

Fire Detection and Tracking without GPS

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Abstract : This work proposes a new method for locating fire accidents. Unlike the current applications, where the coordinates are detected using a Global Positioning System (GPS) module. The project focuses more on limiting the use of components, by the use of “Geo-Location Application Program Interface” developed by “the Google”. The project uses a “Flame Sensor” to detect Fire Accidents using ESP8266 Node-MCU as the development board, which triggers an action of sending the co-ordinates to a registered E-Mail ID using “If This Then That” web service. The Node-RED Flow editor, an application developed by “IBM Watson Internet of Things Platform”, is used to connect various services and environments. Therefore the project proves out to be sophisticated and easy to implement for young researchers, for tracking any mobile device without a GPS Module.

IndexTerms - ESP8266 Node-MCU, If This Then That, MIT App Inventor, IBM Watson IoT Platform, Node-RED Flow Editor, Flame Sensor.

I. INTRODUCTION

During the development of Electronic computers in 1950s, the US Department of Defense awarded contracts for the development of the ARPANET (Advanced Research Project Agency Network). Operating these application specific computers from remote locations was a hectic task. Packet switching network and TCP/IP Protocol suite was then introduced for getting access to the resources from remote locations. A Client-Server model was slowly getting important for creating a network among these computers. In order to do a particular task that only a single computer could perform, there was a need of a pool of resources that could satisfy the needs to complete the task. This pool was a centralized storage that existed in computers named “Servers”. So if a Client wanted a task to be done, its connection to the server was mandatory. As a result this increased work load on the Servers.

Distributed computing came into the picture, where computers were networked together, so that resource sharing was less complicated. John McCarthy, in one of his speeches at Massachusetts Institute of Technology (MIT), suggested that “Utility computing can be viewed as public utility like water and Electricity”. The idea faded, not until in 1999, salesforce.com introduced its own multi-tenant application which was specifically designed to be accessed from a web browser, such that it was used by a large number of customers at low cost over the internet. It is still believed that there were a lot of developments done much before 1999 by J. C. R. Licklider with his work on ARPANET to connect people over connecting the computers through the concept of Galactic-Network. After 2002 several companies started being a part of the “Cloud World”, including Amazon Web Services (AWS), Microsoft Azure, Oracle, Red hat and the most recent competitor being IBM.

The Radio Frequency Identification (RFID) can be traced back during the World War-II in 1935, by Scottish physicist Sir Robert Alexander Watson Watt, where the crew had to be alarmed about the arrival of enemy planes. With the advent of RFID systems in the field of supply chain, Sanjay Sharma and David Brock introduced Networking Technology where linking various objects to the internet with the help of tags was possible. These tags were active and passive RFID systems.

There has been a drastic shift since 1950s, from the “networking of people and the computers” to the “networking of objects”. Today, these networking of objects are known as “Internet of Things (IoT)” or “Machine to Machine (M2M) communication”.

Taking advantage of the present day Cloud services, the proposed design provides a cost effective, and a sophisticated fire alarm and tracking system. A GPS Module depends on a number of factors including proper Line of Sights from a minimum of four Satellites or cell towers and a high quality GPS receiver, in order to produce accurate readings of the location where the fire accidents occur. This paper describes, the integration of Google Maps Platform and IBM Cloud Services for notifying a nearby Fire Station and send accurate co-ordinates of the location of Fire accident without a GPS module. Later, the proposed system can be embedded into any mobile/ stationary device for real-time applications.

II. RELATED WORK

2.1. In the present as well as previous years, there have been researches that focused on ensuring security for the Fire Workers in the Fire Industries [4], the workhouses [9] and the for the lives in the Forests [3] with the help of the concept of “Internet of Things”.

2. 2. A team at University of Utah came up with a solidly built boot that can get the location of workers living indoors [8]. The boot was built on an Inertial Measurement Unit consisting of gyroscope, magnetometer and accelerometer. The sophisticated model interfaced with Application Specific Integrated Circuit (ASIC), is suitable to fit in a pedestrian's shoe, producing an

accurate location of 5m, further with 5.5m in a 3km stretch

2. 3. In contrast with the high navigation errors, arising in an Inertial Navigation System in Micro aerial Vehicles (MAV), which might be in a static or a moving state, in 2017, a new design was proposed, where in order increase the accuracy an Optical flow System can be integrated with INS to estimate the velocity and position of the mobile Device. The project used limited hardware and consumed less power unlike other MAV's. The overall system weighed a few grams navigating in different environments.

