CHAPTER 6

HUMAN TRACKING SYSTEM USING PIR SENSOR

In this chapter detection of user’s activity signals with respect to various contexts either with or without smartphone user’s are achieved by using the combination of PIR sensor and BLE (v4.1) with STM32F407VG microcontroller which belongs to IoT. The PIR sensor-senses the various contexts of user’s activity signal, and transmit the signal into the system via BLE using star topology in IoT. The user’s activity signals received from the BLE is then transmitted into the system which is then recorded or stored locally. Once the user’s activity is detected, an instant short notification message will be sent to the admin server as well as to the smartphone user/groups within the certain transmitter range (up to 50-100m). The main advantage for implementing this system is it requires low cost maintenance then compared with the existing systems.

6.1 DETECTION OF USERS ACTIVITY SIGNALS

Indoor user’s activity signals are detected by the system which uses 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 user’s carrying either with or without smartphone by placing in the different context of user’s body in an organization.

6.1.1 Architecture for Human Activity Detection System

The architecture of the proposed system for the human activity detection is shown in Figure 6.1, where the used PIR sensor - senses the
user’s activity signals within its range and transmits it to the STM32F407VG microcontroller. The BLE which has been connected to microcontroller, then send the user’s activity message to smartphone user/users group and also to the system.

![Diagram](image_url)

**Figure 6.1 Overall designs for the working model system**

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

### 6.1.2 Software Module for System Design

Figure 6.2 shows the software module processes for the detection of user’s activity signals that are captured by PIR sensor which then further transmitted through STM32F407VG microcontroller to smartphone user’s and to human tracking system via BLE. Once the user’s activity signals are detected by the PIR sensor, it immediately activates the STM32F407VG microcontroller notification message alert to send the message from
smartphone user’s and also to the system running for LabVIEW toolkit. 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 6.2 Flow chart representations for software module

6.1.3 Hardware Module for System Design

The hardware module consists of a human tracking system which acts as both the controlling and computation system. Figure 6.3 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 0 or 1, where 1 represents the user’s activity detection and 0 represents the normal idle state.

Figure 6.3 Working module representation of PIR sensor

Figure 6.4 Hardware modules for the design of the detecting system

Figure 6.4 represents the hardware module designed for the proposed system and Pseudocode that has been incorporated in
STM32F407VG microcontroller is also represented in the subsection 6.1.3.1. The PIR sensor is connected to the GPIO (General Purpose Input Output) pin PB-8 of STM32F407VG microcontroller and also connected to an external BLE using Tx pin- PB6 and Rx pin-PB7 of STM32F407VG microcontroller. Then the BLE transmit the user’s activity signals to the nearby smartphone users/group and also to the system in the department of computer science and engineering, Anna University, Chennai-25.

6.1.3.1 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 6.5 shows the user’s activity signals that are captured by LabVIEW toolkit which was installed in the admin server in the department of CSE, Anna University, Chennai-25. The BLE receives the user’s activity signals that are captured by the PIR sensor and is then further transmitted to the BLE connected to STM32F407VG microcontroller, which in turn communicates with the BLE of the server. The back end of the system is as follows: BLE-RFCOMM services discover the channel and Universally Unique Identifier (UUID) that has been connected to BLE open connection, which in turn has been connected 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). If the user’s activity signal is detected by the 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.
6.1.4 PIR-Sensor Input Catching Methods

The user’s activity signals that are obtained by PIR sensor can able to sense the changes in Infra-red radiation within its ranges. The input of PIR sensor is either to detect user’s activity or no-users activity detections, which get changed depending upon the situations. A continuous detection of user’s activity signals has been sent to the STM32F407VG microcontroller and also in the case when there is no-users activity detection, the signal has been again sent to the same microcontroller, where the system which detects the user’s activity comes to an end. In order to obtain an exact time slot of the user’s activity, a simple input catching mechanism has been implemented using a catch variable.

