# Human Activity Detection System Using Internet Of Things

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***Abstract*— Internet of Things (IoT) is the fast growing technology that are prevalent in day-to- day life due to their improved use in ubiquity of smart mobile devices such as smartphones, tablets, notebooks, personal digital assistants (PDA), etc. It could be possible to create a digital world by using the main aim of the IoT enabled things (i.e.) "connected anywhere at any time". Now days human or user activity detection is a major challenging task because detection and analyzing the user activity by using the surveillance camera and other external sensor is a tedious, time-consuming task and requires high hardware cost. The present study highlights the development of human activity detection system by using low cost Pyroelectric Infra-red (PIR) sensor and external Bluetooth Low Energy (BLE) with STM32F407VG microcontroller in IoT. The user activity's signals are detected during week wise manner across various time periods by using LabVIEW toolkit installed in the department of CSE admin server which works within the certain BLE range. When compared the performance results between the proposed system and existing system for the average user activity detection, it was observed to be 88.75% and 83%, respectively.**

***Keywords***- Internet of things; Bluetooth Low Energy; Detection; User activity

## I. INTRODUCTION

Internet of Things (IoT) is the fast growing technology, represents the network of physical device/objects that are embedded with electronics, software and sensors which are then connected with different technology to sense and transmit data among things, things to human, human to things and human to human [1]. IoT is prevalent in day-to- day life due to their improved use in ubiquity of smart mobile devices such as smartphones, tablets, notebooks, personal digital assistants (PDA), etc. The main aim of the IoT enabled things are "connected anywhere at any time". Thus use of automatic system for all kinds of IoT enabled product applications has been increased in the markets which help to detect the human activities either in an indoor or outdoor organization [2].

As per Sanoob et al. [3], external fixed surveillance camera and Closed Circuit Television (CCTV) are highly sensitive to detect the location around the city in various places. But detection of user activity using the external sensor is a tedious, time-consuming task and requires high hardware cost. With reference to this context of research, the currently available huge range of challenges has to be focused in depth so as to create a smart world.

In the present work, development of user's activity detection system by using PIR sensor and BLE with STM32F407VG microcontroller in IoT was discussed. This has several advantages like data transfer with low latency and more efficient for any indoor organization, as well as the system can be implanted anywhere else without having any connectivity issues when compared with existing mechanism as discussed in other related works, especially reference [3]. The present research work not only focuses on the condition for users who carry smartphone along with them, but also equal importance has been given for "without smartphone user" because at both these conditions, the user activity was detected by using PIR sensor. The respective different context user activity signals were captured by the proposed system and this signal are detected during week wise manner across various time periods by using LabVIEW toolkit installed in the department of CSE admin server which works within the certain BLE range. The performance result was evaluated by comparing signals across different time periods.

This paper has been organized as follows. Section II is Literature Survey; Section III is Proposed System; Section IV is Test and Analysis; Section V is Conclusion and Future Direction and References. The brief discussions for all the above sections are as follows.

## II. LITERATURE SURVEY

Muhammad et al. [4] used two PIR sensors to achieve real time implication i.e. to monitor human activity along with its direction with the help of simple data processing techniques. While Hung et al. [5] designed a multi-sensor and multi-modal sensor node for monitoring human and vehicle activity. In 2011, Uddin et al. [6]

reported Human Activity Recognition (HAR) using the joint angle from a 3D model of a human body. In this, the body joint angles are estimated directly using time series activity image acquired from the single stereo camera. These activities are then classified by hidden markov model ad then finally the performances were measured. Though this model looks similar to already proposed binary and depth HAR, it produced better on comparison with other conventional methods.

