Nat. Volatiles & Essent. Oils, 2021; 8(6): 871-878

Cardiac Signal Acquisition And Processing On Android Smart Phones

[1]Dr. Krishna Kumar N.J , [2]Mrs. Sunitha. K , [3]G. Sridevi , [4]Mr Bhaskar Belavadi , [5]Mrs. Ananthi. P

[1]Professor, Department of Electronics and Communication, Gopalan College of Engineering and Management.

[2]Assistant Professor, Department of Electronics and Communication, Gopalan College of Engineering and Management.

[3]Assistant professor, Department of Mechanical Engineering, Centurion University of Technology and Management, Odisha

[4]Assistant Professor, Department of Electronics and Communication, SJBIT, Bengaluru, Karnataka

[5]Assistant Professor, Dept. of Artificial Intelligence and Data Science, Rathinam Technical Campus, Coimbatore

Abstract:

Several projects based on Smart-phone systems have been presented in various industries and many more application possibilities are being studied. A major issue remaining unanswered is the potential of obtaining external information, such as data from other Sensors. Sensor interface is thus achievable provided a proper front-end able to digitize Sensor data and to manage the connection with the Smartphone is adopted. In order to lessen the complexity and the cost of the front-end as well as to reduce its power consumption, an efficient approach for the collection of external sensor data using the Smartphone audio input is suggested in this work. A sensor system comprised of a photoplethysmographic sensor for Cardiac signal monitoring and a pair of electrodes for tissue impedance assessment has been employed. Specific software routines for Android operating system have been written to analyze the obtained Sensor signals giving Visualization, Data storage and basic Data analysis, and so showing the practicality of the suggested technique.

Key Words: Cardiac signal, ECG, Microcontroller, Sensor, Smartphone, Android.

1. INTRODUCTION

Cardiac illnesses are one of the biggest causes of mortality in the globe. Therefore early detection of heart illness before advancement to a severe state is critical. Long term assessment of vital indicators such as heart rate is the most popular approach to monitor the cardiovascular function. Tracking the heart rate (HR) is a strong approach that may be used to identify various cardiac problems such as arrhythmia[1,2]. Numerous non-invasive monitoring/diagnostic approaches have been developed for HR monitoring including cardiac imaging (echocardiography, magnetic resonance imaging (MRI), Electrocardiography (ECG), Ballistocardiography (BCG) and Seismocardiography (SCG) (SCG). These medical approaches may be utilized for diagnosis of heart problems.

The heart is a muscular organ which rests inside a fluid-filled chamber called the pericardial cavity. The wall of pericardial cavity is coated by special membrane known as the pericardium[3,4]. The pericardium has various tasks include keeping the heart confined in the chest cavity, preventing the heart from overexpanding when blood volume rises and retaining heart in place by controlling its movements. The heart is placed in thorax between two lungs. As illustrated in Figure.1. it contains four chambers and four valves including: • Two ventricles • Atrioventricular valves: Tricuspid valve (right side), Mitral valve (left side) • Semilunar valves: Pulmonic valve (right side), Aortic valve (left side) (left side)