If the user’s activity has been detected, then 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 with respect to the time when the catch variables became false to true and true to false, respectively.
Figure 6.6 shows the graphical representation of time slot which has been detected for the various user’s activity by using the catch variable. The catch variable helps during starting and at the end of recording. The smartphone and LabVIEW toolkit receives the signal 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. At the same time of recording, the smartphone take the necessary steps to notify the users/group which plays a vital role to get the exact time slot.

The 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. The catching mechanism helps to get the exact time slot of the user’s activity.

![Graphical representation of timeslot](image)

**Figure 6.6 Graphical representation of timeslot**

### 6.2 TEST AND ANALYSIS

#### 6.2.1 Experimental Setup

Table 6.1 shows the models and specifications of different sensors used in the proposed system while the model of hardware setup used in the proposed system has been represented in Figure 6.7. This hardware setup works under the combination of both PIR sensor and BLE with STM32F407VG microcontroller which belongs to the IoT. The proposed system has been placed anywhere in the indoor organization environments.
within its BLE range i.e., main research lab, research annexure lab, third floor CSE lab and third floor staff room. Whereas Figure 6.8 shows the experimental setup used for detection of user’s activity signals in the department of CSE at Anna University, Chennai-25.

**Table 6.1 Models and specification of sensor used in the proposed systems**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Model</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PIR sensors</td>
<td>Sensitivity range: up to 20 feet(7m)110*70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power supply: 3V-5V</td>
</tr>
<tr>
<td>2</td>
<td>STM32F407VG-microcontroller</td>
<td>Core: ARM® 32-bit Cortex®-M4 CPU with FPU</td>
</tr>
<tr>
<td></td>
<td></td>
<td>external application power supply: 3V and 5V</td>
</tr>
<tr>
<td>3</td>
<td>External BLE(v4.1)</td>
<td>Os: IoS or Android, power input:2.5V-5V,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coverage range 100m</td>
</tr>
<tr>
<td>4</td>
<td>Moto 2G</td>
<td>OS-v6.0 (Marshmallow), Quard-core 2.7-GHz krait450,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1GB-Ram, BLE(v4.0), Sensors-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accelerometer, Gyro, Proximity, Compass.</td>
</tr>
</tbody>
</table>

Datasets are collected using LabVIEW(v14.0)

Figure 6.7 Representation of hardware setup used in the proposed system

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6.2.2 Collection of Datasets based on Day Wise and Week Wise Manner

Datasets are usually collected by two different ways, such as day wise and week wise. At first, day wise user’s activity has been collected from Monday to Friday, where each day starts with a working time from 9:00 am to 4:30 pm. Similarly, datasets were collected for a week wise manner.

Table 6.2 shows the datasets which are collected by PIR sensor with STM32F407VG microcontroller system fixed at four different places such as research lab, research annexure lab, third floor CSE Lab and third floor staff room. The user’s activity signals are collected for all the five working days namely Monday to Friday. From the datasets obtained during Monday to Friday, the average user’s activity was detected to be 81.87%.
### Table 6.2 Average user’s activity detected using day wise manner

<table>
<thead>
<tr>
<th>Days Wise</th>
<th>No. of times room opened</th>
<th>Researchers Lab</th>
<th>Research Annexure Lab</th>
<th>Third floor CSE Lab</th>
<th>Third floor staff room</th>
<th>Average users activity detected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>87.5</td>
</tr>
<tr>
<td>Tuesday</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>82.5</td>
</tr>
<tr>
<td>Wednesday</td>
<td>10</td>
<td>10</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>80.0</td>
</tr>
<tr>
<td>Thursday</td>
<td>10</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>77.5</td>
</tr>
<tr>
<td>Friday</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>87.5</td>
</tr>
</tbody>
</table>

![Bar chart showing users activity detection days wise](image1)

**Figure 6.9 Days wise Vs users activity detection**

![Bar chart showing users activity detection week wise](image2)

**Figure 6.10 Week wise Vs users activity detection**
Figure 6.9 shows the graphical representation of user activity detection with respect to the number of days, which is under consideration. In order to obtain this, an assumption that ‘each room will be opened 10 times in a day’ has been framed. For each time, when the room gets open, the system will detect the user’s activity signals. For this purpose, the system used for data collection has been fixed in various places for collecting the data from Monday to Friday.

