

A Study on Heart Rate Monitoring Systems Using IoT

R.Devi ¹, S.Geetha Gowri ², Dr.K.Sethuraman M.A., M.Phil., PhD.³

Department of Computer Science, Parvathy's Arts and Science College, Dindigul, Tamilnadu, India ^{1,2}

Sky (Simplified Kundalini Yoga), World Community Service Centre, Chennai, Tamilnadu, India ³

ABSTRACT: A person's heartbeat is the sound of the valves in his/hers heart contracting or explaining as they force blood from one region to another region. When it comes to your cardiovascular system heart plays an integral role. If you want to keep a better eye on your overall fitness, a Heart Rate Monitor (HRM) should be a serious consideration. We have recommended the absolute best HRM from chest straps to wrist wearables and more. This paper provides a comprehensive of various heartbeat sensors and currently emerging sensor devices of the Internet of Things (IoT).

KEYWORDS: Internet of Things (IoT), Heart rate monitoring (HRM), Micro controller, Network connectivity.

I.INTRODUCTION

IoT stands for Internet of Things, the term IoT was first coined by Kevin Ashton in 1999. It refers to small devices equipped with direct internet connectivity without needing an external computer. They are usually composed of a main controller and additional connectivity (eg. ESP8266 for WiFi, ENC28J60 for Ethernet) or they are complete System Of Care (SOC) including both the processing unit and the connectivity modems in on single package. Regardless of their form or shape. These devices open new applications for remote sensor and controlling and bring system automation to a new level of performance. Smart devices or Connected devices are designed in such a way that they capture and utilize every bit of data which you share or use in everyday life. And these devices will use this data to interact with you on daily basis and complete tasks.

II. LITERATURE SURVEY

Mir Sajjad Hussain Talpur proposed "The Appliance Pervasive of Internet of Things in Health care systems". His work is based on the name IoT, is syntactically composed of two terms, internet and things. As a result it's usually considered that there are two versions of IoT. "Internet Oriented " or "Things Oriented". These versions focus on the technology developed to improve object visibility and few other advanced technologies mainly in healthcare system . Melanie Swan (November 2012) proposed "Sensor Mania! The Internet of Things, Wearable Computing". In this method he explains that despite the excitement and potential transformative power of IoT. There are barriers to the immediate and ubiquitous adoption of IoT products and service for several users.

Gowrishankar .S, PhD,Prachita.M.Y, Aravind Prakash (July 2017), IoT based Heart Attack Detection, Heart Rate and Temperature Monitor. In this Research the authors proposed design realization of real-time monitoring and alarming system for Health Care.Mamidi Manisha, Katakomb Neeraja, Nemuri Sindhura, Paruchuri Ramya proposed IoT on Heart Attack Detection and Heart Rate Monitoring. In this approach we can detect or track the Heart Attacks or Heart diseases and save the lives of many people using this IoT on Heart Attack Detection and Heart Rate Monitoring.

Kunal Dhariwal, Ashish Mehta (April 2017) in his work Architecture and Plan of Smart Hospital Based on IoT, In this approach, IoT will gradually become the main body of the next generation of information of multiple technologies like internet, RFID, sensor network and embedded integrated application.

How Big is IoT?

This new wave of connectivity is going beyond laptops and smart phones, its growing towards connected cars, smart homes, connected wearables, smart cities and connected healthcare. According to Gartner report by 2020 connected devices across all technologies until reach 20.6 billion.

YEAR	NUMBER OF CONNECTED DEVICES
1990	0.3 million
1999	90.0 million
2010	5.0 billion
2013	9.0 billion
2025	1.0 trillion

Source: HP

HP did a small survey in which they estimated the rise of connected devices over the years and the results are surprising.

What is a Modern IoT Healthcare Facility?

Healthcare facilities are continually evolving to better serve the needs of patients, doctors and staff. To meet regulatory complaints for patient's satisfactions operational efficiency and clinical process of care. A modern hospital must laborate small technologies throughout the facility. Hospital administrators ITE (Institute of Technical Education) and facility managers are specifically tasked with the challenge of providing.

- Safe and secured settings.
- Network Connectivity.
- Critical power.
- Improved Communication.
- Healthcare infrastructure interoperability.

