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# Smart Healthcare System using Low Cost IoT Module

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## *Abstract*

*The use of internet of things (IoT) in a smart healthcare service is very useful due to the increase in accessibility throughout the globe of systems involved in the service. In this paper, we start with review of undeviating relationship between Vital Signs Early Detection (VSED) and Physical Signs Early Detection (PSED), Relationship between (VSED) and (PSED); and ended with a multiple chronic disease parameters measuring system using two prominent technologies namely, Internet of Things (IoT) and ThingSpeak. Outcomes of chronic patients can be improved by identifying the physiological deterioration as early as possible. The multiple chronic parameters measuring systems are like blood pressure (BP) in which one we measure pressure in the arteries when the heart rests between beats called diastolic and second we measure pressure in the patient arteries during the tightening of patient heart muscle called systolic, body temperature and pulse rate. In the proposed system, basic parameters like systolic and diastolic, body temperature and pulse rate of the user are measured, send it to a cloud using ThingSpeak, and then analyzed by medical authority. Medical authorized personnel will take decision on really there is a need of patient visit the hospital or not. In this proposed paper provides a way to observe patients and their need within the comfort of their own homes. Predicting the chronic diseases features on the basis of Early warning score (EWS) from these systolic, diastolic, body temperature and pulse rate measure readings by the proposed system get extracted from the ThingSpeak. These features are extracted and compared with the previous data based and calculate the EWS. It is shown that the proposed system achieves to reduce the unnecessary hospitalized patients.*

***Keywords:*** *Smart healthcare, Internet of things (IoT), ThingSpeak, Early warning score (EWS).*

## 1. Introduction

World Health Organization (WHO) suggested in 2013, Patient to Doctor ratio will increase and predicted the scarcity to accomplish 12.9 million in next ten years" [1]. It is so happen because rapid increase in population it will directly affect on increase in people like aging, disable having chronic diseases etc. National Health Service (NHS) of UK's reported that, they saved seven billion pounds per year by proving good healthcare services remotely and reduced number of hospital visit and hospitalization using information and communication technology [2].

The Veterans Health Administration (VHA) conducted a Care Coordination/Home (CCHT) survey from 2003 to 2007. The main intention behind, when the patient having or finding chronic circumstances and overcome the needless admission and use of Intensive Care Unit (ICU) for long term. Analysis of medical related data for improving

the level of superiority and routine from cohort of 25% decreases in figures of bed days of ICU, 19% decreases in hospital admissions, out of seventeen thousand twenty five CCHT patients who register for this survey. Veterans Health Administration (VHA) conclude that home tele-health implementation is very helpful and affordable way of taking charge of chronic care patients (CCP) in rural and urban areas [3].

Upcoming research is based on wireless patient monitoring system (WPMS). This system play vital role in early diagnosis of the diseases and health related information to the healthcare professionals [4]. WPMS system should capable to collect: 1) collect medical related data via predefined medical devices; 2) understand the medical related data in significant manner; 3) predict the Early Warning Score (EWS) through medical experts with the help of availability of data; 4) carry out suitable action with medical professionals [5]-[6]. This method focus on replacing the traditional method to smart, that includes calculate early warning score in which predicting, preventing and early detecting the diseases [7]. ABPM offers continuous measurement of blood pressure at a predefined time interval for 24-hour period. It helps to detect white-coat hypertension, to the particular who are not taking antihypertensive medication which shows uncertain of normal systolic and diastolic averages. It also gives measurement readings in a particular window size frame. It will help clinical management to identify and detect chronic disease like hypertension and also increase the accuracy of diagnosis [8]. A low cost IoT-based system is utilized to take the measure signals from the users. Patient basic parameters like systolic, diastolic, pulse rate and body temperature send to medical personnel (doctor or nurses) and these signals are sending through a cloud server.

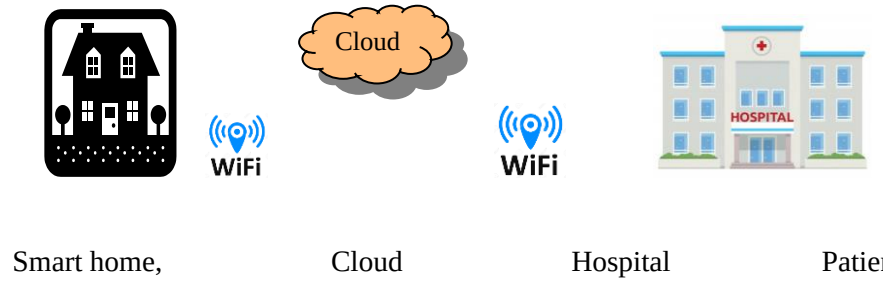


**Figure 1. Smart healthcare flow work for patient monitoring at a distance.**

Figure 1 shows the smart healthcare system for patient monitoring at a distance, smart home consist of IoT device and medical sensors. Medical sensors sensed the respective readings and send it to cloud server through IoT device and at the receiving end (hospital) medical authorized person compare the patient readings with the data base which are available and tell the patient to visit hospital if required. If all the patient readings are normal then there is no need to visit hospital.