The actual collected data by this method has been shown in Table 6.2 and the corresponding comparison has been shown in Figure 6.9. Based on the comparative analysis, the following results can be predicted: The detected average user’s activity was observed to have minimum on Thursday with the value of 77.5%, while it was observed to have maximum on both Monday and Friday with the value of 87.5%. The average user’s activity value was detected to be 83% for the number of days which is under consideration.

Table 6.3 Average users’ activity detected using week wise manner

<table>
<thead>
<tr>
<th>Week Wise</th>
<th>No. of times room opened</th>
<th>Research Lab</th>
<th>Research Annexure lab</th>
<th>Third floor CSELab</th>
<th>Third floor Staff room</th>
<th>Average users activity detected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>25</td>
<td>25</td>
<td>24</td>
<td>25</td>
<td>23</td>
<td>97</td>
</tr>
<tr>
<td>Week 2</td>
<td>25</td>
<td>20</td>
<td>21</td>
<td>21</td>
<td>20</td>
<td>82</td>
</tr>
<tr>
<td>Week 3</td>
<td>25</td>
<td>24</td>
<td>23</td>
<td>23</td>
<td>21</td>
<td>91</td>
</tr>
<tr>
<td>Week 4</td>
<td>25</td>
<td>23</td>
<td>20</td>
<td>21</td>
<td>21</td>
<td>85</td>
</tr>
</tbody>
</table>
Table 6.3 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 these rooms were opened is 25 times in a week days for each first, second, third and fourth weeks, respectively, but an average notification was detected by the system for each week are 97, 82, 91 and 85%.

This result can be compared with the existing surveillance system as reported by Sanoob et al. (2016) in which the system uses PIR sensor with Arduino board connected with BLE, where an average notification detected by the system for each week are observed to be 100, 76, 88 and 68%. When compared these both systems, the proposed system detects an average users activity to be 88.75% while the existing system was observed to be 83%.

These variations may be due to small infrared radiation happening inside the rooms. Also from the Table 6.3 it can be inferred that, the average activity detected during the first and third week is 97% and 91%, respectively which shows that working statistics of the organisation is more in those two weeks (Week 1 and Week 3).

Similarly, Figure 6.10 shows the graphical representation of user activity detection with respect to the number of weeks, which is under consideration. In order to obtain this, an assumption that ‘each room will be opened 25 times in a week’ has been framed. For an each time, when the room gets open, the system will detect the user’s activity signals. For this purpose, the system used for data collection has been fixed in various places for collecting the data from week 1 to week 2. The actual collected data by this method has been shown in Table 6.3 and the corresponding comparison has been shown in Figure 6.9. 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 6.11 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 when compared to the 2.5V level. The PIR sensor can detect user’s activity up to 6.5m area, but its activity detection percentage is high only when used within 3.5m.

Figure 6.11 Meters Vs voltage sensing percentage of PIR sensor
6.3 SUMMARY

The experimental results of the user’s activity signals that are received by PIR sensor with a microcontroller system fixed at four different places in the department of CSE, Anna University, Chennai-25 during the working hours, on the basis of both day wise and week wise manner, are collected with different time periods for the sample datasets. The detected data shows that the average activity observed during the Monday to Friday is 83% with respect to the day wise manner while it was observed to be 88.75% with respect to the week wise manner. When compared between day wise and week wise manner, data obtained through week wise manner was detected to have higher average user’s activity in the proposed system which in turn proved to have better efficiency than compared to the existing system.