Measuring a Heartbeat:

A person's heartbeat can be measured by two ways:

- **Manual way:**Heart beat can be checked manually by checking one's pulses at two locations- wrist (the radial pulse) and the neck (carotid pulse). The procedure is to place the two fingers (index and middle finger) on the wrist (or neck below the windpipe) and count the number of pulses for 30 seconds and then multiplying that number by 2 to get the heart beat rate. However pressure should be applied minimum and also fingers should be moved up and down till the pulse is felt.
- **Using a sensor:** Heart Beat can be measured based on optical power variation as light is scattered or absorbed during its path through the blood as the heart beat changes.

Heartbeat Sensor and Circuits:

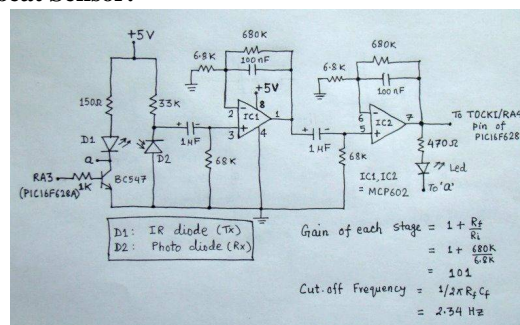
Heartbeat sensor provides a simple way to study the function of the heart which can be measured based on the principle of psycho-physiological signal used as a stimulus for the virtual- reality system. The amount of the blood in the finger changes with respect to time. Heart attack detection using Heart Beat Sensor (Pulse Sensor) works on Photoplethysmography (PPG) technique. The Photoplethysmography is a simple and low-cost optical technique that can be used to detect blood volume changes in the microvascular bed of tissue. This technique often used non-invasively to make measurements at the skin surface (usually a fingertip). It uses an infrared light source to illuminate the finger on one side, and on the other side of the finger a photodetector is placed, this will measure the small variations in the transmitted light intensity.

The light-absorbing property of hemoglobin is used in the measurement of Heart Beat rate. The light from an infrared light source on the underside of the monitor is shone on blood vessels just under the skin. The light that is not absorbed, but reflected back is captured by a photodetector. The variations in the photodetector signal are related to changes in blood volume inside the tissue. The photodetector produces an electrical signal when the reflected back light strikes it. The signal which we obtained from the sensor is an analog signal and it is converted into a digital signal. Furthermore, the signal can be filtered and then amplified to obtain a perfect PPG (PhotoPlethysmoGraph) waveform, which is synchronous with the heart beat.



The sensor shines a light lobe (a small very bright LED) through the ear and measures the light that gets transmitted to the Light Dependent Resistor. The amplified signal gets inverted and filtered, in the Circuit. In order to calculate the heart rate based on the blood flow to the fingertip, a heart-rate sensor is assembled with the help of LM358 OP-AMP for monitoring the heartbeat pulses.

Circuit Diagram of Heartbeat Sensor:



The basic heartbeat sensor consists of a light emitting diode and a detector like a light detecting resistor or a photodiode. The heart beat pulses causes a variation in the flow of blood to different regions of the body. When a tissue is illuminated with the light source, i.e. light emitted by the led, it either reflects (a finger tissue) or transmits the light (earlobe). Some of the light is absorbed by the blood and the transmitted or the reflected light is received by the light detector. The amount of light absorbed depends on the blood volume in that tissue. The detector output is in form of electrical signal and is proportional to the heart beat rate.

The circuit shows ON/OFF control scheme using a transistor for an infrared light source inside the heart beat sensor module HRM-2511E. The signal from the transistor must be pulled high in order to turn on the IR LED. The photodetector output (V_{sensor}) contains a weak and noisy PPG signal that goes to a two-stage filter and an amplifier circuit for further processing.

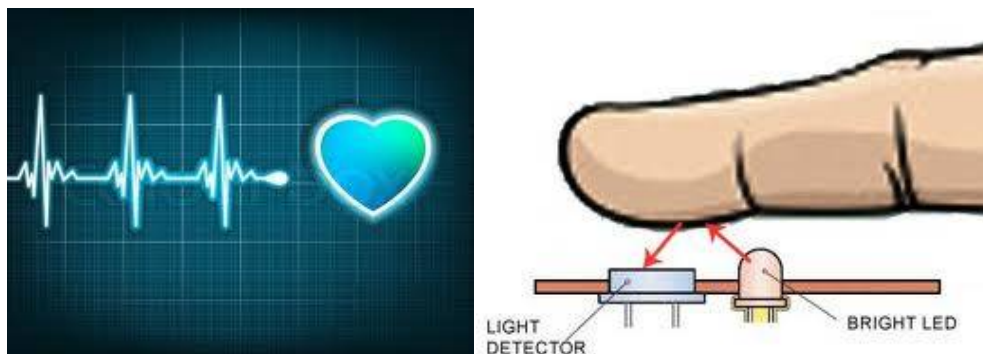
Principle of Heartbeat Sensor:

In order to detect the pulse we will pass light (using an LED) from one side of the finger and measure the intensity of light received on the other side (using an LDR). Whenever the heart pumps blood more light is absorbed by increased blood cells and we will observe a decrease in the intensity of light received on the LDR. As a result the resistance value of the LDR increases. This variation in resistance is converted into voltage variation using a signal conditioning circuit usually an OP-AMP. The signal is amplified enough to be detectable by the microcontroller inputs.

The signal given to the microcontroller input will look somewhat like shown in the image above in a oscilloscope. The microcontroller can be programmed to receive an interrupt for every pulse detected and count the number of interrupts or pulses in a minute. The count value of pulses per minute will give you the Heart rate in BPM (Beats Per Minute).

Alternatively to save time, only the number of pulses for ten seconds are counted and then multiplied by 6 to get pulse count for 60 seconds per minute.

The heartbeat sensor is based on the principle of photo phlethysmography. It measures the change in volume of blood through any organ of the body which causes a change in the light intensity through that organ (a vascular region). In case of applications where heart pulse rate is to be monitored, the timing of the pulses is more important. The flow of blood volume is decided by the rate of heart pulses and since light is absorbed by blood, the signal pulses are equivalent to the heart beat pulses.



There are two types of photophlethysmography:

Transmission: Light emitted from the light emitting device is transmitted through any vascular region of the body like earlobe and received by the detector.

Reflection: Light emitted from the light emitting device is reflected by the regions.

Working of a Heartbeat Sensor

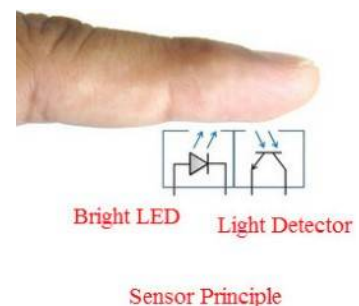
The heart beat sensor circuit diagram comprises a light detector and a bright red LED. The LED needs to be of super bright intensity because maximum light passes and spreads if a finger placed on the LED is detected by the detector.

The basic heartbeat sensor consists of a light emitting diode and a detector like a light detecting resistor or a photodiode. The heart beat pulses causes a variation in the flow of blood to different regions of the body. When a tissue is illuminated with the light source, i.e. light emitted by the led, it either reflects (a finger tissue) or transmits the light (earlobe). Some of the light is absorbed by the blood and the transmitted or the reflected light is received by the light detector. The amount of light absorbed depends on the blood volume in that tissue. The detector output is in form of electrical signal and is proportional to the heart beat rate.

This signal is actually a DC signal relating to the tissues and the blood volume and the AC component synchronous with the heart beat and caused by pulsatile changes in arterial blood volume is superimposed on the DC signal. Thus the major requirement is to isolate that AC component as it is of prime importance.

The output from the detector is first filtered using a 2 stage HP-LP circuit and is then converted to digital pulses using a comparator circuit or using simple ADC. The digital pulses are given to a microcontroller for calculating the heart beat rate, given by the formula-

BPM(Beats per minute) = $60 \times f$, Where f is the pulse frequency.



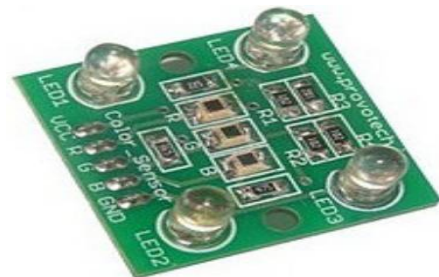
Types of Heartbeat Sensors

✓ Analog Heartbeat sensors:

The Heart Beat Sensor is designed to provide analog output of heart beat when a finger is placed on it. When the Heart detector starts working, the top most LED will starts flashing with every heart beat. The output of this sensor can be connected to Micro Controller directly to measure the heart beat. It functions on the principle of light modulation by blood flow through the nerves of the finger at every pulse. The module output mode, analog output mode is simple

Features:

- Heartbeat Indication by LED.
- Instant output analog signal for directly connecting to micro controller.
- Module output mode, analogue output is simple. Compact size.
- Working voltage +5v DC.
- High quality PCB FR4 Grade with FPT certified.