Liu et al. in 2013 [7], reported the human body orientation identification both in static and motion condition measured by dynamic bayesian network, with respect to various parameters like different speeds (slow, moderate and fast) and distances (nearer and far). This are carried out using RGB camera-depth PIR sensor which was mounted on hallway, ceiling and opposite walls. Yun & Lee [8] followed activities that are classified by Bayesian Network, Multi-Layer Perceptron (MLP), Naive Bayes (NB) and Support Vector Machine (SVM) algorithm. Chen et al. [9] used depth and inertial sensors to detect the action of users with the aid of artificial neural networks that were classified by bayesian decision, least-squares and dynamic time warping. In this tree structure, tri-axial gyroscope, tri-axial accelerometer and tri-axial magnetometer were incorporated to generate accelerometers and rotation signals based on the action performed by a human.

In the same year Gaglio et al. [10] recognized human activity along with kinetic information sensed by using Red, Green, Blue plus Depth (RGB-D) camera that are classified by K-means clustering, SVM and hidden Markov models. They also performed four relevant works based on RGB-D image fusion such as hierarchical maximum, entropy markov model, markov random fields and eigen joints. Nef et al. [11] reported a Human Activity Daily Living (ADL) recognition using PIR sensor present in a smart home. A considerable data were obtained only in certain rooms such as the bathroom, TV room and living room which include either ADL (or self-care) related to the physical activities or Instrumental ADL.

Shanthi et al. [12] discussed about building, monitoring and control system by using Wireless Sensor Networks. For example, the utilization of excess energy by electric appliances in case of absence of any person has been detected and it is switched-off by using (Advanced Risc Machines) ARM controller, whereas mbed NXP LPC1768 integrated with the LabVIEW, was used for continuous monitoring the status of various appliances like fan and light with respect to human activity in the indoor environment and are automatically controlled by using PIR Sensor. Saravanakumar et al. [13] designed human detection robots that are automated move in all the direction which is a robot that can detect the presence of a human. It sends the signal from the transmitter to the receiver side and alerts it to the user by a continuous buzz.

Sathishkumar & Rajini [14] detected human movement using the PIR sensors. In this model, the system triggers an alarm to detect the presence of a person in a specific interval of time and simultaneously it transmits the information regarding how many persons are intruder via message to the SMS through Global System for Mobile communication (GSM) Modem. Sanoob et al. [3] designed a system that uses PIR sensor with Arduino board connected with BLE, and detected user activity signal for a week and the average notification detected by the system for each week are observed to be 100, 76, 88 and 68%.

All these existing works briefly discussed above, relates with the concept of the proposed system discussed in this paper. The proposed system has observed to work more efficiently than compared with these existing systems.

## III. PROPOSED SYSTEM

### A. *Detection of Users Activity*

In the proposed system, indoor user's activity can be detected by using PIR sensors, BLE with STM32F407VG microcontroller setup, that are fixed in various places such as main research lab, research annexure lab, third floor CSE lab and third floor staff room with respect to either user's without or with IoT enabled devices (in the different context) in an any organizations.

### B. *System Architecture for Human Activity Detection*

The system architecture for the human activity detection is shown in Figure 1, where the used PIR sensor - senses the user's activity signals within its BLE range and transmits it to the STM32F407VG microcontroller. The BLE which has been connected to microcontroller, then send the user's activity alert to smartphone user/users group and also to the LabVIEW toolkit installed in the department of CSE admin server. As a consequence, in the toolkit, registered BLE-MAC address, name of the smartphone user's and then stored user's activity signals were displayed.