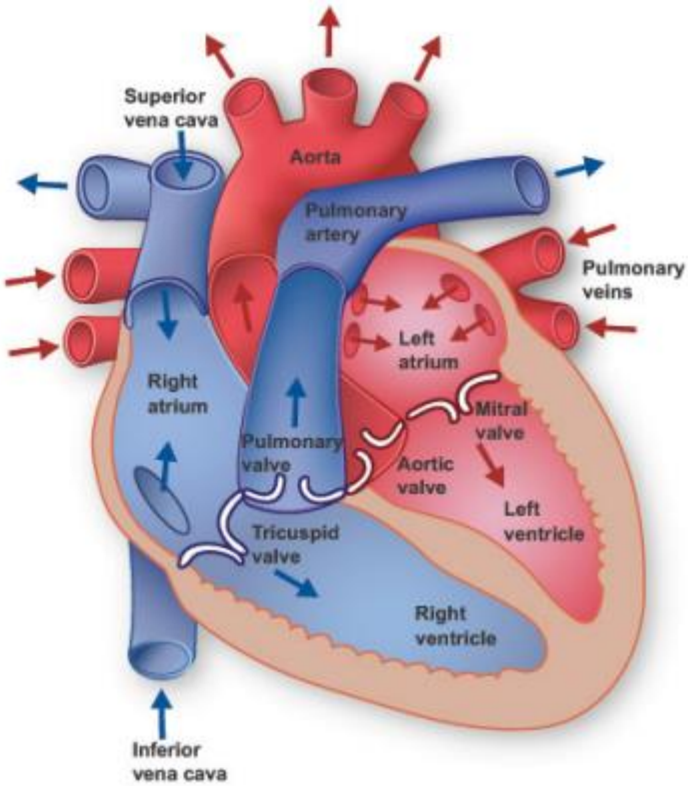

Figure.1. Diagram depicts the heart's internal structure, showing its chambers, valves, vessels, and arteries. Red and blue components show oxygenated and deoxygenated blood routes, respectively[5].

While the right side of the heart gets de-oxygenated blood from the body, the left side receives oxygenated blood from the lungs and returns it to the heart. A series of valves must be closed before blood may flow out of each chamber. Valves are leaflets that serve as one-way inlets and one-way exits for blood entering and exiting a ventricle, respectively. Blood cannot flow backward unless there are valves in place[6]. The heart's conduction system, which explains the heart's role as a pumping organ, will be discussed in the following sections. Doctors may be called in by a patient who is suffering a cardiac irregularity and is concerned[7,8]. The doctor typically measures the patient's vital signs, such as heartbeat, ECG, and blood pressure, and may send them to a specialist for further examination. It might take weeks or perhaps longer to get the results you're looking for. As a consequence of the test findings, it may be necessary to do further tests, such as wearing a Holter monitor for a whole day or longer. Following a standard diagnostic procedure, patient convenience and the time it takes to prepare the results are two possible problems. This is why several techniques and technologies for monitoring vital signs have been created that are wearable, portable and geared for long-term monitoring as well as providing real time analysis of the signals acquired. Because the patient is at home and wearing a vital signs monitor, the findings may be analysed in real time.

2. PROPOSED SYSTEM

Software applications for a wide range of functions are now widely available because of the widespread use of smartphones and tablets. Many areas of daily life can no longer be done without mobile phones. The scientific community has lately been interested in the availability of powerful computing units, embedded sensors, and several standard communication interfaces. Smart phone systems have been used in a wide range of sectors, and new applications are being developed all the time. The ability to acquire external information, such as data from other sensors, is still an open question. Due to their nature as consumer gadgets, Smart phones include USB and Bluetooth ports[9]. With the right front-end for digitising sensor data and communicating with smartphones, a sensor interface is feasible. To decrease the cost and complexity of the front-end, an efficient approach for acquiring external sensor data using the audio input of a Smart phone is suggested in this study. Smart phones will be used to monitor the health of patients under the planned system. The heart rate of the patient is monitored using a Heart Beat Sensor. The patient's breathing is monitored by use of a Respiratory Sensor. A Pulse Sensor is used to monitor a patient's heartbeat. Oxygen saturation in patients is tracked by a pulse-oxy sensor. Smart phones will be used to keep tabs on every aspect of the patient's health. Caregiver will be alerted about any changes in health through Bluetooth.

In-system programmable Flash memory of 8K bytes makes the AT89S52 a high-performance 8-bit microcontroller with low power consumption. Incorporates Atmel's high-density nonvolatile memory technology and is 80C51 instruction set and pin out compatible. With the on-chip Flash, a nonvolatile memory programmer or the system itself may rewrite the programme memory. On a single monolithic chip, the Atmel AT89S52 microcontroller combines an 8-bit CPU with in-system programmable Flash, allowing it to be used in a variety of embedded control applications[10]. Two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial interface, an on-chip oscillator and clock circuitry are all standard features of the AT89S52. At the same time, the AT89S52 has a static logic architecture that allows it to operate down to zero frequencies and has two software-selectable power saving modes. When in Idle Mode, all of the peripherals such as the serial port, timer/counter, and RAM continue to work.

