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Implementation of Geo-fencing to monitor a specific target using Point in Polygon Algorithm

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Abstract - *Geo-fence is a method in which we use GPS, RFID, Wi-Fi or cellular data to provoke an action whenever our device or RFID tag is inside or outside a virtual borderline. Some of the most common applications of Geo-Fence are in automation, management, security, and marketing. Some geo-fences are set for monitoring activity in safe areas, which allows the administrator to get notified or alerted when anyone enters or exits that specific area. In this project paper, we have demonstrated the use of Geo-Fence using NodeMCU. A virtual border or fence is created.*

***Key Words*: Geo-Fencing, Internet of Things, NodeMCU, ESP8266, Neo 6M, Location Based Services.**

1. INTRODUCTION

Security methods and navigators have continually become a necessity of a human's existence. The incidents of leading Radios have caused progressive changes in these fields. Equipment stealing is a harsh question in many corporations containing conveyance and building, exceptionally for more meaningful trades. There is no resolution in listening to the shift of the bus, and we mix up the current condition and position of the jeeps. The GPS - located car radio detection and ranging is an individual's ultimate understandable habits. The Global Positioning System (GPS) is a scheme that determines trustworthy part and period news always in some weather condition on dust. We are going to answer the site following question by utilizing GPS located listening whole accompanying a geo-swordsmanship wherewithal to path the bicycle. This arrangement covered any important parts that linked subsidiary ideas to ideas about the position of the automobile to a detached consumer. Geo-swordsmanship authorized detached listening of terrestrial districts among a in essence fence (geo-fence), and mechanical detections when it traced movable objects that filed or withdrew these extents.

2. LITERATURE REVIEW

The literature survey of some of the research papers referred is given in this section.

The paper [1] talks about the Geo-fencing infrastructure. Geo-Fence is a feature that makes use of Global Positioning System (GPS) or RFID i.e. radio frequency identification to create geo-boundaries. It entails both continuous location of the mobile device and continual matching of the mobile's position with a set of geo-fences. This paper talks about the Location based services (LBS), geofencing, its working and applications. LBS are mobile-phone-based services that take into consideration the device's geographic location. Information is provided by LBS. Because LBS are so reliant on the location of the mobile user, the major goal of the service provider's system is to figure out where the user is. Geo-fencing encircles a geographic area with GPS coordinates, and uses the location data of a mobile user to determine his or her proximity to that region. There are 2 types of Geo-Fencing namely Circular Geo-Fence and Polygonal Geo-Fence. In circular, a radius is decided and the circular area around a specific point is fenced. Whereas in a polygonal Geo-Fence, the latitude and longitude values are used to create the gro-fence. So, the basic idea of Geo-Fencing is explained in this paper along with some applications.

The paper [2] discusses the use of Geo-Fencing and Machine learning in tracking Covid-19 Patients. The aim of the proposed project was to control the pandemic on National and personal level. The role of geo-fence is to trace the user's location. Also the location of the people that have come in contact with the infected person. An App with inbuilt features of Geo-Fencing was created which created geo-fences around the user and people around him/her.

In the paper [3] the use of Geo-Fence in location tracking of vehicles is explained. The rate of vehicle theft is increasing day by day, and the problem is becoming worse. This system is designed for the protection of vehicles in an efficient way and economic way. A geo-Fence can be created in which the vehicle usually travels. And the location is tracked using the GPS module and is visible on the google map and Ubidots platform. So whenever the vehicle is out of the fence, the owner is notified and the action can be taken respectively. This will help the owner to track the location details of the vehicle and protect the vehicle.

A system to protect children from child maltreatment (CM) is proposed in the paper [4]. The issue is increasing rapidly in the 21st century. An application is made in which we can set the limit of the mobile user to a specific area. The location of the child is traced by the mobile phone GPS. Also some different modules lik communication and voice recording modules are introduced. Whenever the child is outside the

area set on the app, the parents are notified and a notification on the child's mobile is also displayed. Then the child can select I'm safe option if he/she is safe. This IT based application with geo-fencing techniques is introduced in this paper.

In paper [5] Victoria Bopearachchi proposes a novel strategy to track covid-19 patients using a GPS-based tracking system which can provide a live map of the patient's position. The suggested system includes an ESP8266-12E, a push button, battery and a NEO-6M GPS module. Through communication with satellites, the NEO-6M GPS module sends and receives signals carrying information on the user's location. Latitude and longitude information is read if nodemcu connected to Wi-Fi successfully; else, position coordinates are saved on the server. Real-time mapping of patients is also provided on a web application.