## 2. Research Method

Several studies have been published on telehealth monitoring system; this section presents some of the important works. Presently medical devices only support USB and Bluetooth (BT) from telehealth domain the reason is limitations of power, number of devices connected and range [9][10]. Still one more wireless technology i.e., Zig-Bee having very good characteristics like transmission and reception range, low power consumption, having good number of devices connectivity and it also supports tele-care domains on a single wireless technology [11].

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Alesanco [12] used 3G mobile networks simulations as well as analyzed and show the medical instantaneous electrocardiogram (ECG) signals. As per the medical trials concern 4 second is the maximum usual delay in electrocardiogram (ECG) and authors organize their transmission algorithm and transmission procedure in such a way that, and they tryout signal delay less than 4 second. Trigo et al. [13] offered a trial artefact execution of coincident ECG broadcast via the IEEE 11073 standard family, whereas coordination on behalf of ECG apparatus specialty is silent continuing. The same tryout creation wasn't clinically evaluated, but implement in regular practicability [14]-[15].

# 3. Theory

## 3.1 Labelling Vital-sign Data

Vital-sign data classification needs precise labelling of "abnormal" and "normal" vital-sign data. In one-class classification, only the "abnormal" label is used for representation. It depends upon the complete specification of "abnormal" data class and it required analysis of safety-control system, like patients, for the comparison of "abnormal" sample data with the "normal" data. On the other hand, if we consider adequate sample of "abnormal" data, but in two-class classification (TCC) loom might be taken in which together "abnormal" and "normal" sample data are used, and "abnormal" cluster is clearly modelled. In this data labelling is very important for the success of accurate data, for the practical clinical datasets. Large amount of data gathered from continuous patient monitoring so to handle that practical clinical data sets is tedious job for any medical professionals to label for each patient in the existing hospital. One way to overcome this tedious task, it is better for clinician to labelled only those patients to whom known abnormalities occurred practically [16], sometimes it happens with only to those patients having straightforward univariate alerting criteria example heart rate (HR) $\geq$ 120 beats per minute were recognized for the period of retroactive testing [17], [18]. Many researchers' wants to predict the early warning score (EWS) to detect the vital signs; there is a possibility of underscoring as well as over scoring. Here, over-scoring leads to unnecessary calling of medical personnel and under-scoring create delay in the detection of patient health worsening [19]. It is not totally depend on the use of rigid patient outcome, perhaps once release to give group labels since many time it happens that patients have negative outcome like unexpected cardiac arrest or emergency access to ICU, it might be a a periods of "normal" bodily processes, conceivably earlier to their worsening in the patient health, and in similarly way with the periods of "abnormal" physiology earlier to entire revival.

Review paper gives details of the 4-D dataset analysis comprising oxygen saturation (SpO2), heart rate (HR) and breathing rate (BR); the arithmetic mean of blood pressure called as systolic diastolic average (SDA). Total 332 patients dataset was acquired which was admitted in the ICU for different diagnosis during three consecutive tryout conducted between November, 2006 and August, 2007 at the Presbyterian Hospital, University of Pittsburgh Medical Centre (UPMC), and collect over 18 000 h of 4-D vital-sign data sample [20]. All basic vital-sign measurements including heart rate (HR), SpO2, diastolic and systolic blood pressure (BP) were generated by their comfort zone monitoring equipment with a sampling rate of 20 seconds. The blood pressure is also measured noninvasively with an hot-air balloon cuff coupled to the bedside monitor, same time systolic and diastolic blood pressures also calculated by it. Taking the arithmetic mean of these two basic parameter was then calculated its arithmetic, and commonly it is referred as the Systolic Diastolic Arithmetic (SDA). Consulting with medical experts artefact refusal was carried out by rejecting sample data outside the following ranges, [20]: SDA 20–180 mmHg , HR 30–300 bpm, SpO2 60% and more acceptable.

## 3.2 Existing One-Class Methods

One-class classification (OCC) is used to form a model of "normal" bodily processes, and subsequently detecting deviations missing from that model and recognized them as being "abnormal" by existing works [21]– [23]. A common come out involves forming measure of the sharing of vital-sign sample data.

