Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 6, July 2021: 6152- 6162

Research Article

Gesture And Motion Based Crew Management System In An Airport

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Abstract

In this generation, management systems have brought a considerable change in keeping various conglomerates stable, responsive and efficient. One such low-cost resolution for the organizations with a large workforce that involves physical activities/tasks is the Real-Time Gesture and Proximity Based Employee Management System (RTGP-EMS). The ability to track and reassign any employee at any point of time due to the spontaneous and simultaneous functionality of the system facilitates such companies with ease of both control and flexibility over the location, number of employees, and the variegated amount of tasks. As implemented, RTGP-EMS can ease the tracking of all ground staff in an airport simultaneously and real-time.

Keywords: Motion Sensor, Bluetooth Low Energy(BLE), Global Positioning System(GPS), Message Queueing Telemetry Transport(MQTT), Real-time Tracking, Employee Management System, Proximity.

1. Introduction

Every organization whether it is big or small has human resource challenges to overcome. EMS provides strategic talent management software that improves the effectiveness and business results of employee management. Typically the module consists of various employee management tasks like employee history, performance and generates reports. Further, an EMS consists of crucial work-related features and important personal information about every employee. The employee management system can

- Improve Workforce Management Efficiencies
- Employee Engagement and Flexible management boundaries
- Securing Employee Information
- HR Data Analytics and Metrics
- Optimizing workload and streamlining administrative tasks

To be recognized for their work is one of Millennials' most crucial expectations, according to a Fortune Performance management software which enables managers and employees to exchange 360° feedback in real-time, and in turn, helps these idealistic employees understand that their work is not only appreciated but critically important to helping the company meet aggressive goals.

It is understood that Employee management software allows managers to monitor progress and give appropriate feedback in real-time without disrupting the workflow. In order to attract and retain this new wave of employees, companies must create an environment where expectations are both understood, met and at the same time make sure that it will be a boon in return.

In order to demonstrate the implementation of the proposed system, we shall consider an airport as the environment that services thousands of flights every day. Fig. 1 shows how the top view of an Airfield on a busy day at an International Airport looks like. Each Aircraft involves about 10 to 20 ground employees alone while Cargo flights need more than that of 20 due to the higher quantity payload and their fragile nature. A recent economic impact study conducted for Airports Council International has inferred that about 1.2 million people work at 485 commercial airports in North America, United States. The term Aircraft Maintenance refers to the performance of tasks required to fulfill the continuing airworthiness of an aircraft or its component, including overhaul defect rectification, inspection, replacement, compliance with airworthiness directives, and the embodiment of modifications and repair. An airport is filled with thousands of people, staff members and pieces of equipment at any given moment, which amounts to millions of dollars in investment moving around just a few square miles of area.

However, it is surprisingly easy to lose track of vital equipment and people in these busy locations, which in turn leads to a loss in airport management's time and money in resolving such issues. There is a lot happening on the tarmac which is essential for airlines to know exactly where not just the planes, but all vehicles, are on the ground. Imagine the possibilities for keeping track of both tools and equipment within the terminal and on the tarmac. For instance, when a passenger requests a wheelchair, an employee closest to the location who is at the same time ideal can be assigned the task in order to aid the needy immediately!