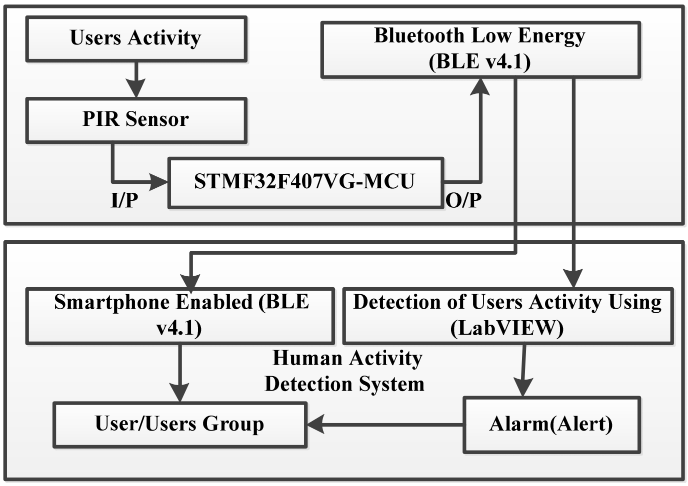


Figure 1. Working model for the designed system

### *C. Software Module for Designed System*

Figure 2 shows the software module processes in the form of flow chart representation. The flow chart starts from the user activity detection by the PIR sensor, if detected; the state will be represented as ‘1’, otherwise ‘0’. In case of ‘1’ state, it transmit the signal to microcontroller via BLE. Then the alert will be further send to LabVIEW toolkit as well as to smartphone user/user group.

In the system, STM32F407VG microcontroller activates the smartphone application component, once it receives the user’s activity signal detection alert from the PIR sensor. The BLE acts as an intermediate to transmit the signal in between the STM32F407VG microcontroller and smartphone users.

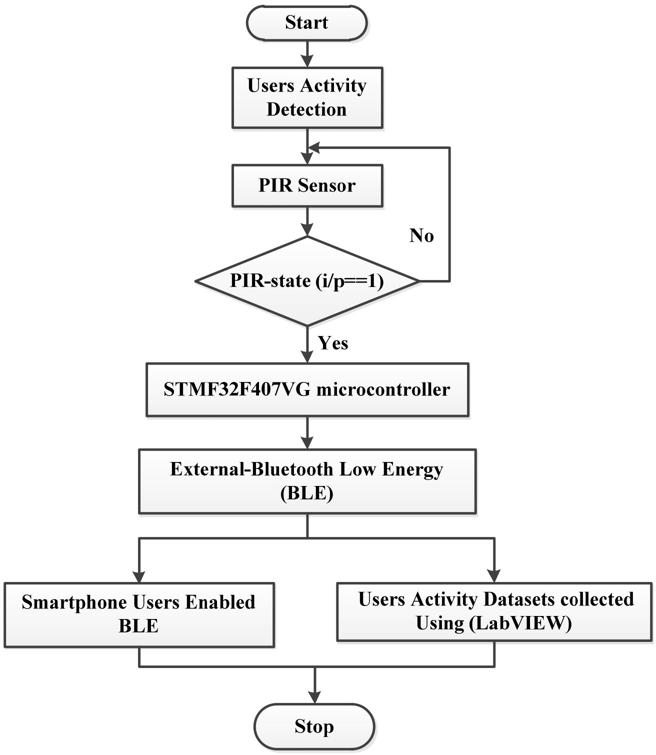


Figure 2. Flow chart for software module

### *D. Hardware Module for Designed System*

#### *1) Working model of PIR sensor*

The hardware module controls the computation system. Figure 3 represents the block diagram of the PIR sensor working model. The sensing element in PIR sensor senses the change in infrared radiation and then it is served to the sensing Integrated Circuits (IC), where the amplification of the signal occurs. While the delay sensitivity control circuit is used to adjust the delay and the sensitivity of the sensor. The sensor output is directly transmitted to the STM32F407VG microcontroller digital input pins. The output of the sensor was observed to be either ‘1’ or ‘0’, where ‘1’ represents the user’s activity detection and ‘0’ represents the idle state, respectively.

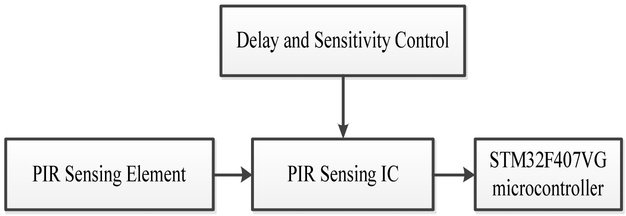


Figure 3. Working module of PIR sensor

*2) Input catching methods by PIR-Sensor*

The user’s activity signals that are obtained from PIR sensor can able to sense the changes in Infra-red radiation within its ranges. For PIR sensor, the input is either the detection of user’s activity or not, which get changed depending upon the situations. A continuously detected user’s activity signal has been sent to the STM32F407VG microcontroller in both the cases. To obtain an exact time slot of the user’s activity, a simple input catching mechanism has been implemented using a catch variable.

