

Heart Rate and ECG Wireless Monitoring Techniques: A Survey

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Abstract

Body health monitoring is so important to us for ensure that our health is in an excellent case. The systems for Health monitoring are a new subject and significant research scope nowadays. There are many significant vital parameters in the health observing systems, Heart Rate (HR) is one of the most important signs of these parameter to be monitor; it is a vital indicator of people's physiological state. Monitoring of heart rate oftentimes includes high costs and complex application of sensors and its systems. Therefore to cover this needed it must advance systems that are able to measure HR and ECG systems for the purpose of monitoring. This paper focuses on reviewing the monitoring of the heart rate systems with the uses of a fingertip sensor and electrocardiogram other remote technologies. More than forty of the heart rate measuring and observing systems and Electrocardiogram systems have reviewed and grouped into two groups one for heart rate and the other for wearable ECG, presented its features and common specifications for each of them, resulting from this review that the authors have focused on designing systems that can be optimum choice for illness people which they have needed to be continuous monitoring. The systems are acceptable error rate and some of them allow the user to freely move based on the wireless technology, the systems easy for usage by the patient or elder people and with a suitable cost. Also, this paper presents security, personality, reliability of systems and the quality of the signal.

Keywords: Heart Rate, Monitoring, ECG, photoplethysmograph, electrocardiogram.

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1. Introduction:

Health observing is significant to have orderly checking to ensure that our bodies stay with a healthy and perfect case. In general, the observed vital signs to monitor the body health namely, weight, blood pressure temperature, Heart Rate (HR), glucose and ECG are of essential importance. These parameters will clear to us some important information related to body health [1]. The times' number the heart beats in one minute is referred to as heart pulse or rate. Generally, the heart rate values change from one body to another. Also, the pulse

rate and pulse regularity will change as the age change [2]. A monitor device permits the persons to measure their beat per minute in actual time or register it for studying later. The heartbeats have different values; this differentiation is according to age and gender [3]. Table (1) illustrates these values

In the last decades, the diagnosis of heart illness typically has based on a registration of an Electrocardiogram (ECG) signal. An ECG registers the heart electrical activity, which is utilized to measure the regularity and rate of heartbeats, the chamber's position and size, the influences of drugs, and the presence of any damage to the heart [4]. The Diagnosis of the heart disease utilizing ECG waveforms may be done by either correlating the ECG waveform with a typical healthy waveform or by utilizing more complex algorithms to process heart disease in depth [5]. At the clinical regulation, the heart rate is obtained with measure R-R intervals to the ECG signals getting minimally with three electrodes, one of them serve as a ground which is connected to the right leg[6]. In this paper, we plan to survey the current technology in the scope of heart monitoring systems and an outline for challenges at present and future times. At the clinical regulation, the heart rate is obtained with measure R-R intervals to the ECG signals getting minimally with three electrodes, one of them serve as a ground which is connected to the right leg[6]. In this paper, we plan to survey the current technology in the scope of heart monitoring systems and an outline for challenges at present and future times. The reviewed papers for these systems are in the period from 2008 to 2018.

2. Literature survey

In order to understand and be familiar with the systems for health monitoring, therefore it must be made a survey on the most important monitoring systems focuses on their important features, it's design and their results.

2.1 wireless heart rate monitoring systems

The paper in this section shows the systems that are used to monitor the heart rate for patients. In the general format, these systems are measuring the heart rates, processing the acquired data, store, and make a decision to send an alert message to the specialist doctor. The design and development of a new integrated device for

measuring heart rate utilizing fingertip to enhance assessing the heart rate has displayed by M.M.A. Hashem and et al in [7] they have used the Heart Rate Measuring (HRM) device. Three stages are used to detect pulses on the fingertip that include pulse detection, signal extraction, and pulse amplification. Finally, they have contrasted the performance of the heart rate monitor device with the determination of the Electrocardiogram and manual p measurement pulse of heartbeats of 90 people with different ages. The contrast results have showed that there is a small error rate for the device which is negligible. Table (2) illustrates the comparison result with ECG for accuracy [7].

