

# Outdoor Localization of Robot with RSSI for Iot Connected Smart Devices



Rajesh Singh, Anita Gehlot, Amit Kumar Thakur, Pradumna Mohan

**Abstract:** *Wireless sensor Technology has evolved as a true leader in the current era, surpassing the conventional wired technology. It gains over the conventional wired technology in respect of being more efficient and robust. In order to confine and transmit the data to the specified destination, Wireless sensor technology has shown its mettle to do things at great ease. Thus the door to the area of all future research related to localization system and various technologies have opened. So to identify the location of the data is of prime importance as the essence lies in the fact that from where the data has been collected. Spotting the sensor nodes using suitable algorithm is commonly termed as localization, which is a fascinating area of interest in the field of research and many researchers have carried out their exhaustive work in this area. In order to match up with the pace of the fast evolving technologies, it is the utmost need to develop and design a low-cost, highly efficient localization technique for wireless sensor technologies.*

**Key words:** Algorithm, localization system, sensor nodes, Wireless sensor

## I. INTRODUCTION

The development in the sensor technology has given rise to a very popular way of communication of trillions of sensors at a time through a network to offer efficient solutions for real time problems known as Internet of Things (IoT) and the network of these multiple sensors with base station is called Wireless Sensor Network (WSN). [1] Different algorithms and localization techniques are employed for the indoor and outdoor localization of IoT devices. Smartphone-Assisted Localization Algorithm (SALA) is an algorithm which uses smart phone as mobile beacon that can locate itself by sensor fusion method in the indoor environment [2]. Making sensors mobile can enhance the capabilities of the system to monitor the environmental parameters more efficiently and in a dynamically decentralized way. [3] Another modus operandi for a robot to guide to a desired location in indoor atmosphere is to bring into play the static nodes at strategic locations which will be communicating with the receiver at mobile robot with the help of ZigBee compliant RF modem (2.4 GHz IEEE 802.15.4). [4] Similar techniques can be used for outdoor localization using RSSI based algorithm and can acquire and analyze real time data in LABVIEW. [5].

In this paper we are discussing the RSSI based algorithm with static nodes communicating with the mobile robot using real time data acquisition and analysis. Information fusion SLAM (IF-SLAM) method specifically developed for simultaneous localization and mapping can be employed for Search and Rescue (SAR) environments

[6] Another technique to locate or control the path of mobile robot is using Internet. [7] There are various applications of this kind of localization which involves the fire extinguishing bot which can detect fire using wireless camera, flame sensors and the extinguishing of fire can be processed by sending a command from mobile phone. [8]

The another application of this is to monitor the plantation and relevant growing levels by robotic intervention and weed control in the field of agriculture. [9] Other ways to solve localization problem include use of cloud database which is having reference images of relevant location and road network map. Minimal on board hardware can recognize the location of mobile robot using RTI model and network-delay-compensation algorithm. [10] Similarly machine learning algorithms also can be employed by giving road network map images as learning data to machines for localization. [11] In dynamic scenarios MAS approach is used for localization. [12] Multi sensor data fusion playing vital role in localization requires fault tolerance. Multi sensor perception system is used for tolerating the faults without affecting the system. [13]

## II. HARDWARE DEVELOPMENT

There are multiple techniques to track and control the position of the mobile robot in outdoor environment. The following block diagram (Fig.1) shows the technique of tracking the location of a mobile robot in outdoor environments. The controller used in this block diagram is Genuino Nano which is powered by a 12V, 7A battery. But as the controller can only sustain input voltage of 5V, we are using a 5V regulator IC (7805) in between the controller and the Battery. The controller is connected with the different I/O devices such as LCD, GPS module and Node MCU Wi-Fi Modem (ESP 8266). The GPS module connected to track the position of the mobile robot in outdoor environments. The LCD is used to display the position of the robot and status of the current location of the robot. The robot is connected to IoT server using Wi-Fi modem which continuously communicates the site of the mobile robot with the server. The controller is connected to motor driver IC which is used to have power over the motors of the robot.