Supreeth SK et al. [6] proposes a system which uses a sensor network to track the whereabouts of animals in sanctuaries and national parks without causing harm to the animals. The proposed system uses sensors to detect animal positions. The sensed information is stored to the cloud server and also displayed on a LCD screen. The proposed system improved knowledge about animal ranges and ecosystems. But comes with some drawbacks like expensive High-end technologies.

G. Ramesh et al. [7] proposes a system to precisely pinpoint the animal's location inside that wide space. The proposed tracking system is based on GPS and the WIFI Module, which runs in real-time on the Arduino-ATmega328P. In the proposed system, the GPS module is used to get the coordinates. Through the Wi-Fi module the data is stored on the cloud. A web Application is created to receive the coordinates of location from the Wi-Fi module. When compared to other tracking technologies, the proposed system is fast and accurate method of determining the location of the animal.

According to [9] technology provides a high- security system that protects automobiles from being stolen. It also delivered an alert to the user depending on the location's boundaries by utilising the Internet of Things (IoT). In this investigation, the system could simply monitor and track the car's location and send an alert when the vehicle left the geo - fencing area. However [10] a similar kind of system is also used for the covid 19 patient monitoring, The system is divided into four levels, each with its own set of capabilities: wearable sensors, a cloud server layer, an IoT gateway layer, and a client application layer for viewing and analysis. The wearable sensors layer comprises of wearable biomedical and GPS sensors for physiological metrics, as well as GPS and Wi-Fi Received Signal Quality Indicator collection for healthcare applications and user Geo-fencing. Also this kind of system are also being tried to put their application in wildlife monitoring domain [8] the authors concentrate on three types of animal monitoring applications: position tracking, ecosystem environment observation, and behavioral patterns identification.

3. PROPOSED WORK

The project is creating a Geo-Fence using NodeMCU and GPS module. It creates a virtual boundary or fence that covers a physical area. It creates a wall between that area and the outside environment. But geo-Fence is not like a physical fence, it can detect the movement of the object or body within the fence only. In this project, we used the polygonal Geo-fencing technique. The objectives of the project will be like to track the target location, to display the target location on Google Maps, to give target status i.e. Inside or Outside geo-fence, to Alarm with buzzer and LED light when the target is outside. The hardware needed for the proposed system will be Node MCU, GPS module- Neo 6M, LIPO Battery.

The most important task in geo-fence is deciding whether the object is inside or outside the virtual fence we created. The fence can be of any shape. For example figure 1. This problem is solved by assuming that the fence is of polygonal shape. Considering this we chose this algorithm.

Let's suppose that the shape of the fence is of N dimensions. The coordinates of all the vertices are given as Vn (Xn, Yn) format. The coordinate of target point is given by T (Xt, Yt). In this algorithm, the sum of angles between the consecutive lines which are drawn from the tracking point to vertices is the deciding factor that will decide whether the target point is within or outside the fence. The sum can be taken clockwise or anticlockwise.

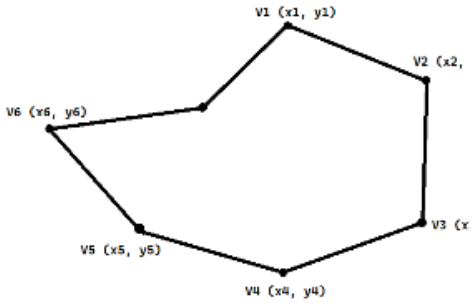

Fig-1: Point-in-Polygon

The steps for calculating the angle between the two coordinates are given below. The dot product of two vectors (|a.b|) = |a|.|b|.cos(θ). Here, 'a' is the vector from tracking point to vertex 1 and b is the vector from tracking point to vertex 2.

$$a = (x1 - xt)i + (y1 - yt)j$$

$$b = (x2 - xt)i + (y2 - yt)j$$

From dot point we can write,

$$\theta = 〖\cos〗^{(-1)} ((|a.b|)/(|a| .|b|))$$

In this way, we can find all the angles between all the consecutive points.

The flowchart below shows the steps of the algorithm. If the addition of all the angles is equal to 360 then the target is inside the fence and if not, then the target is outside the fence.