2. 4. In the field of mobile communications [1], the tracking of a mobile phone user was done by extracting the text files obtained from the cell towers with the help of GPS receiver simulation, eliminating the use of GPS.

III. PROPOSED MODEL AND ITS IMPLEMENTATION

For the detection of Fire at places for surveying purposes, we have embedded the system in to a mobile Robot that can be navigated using Wi-Fi with the help of a mobile application, through HTTPS (Hyper-Text Transfer Secured protocol) broker over POST(request method). An ESP8266 Node-MCU has been used as the controller, which has an in-built Wi-Fi. Node-MCU is interfaced with a fire sensor and 4 DC motors. The project can be divided into two sections. Section 3.1 defines architecture for Robot Navigation, and Section 3.2 defines the proposed method for Robot Intelligence.

3.1 Robot Navigation:

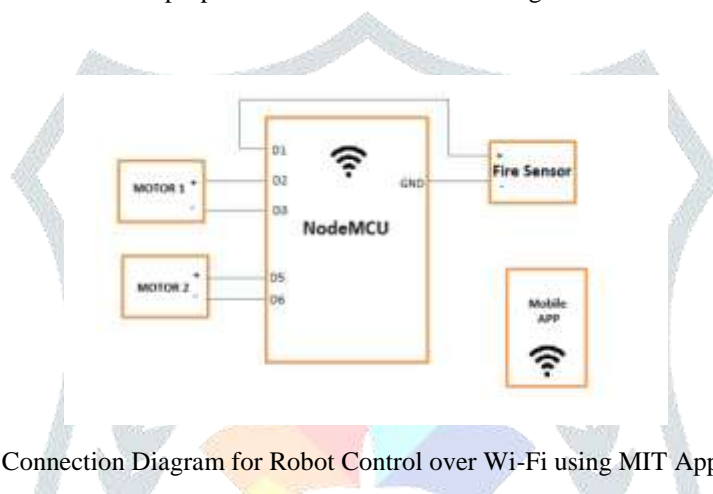


Fig. 1: Connection Diagram for Robot Control over Wi-Fi using MIT Application.

Development Board	ESP8266 Node-MCU
Operating Voltage	3.3V
Digital I/O Pins	12
Analog Input Pins	1
Flash Memory	4MB
SRAM	128KB
MCU	32 Bit-Tensilica-L106
Wi-Fi	2.4Ghz, WPA/WPA2
Operation Modes	STA/AP/STA+AP
Output Power	+20dBm
Deep Sleep Power	< 10µA
Stand-by power consumption	< 1.0 mW
Interfaces	UART, I2C, I2S, IRDA, PWM, GPIO, SDIO 2.0, (H)SPI

Fig. 2: Specifications of ESP8266 Node-MCU.

An ESP8266 Node-MCU has an in-built TCP/IP Protocol Stack, which can be used to connect to various local Wi-Fi networks with ease. The following are the software tools used for building a robot controlled over a Wi-Fi.

3.1.1. Arduino IDE: An integrated development Environment that consists of text editor and can be used to communicate with a variety of development boards such as Arduino Series, Spark Fun, Intel, WeMos etc. The IDE can be used to compile and upload programs on to the boards.

3.1.2. MIT App Inventor: It is an open source online web service developed by Google, and maintained by Massachusetts Institute of Technology. The service is user friendly and easy for the beginners to develop applications for both front-end as well as back-end.

