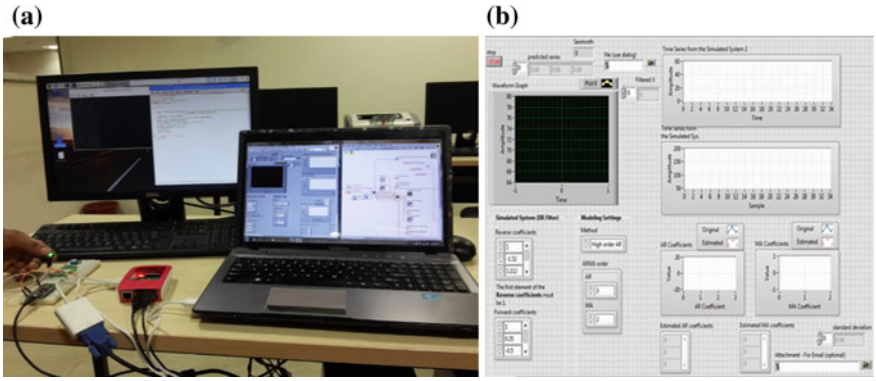

Fig. 2 **a** Hardware setup. **b** Software setup of system developed

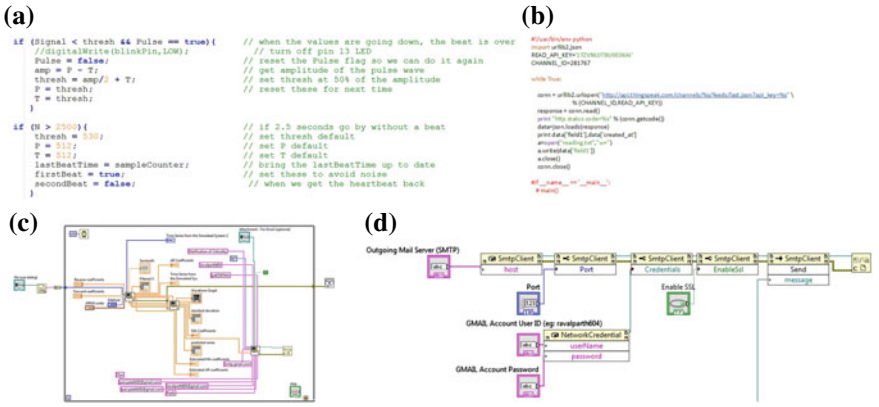

Fig. 3 **a–d** System implementation code

4.2 System Logic Implementation

Figure. 3a–d shows the logic design of the system designed in LabVIEW, GUI designed for ARMA modeling, and prediction for heart rate analysis. Reverse and forward coefficient used for the IIR filter will be set according to our real-time data series for filter design. Filter X shows the array of filtered samples as output. High-order AR method is used in ARMA modeling and prediction analysis because it gives high accuracy than Yule–Walker and polynomial methods for univariate time series data. ARMA order is a combination of AR and MA coefficients and it can be set according to our application requirement of prediction series. AR and MA coefficient values should be greater than or equal to zero and AR coefficient order is greater than MA coefficient order. Estimated AR and MA coefficients are used for predicting future value of prognosis condition. Standard deviation gives the error between original data and each predicted value.

5 Results and Discussion

Figure. 4a, b shows the results obtained from analog signal collected from pulse sensor. Real-time data feed to LabVIEW for analysis through NodeMCU module.

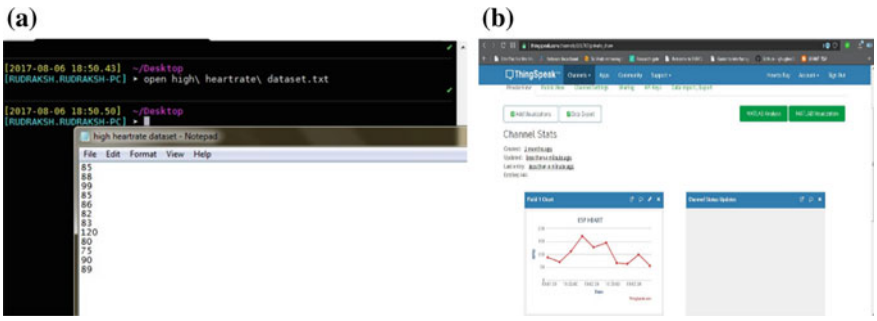

Fig. 4 **a** Pulse sensor values. **b** Prediction series result

6 Conclusion and Future Work

The system is able to identify the disease issue by analyzing collected real-time data from sensors using ARMA model and detect the critical condition of a particular disease and notify patients and registered medical experts as shown in Fig. 5.

It is an important aspect to consider the future expansion of any developed work and to concentrate on future scope of the implemented work. Some future extensions can be considered for the developed prognosis and diagnosis based body monitoring and reporting system as follows:

- System can import more than one vital sign parameter included in the developed system.
- In future work, system can provide solution for the avoidance of the critical state.
- Scalability and accuracy can be improved by implementing new algorithm for gateway medium.

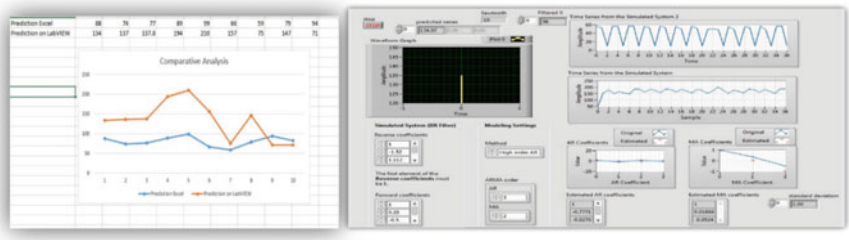

Fig. 5 Comparative analysis between ARMA model and real-time data log

References

1. Ying Z, Rui K, Shihong X (2014) Research on glucose concentration predicting based on ARMA model. In: 2014 prognostics and system health management conference (PHM-2014 Hunan)
2. Mohanraj T, Keshore R (2017) Patient monitoring system using LabVIEW. In: Int J Emerg Technol Comput Sci Electron (IJETCSE) 24(4). ISSN: 0976-1353
3. Singh D, Tripathi G, Jara A (2014) A survey of internet-of-things: future vision, architecture, challenges and services. In: 2014 IEEE world forum on internet of things (WF-IoT)
4. Mukherjee S, Dolui K, Datta S (2014) Patient health management system using e-health monitoring architecture. In: 2014 IEEE international advance computing conference (IACC)
5. Zhou B, Ma Q, Song Y, Bian C (2016) Cloud-based dynamic electrocardiogram monitoring and analysis system. In: 2016 9th international congress on image and signal processing, biomedical engineering and informatics (CISP-BMEI)
6. Mahalakshmi G, Sridevi S, Rajaram S (2016) A survey on forecasting of time series data. In: 2016 international conference on computing technologies and intelligent data engineering (ICCTIDE '16)