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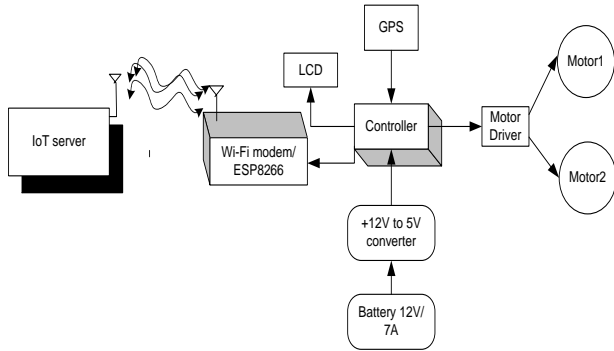
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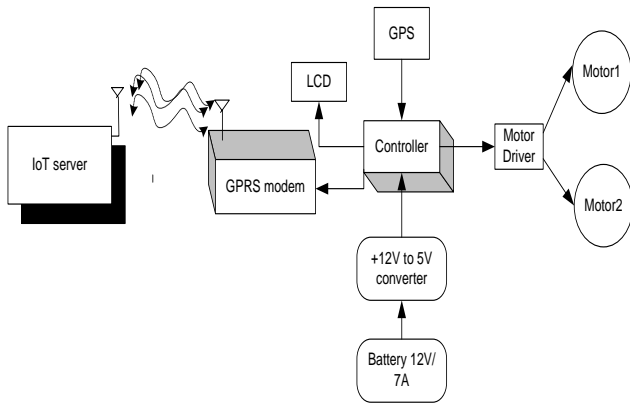
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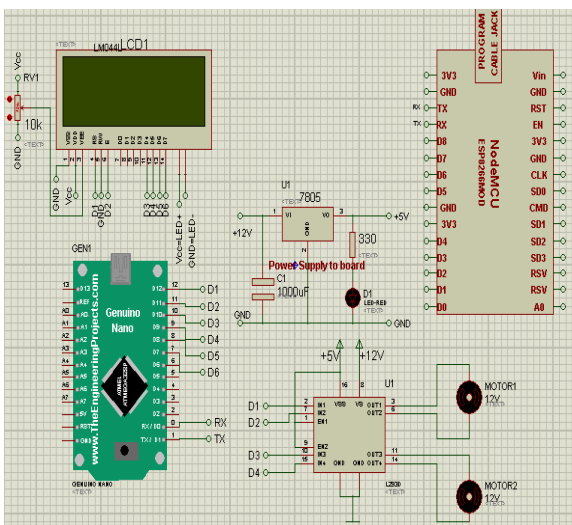
**Fig1. Mobile robot unit1 with ESP8266**

The next block diagram (Fig.2) also shows the block diagram for a mobile robot which is also connected to GPS but is communicating with sever through GPRS modem. This is nothing but another robot which is communicating its position with the first one. The two robots are continuously communicating their own positions with each other and maintaining the sync to accomplish a particular task in outdoor environments with localization technique.