When the system detects the user’s activity STM32F407VG microcontroller sent the detected user’s activity signal to the catch variable, which results in the shift of the catch variable from true to false, and the same process comes to an end when catch variable changes from false to true (i.e.) when it comes to an end, the output state of the sensor gets changed from “low to high” and the catch variable has been set to show ‘true’. When the user’s activity is not detected, then the output state will get changed from “high to low” and the catch variable is changed to false now. The slot can be determined depending upon the catch variables (either false to true or true to false) with respect to time.

Figure 4 shows the graphical representation of time slot which has been detected for the various user’s activity by using the catch variable. During starting and at the end of recording, catch variables are used. The smartphone and LabVIEW toolkit receives the signal at one end when the user’s activity has been detected from the STM32F407VG microcontroller and then it stops to record the receiving signals on the other end of the same microcontroller. Simultaneously during recording, the smartphone does all the necessary steps to notify the user/user’s group for getting the exact time slot.

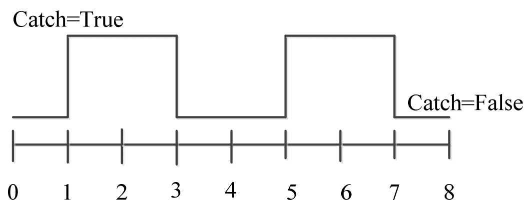


Figure 4. Graphical representation of timeslot using the catch variable

*3) Outline for Overall Hardware Module*

Figure 5 represents the real time system design for the proposed system and Pseudocode, which is incorporated in STM32F407VG microcontroller.

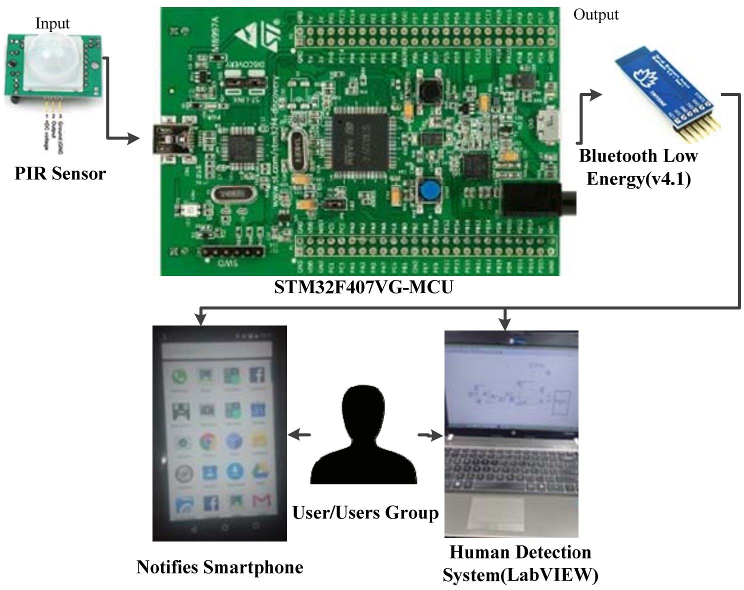


Figure 5. Real-time system design

The PIR sensor is connected to the GPIO (General Purpose Input Output) pin PB-8 and also to an external BLE using Tx pin- PB6 and Rx pin-PB7 of STM32F407VG microcontroller. The BLE then transmit the user's activity signals simultaneously to the nearby smartphone users and to the system installed in the department of computer science and engineering, Anna University, Chennai-25.