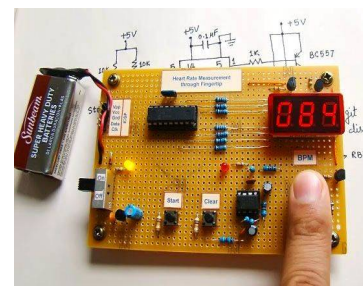


Digital Heartbeat sensors:

The Heart Beat Sensor is designed to provide digital output of heart beat when a finger is placed on it. It functions on the principle of light modulation by blood flow through the nerves of the finger at every pulse. The module output mode, Digital output mode is simple, Serial Output is with exact readings.

Features:

- Heartbeat Indication by LED.
- Instant output digital signal for directly connecting to micro controller.
- Total heartbeat count can be obtained serially (TLL), every
- Module dual output mode, digital output is simple, serial output exact meaning.
- Compact size.
- Working voltage +5v DC.
- High quality PCB FR4 Grade with FPT certified.



minute.
with

Heart rate Monitoring Devices:

Chest Straps:

Heart rate monitoring chest straps are most of them are made of long belt-like elastic band that wraps snugly around your chest, a small electrode pad that sits against your skin, and a snap at the transmitting. These heart-rate monitors works differently than the other ubiquitous wrist-bound monitors or a new wearable because they use electrocardiography to record the electrical activity of your heart.

✓ How it works:

Built-in electrodes record the signals of the heart's electrical connectivity as it pumps blood. All you really need here is what we call the R interval . It's the big, pointy line going upward in an electrocardiogram(ECG). That's the point of contraction of the left ventricle. If you've put the device on properly, it's going to get a very good estimation for your heart rate.



✓ **Pros:**

The chest strap has been around the longest (nearly four decades) and is the best studied of all the devices, making it the gold standard. It is the most common, reliable, durable, and affordable of the bunch. This is the number one option for people who are seriously training.

✓ **Cons:**

Placement is everything. The positioning should be just below the nipple line. That makes it difficult for obese people (BMI over 30) and women. The lower you put it, the farther away you get from the heart, the higher the chances the signal is going to be poorer.

Wrist -worn:

Wearable computing as a category is being defined by smartwatches and wristband sensors. The heart rate monitor is based on a difficult to pronounce technology called photoplethysmography, but it basically comes down to using green LED lights paired with light-sensitive photodiodes to illuminate your skin and measures changes in light absorption. This lets the device detect the amount of blood flowing through your wrist at any given moment. Because blood is red, it reflects red light and absorbs green light. "When your heart beats, the blood flow in your wrist — and the green light absorption — is greater. Between beats, it's less".

✓ **How it works:**

Wrist-worn straps use light—typically green LED lights and light-sensitive diodes to measure HR in a process known as photoplethysmography (PPG) when your heart beats, the blood flow in your wrist and the light absorption are greater than between beats. By flickering the light hundreds of times per second. Wrist straps can be determined how frequently your heart is beating. When the light reflects off the blood, it is captured by a sensor and gets processed by an algorithm, along with an accelerometer measures movement, to produce the HR, but while green light is decent at picking up HR, scientists are learning more toward red and infrared light for greater accuracy as the wavelengths penetrate the skin better.



✓ **Pros:**

Though it debuted about 10 years ago, technology has only recently improved to make it a viable alternative to the chest strap. All wrist-worn devices that feature both green and infrared PPG, like the Apple Watch and Fitbit Ionic, were accurate within 5 percent. Wrist HR is also a lot less cumbersome than a chest strap making it easier to use every day, whether you're hitting the gym or sitting at your desk.

✓ **Cons:**

Skin color and size matters. The darker the skin, the more difficult it is for the PPG to shine a light through bodily tissues to record HR. It usually ends up with lower numbers because it's missing beats. Also, if you have really small or bony wrists, the band might shift too much, letting in light from the outside world, which will interfere with the PPG. But also resist choking your wrist PPG is calibrated to work on human resting tissue, so when you press down on it, you change the density of that tissue, which ruins the measurement. It should be just tight enough so that it doesn't slide or wiggle when you move.