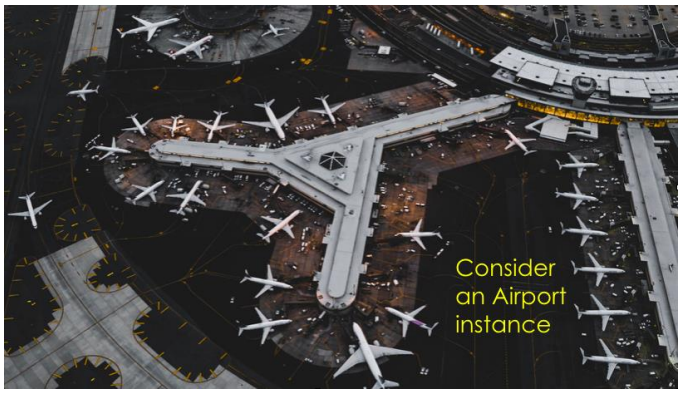

*Image Source: Google

Fig. 1: Top View of an Airfield

2. Related Works

There have been many recent developments in the field of Activity Tracking Systems. The "Crew activity tracking system: leveraging flight data for aiding, training and analysis" done by T. J. Callantine [1] wherein Flight Operational Quality Assurance (FOQA) programs analyze flight data from line operations to detect "operational irregularities that can foreshadow accidents and incidents," and proactively disseminate this information to flight crews and maintenance personnel. Crew Activity Tracking System (CATS) implemented for the flight deck used knowledge about the pilot's task and the current operational context to predict nominal activities and interpret actual pilot actions. By analyzing pilot action data in conjunction with clearance constraints and other flight data parameters, it helps disambiguate errors from other causes of abnormal flight conditions and characterize error-inducing contexts in operational terms. The "Real-time vehicle monitoring and positioning using MQTT for reliable wireless connectivity" put forth by Idris and Izwan [7], investigates problems by measuring and benchmarking two-way communication latency, data reliability using a lightweight machine-to-machine (M2M) protocol called Message Queue Transmission Telemetry (MQTT) and positioning accuracy using low-cost GPS equipment. A prototype of a vehicle monitoring platform that consists of an on-board-unit and central monitoring server was developed to facilitate the research study.

Further, "Challenges and Implementation of the Effort Tracking System" [10], designed to provide a transparent view of the organizational effort on a software project. It talks about the architecture of the Effort Tracking System (ETS), the inputs and outputs generated from the system. The authors, Shalu Gupta and Nilesh Kumar discuss and compare the manual system of tracking effort with the ETS using test of hypothesis. Statistical analysis performed on these two data sets to determine which system provides actual efforts drawn

from employees using software projects shows how the system helps the project managers in the estimation, planning, identifying the critical factors for the project. The ease of use in an Android-based live tracking system was demonstrated by Etuk, Enefiok and Uzochukwu, in "An Android-based Employee Tracking System" [4], where scheduling Information and time-off requests considered a part of Personnel tracking would enable managers to know when employees are expected to actually be in the office or other work areas. The system was implemented using JAVA programming language, and the result was stored in the SQLite database. The system adopted an Object-Oriented Analysis and Design (OOAD) approach which consists of well-planned iterative steps. Indoor live tracking put forth by [2] and [11] seemed efficient, used RFID tags which were for very short ranges. The Gesture and Proximity Activity tracking system was able to overcome all aspects by achieving live-tracking of the large workforce without limiting to just transportation and carriage vehicles using low-cost feasible equipment.

3. Intention

The process of tracking an entire workforce in real-time and simultaneously can be done by the Real-time Gesture and Proximity-based Management System. Some of the specific aspects that this system aims at solving are:

3.1 On-Board Servicing

3.1.1 Cabin Service

Ensures passenger comfort and alteration of seat configuration and cabin fittings.

- Include replenishing onboard consumables.

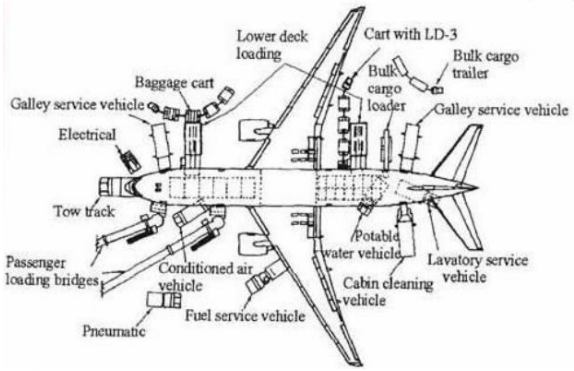

**Image Source: LinkedIn*

Fig. 2: Layout of Operations carried out in a flight after Chock-In

3.1.2 Catering Service

- Airline Service Trolleys

3.2 Ramp Service

- Guiding aircraft in and out of parking position (Marshalling)
- Hauling with pushback tractors and Lavatory drainage
- Gate checked luggage on the tarmac as passengers disembark

- Handling Air Cargo (Cargo dollies and cargo loaders)
  - Catering Trucks, Wheelchair Lifts
  - Hydraulic mules (units that provide power to an aircraft externally) and De-icing

3.3 Passenger Service

- Handling Check-Ins
- Assisting With Boarding
- Communicating With Passengers

3.4 Field Service

- Dispatches the aircraft

- Air Traffic Control (ATC) maintaining communication with rest of the airline operations at the airier.