*4) Pseudocode for STM32F407VG Microcontroller*

**Input:** Users activity signals;

**Output:** PIR_state==1 or 0;

```
Step 1: Start
Step 2: Initialize the hardware (STM32F407VG microcontroller)
Step 3: Declare the i/p and o/p variables
Step 4: Initialize _UART
/*Configure USART*/
Set Baud_rate 9600;
Set Word_length 8 bits;
Set No_parity_no;
Set Hardware_flowcontrol_none;
Set Tx_Transmit| Rx_Receive enabled;
Step 5: Initialize _GIPO
/*Configure PB8 in i/p mode*/
Set GIPO_PIN_8 for i/p from PIR sensor;
Set USART1_Tx_PB6 |Rx_PB7;
Step 6: Getting i/p from PIR sensor via USART
If (PIR_state_ i/p==1)
{
User's activity detection
}
Else (PIR_state_ i/p ==0)
{
No user's activity detection
}
Step 7: Initialize delay
Step 8: End
```

Figure 6 shows the block diagram for user's activity signals captured by LabVIEW toolkit which is installed in the admin server. The BLE receives the user's activity signals captured by the PIR sensor and is further transmitted to the BLE connected to STM32F407VG microcontroller, which in turn communicates with the external BLE of the server. The back end of the system is as follows: BLE-RFCOMM services discover the channel and Universally Unique Identifier (UUI) connected to BLE open connection and then further to BLE read and write. Finally, in a text file, user's activity detection datasets has been stored in the file path (E:\pir\users activity detected.txt).

Suppose, if the user's activity signal is detected by the PIR sensor, then it sends message to the case structure which will raise an alarm (beep sound), otherwise it can be assumed that PIR sensor did not detect the user's activity signals.

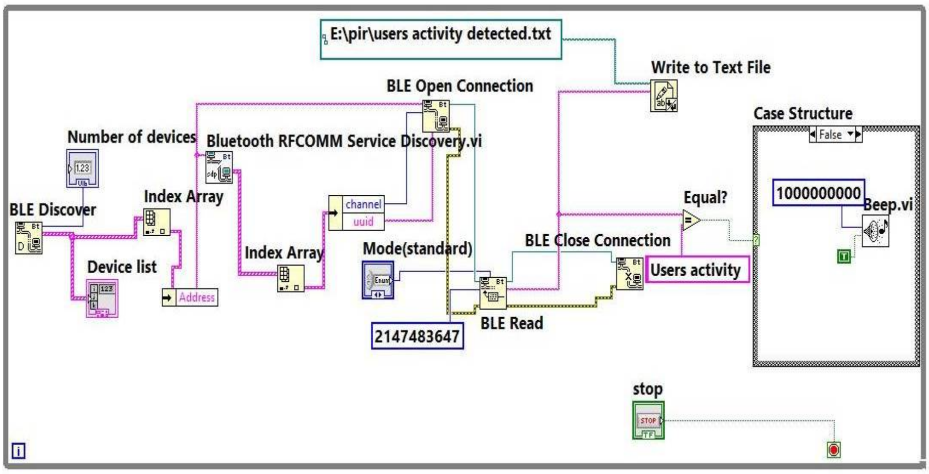


Figure 6. Block diagram for user's activity detection system using LabVIEW

## IV. TEST AND ANALYSIS

### A. *Experimental Setup*

Table 1 show the models and specifications used in the proposed system while the picture of hardware setup used in the proposed system has been represented in Figure 7. This hardware setup works under the combination of both PIR sensor and BLE with STM32F407VG microcontroller in IoT. The proposed system can be placed anywhere in the indoor organization within its BLE range. But for the convenient to carry out the experimental observation: main research lab, research annexure lab, third floor CSE lab and third floor staff room was chosen. Whereas Figure 8 shows the real time experimental setup used for detection of user's activity signals in the department of CSE at Anna University, Chennai-25.