In order to exchange data over small distances between fixed and mobile devices, Bluetooth has developed a proprietary open Wireless Technology standard that allows PANs (personal area networks) with high degrees of security to be created. It has the ability to connect to several devices and so eliminate synchronisation issues. There is a limit of seven devices that a master Bluetooth device may interact with at once in a PICONET, however not all devices achieve this number. By mutual consent, the slave may become the Master and the Master can become the slave. Tracking and identifying the position of items in real-time is accomplished by attaching or embedding Nodes/tags to or embedded in the monitored objects, and utilising Readers that receive and interpret the wireless signals from these tags to establish their locations.

Electrocardiograms (ECGs) employ the skin's electrical activity to detect and magnify heartbeat-induced depolarization of the heart muscle. A charge is present across the cell membrane of each cardiac muscle cell while it is at rest. De-polarization, the process of lowering the electrical charge to zero, activates the cell's contractile machinery[11,12]. An ordered wave of depolarization propagates across the ventricles, the atrium, and the intrinsic conduction pathways of a healthy heart with each pulse. This wave is produced by cells located in the sinoatrial node. The voltage between two electrodes implanted on each side of the heart is shown as a wavy line either on a screen or on paper as little rises and falls. This display shows the overall beat of the heart, as well as the weakening in various sections of the heart muscle. Health care delivery at home and self-care will be transformed by advances in biomedical equipment, bioengineering, and information and communication technology (ICT). Patients' health has been greatly improved because to the recent installation of a wireless body sensor network.

Pulse Oximeters evaluate Pulsatile blood's ability to absorb red and infrared light. They are a low-cost, continuous, and transportable solution. At the red light wavelength of 660nm, oxygenated blood absorbs light; at the 940nm wavelength, deoxygenated blood absorbs it (infra-red). Using two light emitting diodes, at 600nm and 940nm, Pulse Oximeters quantify the quantity of red and infra-red light emitted by tissues passed by the light beams. Oxyhemoglobin (HbO) and Deoxyhemoglobin (HbD) absorb light differently, and the gadget processes this information to calculate an oxygen saturation level. Patients' Oxyhemoglobin levels may be monitored at any given time. An oximeter is able to provide information on pulse rate, oxygen saturation, and cardiac output. However, they are far from ideal displays.

When it comes to gases and liquids, a Pressure Sensor is used to gauge the pressure. Force per unit area is often used to indicate pressure, which is the amount of force needed to keep a fluid from expanding. In most cases, a pressure sensor is a transducer that creates a signal in response to applied pressure. Classifying pressure sensors by their measurement ranges, operating temperatures, and most crucially their kind of pressure is a simple matter.

A set of smartphone-based ECG-based devices, while the second group uses PPG to evaluate cardiac parameters and diagnose anomalies in the heart. There are three subgroups within the first one. Using a smartphone to analyse an ECG, Visualization systems are being recorded. Data logging and analysis of ECG and PPG data on a server, smartphone, and tablet computer. The first class of ECG based systems includes those early and recent devices that use built-in sensors in a smartphone or other wearable sensors to capture ECG signals.