The result of the designed device of Imtiaz Khan, and others [8] show that a fingertip arrangement has the best result since a fingertip provides less absorption and greater reflection of light. The author presented and implemented a device with small in size, portable, energy efficient, has the ability to store data, and it is quite suitable to communicate with remote devices via cellular communication and Bluetooth in a medical emergency situation. Their designed system depends on the analyze of the change level of the light that reflected after the project of infrared light to suitable parts of the body like a wrist, temple area of the head, or fingertip. The authors apply their device for 22 volunteers to Measure the heart rates from a different age. At the same time, an FDA has approved digital automatic blood pressure monitor measured their heart rate which is found that there a little different which can be neglected. The algorithms in [4] are executed by Mohamed FEZARI and others for analyzing heartbeat rate signals in the real-time, how to combine information of diverse sensors such as blood pressure, and temperature, and to transmit the data.

The system in figure (1) has permitted specialists to get the heartbeat rate record of the patient by mail every twenty-four hours. Different actions are applied to persons to test the proposed system presented by Naman Jain, Priya. G and Ramya. [1], they have offered the design of inexpensive heart rate observing device from fingertips based on the Bluetooth innovation. The Heart Rate (HR) module picks up the heart rate signal by a non-invasive method (Photoplethysmography) from the patients and sends the signal wirelessly to android application or computer utilizing Bluetooth module. The author result which they have obtained to offered in two tables (table 3 and table 4) which are got from five-person that they have shared in their test. The persons have from different ages between twenty to thirty years old and they have in perfect health case and they have under stress actions (like walking). The results from the prototype instrument then compared with the ECG rates. It shows that it is within the allowable range (such as 2-3 percent). So, it is concluded the instrument work completely and gives a precise heart rate rates. Also, there have some limitations on the Bluetooth module like the maximum domain that it can operate inside a radius of 15-20 meter.

M.K. Srivastava and others [9], they used in their described system a belt that the patient wearing it around its chest. The heart rate gathered by the sensor was sent wirelessly to the receiver, they used RF transmitter/receiver pair for transmitted and received in their system. They developed an algorithm that was programmed inside that microcontroller to work the counting system for heart rate. Their result that obtained utilizing these developed devices when compared to the result that obtained from the manual test inclusive the count of heart rate was found satisfying. Their proposed system was available to family, hospital, sports healthcare, community medical treatment, clinic, and other medical objectives. A Bluetooth terminal application was developed by Avvaru Srinivasulu [2]. A small framework for heart attack detection with the usage of wireless communication was presented by Abhiyash Hodge and others [10] their system worked as when there are abnormal values were detected from the sensor then transmitting a message by NRF module to the receiver and alarm the physician. Their result as shown in table (5) illustrate that the graph of the PPG signal and the heart rate that they got it from the sensor were different from person to person and since the ages of the persons are deferent then the threshold value was different too.

The heartbeat observing framework utilizing GSM technology was discussed by s.vinodhini, and et al. [11]. Heartbeat sensor constantly monitored the patient's heartbeat and in case of any anomaly the system. Transmitted the message to the doctor or relatives of the worried person, and for executing these process, the system utilized heartbeat sensor, GSM module and to control all these devices an Arduino was used. The result showed that the heartbeat rate was measured and analyzed for five persons. The rates were got by the system were tabulated and then compared with the standard rate. The health situation record was stocked in the database and sent to the mobile number of the patient utilizing the GSM modem. Table (6) showed this resut.