### B. *Requirements for the System*

TABLE 1: Models and specifications used in the proposed system

| S.No | Models | Specifications |
|---|---|---|
| 1. | PIR sensors | Sensitivity range: up to 20 feet(7m)110*70<br>Power supply: 3V-5V |
| 2. | STM32F407VG- microcontroller | Core: ARM® 32-bit Cortex® -M4 CPU with FPU external application power supply: 3V and 5V |
| 3. | External BLE(v4.1) | Os: IoS or Android, power input:2.5V-5V, Coverage range 100m |
| 4. | Moto 5G | Android v7.0 Nougat OS), Qualcomm Snapdragon 430 octa-core processor (1.4GHz) with Adreno 505 GPU<br>Dual nano SIM with dual-standby. 4G LTE (Cat 4) UMTS/HSPA+ GSM/EDGE<br>2800mAH lithium-ion removable battery,ram -3Gb BLE(v4.2), Sensors-Accelerometer, Gyro, Proximity, Compass. |
| Datasets are collected using LabVIEW(v14.0) | | |
| **Admin Server-** Windows 2008 enterprise, quad-core, 24Gb-ram | | |

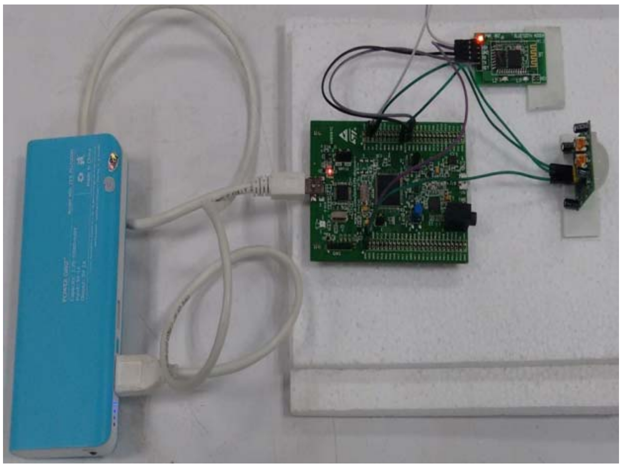

Figure 7. Snapshot of hardware setup used in the proposed system


Figure 8. Real time users' activity signals detected using PIR sensor

### C. *Collection of Datasets during Week Wise Manner*

Table 2 shows the datasets which are collected by PIR sensor that are fixed at four different places such as a research lab, research annexure lab, third floor CSE Lab and third floor staff room. In this system, an assumption that 'the number of times the door of these rooms were opened by the user is 25 times/week'. For an each time, when the room gets open, the system will detect the user's activity signals. The average user activity detection notification by the system was observed to be 97, 82, 91 and 85% for the first, second, third and fourth week respectively. These variations may be due to small infrared radiation happening inside the rooms.

This result can be compared with the existing surveillance system as reported by Sanoob et al. [3] in which the system uses PIR sensor with Arduino board connected with BLE. The average notification detected by the system was 100%, 76%, 88% and 68% for the first, second, third and fourth week respectively. On comparison between these two systems, the proposed system detects 88.75% as the overall average user's activity while for the same existing system showed 83%.

TABLE 2: Average User's Activity Detected Using Day Wise Manner

| **Week Wise** | **No. of times room opened** | **Users activity detected in various rooms out of 25** | | | | **Average users activity detected (%)** |
|---|---|---|---|---|---|---|
| | | **Research Lab** | **Research Annexure lab** | **III floor CSE Lab** | **III floor Staff room** | |
| Week 1 | 25 | 25 | 24 | 25 | 23 | 97 |
| Week 2 | 25 | 20 | 21 | 21 | 20 | 82 |
| Week 3 | 25 | 24 | 23 | 23 | 21 | 91 |
| Week 4 | 25 | 23 | 20 | 21 | 21 | 85 |

Also from the Table 2 it can be inferred that, the average activity detected during the first and third week is 97% and 91%, respectively when compared with other two weeks (Week 2 and Week 4). This shows that working statistics of the organization is more in those two weeks (Week 1 and Week 3).