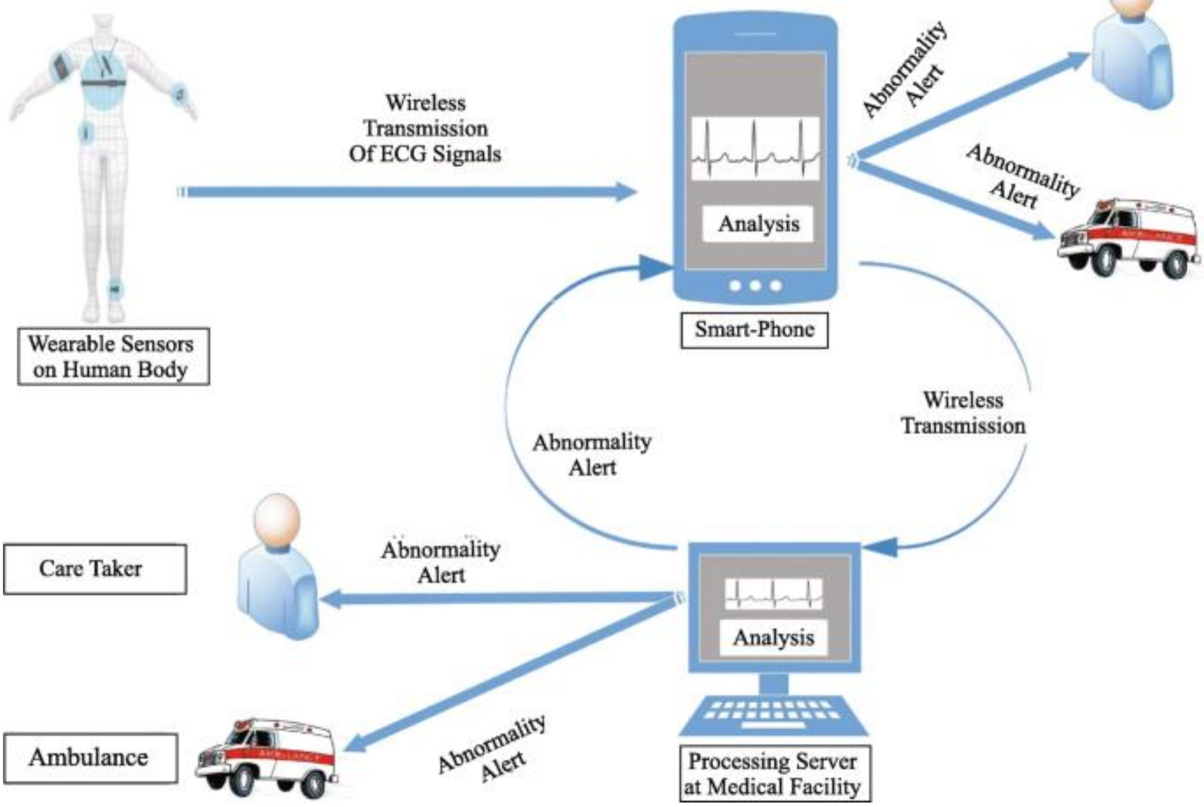

Figure.2. Representation of smart phone based cardiac monitoring systems

Infrared, Bluetooth, or other radio communication mechanisms are used to send data to the smartphone after the recording. PDAs and smartphones are used to display these digital ECG signals for further investigation. The patient may observe the signals and then transmit them to a medical professional/cardiologist for further examination. " Unfortunately, anomaly detection is still a manual process, which is a key shortcoming of these systems. Those with heart trouble can't bear the procedure's long wait period. As a result, researchers have created systems that fit into the second class[13,14]. Client-server architecture is used to build these systems, with the smartphone serving as the client. Using Wi-Fi, GSM, 3G, or 4G, it collects data from sensors and sends it to a central server. These servers are equipped with ECG analysis algorithms that identify abnormalities and send back a report/alert to the patient and their physicians. These technologies automate the analysis, but there is no real-time feedback when abnormalities are detected. Network and server performance at their highest levels, as well as heavy traffic on the transmission medium, are constantly required in order for the system to function. All of these issues are addressed in the last and third subcategory, which utilises a smartphone to collect, analyse, identify, and generate alerts for ECG data. Using this sort of technology, the patient, caregiver, and doctor are alerted in real-time to any irregularities that may be present. Figure 2 depicts these systems in broad strokes.