Fig. 2 depicts the relative positions of the staff carrying out the different operations with respect to the flight. Thus the system is to live-track every employee's activities and the support equipment's statuses too (although only lesser fault-tolerant equipment are advised to be monitored due to presence of a large number of embedded devices already in the system).

In order to track the activities of the ground staff, the basic principle is to use the motion sensor to calculate movement/activity based upon vibrations produced. Further, every field employee's activities are only tracked on the airfield in order to maintain both moral ethics and private space. The location of an employee can be determined using two different methods: i) BLE or ii) GPS. The basic necessity to initiate the entire tracking system is to confirm the presence of the staff which is done using the concept of Geo-Fencing. Once the relative position of the employee is definite, and if within range then by means of MQTT data is transmitted to the dashboard.

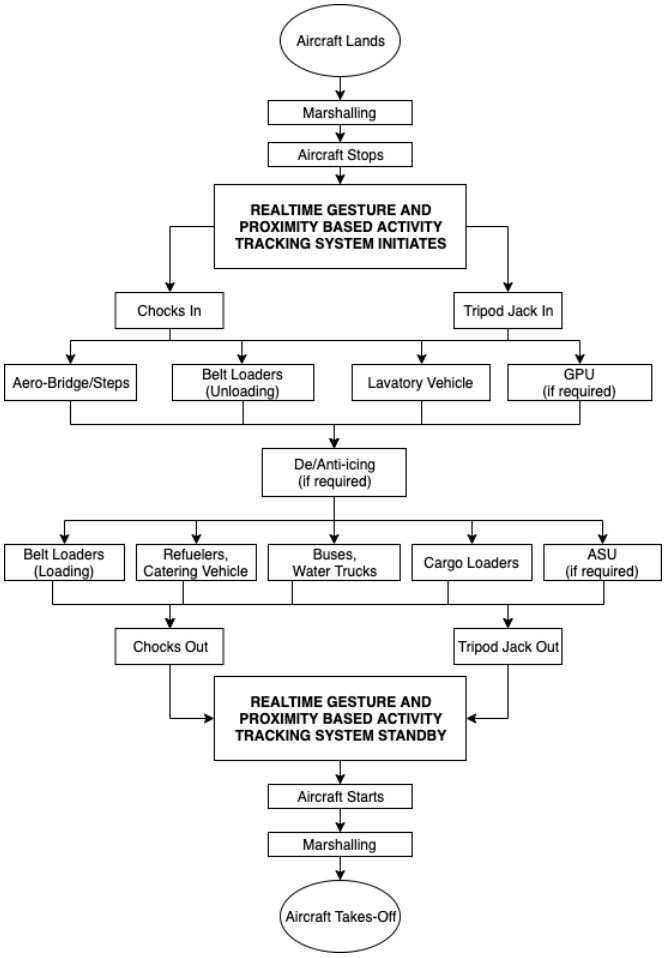

Fig. 3: Process of Operations when a flight is in the Airfield

To be more specific, the data we transmit is basically the values of the motion sensor, namely: i) Yaw ii) Pitch iii) Roll iv) Acceleration along x-axis v) Acceleration along y-axis and vi) Acceleration along z-axis, along with either raw GPS coordinates, which are: Longitude and Latitude, or using the RSSI value transmitted by the BLE beacon.

We will deal with the following tasks-

- Locating and Track Airport Staff Members involved in-
- Airport Ground Support Equipment and Vehicle Tracking
- Airport Equipment Condition Monitoring

Each task can be differentiated by the deployment type, wherein,

i) An employee can be given

1. A wearable device (worn on the wrist) that consists of a Motion sensor consisting of: a Gyroscope (for angular rotational) and Accelerometer along with BLE beacon/GPS, and will be non-invasive (or)

2. A mobile application installed on the cellular device (Only for organizations which allow Mobile Phones during working hours)

ii) The vehicle tracking can be adopted by simply fitting a small module of interfaced Micro Controller Unit (MCU) and either BLE beacon (or) GPS on the deck.

iii) Equipment condition monitoring can be performed by adopting a physical measurement sensor (such as pressure for tires or temperature for icing) interfaced with an MCU.