Earphones

Heart rate sensors are integrated into headphones, which means one less device to have to put on if you're a fan of working out or running to music. The same fantastic in-ear heart rate monitor and applies it to a truly wireless ear bud from factor. This means there isn't even a cable connecting the two ear buds together offering a far more liberating exercise experience allowing you to track your runs using your phone's GPS, augmented with the heart rate monitor data.

✓ **How it works:**

There are three types one that looks and functions like headphones, another that attaches to the earlobe and the another that goes on the top of the ear. Just like in wrist wearables, PPG is used to capture HR. Blood flow is generally less at the ear than at the wrist. So it has to be placed really well and not move very much for it to work.



✓ **Pros:**

As a runner who doesn't like wearing things, we can see the ear device being attractive.

✓ **Cons:**

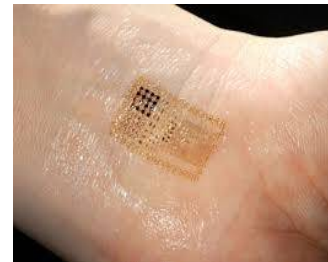
It's so new that none of the products on the market have been validated through non-biased scientific research. Another big concern is motion. Once you start moving, these things get bad really fast. Even this happen with [regular] headphones, they just fall out. Similar to how your music gets a little softer, so does the HR data.

Smart Patch:

The smart patch has been in the works since 2014, and it's taken a lot of development and several prototypes by Patch Therapeutics to get to where it is today as a favourite and successful project, getting ready to go into production in a few months. It's an electrocardiogram, or ECG, sensor, and it's also a three axis accelerometer. These two small, but crucial pieces of technology, patch can track your heart rate variability (HRV), heart beats per minute (BPM), breathing rate and consistency, moods, movement, and downtime. There's also a place in the patch corresponding app to record your thoughts, so you can start to see patterns and make connections between your physical reactions and your emotional ones.

✓ **How it works:**

It is more accurate and more reliable than an ordinary wrist based HRM, the patch itself is totally discreet, you wear it under your clothes, unless someone is feeling your torso intently, no one will ever know you are wearing it. When it senses that you are sensed out or need a mental break, it will vibrate. Then it will vibrate in rhythm to help you focus on your breathing and calm your mind and body. There is no need to look at your phone for what to do, just exhale when the patch gently vibrates. Four different breathing exercises are included with the patch, one to help you better control your heartbeat, one to help you become calmer, one to relax your mental state and one to reinforce all of these techniques



✓ **Pros:**

The patch is super thing, at just over six millimeters. There are no straps on it, it just attaches to the body with stickers, much like a doctor would use with an in-office, ECG test. After using the patch for sometimes people can easily learn how to regulate their breathing and stress level on their own. This patch is just like a fitness tracker can help us reduce our excess weight. This product looks like a real aid to help people live better lives.

✓ **Cons:**

This device is not much comfortable for all day wear, especially on hot days, and especially for men with hair on their chests. It could hurt to take off so is a regular manscaping routine necessary for some men who want to wear a smart patch. The product has minimal usage so far however the upside is that the patch is one of the few smart products on the market that earnestly addresses the issue of the society.

Pros and Cons of Heart Rate Monitoring:

Pros:

- Utilizing a heart rate monitor for any activity gives you definitive data on what effort level it takes you as an individual to accomplish a given task as well as under what circumstances.
- A heart rate monitor is a fantastic tool giving you clear indication and evaluation of the condition of your cardiovascular system during physical activity. Again, awareness is power! This is great information to share when you see your doctor at your yearly physical.
- Using heart rate monitor can be your personal coach. Your heart rate along with your "perceived exertion rate" can tell you if you need to up your intensity, pull back and or tell you that you are in your groove. This helps to hone in on exactly what you want to accomplish and insure the best results for the time that you put in to your fitness plan enhancing workout safety as well.

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization

Volume 7, Special Issue 8, September 2018

International Conference on Emerging Trends in Science, Technology and Mathematics (ICETSTM-2018)"

22nd August 2018

Organized by

Department of Computer Science, Parvathy's Arts and Science College, Dindigul, Tamilnadu, India

- Indicates your heart's ability to "recover" from a given exercise and or interval within a workout once again giving you more info on the condition of your cardiovascular system. Faster recovery rate indicates enhanced cardiovascular capacity.