3. ELECTROCARDIOGRAM (ECG)

In electrocardiography, electrodes are used to record and measure the electrical activity of the heart for a predetermined length of time. ECG stands for electrocardiogram, which is a graph depicting the voltages and times at which they were recorded (ECG). During each pulse, an ECG shows the pattern of depolarization and repolarization of the heart muscles. Willem Einthoven performed the first ECG test in 1901 while working in the Netherlands. Traditional ECG devices use leads with Negative and Positive poles, which are used to perform the test. The heart's electrical activity is measured by these leads, which are linked to the patient's skin. ECG is now the most extensively used, cost-effective, and accurate diagnostic without any adverse effects today. ' Figure 3 shows an example of a typical ECG waveform. A typical ECG waveform has five points called P, Q, R, S, and T, each of which represents one cardiac cycle. P and T waves, which depict ventricular repolarization, are atrial depolarization[15]. Ventricular depolarization is represented by the QRS complex, a grouping of three points Q, R, and S. The QRS complex of the ECG waveform is the most essential and informative component. The peak of the R wave is utilised to measure heart rate by the R-R interval, and it is employed as a reference point for the detection of other points. Next, we'll take a look at the work that's been done to automate the whole process of ECG analysis.

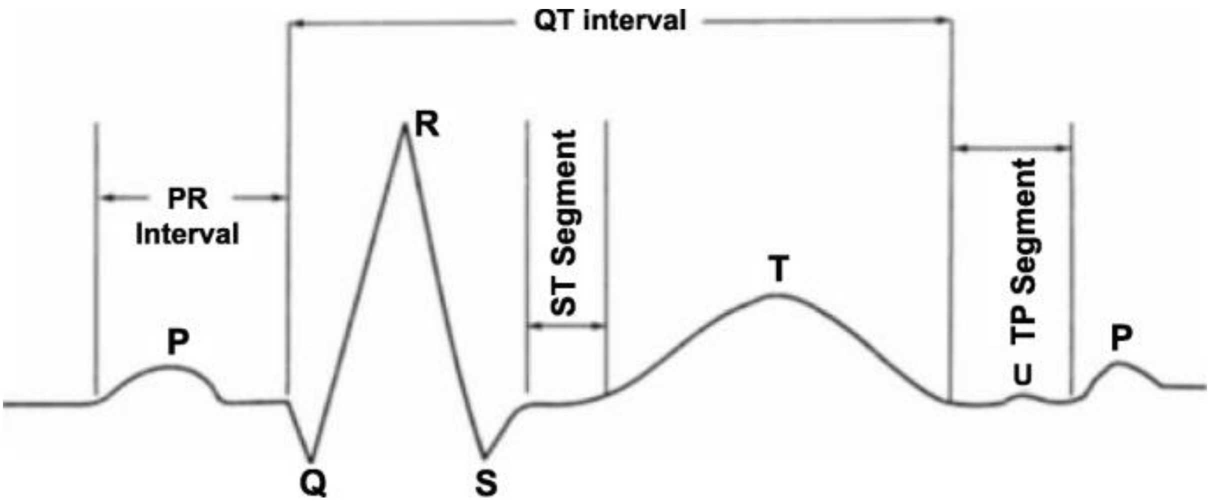

Figure.3. Typical ECG waveform of cardiac cycle

4. SMARTPHONE BASED ECG RECORDING

Circuit board with an ARM microcontroller and Android smartphone app are used to receive, store and show ECG signals on the shirt's screen in the shirt's electronics. Figure.4 shows a general representation of these systems' structure. In the world of telemedicine, all of these smartphone-based solutions are included. Telemedicine is the use of communication technology to provide interactive medical treatment, information, and services to patients at a distance. With the aid of these smartphone-based monitoring technologies, telemedicine allows continuous monitoring, direct patient-cardiologist contact, improved efficiency, cheaper costs, and more efficient use of time for all parties. In developing nations like India, Pakistan, and Bangladesh, the notion of telemedicine may have a big impact. Remote monitoring may be a great help to individuals in these nations, since healthcare services and hospitals are spread out over large distances. Wearable sensors, Android smartphones, and the Internet (2G/3G) were used in Bangladesh to create an ECG monitoring system. It can transfer ECG signals to the doctor's computer, where he may evaluate and provide feedback through the Internet. Security, confidentiality, and legal elements of data, network performance, bandwidth consumption, and the quality of telecommunication equipment are key considerations for telemedicine and smartphone-based systems. Using telemedicine, these smartphone-based heart monitoring devices deliver real-time input to patients and doctors. Despite the fact that these technologies have automated the process of real-time cardiac monitoring, they have not automated the identification of abnormalities. An irregularity in the ECG signals must be manually analysed by the cardiologist before any precautions or medications may be prescribed. This detecting mechanism must be automated immediately. When anything goes wrong, the monitoring system should be able to tell right away.