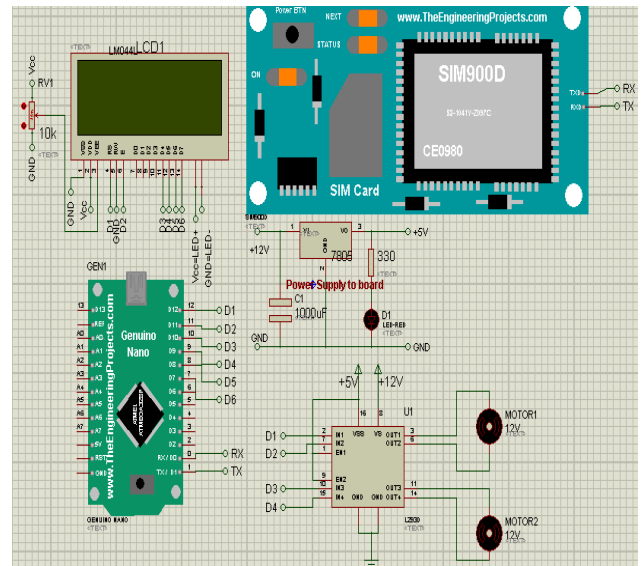
**Fig2. Mobile robot unit2 with GPRS**

The (Fig.3) & (Fig.4) are the Proteus models we have built for both the mobile robot unit 1 and mobile robot unit 2 respectively. In the first proteus model Rx and Tx pins of Node MCU ESP 8266 are connected with the TX and Rx pins of controller to communicate with the Wi-Fi protocol.



**Fig3. Schematics diagram of Mobile robot unit1 with ESP8266**

In the next model i.e. the model for mobile robot unit 2, we are using GPRS Modem (SIM900D) to communicate with the server. The models are also consisting the circuits for motor driver IC and also the voltage regulator circuitry along with the LCD display which is used to display the existing location of the mobile robot continuously.



**Fig4. Schematics diagram of Mobile robot unit2 with GSM/GPRS**

## III. COMPONENTS

**Node MCU (ESP8600):**Node MCU comprises of a firmware which effectively works on the ESP8266 Wi-Fi SoC from Espressif Systems and a hardware which is based on the ESP-12 module. Node MCU is considered to be an open source IoT platform. Node MCU can technically be referred as the firmware, and to a certain extent it can be called as development kits. The firmware uses the Lua scripting language as the mode of communication. The basis of firmware is the eLua project, which is built on the Espressif Non-OS SDK platform for ESP8266.

**SIM 900D :**SIM 900D is considered to be one the most reliable wireless module with added advantage of being compact in size. Due to its compactness, the benefits are huge and it is a complete Quad-band GSM/GPRS module in SMT type embedded with a very powerful single-chip processor integrating ARM926EJ-S core. Having its wide utility in the industry, SIM900D transports GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax consuming low power in a diminutive form factor. Bearing a minuscule configuration of 33mm x 33mm x 3 mm, SIM900D is very robust in filling up the space requirements in M2M applications.

## IV. SOFTWARE DEVELOPMENT

In this section the software design of the two robots is discussed with the help of the flowchart for program of both the mobile robot units, i.e. mobile robot unit 1 and mobile robot unit 2. At the start of the program we are initializing the LCD display, Serial communication, and also sensors through initializing commands and calling of header files for various sensors and modules attached to the controller.



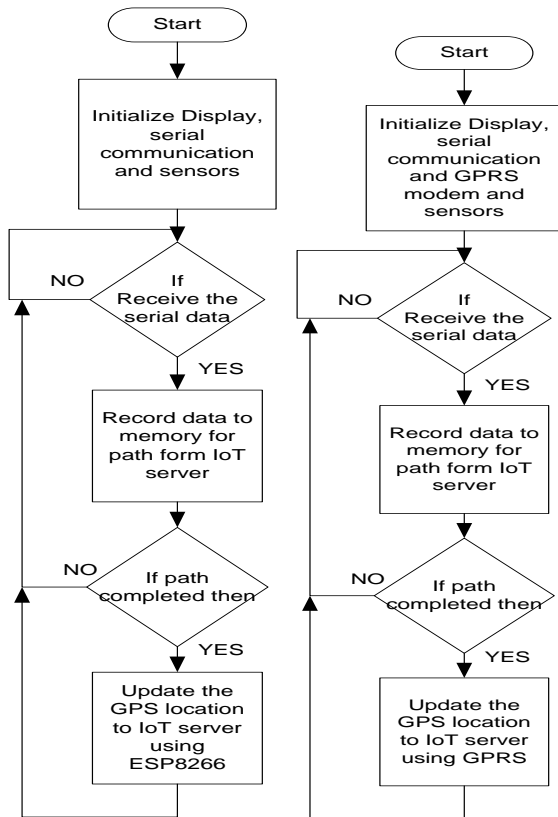
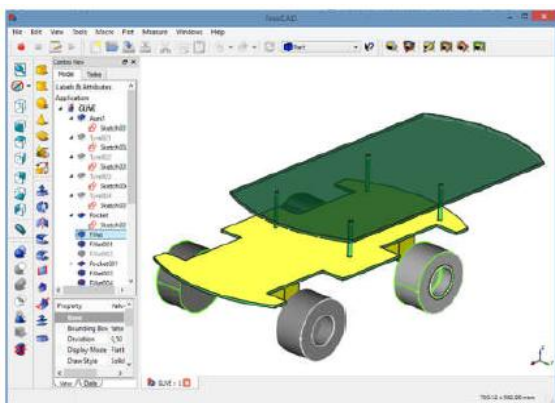