A flexible system for observing HR with Bluetooth or GSM was presented by Miss. Saumya Sunil Naik, Prof. D. S. Vidhya and other authors in [12]. The framework calculated the heart rate in beats per minute (BPM) with the assist of microcontroller, the measured BPM were shown on a liquid crystal display and transmitted a short message with current BPM value, at any time the heart rate been up or beneath a constant threshold, a buzzer alert connected to the patient module would be making an alarm. It so guaranteed flexibility in real- time remote observing regardless of distance and place. The monitor systems [1, 9, 10, and 7] that their results were taken to compare with standard values or another device to prove the accuracy of them, table (7) shows these values and show a result that these systems had an acceptable range of error values or small values which could be negligent.

2.2: Wireless ECG monitoring systems

The essential portion of the wireless ECG observing system is Wireless body area network (WBAN). The miniaturized components, the smart systems integration, sensor nodes with low power joined to the body for observing physiological actions are permitted by WBAN. Also, the anxieties about the side effect of electrodes on the human body are remedied [13] and with commendations to best electrode placements on the body [14]. In the confession of sleep apnoea, a real-time observing system, lower cost, Med Assist has been advanced [15]. Utilizing the WBSN, power-efficient ECG compression with a lower complexity has been advanced for data acquisition and compression [16]. The real-time observing and registering of ECG signal for the patient has been advanced by utilizing Holter based portable ECG system with two smartphones to cardiovascular diagnosing [17]. To some extent, the precision and power problem has been solved by utilizing power-saving, RFID based USB ECG or wireless devices and lightweight [18] but as yet there are standing threats for the security of data [19]. Various ECG characteristics revelations systems based wavelet transform based mobile phones have developed [20] inclusive a photo-guided ECG signal revelation [21], BSN-based status QRS revelation [22]. Systems which are fully mobile-based are offering development in the processing capacity and technology in the portable medium. A new remote observing system (with multi-parameter) based on the browser/server type has been advanced. This system consists of an internet network, server monitoring center, and personal computer-based multi-parameter monitors on the www, using a general packet radio service, a global positioning system, and multimedia messaging service for transportation the ECG data gained and stocked in Holter monitor by the Internet. Heart Saver was advanced [23] which is a movable medicinal device, to monitor real-time ECG signal and to an automatic detect for different cardiac diseases. This is a system with Android mobile based on application software that transmits a message relative to the patient's location and situation to a doctor. A system with an ECG sensor sticky pad has executed to monitor the ECG continuously using Planar Fashionable Circuit Board technology. It utilizes dry electrodes for minimal excitement of the skin, with wireless power for safety, a low priced sensor chip which is bonded on fabric, and adequate to long-term observing [24]. A system that is used to combine the capability of the diagnosis of ECG signal, the ECG real-time processing, the transportability, and patient remote control [5], the system has demonstrated how to analysis heartbeat signals in real-time by a single-chip microcontroller. In addition, it also gives the doctors permission for getting the heartbeat rate files for the patient in time with every twenty-four hours by email. In addition, the usage of the zero crossing algorithms to count heart rate gives the system an important feature. The desired processing time for creating and storing to the diagnosis byte is 1.25 ms, which is made the system fast enough. The total power

consumption and weight of the hardware that is desired in the measure, diagnose, and store the ECG signals have reduced by implementing the system on a single chip microcontroller. The android application has advanced by Shweta Yadav, Tanvi V. Pulekar and A.N.Cheeran [25] to observe the patient's vital signs and transmit them wirelessly to the doctor. The observing system of the patient is linked with the application via Bluetooth Low Energy. The parameters have obtained, treated and showed on the Android application and then transmit in the real time to the server utilizing forward file transfer protocol and high level of compression. The readings are stored in SQLite database of the phone. Irregular heartbeat or cardiac arrhythmias state that has the concentration of the authors [26], they have proposed a system for observing and caution cardiac arrhythmias, which utilize technology to decrease the required amount of medical manpower. The system has provided for observing services, observed the Electrocardiogram value, plotting electrocardiograph history, and contained an automatic caution system that warned caregivers by a short message and a call when detected an abnormal ECG situation. The final results have showed that this observing and caution system for cardiac arrhythmias has with precisely detected values and transmitted warnings in 18 of the 20 samples that were performed ninety percent of all samples. In all abnormalities situations, that detected by the system, the application has dialed and transmit a short message to the recorded phone number in all situations. Table (8) illustrates wireless /mobile ECG observing systems clearly appears that:

1. The stability of the system is low for smartphones and it is high while executed on PDA or PC.
2. PC or PDA has a cost higher than smartphones which have lower-cost.
3. Also by utilizing smart/mobile phones the Time delay is noticed when compared with the PC.