Figure 9 shows the graphical representation of user activity detection with respect to the number of weeks, which is under consideration and same assumption. From the graph based on the comparative analysis, the following results can be predicted: The detected average user's activity was observed to have minimum on week 2 with the value of 82%, while it was observed to have maximum on week 1 with the value of 97 %. And for week 3 the value was observed to be 91%.

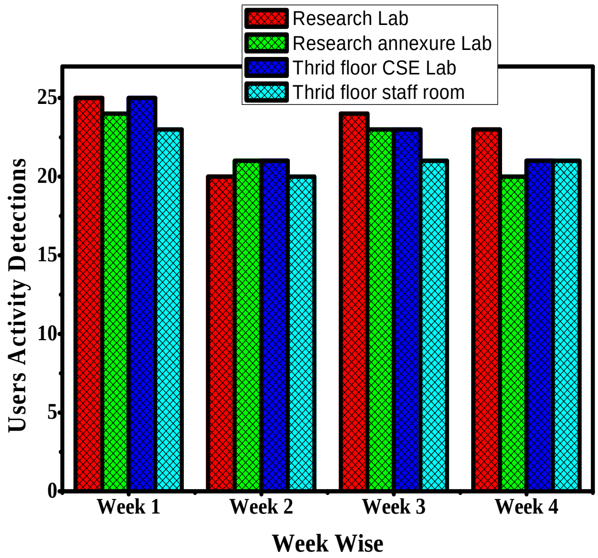


Figure 9. Week wise Vs users' activity detection

Figure 10 shows the meters Vs voltage sensing percentage of the PIR sensor at 5V and 2.5V levels. The experimental results were carried out by using the PIR sensors connected to the STM32F407VG microcontroller under two different voltage levels options like 5V pin and 2.5V pin. It should be noted that depending on the applied voltage levels, the sensitivity of the sensor range varies. The accuracy of detection percentage was observed to be high when the operating voltage is 5V (i.e. detection of user's activity up to 6.5m) then compared to the 2.5V level (i.e. detection of user's activity within 3.5m).

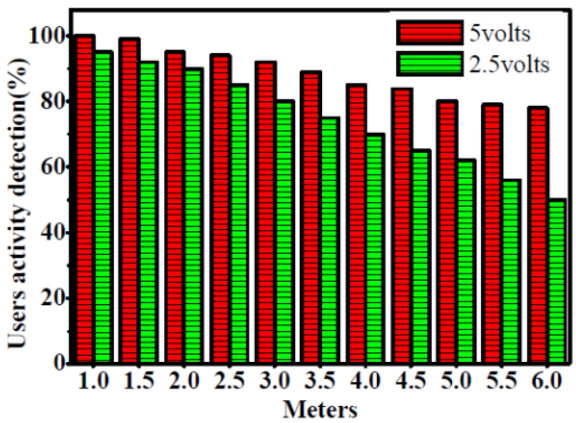


Figure 10. Meters Vs voltage sensing percentage of PIR sensor

## V. CONCLUSION

In the present research, development of human activity detection system by using PIR sensor and BLE with STM32F407VG microcontroller in IoT was discussed. The present research focuses on both the conditions of user – either with or without IoT enabled devices. In the week wise manner, user activity's signals data was collected by using LabVIEW toolkit installed in the department of CSE admin server which works within the certain BLE range. Based on the performance analysis the following remarks can be predicted: The average user activity detection notification by the system was observed to be 97, 82, 91 and 85% for the first, second, third and fourth week respectively. On comparison, the proposed system detects 88.75% as the overall average user's activity while for the same existing system showed 83%.

Future Direction: Different systems can be developed and its performances can be measured by using different wireless technologies that supports IoT such as Zigbee, Z-waves, Near Field Communication (NFC), IPv6 Low-power Wireless Personal Area Network(6LowPAN) etc.,

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