As shown in Fig. 3, the proposed system is to be incorporated in the current process of operations of when a flight arrives and departs from the airport. The data is transmitted by the use of MQTT protocol and MQTT broker, wherein each stream of data is identified by a unique topic. Further, the data, which is acquired in real time at the client end, is fed to an algorithm that concludes whether a specific staff, recognized by a Universally Unique Identifier (UUID) is actually working or ideal. Later, the entire session of the employee servicing the flight is pushed into a database and will consist of not only the transmitted data but also the inferred results to check the system's integrity in the future!

4. Methodology

Every type of deployment model in this system has got the same flow of operations. Either the mode (or) device used may vary, but the end goal will remain the same, which is to track and predict the task being performed by any of the employees at any point in time. Further, we extend this to a Rapid Turn Around System, which will not only be able to track the employees but includes the monitoring of the equipment that they use and provides status updates, which can save the time of an inspection team and going on-spot to analyze the situation after the problem has occurred. Thus allowing an easier fault detection mechanism as the location will be referenced to the UUID assigned to the equipment.

Fig. 4 shows the flow of operations in Gesture and Proximity Based Activity Employee Management System and the acquired data from sensors such as: 6 values from Motion sensor (3 - Gyroscope and 3 - Accelerometer) along with the GPS coordinate/BLE's RSSI value, including the UUID assigned to the device is transmitted across a connected network via MQTT protocol.

4.1 Deployment Models

As proposed, we introduce three different deployment models, whose core concept and background will remain the same; Activity Tracking System. Airline Maintenance consists of three main components, namely,

- Ground Staff
- Powered Support Equipment and Vehicles
- Non-Powered Ground Support Equipment (GSE)

4.1.1 Employee Tracking

The ground staff members are one of the most vital components of an Airline maintenance system. They are responsible for performing various tasks according to the schedule provided, take educated decisions in case of a malfunction, and eventually are the ones who work at the highest risks at an Airport. Their performance and safety is one that is always considered top priority by all Airline Industries who spend billions of dollars, ensuring it but at the same do not compromise in the efficiency, especially that of the field-staffs.

- **Employee Tracking using a wearable device**

Most companies would like to maintain confidentiality and may instruct staff to hand-over (or) restrict phones in the work environment. For such cases, a wearable device is fabricated, which can be as small as Fitbit but does the job. It can connect to a Network provided by the organization itself. This increases confidentiality by a huge margin.

The concept of Wireless Sensor Network refers to a secure group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. This networking facilitates corporate with high clearance access to employees in both

governance of work-flow without compromising security. In such a controlled environment, the use of a localized server will only be necessary if the organization spans over a few hundred in the workforce. The wearable device will never bother the employee while working, and further does not depend on any manual intervention during tracking, thus making the entire system automated, as it is proximity (or) relative-location based and will be triggered according to the geographical perimeter determined prior, based on the target flight's dimensions. Although there are different types of deployment models that are proposed, the core workflow will remain the same for all, as represented in Fig. 4.

- **Employee tracking using a mobile phone**

Some companies may be liberal enough to allow personal cell-phones which can be an added advantage in return.

This deployment model involves a customized application on the staff's phone which must support two key features:

- Assisted GPS
- Gyroscope and Accelerometer (In-Built)
- Networking facility - To connect to the Internet (or) a private WiFi Hotspot (Network) based on confidentiality.