Table (9) has showed selected systems for monitoring and summaries for their different details for sensors, modules, cost, implementations, and their medical application which is one of the goals of these systems.

3. The reliability of systems and the quality of the signal

Acceptable monitoring systems (systems for heart rate measuring or ECG wearable systems) for the clinical and medical standard, high quality, abnormal status detects in the early time, supported a precise decision, and, current time for the data acquired of the patient are the requirements to be taken into account. Moreover, the observing systems must be easy to use, to wear and to understand. Also, it should be with great acceptability for physician and patient. Divers observing systems have been sophisticated to process quickly [27], little size [28], consuming less energy [29]. divers networks like as PAN, WSN, WBAN, UMTS and to transmit data utilizing GPRS, 4G, CDMA, 3G, GSM, Bluetooth, Zigbee, WiMAX, WiFi, WAN, and LAN are forming

Wearable technology. Also, the survey has mentioned that the wearable observing systems dependent on the connection technology. In addition, problems of the price while utilizing GPRS to data connection have been informed [30], and the problems of covering area while utilizing Bluetooth technology according to its short extent [31]. So one of the prime obstacles of diffusion e-Health observing systems are the small converge scope were forced the patients within beds fitted, smart textiles, smart rooms with devices for the observing [30].

4. Privacies and Securities

The most serious and important factors for the patient's data are security and privacy. In the wireless sensor networks, Al Ameen et al. [32] have tried to process this problem. a depth looking on WBAN healthcare implementations have executed by Jovanov and Milenkovic [33]. The transportation of the vital signs by utilizing WBAN has discussed by and Chen and Pompili [34]. The emphasis is that importance of the user's priorities and the need for authors for the concentration must to include the user's priorities while the design of the wearable sensor systems. The designing of home-based medical instruments [35] and problems and challenges attached to WBAN by centering on movable-based systems [36] have shed on by Latre et al. a fundamental characteristic for the battery operated devices and wearable for the purpose of observing it is Low power consuming. So, the workable challenge in the design of the observing devices is to minimize consumption of power to extend battery lifetime. The energy is consumed for the processing of data and the transporting, the transportation of data to the unit processing constant computer demand more power than the data processing. For example, a movable ECG monitor needs 35 mA/h to data transport, signal analysis, and process with more than 50 % of the power consuming only to transport. Furthermore, current-time data transportation and high-quality demand in a combination with numerous devices (laptop, tablet, and PC) [37]. Long-range working for such devices and systems can be considered as a dangerous bluster for the battery lifetime and dangerously transportation of fundamental data [38].

5. Conclusion

we conclude from this survey that the monitoring systems have reviewed in this paper show the necessary needed for this monitoring for patients people to monitor their vital signs to make a decision by the doctors about their health to give them help to the illness people may be saving their life, according to receive an alert in the fit time. Also, the authors of these systems have aimed to perform designs and implementations of the systems with low cost, robust, effective, easy to deal with, and suitable for their situation and place. The used of wireless technology gives these systems more flexible, this flexible represented by the used of different wireless technologies such as Bluetooth [2],[47], GSM [11], Zigbee [4], and others based on the need of the distances in communications of the data. On the other hand, some

of these technologies in some times conceders having a disadvantage because of their short range [Bluetooth], or because its high cost as GPRS [30].

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Figures and Tables

Table (1): Heart Rate (HR) values [3].