Fig5. Flow chart of Mobile robot unit1 with ESP8266 / Fig6. Flow chart of Mobile robot unit2 with GPRS

After initializing the different sensors and LCD display through LCD commands, the code will enter a loop where it will wait for the data to receive from IoT server which is continuously getting updated with the GPS locations from both the bots. As soon as the information is received from IoT server the path which is given by the server is amassed in the memory of the controller. The code will continuously check for the completion of the path. If the path is not completed it will repeat the above steps by remaining in the loop. If the path is completed then the robot will update its position and path to IoT server using GPRS Modem in case of mobile robot unit 2 and with the help of Wi-Fi modem in case of mobile robot unit 1 respectively. The codes are written in Arduino IDE platform which is very popular IDE for coding of all kinds of Arduino boards. In this way both the robots will be synchronized through IoT server and will localization goal is achieved using 2 Mobile robots.

V. FREECAD MODEL FOR MOBILE ROBOTS:



IV. RESULT AND DISCUSSION

A. Control Algorithms and Calculations

Control algorithm is developed under Arduino IDE (C Language). For operation, target (key) points should be manually entered by the programmer in two float precision array format, one for latitude and the other for longitude components. Thus, the size of each array is the number of key points. Before each test, the key points were selected in desired order by Google Earth (Figure below) saved as “kmz” file and converted to text file by a free online tool. The text formatted coordinates were then copied easily as corresponding array elements.



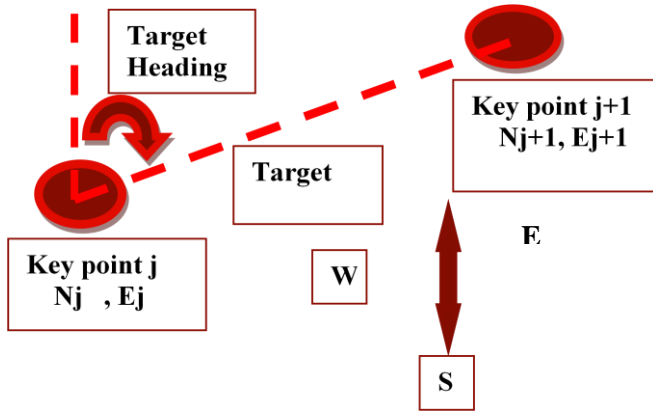
B. Finding Initial Location

Since the vehicle is randomly placed in the test field, the first duty is to find this unknown point. It is simply achieved by 60 seconds of static acquisition of GPS data. After 60 measurements, the average of the latitude and longitude components is assigned as initial point.