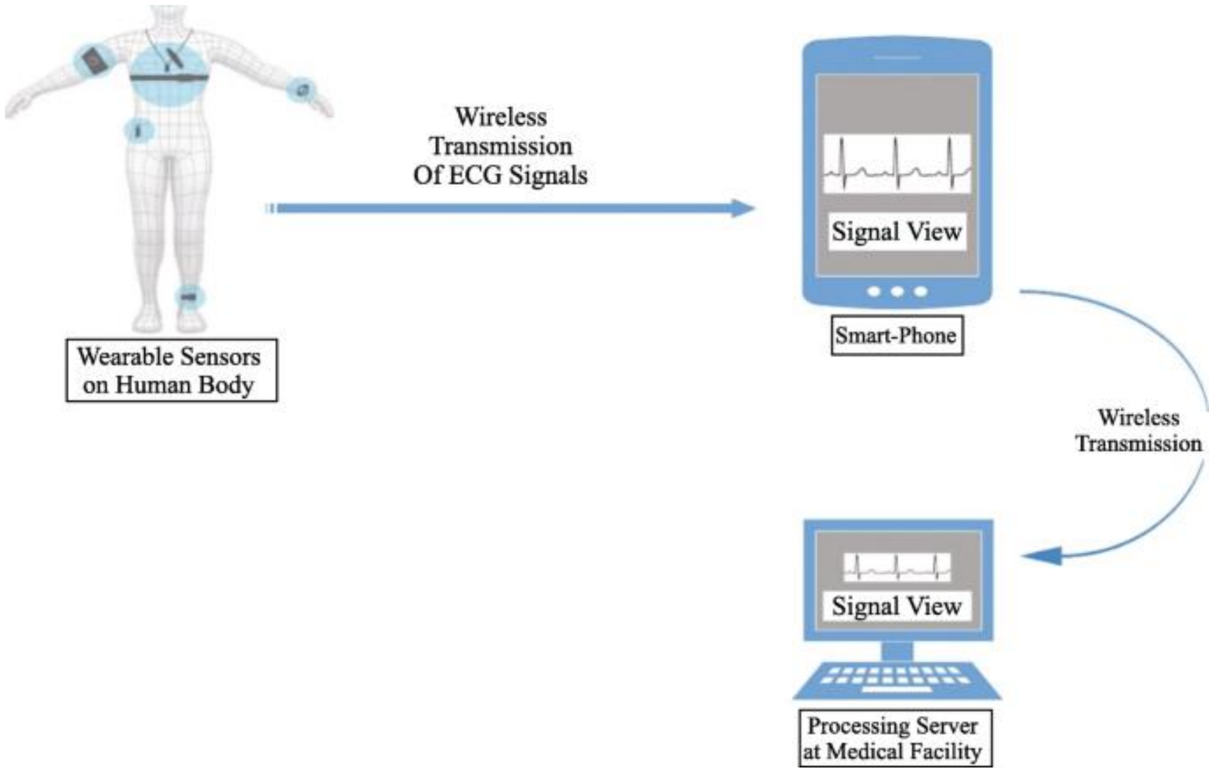

Figure.4. Generic representation of Smartphone based ECG recording

5. CONCLUSION

Cardiovascular monitoring devices are required now more than ever because of the rising incidences of cardiovascular disease. Smartphones have become more important in heart health monitoring due to their improved characteristics, such as their durable sensors, wireless communication technologies, and high-speed processors, as well as their widespread use. This study presents a comprehensive overview of smartphone-based systems for real-time cardiac monitoring and anomaly diagnosis. Wearable sensors and cellphones were used to analyse ECGs for the diagnosis of cardiac abnormalities.