## 3.3 Existing Two-Class Methods

Since there is no sufficient amount to approve a two-class approach of labelled patient data, there are hardly any examples of TCC approaches to the dilemma of patient vital-sign monitoring (PVSM). Parati G comes to one conclusion that a large set of data is used which allows the "abnormal" class, to be accurately modelled. It is noted that might be in the boundary, achieve TCC in which every type of abnormality is unequivocally modelled. To construct such modelled required enough sample data and would also not array up to datasets of upper dimensionality; denotation, adding together a original vital sign would begin additional modes of abnormality due to the additional vital sign, promising covariance by modes of abnormality starting from another vital signs [24].

## 4. Results

The primary aim of this paper is to understand Tele Monitoring programs in the context of chronic diseases properly linked with the existing clinical effect. This paper shows implement low cost IoT module for Tele Monitoring by using Internet of Things (IoT) and ThingSpeak. ThingSpeak is very popular IoT platform where the medical authorised person can observe and analyze the patients basic parameters reading, it can also allows user to aggregate analyze and visualize live data streams in the cloud [24]. This IoT module helps in continuous measurement of chronic disease with the help of basic parameters like blood pressure (BP) which includes (diastolic and systolic), pulse rate and body temperature during the whole day without limiting the patient mobility. Assembly of low cost IoT module for smart healthcare system shown in fig. 2. In this proposed system the main component is ESP32, fig. 3 show pin diagram of ESP32, the speciality of ESP 32 is having microcontroller as well as wi-fi module in the same package, small in size and cost is also low. ESP32 is invented by Espress if Systems a Shanghai-based Chinese company, and used TSM Cusing their 40 nm process for the manufacturing [25].

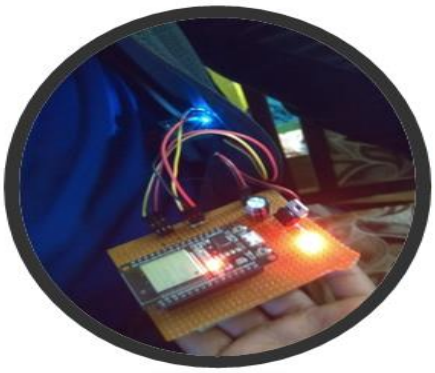

**Figure 2. Assembly of low cost IoT module for smart healthcare system.**

Demonstration of low cost IoT module for smart healthcare system with blood pressure sensor module shown in fig. 4.

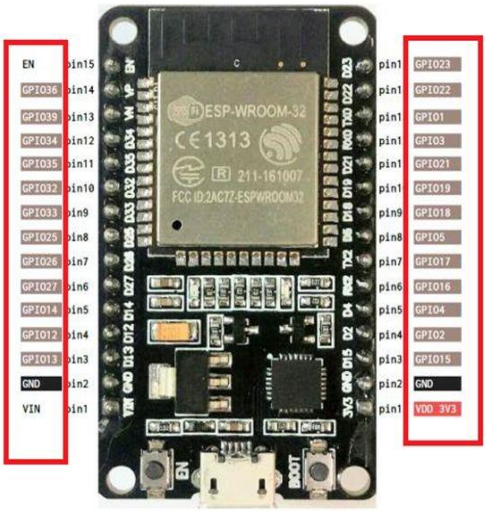


**Figure 3. Standard Pin Diagram of ESP32.**

**Figure 4. Demonstration of Smart healthcare system with low cost IoT module**.

## 4.1 Graphical Analysis of Measurement of systolic, diastolic and pulse rate parameters

Blood pressure (BP) is force of patient blood closed to against the fortifications of patient arteries. Every time patient heart beats, as it is pumped in the region of patient arteries. There are two types of BP, one is called systolic in which patient BP is highest when patient heart beats refill the blood; and second is called as diastolic whenever the patient heart is at relaxes between beats, in that case patient BP falls [26]. Fig. 5(a), 5(b) and 5(c) shows graph of systolic, diastolic and pulse rate parameters over ThingSpeak platform.