C. Movements between Key Points: Distance & heading calculations:

After determination of initial vehicle coordinate, the next step is to calculate the target heading and target distance to the next (and thus the first) key point. For calculation of these parameters, we have developed two main functions that require two coordinates (current and target) and thus four parameters as input. For target heading calculation, the ratio of the differences between target ( $N_{j+1}, E_{j+1}$ ) and current ( $N_j, E_j$ ) points are used. The target is defined as the angle between north and target point with origin considered as current point (Fig.6). That is, with  $\Delta N$  and  $\Delta E$  denoting the differences between north and east components, the target heading is calculated by: Target(heading)= $\text{del}(E)/\text{del}(N)$ . Depending on relative target position, target angle can take values from 0 to 359 degrees. Thus, the proper angle value is further achieved by considering the relative position in four quadrants principle. After calculation of target angle, the vehicle starts a clockwise rotation on its axis with half of its maximum speed. At the same time, the heading angle is updated by continuous acquisition of magnetometer data. As soon as the difference between the (calculated) target heading and (updated) current heading gets below 1 degree, the rotation stops. After heading adjustment, the next step of the control algorithm is to determine the forward movement duration, which requires the distance and velocity parameters.

For this, we first calculated the speed of the vehicle in forward movement mode, which was found to be 40 cm/s (1.45 km/s). The distance is the target distance and calculated by a second function that has the same inputs as target heading calculation function. As mentioned earlier, the 1 second changes in north-south and east-west direction were found to be 32m and 23 m, respectively.



## V. CONCLUSION AND FUTURE SCOPE

Unmanned vehicle control algorithm was developed via Arduino IDE and embedded to Arduino UNO (Genuino Nano). The GPS sensor and magnetometer are the key elements for detecting the location and orientation of the vehicle. The target heading and distance calculations within desired key points are independent of initial coordinate. However, the accuracy of the detected initial coordinate directly affects the consistency of these calculations since inaccurate detection yields wrong target heading and target distance parameters to the first key point. The vehicle's velocity determines the forward movement durations between key points and thus the algorithm should be updated (Eq. 4) for a different velocity. The performance of the control algorithm was satisfactory for future autonomous driving applications. Further studies may include obstacle detection and path update algorithms to be developed via Genuino Nano.

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## AUTHORS PROFILE



Dr. Rajesh Singh is currently associated with Lovely Professional University as Professor with more than fifteen years of experience in academics. He has been awarded as gold medalist in M.Tech and honors in his B.E. His area of expertise includes embedded systems, robotics, wireless sensor networks and Internet of Things. He has organized and conducted a number of workshops, summer internships and expert lectures for students as well as faculty. He has twenty three patents in his account. He has published around hundred research papers in referred journals/conferences.

Under his mentorship students have participated in national/international competitions including Texas competition in Delhi and Laureate award of excellence in robotics engineering in Spain. Twice in last four years he has been awarded with "certificate of appreciation" and "Best Researcher award- 2017" from University of Petroleum and Energy Studies for exemplary work. He got "certificate of appreciation" for mentoring the projects submitted to Texas Instruments Innovation challenge India design contest, from Texas Instruments, in 2015. He has been honored with young investigator award at the International Conference on Science and Information in 2012. He has published ten books in the area of Embedded Systems and Internet of Things with reputed publishers like CRC/Taylor & Francis, Narosa, GBS, IRP, NIPA and RI publication. He is editor to a special issue published by AISC book series, Springer with title "Intelligent Communication, Control and Devices"-2017 & 2018.



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Dr. Amit Thakur is currently associated with Lovely Professional University as Associate Professor with more than seventeen years of experience in academics and research. His area of expertise includes renewable energy resources and Robotics. He has organized and conducted a number of workshops, summer internships and expert lectures for students as well as faculty. He has published around eighteen research papers in referred journals/conferences. He is the Life member of The Indian Society for Technical Education (ISTE), faculty member of Society of Automotive Engineers (SAE), life member of The Aeronautical Society of India (AMeASI). He is the editorial board member and reviewer of various reputed journals. He successfully completed three week summer school programme on Environment at Tsinghua University, Beijing, China.



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