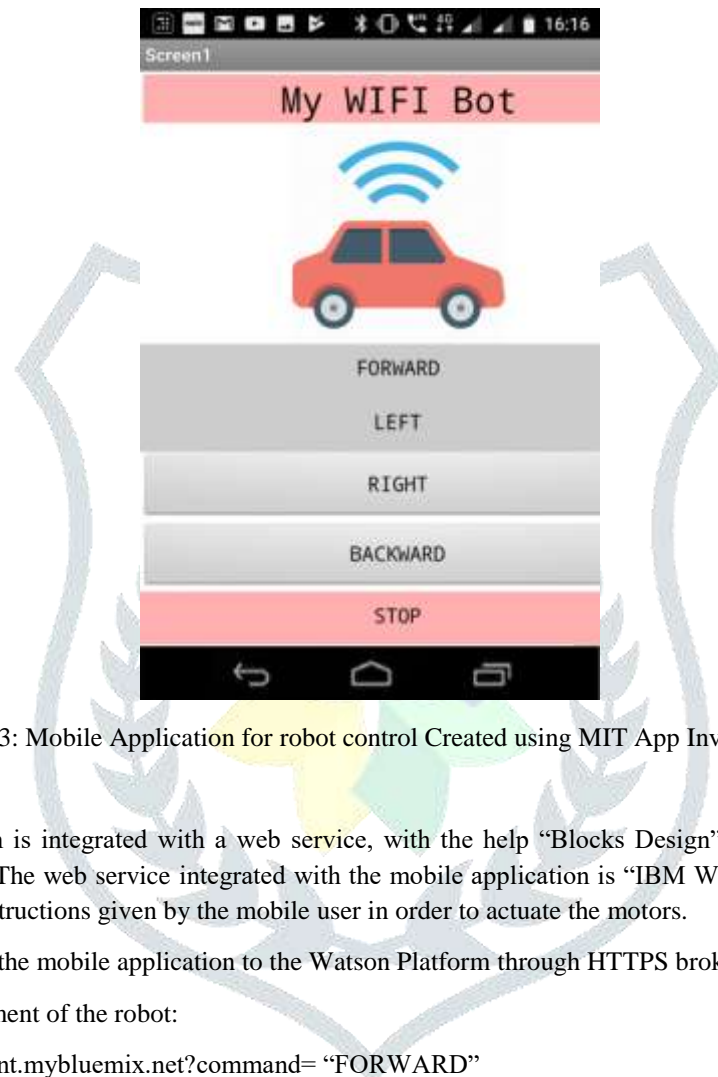


Fig 3: Mobile Application for robot control Created using MIT App Inventor.

Each button in the application is integrated with a web service, with the help “Blocks Design”. “Block Design” is a back-end design in MIT-App Inventor. The web service integrated with the mobile application is “IBM Watson IoT Node-RED Platform”, which is used to trigger the instructions given by the mobile user in order to actuate the motors.

The instructions are sent from the mobile application to the Watson Platform through HTTPS broker.

Instruction for Forward movement of the robot:

`https://your_ibm_cloud_account.mybluemix.net?command= "FORWARD"`

Instruction for Backward movement of the robot:

`https://your_ibm_cloud_account.mybluemix.net?command= "BACKWARD"`

Instruction for Left movement of the robot:

`https://your_ibm_cloud_account.mybluemix.net?command= "LEFT"`

Instruction for Right movement of the robot:

`https://your_ibm_cloud_account.mybluemix.net?command= "RIGHT"`

Instruction for stopping the robot:

`https://your_ibm_cloud_account.mybluemix.net?command= "STOP"`

3.2 Robot Intelligence

The following section, describes the proposed model for detecting, acquiring and notifying the location of fire accident, entirely using Google and IBM Cloud as shown in Fig. 4(a).

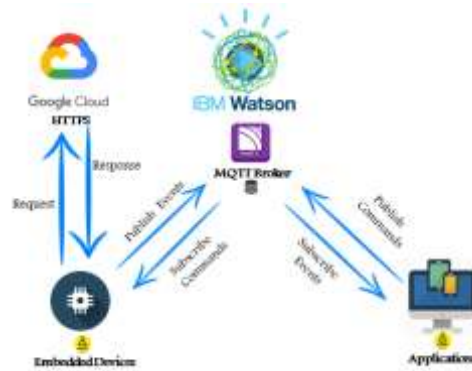


Fig. 4(a): Proposed model for fire detection and tracking without GPS.

In the above proposed model, the development board ESP8266- NodeMCU, uses two servers at a time, namely “Hyper-Text Transfer Protocol Secured (HTTPS)” and “Message Quering Telemetry Transport (MQTT)”.

3.2.1. Hyper-Text Transfer Protocol Secured (HTTPS): HTTP Secure (HTTPS) is an extension of the Hypertext Transfer Protocol (HTTP) for secure communication over a computer network. The communication protocol is encrypted using Transport Layer Security (TLS) and Secured Socket Layer (SSL). It uses Port number 443, and requires domain verification, the reason why it is much secured than HTTP. It is an asymmetric “request-response” client-server protocol. The HTTPS Client sends a request to the server. The server then returns a response.