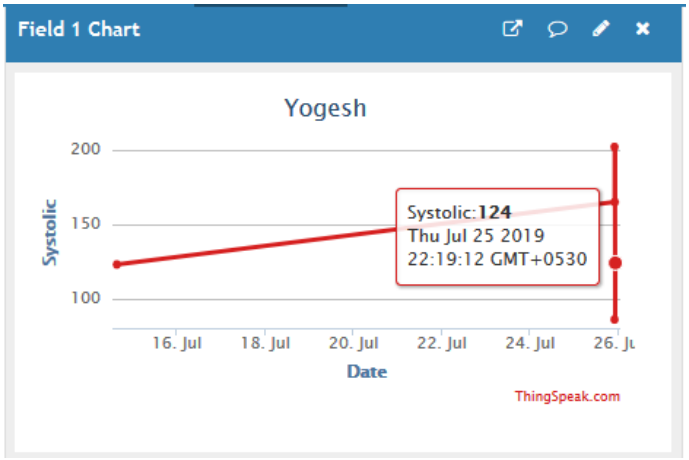


**Figure 5 (a). Graph of systolic parameter over ThingSpeak platform.**

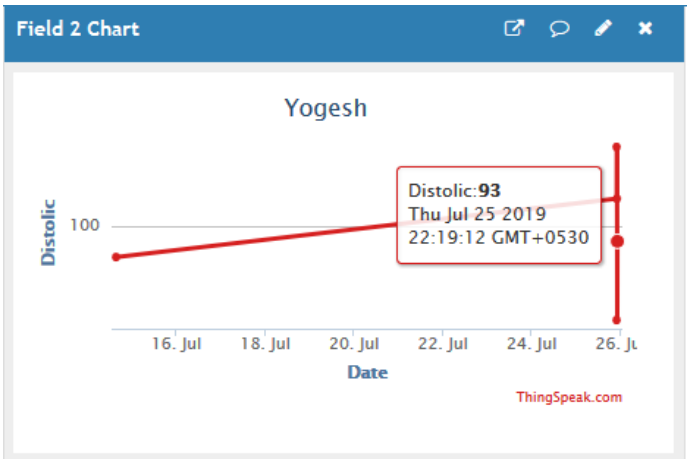


**Figure 5 (b). Graph of diastolic parameter over ThingSpeak platform.**

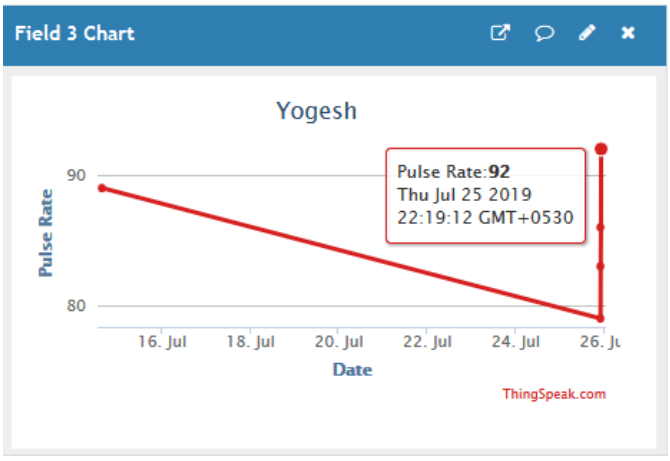


**Figure. 5 (c) Graph of pulse rate parameter over ThingSpeak platform.**

Table 1(a), 1(b) and 1(c) shows the excel sheet of systolic, diastolic and pulse rate readings with date and time, directly from ThingSpeak and it is very easy to evaluate the clinical data.

| Sheet for Systolic Reading | | |
|---|---|---|
| Date and Time | Yogesh | Field1 (Systolic) |
| 2019-07-25 22:19:12 GMT+0530 | 1 | 124 |

**Table 1 (a) Excel Sheet of systolic parameter over ThingSpeak platform.**

| Sheet for Diastolic Reading | | |
|---|---|---|
| Date and Time | Yogesh | Field2 (Diastolic) |
| 2019-07-25 22:19:12 GMT+0530 | 1 | 93 |

**Table 1 (b) Excel Sheet of diastolic parameter over ThingSpeak platform**

| Sheet for Pulse Rate Reading | | |
|---|---|---|
| Date and Time | Yogesh | Field3 (Pulse Rate) |
| 2019-07-25 22:19:12 GMT+0530 | 1 | 92 |

**Table 1(c) Excel Sheet of pulse rate parameter over ThingSpeak platform.**

## 5. Discussion

Most of the times it happens that hospital visit transportation charge is more than the doctor consultation fees and time required is also more to personally visit doctor at hospital. This proposed system will help to overcome this parameter with the help of Information and Communication Technology (ICT) and it helps to overcome the geographical distance between rural people and doctor. Now proposed system easily interfaced with body temperature sensor and BP sensor and send the measured data on cloud server with the help of blynk server, and available globally to the doctors.

## 6. Conclusion

This paper has initially presented telehealth monitoring system with different wireless technology and compare with their characteristics. This paper also knows that two class methods is always better than the existing one class methods. Design a low cost IoT module which improves the classification performance, and also compare the proposed system with the existing Ambulatory Blood Pressure Monitoring system (ABPM) and demonstrated that our proposed system is having more usefulness than the existing one.

The advantages of this system is very cost effective, easily interfaced BP sensor and Body sensor easy to access the measured reading globally and operation is very user friendly. Availability of internet is the only limitation. This system can be easily used in the rural area and help doctors and patients to exchange their service at their comfort zone and overcome the geographical barriers between rural patients and specialist medical personnel. Whatever the results are proposed in this paper required external validation and clinical trials.

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