Ages	Heart Rate
adult	72 BPM
Babies	120 BPM
Older children	90 BPM

Table(2): HR comparion with ECG [7]

Electrocardiogram (bpm)	HRM device (bpm)	Error Rate (%)
76	78	2.56
78	78	0
76	72	5.56
82	84	2.38
83	84	1.19
85	90	5.56
77	84	8.33
79	84	5.95
89	96	7.29
88	90	2.22

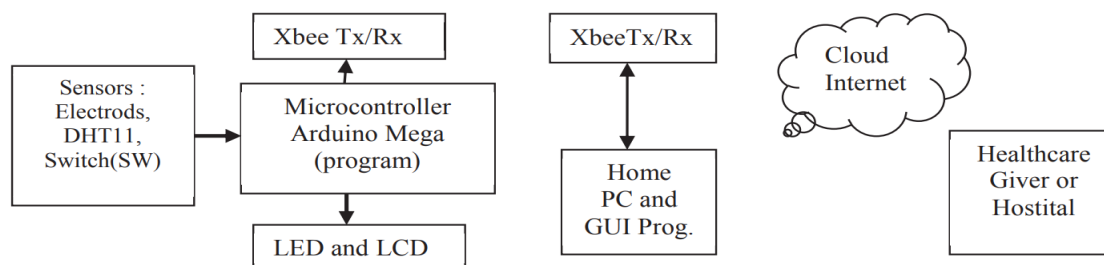


Figure1 : The monitoring system block diagram [4].

Table (3) : sitting persons [1].

	Heart rate obtained from prototype	Heart rate obtained from ECG
Subject 1	68	69
Subject 2	75	75
Subject 3	71	73
Subject 4	81	79
Subject 5	72	72

Table (4) : walking persons [1].

	Heart rate obtained from prototype	Heart rate obtained from ECG
Subject 1	72	74
Subject 2	78	73
Subject 3	76	77
Subject 4	83	85
Subject 5	72	70

Table (5): heart rate results [10].

Sr. no	Avg. Age (in yrs.)	Average max. heartrate	Target HR Zone(BPM)
1	20	200	120-180
2	30	190	114-171
3	40	180	108-162
4	50	170	102-153
5	60	160	96-144
6	70	150	90-135

Table (6): Heart Rate results [11].

S.No	Person's Age (Years)	Heart Rate (Beats/min)
1	21	70
2	22	71
3	20	67
4	23	71
5	22	69

Table (7): Error Rates for monitoring systems.

Author	Original System	Compare with	Result of Error rate
Naman Jain et al [1].	HR Prototype	ECG	2-3 percent
Imtiaz Khan and others [8].	HR Monitor	OMRON	Little different which is can be negligent
M.K. Srivastav et al [9].	HR Monitor	Manual test	Satisfying.
M.M.A. Hashem, Rushdi Shams and et al [7].	HR Monitor	ECG	Small error rate for the device which is negligible

Table (8): chosen ECG wireless/mobile-based system.

Author or Title	HW/SW	Modules Medical	Application	Implementation	Cost
Bansal et al. [40]	Matlab	PC/wireless	Digital processing and monitoring	Real-time	High
Dong-Her et al. [42]	RFID	Mobile	Elderly Monitoring	Home/Trail	Low
Hsieh et al. [41]	XML	Mobile	ECG and image	Hospital/trial	Low
J.S.Prasath[46]	Microcontroller/Matlab	wireless	ECG monitoring	Remote monitor / in hospital	Low
Mohamed Fezari and el.a[5]	Microcontroller	Wireless	diagnosis of the ECG signal	Real time	Low
Dilmaghani et al. [39]	SimpliciTI	Remote	Chronic Diseases	Home/Protocol	High
Vitarak Techatraiphum[26]	Arduino/Pan-Tompkins algorithm	e-Health Sensor/Wireless	Monitor Cardiac Arrhythmias	home/patient phone	Low
Shweta Yadav and others[25]	Microcontroller	Palm Patient Monitor(portable)	Monitor vital signs include ECG	Remote monitor/ home	Low
Med Assist [15]	SVM	Smartphone	Sleep apnoea	Simulation	Low
Tan et al. [43]	Linux based	Portable	Signal measurement	Simulation	High
Oresko et al. [16]	Lab View/Matlab	Real-time	Cardio vascular disease	Simulation	High
Heart Saver [23]	Microcontroller	Mobile	Cardiac diagnosis	Simulation	Low
MEDIC [44]	WSN	PDA	Individual care	Home/RT	High
V. Chan, P. Ray and N. Parameswaran[30]	Symbion operating system/ J2ME/ J2EE	e-Health sensors/Smartphone	Mobile heart monitoring	Real time	High