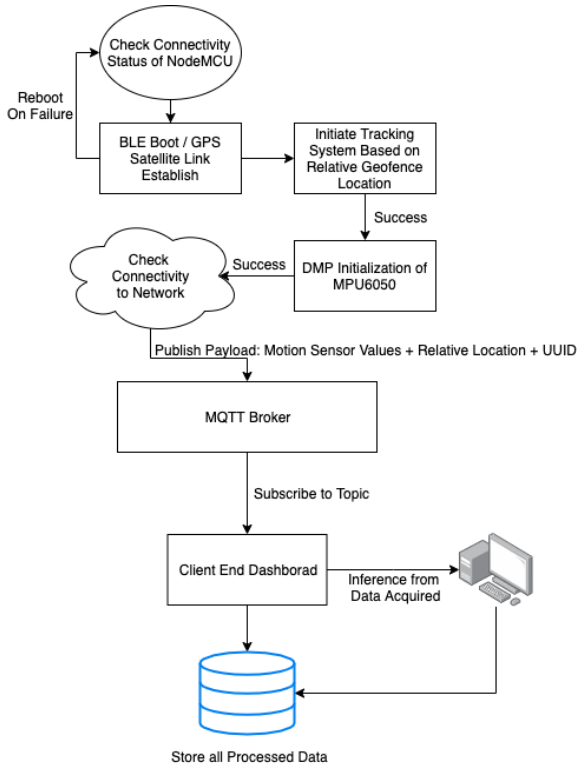

Fig. 4: Flow of Operations in Gesture and Proximity Based Activity Employee Management System

If successfully available, these features can be tweaked, and using MQTT protocol, can be made accessible from the user's handheld device at the organization's private server itself. Further, to contain the staff's privacy, the application developed must satisfy various policies that are put forth by the Government. This application can be easily developed using Bluetooth BLE Gatt Characteristics module available open-source on Android Studio for developers. Thus huge profits are made as it involves absolutely no hardware fabrication for each employee.

Although this deployment may be more vulnerable and less secure for organizations that handle very sensitive data, or confidential communication. Although advanced security and encrypted payload transmission are available through SSL-MQTT web-sockets, the reliability on human increases as the mobile application is installed locally on the user's phone. An alternative to provide Office-Use only cell phones within the vicinity of the company will definitely surpass all disadvantages, and as a matter of fact, can be reliable for easier communication during working hours.

4.1.2 Powered Support Equipment and Vehicles

One of the extended applications of this system is its ability to live-track vehicles such as loaders, aircraft refuelers, busses, hydrant trucks, tractors and so on. This can be accomplished by assigning unique formatted UUID's along with onboard GPS which can be connected to the safe frequency range network at an Airport. The data acquired from these are co-related with those of employees for instant access and usage where alternate services may be immediately demanded.

4.1.3 Non-Powered Ground Support Equipment (GSE)

Service stairs, jack lift, chocks, dollies for cargo pallets, are essential components that need to be live tracked too.

4.2 Software Interfaces

This section contains:

- A mobile application in case of an app-based deployment model, that has an in-built Gyroscope and Accelerometer.
- NodeJS runs a script to scan and report all Bluetooth advertisements from beacons (within the BT range).
- A client end web-browser to receive updates and alerts from the system, which must be an HTML5 version compatible for uninterrupted data.

4.3 Hardware Interfaces

The hardware interface includes

- WeMos D1 R1 (or) NodeMCU (Micro Controller Unit)
- MPU6050 - Motion Sensor
- BLE Beacon/GPS (NEO-6M) based on the deployment module.
- An Administrator workstation enabled with Internet connectivity/Local Area Network (LAN) to receive frequent updates and alerts posted by the system.

4.4 Role of Motion Sensor BLE and GPS (NEO-6M)

BLE is a Bluetooth technology that is a high speed, low powered wireless technology link that is designed to connect phones or other portable equipment together. This is known for the use of low power radio communications to link phones, computers and other network devices over a short distance without wires also termed as a specification - IEEE 802.15.1, aimed at novel applications in healthcare, fitness, beacons, security, and so on. The Bluetooth Low Energy (BLE) beacon is basically a small BT advertiser that continuously transmits data packets that contain meta-data. It includes a feature called RSSI (Received Signal Strength Indication) value which can be used to correlate and derive the distance. Thus allowing us to triangulate amongst various receivers and give us a relative position. While using BLE many BLE receivers will be placed in the airfield. On the other hand, GPS (assisted GPS in mobile phones) directly connects to the satellite and gives Latitude and Longitude, and thus can be Geo-fenced with the flight as the center and a fixed radius as the area of coverage depending on the dimension of the flight.