Cons:

- HRMs have come a long way since their introduction in the early 1980s but inconsistency remains one of the primary disadvantages. HRM users commonly complain about inconsistent readings, which make it difficult to track how hard you're working during an activity. This appears to be a problem across the board, from inexpensive HRMs to pricey ones.
- In order to reap the maximum benefits from exercise, you need to train in a particular zone of your maximal heart rate. Training with a heart-rate monitor helps make sure you do this, thus increasing your exercise benefits and improving your performance. Although many trainers swear by them, there is no hard evidence to show that using an HRM improves performance.
- Adding an HRM to your training regimen is an added expense and without the science to back up its use, it could be money wasted. Further, many people don't adhere to their use long term. The least-expensive HRMs can cost about \$39.99 and typically lack a lot of features. A really good HRM can cost more than \$100. It's best to make sure a heart-rate monitor is right for you before taking the plunge.
- Before purchasing an HRM, try tracking your heart rate on your own. You will likely find that it is easy, convenient and more consistent. During activity, simply press your index, second and third finger into the inside of your wrist and count the beats for 10 seconds, then multiply by six to get the beats per minute. Increase the intensity of the activity and repeat until you are in your target zone. With practice, you will be able to tell by the exercise intensity whether you are training in your target zone or not.

Comparative Analysis

People who want the most precise heart rate measurements should stick with a chest strap. It may be somewhat uncomfortable, but you'll get the best results. Based on the above explanations, optical heart rate monitors will provide a fairly accurate reading, but you have to make sure that the wristband is strapped to your wrist properly. It has to be in the correct location (just below the wrist bone) and fastened securely, there can't be a gap between the sensor and your skin, and the tracker shouldn't be able to slide around on your wrist, headphones will fall often so that it cannot predict accurately. Lastly, you have to ensure that both the optical sensor and your skin are clean and free of perspiration. Although its heart rate monitor was so close in performance to its competitors. It's not only serious athletes who should be concerned with heart rate. Keeping an eye on your heart rate over time is a great thing you can grab onto that says, 'I'm in shape' or 'I'm not.' So no matter the type of monitor you choose, your heart rate is a metric that's worth keeping track of as you work to reach your fitness goals.

III. CONCLUSION

We all know that heart attack can kill your life in three attempts. We can detect so many different diseases by detecting it previously. Based on heart beat we can predict a person is in stress or not. Health care sensors are playing a vital role in hospitality. In this paper we have discussed about the various aspects of heart rate monitoring systems. And truly ubiquitous advantages and disadvantages of HRM. Later headed over with the trending heart rate monitoring devices using IoT along with its pros and cons. These devices are portable and easy to use. It can be used in over daily lives to monitor our anxiety and stress levels which might help in better leaving. Modern Technologies have developed in such a way that from notes comfortable and better life which is disease free.

Prevention is Better than Cure

Acknowledgement

We gratefully acknowledge the support of our department Honourable HOD, Assistant HOD and respected Staff members with their effective guidance and motivation for this project.

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization

Volume 7, Special Issue 8, September 2018

International Conference on Emerging Trends in Science, Technology and Mathematics (ICETSTM-2018)"

22nd August 2018

Organized by

Department of Computer Science, Parvathy's Arts and Science College, Dindigul, Tamilnadu, India

REFERENCES

- [1]. Melanie Swan, Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0, Journal of Sensor and Actuator Networks.
- [2]. Gowrishankar S., PhD, Prachita M. Y, Arvind Prakash, IoT based Heart Attack Detection, Heart Rate and Temperature Monitor, International Journal of Computer Applications (0975 – 8887) Volume 170 – No.5, July 2017 .
- [3]. Kunal Dhariwal, Ashish Mehta, Architecture and Plan of Smart Hospital based on Internet of Think (IoT), International Research Journal of Engineering and Technology (IBJET), vol-04 issue-04, April 2017.
- [4]. Mir Sajjad Hussain Talpur, The Appliance Pervasive of Internet of Things in Healthcare Systems.
- [5]. Mamidi Manisha, Katakam Neeraja, Vemuri Sindhura, IoT on Heart Attack Detection and Heart Rate Monitoring, International Journal of Innovations in Engineering and Technology (IBJET).
- [6]. Sejal Patel, Narendra Singh, Sharmil Pandya, IoT based Smart Hospital for Secure Healthcare System, International Journal on Recent and Innovation Trends in Computing and Communication.