3.2.2. Message Quering Telemetry Transport (MQTT): It is a Client-Server “Publish-Subscribe” messaging transport protocol. The client and the server are subscribed to a common “topic”, where the server sends response messages to the client continuously. Such as in this case the common topic shared by Node-MCU and IBM Watson is “location”. The one sending the message, that is Node-MCU, is a Publisher, and the one receiving the message, that is Watson Platform, is a Subscriber.

3.2.3. IBM Watson™ Internet of Things Platform: It is a flexible tool kit that provides all the resources needed for accomplishing the tasks for connecting, controlling and monitoring things over the Internet. Watson can collect data from devices through various device gateways, device management, upon which Edge Analytics [6], Machine learning, Visual Recognition, Speech-Text, Text- Speech, real- time monitoring, Automation [5] [7] including cognitive computing and many more can be performed on real time data or simulation tools. It provides a free Cloud storage of 256MB for “Standard Lite Plan Users”. Further for the premium plans, charges are applied for additional cloud storage.

3.2.4. Node-RED Platform Flow Editor: It is one of the services in IBM Watson IoT platform. A single Cloud Foundry Application links to a flow editor platform, which can be used to integrate Web services, Hardwares and Application Program Interfaces (API) with the help of inter-connection of various “Nodes”. The nodes are formatted in JavaScript Object Notation (JSON). A Node-RED Flow is shown in the Fig. 6.

3.2.5. Geo-Location API: Geolocation API is an Application Program Interface developed by Google. It follows “Client-Server” architecture, where the communication is done using HTTPS over POST. The API determines the current position of a user with the help of information collected from the nearby cell towers and IP Addresses of Wi-Fi nodes that the Client can detect. It approximates the co-ordinates obtained from towers and nodes in that radius. The more the towers/nodes/ routers, the more is the accuracy. The requests from the client can be initiated using a unique “API Key” given to each user. The requests, responses and content are formatted using standard JSON script.

3.2.6. If This Then That: If This Then That (IFTTT) is an online open source web-based service, which can be used to automate web application tasks. IFTTT consists of components such as Triggers, Services, Actions, Applets and Ingredients. IFTTT uses simple conditional statements. The Recipie/Applet is triggered depending upon the changes occurring in a service.

3.2.7. Embedded devices: Here the embedded devices used are ESP8266 Node-MCU and a Fire Sensor. The details of which are given in section 3.1. The crucial component being the “Node-MCU”, is responsible for executing two servers at a time.

3.2.8. Applications/GUI: The two Applications used at the user-end are the “MIT App for Robot Control” and the “E-Mail Service”, which is used to notify the accident.

3.2.9. Proposed Method: The proposed method is mentioned in Fig. 4(b). Assuming that the fire is detected at a location, the fire sensor returns a digital “1”. When Fire Sensor returns a “1”, Node-MCU requests the HTTPS server of the Geo-Location API to return the co-ordinates to the client (Node-MCU). Simultaneously, since Node-MCU and IBM Watson are subscribed to a

common topic “location”, the co-ordinates received by the Node-MCU from the Google Cloud are then published to Node-RED on IBM Watson IoT platform, using “payload”, i.e. the co-ordinates are appended with the help of payload during the execution of program. The flow for Node-RED is given in Fig.7. When the co-ordinates are published on Node-RED, the flow triggers “If This Then That (IFTTT)” Service, which is setup as “If Webhooks then E-Mail”. Webhooks are a user- defined HTTP callback which triggers the event name “MyEvent” which is basically the “Event of publishing co-ordinates in Node-RED”, this event generates an action of sending an E-Mail to a registered E-Mail ID.