4.5 Interfacing MPU6050 with NODE-MCU

The NodeMCU is a Micro Controller Unit is an open-source software and hardware development environment that is built around a very inexpensive System-on-a-Chip (SoC) called the ESP8266, which facilitates the wifi capabilities. It has a compact design and multi-digital pin configuration to interface both GPS as well MPU6050 at the same time. The sample output obtained from interfacing MPU6050 with the NodeMCU is put up in Fig. 5.

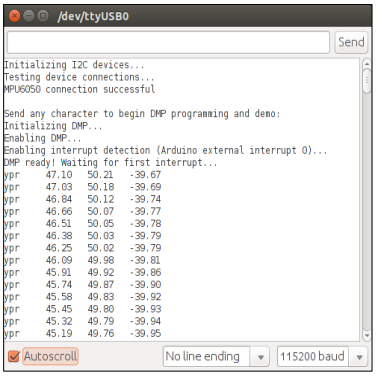

Fig. 5: Output of Yaw, Pitch and Roll when Arduino (NodeMCU) is interfaced with MPU6050

Using the open-source IDE - Arduino, programs are uploaded to it and the below output is seen in the Serial monitor. Further, MPU6050 is a 6-axis Inertial Measurement Unit (IMU) sensor, which gives a total of 6 values, 3 based on each Accelerometer and Gyroscope. Using open-source libraries, raw values of the sensor can be retrieved and printed on the Serial Monitor. Further, it contains a Digital Motion Processor (DMP) which fuses the accelerometer and gyroscope data together to minimize the effects of errors inherent in each sensor.

4.6 MQTT Broker and MQTT Protocol

Message Queueing Telemetry Transport is an open ISO standard lightweight, publish-subscribe network protocol that transports messages between devices. The protocol usually runs over TCP/IP. It is a publish-subscribe based messaging protocol used in the Internet of Things which is bandwidth-efficient. An MQTT client is basically any device (from an MCU up to a full-fledged server) that runs an MQTT library and connects to an MQTT broker over any network. Being data-centric protocol, here in our application we program the NodeMCU to connect to "iot.eclipse.org" which is a broker, and is further referenced to a data-stream identified by a unique identifier called Topic. Thus anyone having a valid address of the Topic, any number of devices can Publish/Subscribe at any point in time, simultaneously for real-time data transmission. This basic principle is portrayed in Fig. 7 using a few sample Publishers and Subscribers.

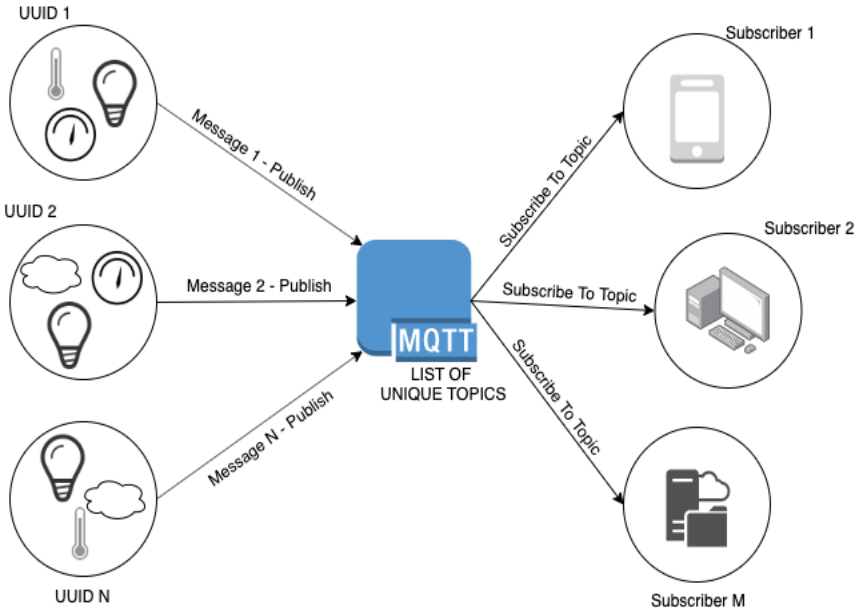

Fig. 6: MQTT Pub-Sub Architecture

The topic is generally a string reference which an organization can customize according to requirement. This topic can point to the data access location of a specific staff's live feed using UUID.