XML extensible markup language, PDA personal digital assistant , WSN wireless sensor network, SVM support vector model, RFID radio frequency identification, RT real-time, J2ME Java 2 Micro Edition and J2EE Java 2 Enterprise Edition.

Table (9): Selected systems of heart rate and wearable systems.

Author	Platform	Sensor/ size	Modules	Medical application	Implementation	Cost
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Mohamed fezari [5]	Electrodes	Sensor nodes	Wearable sensors	The diagnosis capability of the ECG signal	Real time	Low
Jubadi and Sahak[45]	Sensor	Fingertip device	Monitoring/wireless	Heart rate monitor	Remote monitoring	Low
Hashem and the other[7]	Optical sensor	Fingertip device	Measuring	Measure the heart rate and comparing with ECG	Real time measuring	Low
Imtiaz Khan[8]	Optical sensor	Fingertip device	Monitoring /wireless	Measure Heart rate	Real time monitor	Low
J.S. Prasath [46]	Electrodes	Sensor node	Wearable sensor/wireless monitoring	Monitor the ECG heart rate monitoring	Remote monitor/ in hospital	Low
FEZARI and others [4]	Sensors/ Electrodes	Sensor nodes	Wearable sensor/wireless monitoring	Monitor the ECG in home	Remote monitor/ to Healthcare Giver or Hospital	Low
Naman Jain[1]	Optical sensor	Fingertip device	Wireless Monitoring	Heart rate monitor	Proto type, communicate the PC/smart phone	Low
M.K. Srivastava[9]	Electrode	belt wear around the chest	Wearable sensor for wireless monitoring	Heart rate monitor	Proto type for family, hospital, sports healthcare, community medical treatment, clinic, and other medical objectives	Low
Bandana Mallick[3]	Sensor	Fingertip device	Monitoring	Monitor heart rate and alarm	Real time monitor	Cost effective
Avvaru Srinivasulu [2]	Pulse sensor	Fingertip device	Measuring and monitoring	Heart rate monitor	Remote monitor to personal phone	Cost effective
Shweta Yadav and others [25]	Sensor	Palm Patient Monitor	Wireless monitoring	Monitor vital signs	Remote monitor/ home	Cost effective
Vitarak Techatraiphum and at el.[26]	Sensor/ electrodes	e-Health Sensor Platform Complete Kit	Wearable sensor for wireless monitoring	Monitor Cardiac Arrhythmias	Remote monitor / patient phone	Cost effective
Abhiyash Hodge and others [10]	Sensor	Pulse sensor/Herat beat sensor	Monitoring	Heart rate monitoring and alert (vigilant) system	identify real time heart condition of many patients at a time to doctor's cabin	Cost effective
S .VINODHINI and others [11]	Sensor	pulse oximeter	Wireless Monitoring	Heart rate monitoring	hospitals and in patient's remote location	Low
Miss. Saumya Sunil Naik and at el.[12]	Sensor	Pulse Sensor	Wireless Monitoring	Monitoring and Alerting System	Real time monitor for patient phone	Low
[V. Chan, P.	Sensor	e-Health	Wireless	Mobile heart	Real time	High

Ray and N. Parameswaran [30]		sensors	Monitoring	monitoring system	monitor	
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