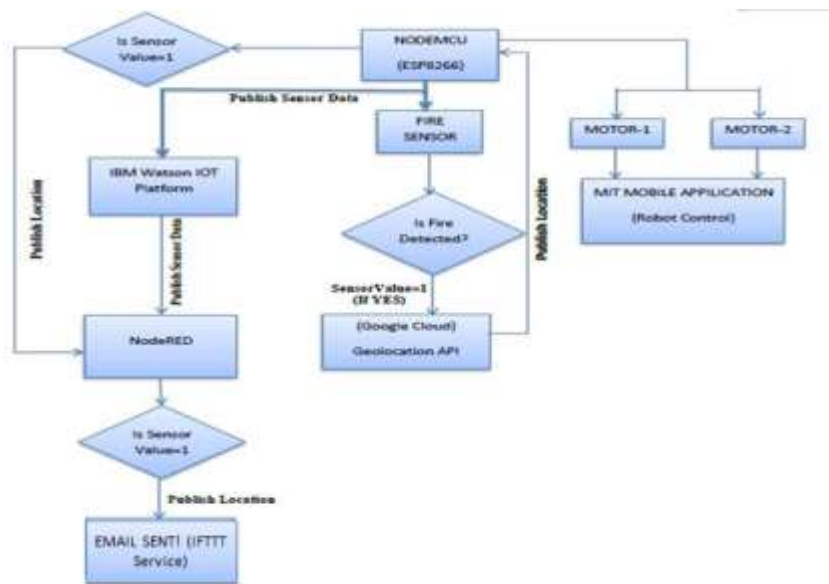


Fig. 4(b): Flow chart for Fire Detection and Tracking without GPS.

IV. RESULTS AND DISCUSSION



Fig. 5: Fire Input

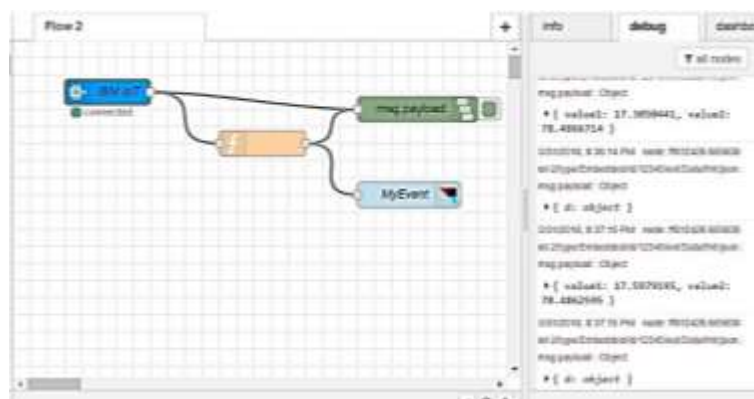


Fig.6: Output on Node-RED Platform.

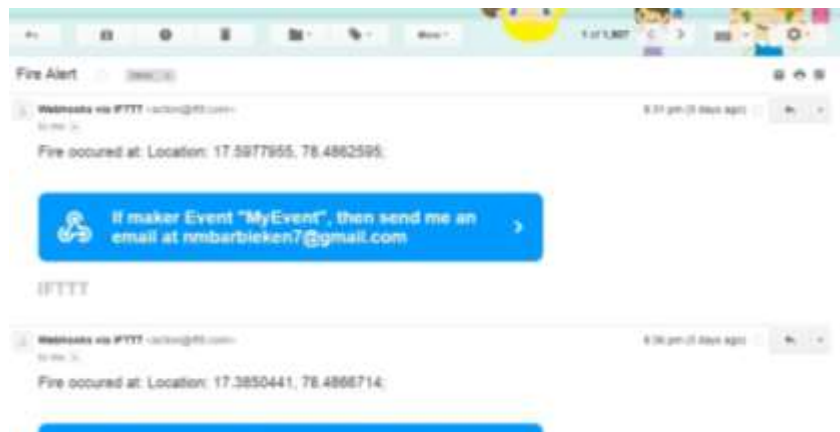


Fig. 7 :E-Mail Notification (GMAIL).

When a Fire input is given to the fire sensor, the Node-MCU publishes the co-ordinates to the Node-RED Platform, shown in Fig. 6. and were mailed to the registered account, as shown in Fig. 7. The co-ordinates displayed are as follows:

LATITUDE: 17.5977955

LONGITUDE: 78.4862595

ACCURACY: 45%

Upon further analysis, the location of fire detected was 100m away from the actual location, as displayed in Fig. 8. The accuracy may vary depending on the number of cell towers or routers surrounding the device.



Fig. 8: Mapped co-ordinates.

V. FUTURE SCOPE

With Advents in Satellite/Wireless communications, the project can be upgraded and implemented in vast areas or on a global level, where lives in the outskirts/Urban areas, facing frequent Fire Accidents can be saved in the earliest way. In order to increase the correctness of the detection of fire, highly accurate sensors, camera modules, high speed wireless communication and other peripherals can be used. With the progress in the researches focusing on Long ranges of communication, notifying the help centers situated at longer distances, surrounding the affected area can be possible in lesser time and with the equipment at minimum costs. The above design can also be embedded into Unmanned Aerial Vehicles which can be used for monitoring and surveying purposes, and also at the same time as lifesaving vehicles in future.

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