4.7 Data and Inference

The data retrieved from the sensors is displayed on the dashboard. Further, a graphical representation of the motion sensors is plotted in a live manner to infer quickly when compared to just raw meaningless values. On the client end, the data is also calibrated by considering the mean normalization of the squared-error value of the

first 100 data that is transmitted. Apart from the activity status itself many other essential features such as the following derived -

- Session Number (As an employee may serve multiple flights in a day)
- Session Entry Time
- Session Exit time
- Total In-Range Time (or) Session Time (Session Exit time - Session Entry Time)
- Last Activity Start Time
- Last Activity Stop Time
- Session Active Time (Determined according to vibrations and movement after the calibrated threshold is determined)
- Total Active Time
- Relative Distance of a field employee with respect to the Aircraft

Based on calibrated thresholds the alerts are posted through either the administrator's mobile app. or the prompt alert on the dashboard itself! The RSSI value transmitted from a BLE beacon can be mathematically converted into the distance between the beacon and the receiver. Thus after all the processing of data acquired, it is formulated as a data packet and pushed into the database (here SQLite) in an encrypted format ensuring both future reference and security.

4.8 Simulation

- The simulation was performed for the real-time tracking of activity for a single ground staff.
- The following hardware was incorporated onto a single breadboard for the wearable device:
  - NodeMCU - Microcontroller
  - MPU6050 - Gyroscope & Accelerometer Sensor
  - NEO-6M - GPS module
  - 5 Volt Battery
- The Software involved in the simulation was:
  - Arduino Code running on NodeMCU for transmission of MPU6050 data along with GPS coordinates.
  - HTML, CSS to structure and design the webpage.
  - JavaScript to receive the data, perform client-side logic and update the web page dynamically with inferences and graphs.
- Every time the web page loads, calibration is performed by considering the first 30 values, calculating the mean, and using it to normalize the incoming data.
- Further, the threshold for Accelerometer and Gyroscope readings are optionally taken as input for the calculation of vibration, thus used to conclude a person's activity as IDLE or ACTIVE.
- The latitude and longitude of the center of the aircraft is additionally taken as input to suit different locations and thus calculate the distance of an employee from the origin.

5. CONCLUSION

Employees are the strength of any organization, and more so in case of a growing business, such a workforce becomes increasingly vital to manage especially in terms of human resources. Fig. 8 shows the successful implementation of the proposed system, which can further be fabricated into a very small unit using PCB printing and become a completely Non-Invasive solution to such an everlasting issue.

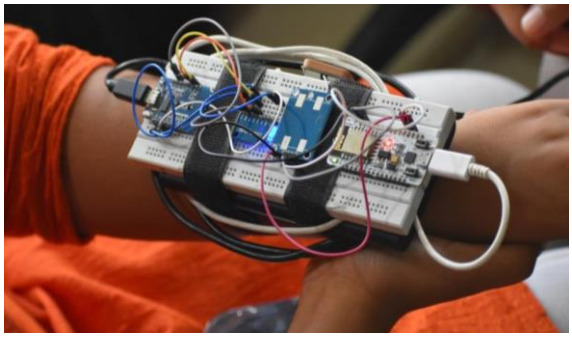

Fig. 7: NodeMCU interfaced with GPS and MPU6050

Fig. 9 shows the real-time data transmission from the sensors and being plotted for visualization. As visible the webpage will convey the inferences such as distance from the center of the plane, using either BLE beacon technology or using latitude and longitude from the GPS module. Further, the data along with inferences that is displayed on the webpage is pushed to a local SQLite Database for every session an employee is involved with.

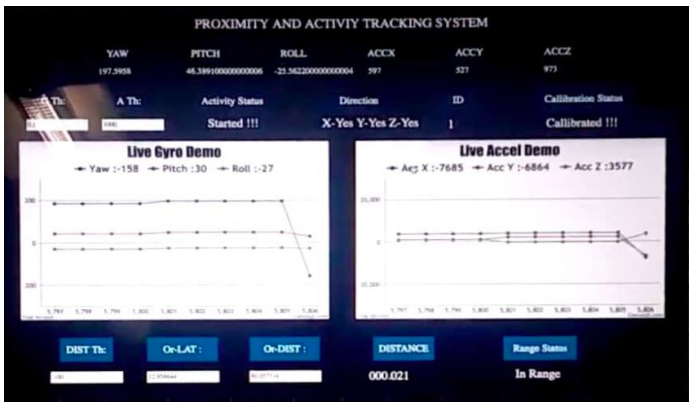

Fig. 8: Webpage plotting real-time data transmitted from the prototype.