REFERENCES

1. N. N. Malik, “Integration of diagnostic and communication technologies,” Journal of Telemedicine and Telecare, vol. 15, no. 7, pp. 323–326, 2019.
2. J. Sarasohn-Kahn, How Smartphones Are Changing Health Care for Consumers and Providers, California HealthCare Foundation, Oakland, Calif, USA, 2018.
3. Zhang K, Song L, Lu D. Design of remote ecg monitoring system based on gprs. In: Proceedings of 2011 International Conference on Computer Science and Network Technology, vol. 1. Piscataway: IEEE; 2017. p. 319–22.

4. Goh K, Lavanya J, Tan E, Soh C, Kim Y. A pda-based ecg beat detector for home cardiac care. In: 2005 IEEE Engineering in Medicine and Biology 27th Annual Conference. Piscataway: IEEE; 2016. p. 375–8.
5. Chen X, Ho CT, Lim ET, Kyaw T. Cellular phone based online ecg processing for ambulatory and continuous detection. In: 2017 Computers In cardiology. Piscataway: IEEE; 2007. p. 653–6.
6. Gao H, Duan X, Guo X, Huang A, Jiao B. Design and tests of a smartphones-based multi-lead ecg monitoring system. In: 2019 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC). Piscataway: IEEE; 2019. p. 2267–70.
7. S. Agarwal and C. T. Lau, “Remote health monitoring using mobile phones and Web services,” Telemedicine Journal and E-Health, vol. 16, no. 5, pp. 603–607, 2019.
8. G. Pare, M. Jaana, and C. Sicotte, “Systematic review of home telemonitoring for chronic diseases: the evidence base,” Journal of the American Medical Informatics Association, vol. 14, no. 3, pp. 269–277, 2017
9. H. Zheng, C. Nugent, P. McCullagh et al., “Smart self management: assistive technology to support people with chronic disease,” Journal of Telemedicine and Telecare, vol. 16, no. 4, pp. 224–227, 2019.
10. W. Verkruysse, L. O. Svaasand, and J. S. Nelson, “Remote plethysmographic imaging using ambient light,” Optics Express, vol. 16, no. 26, pp. 21434–21445, 2018.
11. Kai L, Zhang X, Wang Y, Suibiao H, Ning G, Wangyong P, Bin L, Chen H. A system of portable ecg monitoring based on bluetooth mobile phone. In: 2018 IEEE International Symposium on IT in Medicine and Education, vol. 2. Piscataway: IEEE; 2018. p. 309–12.
12. Zou Y, Guo Z. A palm pilot based pocket ecg recorder. In: Proceedings 2013IEEE EMBS International Conference on Information Technology Applications in Biomedicine. ITAB-ITIS 2013. Joint Meeting Third IEEE EMBS International Conference on Information Technol. Piscataway: IEEE; 2013. p. 110–2.
13. Secerbegovic A, Mujˇci’c A., Suljanovi’c N, Nurkic M, Tasic J. The research mhealth platform for ecg monitoring. In: Proceedings of the 11th International Conference on Telecommunications. IEEE; 2018. pp. 103–108.
14. Gonzales L, Walker K, Keller K, Beckman D, Goodell H, Wright G, Rhone C, Emery A, Gupta R. Textile sensor system for electrocardiogram monitoring. In: 2019 IEEE Virtual Conference on Applications of Commercial Sensors (VCACS). Piscataway: IEEE; 2019. p. 1–4.
15. Morrison T, Silver J, Otis B. A single-chip encrypted wireless 12-lead ecg smart shirt for continuous health monitoring. In: 2018 symposium on VLSI circuits digest of technical papers. Piscataway: IEEE; 2018. p. 1–2.