The implementation of the proposed system was able to overcome the challenges that the current system faces, such as handling live transmission of data in real-time and simultaneous activity tracking.

6. Future Work

- A machine learning prediction model can be constructed in order to accurately classify what exact activity an employee is performing from the extracted features of MPU6050 (3 - Gyroscope and 3 - Accelerometer) and including the relative position of the staff with respect to the aircraft itself.

- Further analysis as to how efficiently a person is working can be determined and a detailed monthly report can be automatically generated.

- This system can also be implemented for monitoring equipment in other large industries that involve complex mechanical instruments to measure/quantize environmental factors such as temperature, pressure, fluidity, and so on. Thus digitizing the entire industry, and providing a more safe working-area for the staff, especially from health-hazard zones.

The entire setup shown in Fig. 8 is fabricated into a single unit using PCB printed and can be mounted onto a 3-D printed block, which matches the dimensions of a Fitbit and can further be made even smaller..

References

[1] Callantine, T. J. (2001, October). The crew activity tracking system: Leveraging flight data for aiding, training and analysis. In 20th DASC. 20th Digital Avionics Systems Conference (Cat. No. 01CH37219) (Vol. 1, pp. 5C3-1). IEEE.

[2] Geng, L., Bugallo, M. F., Athalye, A., and Djurić, P. M. (2012, August). Real time indoor tracking of tagged objects with a network of RFID readers. In 2012 Proceedings of the 20th European Signal Processing Conference (EUSIPCO) (pp. 205-209). IEEE.

[3] Chan, Y. T., Hu, A. G. C., and Plant, J. B. (1979). A Kalman filter based tracking scheme with input estimation. IEEE transactions on Aerospace and Electronic Systems, (2), 237-244

[4] Etuk, E. A., and Onwuachu, U. C. (2016). An Android based Employee Tracking System. International Journal of Computer Applications, 153(3).

[5] Stiefmeier, T., Ogris, G., Junker, H., Lukowicz, P., and Troster, G. (2006, October). Combining motion sensors and ultrasonic hands tracking for continuous activity recognition in a maintenance scenario. In 2006 10th IEEE International Symposium on Wearable Computers (pp. 97-104). IEEE.

[6] Ogris, G., Stiefmeier, T., Junker, H., Lukowicz, P., and Troster, G. (2005, October). Using ultrasonic hand tracking to augment motion analysis based recognition of manipulative gestures. In Ninth IEEE International Symposium on Wearable Computers (ISWC'05) (pp. 152-159). IEEE.

[7] Idris, I. (2017). Real-time vehicle monitoring and positioning using MQTT for reliable wireless connectivity (Doctoral dissertation, Queensland University of Technology).

[8] Ilin, I., Shirokova, S., and Lepekhin, A. (2018). IT Solution concept development for tracking and analyzing the labor effectiveness of employees. In E3S web of conferences (Vol. 33, p. 03007). EDP Sciences.

[9] Hoffman, K. D., Kelley, S. W., and Rotalsky, H. M. (1995). Tracking service failures and employee recovery efforts. Journal of services marketing.

[10] Gupta, S., and Dokania, N. K. (2013). Challenges and Implementation of Effort Tracking System. International Journal of Engineering Research and Technology, ESRSA Publications, 2(10).

[11] Tabbakha, N. E., Tan, W. H., and Ooi, C. P. (2017, November). Indoor location and motion tracking system for elderly assisted living home. In 2017 International Conference on Robotics, Automation and Sciences (ICORAS) (pp. 1-4). IEEE.

[12] Chea, A. C. (2011). Activity-based costing system in the service sector: A strategic approach for enhancing managerial decision making and competitiveness. International Journal of Business and Management, 6(11), 3