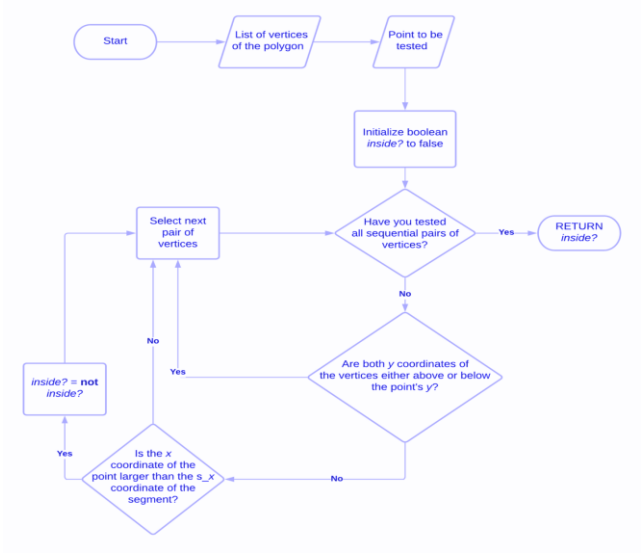

Fig-2: Flowchart of point-in-polygon algorithm.

- θ_sum = θ_1+ θ_2 + θ_3 +... + θ_n = 360

  Target position is inside

- θ_sum = θ_1+ θ_2 + θ_3 +... + θ_n ≠ 360

  Target position is outside.

The sample geo-fence is created using Google Map for getting the coordinates points latitude and longitude values. By using these values, we'll make a virtual geo-fence for the system. Here, we've created my geo-fence using 8 coordinate points.

The target status will be inside if the location is within these coordinate points and vice versa. Our system will verify the location of the device using a GPS module and display the output on the server we created.

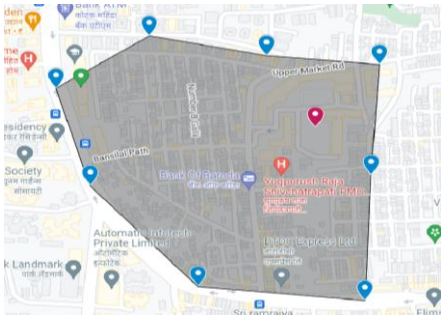

Fig-3: Geo-Fence image.

We used Node MCU for controlling the system. The Neo 6M module was used for tracking the location. A LIPO Battery with Charging and Discharging IC is connected to the controller.

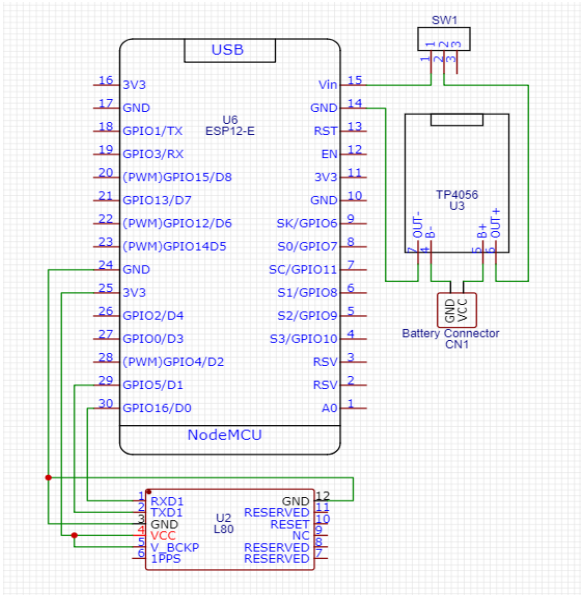

Fig-4: Circuit Diagram

Various libraries were imported like TinyGPS++, ESP8266WebServer, WifiClient, etc for the project. An array was created first for storing the latitude and longitude values of the coordinates. Once the GPS turns on and is connected to the Node MCU, the location will be displayed on the web server which is created using HTML and CSS. Using this location, the point-in-polygon algorithm is applied and the target status can be given to the server. We've also interfaced a Buzzer and LED to the Node MCU. If the target status is outside, the buzzer we interfaced will make a sound and also the LED will glow for a time duration.

4. RESULT AND DISCUSSION

The location of the target is tracked and displayed on the web server created. The parameters like Latitude, Longitude, No. of sats and the target Status are displayed on the server. Also we can check the current location of the device on Google Maps. The below image illustrates the web server.

Fig-5: Web Server

The results of this project show that the system developed gives many advantages and benefits to the user. In the end, this project proved its effectiveness as it provided approximately 95% location accuracy compared to the actual card on the mobile phone.

5. APPLICATION

The designed system is flexible to implement on any of the below applications.

1. Cattle grazing management
2. Vehicle theft Control
3. Child Safety
4. Geo-fencing in agriculture.
5. Geo-fencing in the forest

6. CONCLUSIONS

The designed system provides accurate status of the target device by using various communication technologies like hardware and software systems. The position of the device was also displayed on the web server and the Target of the device was displayed. The system can help in various fields.

This system has been tried out in various conditions and gives accurate results. It can be used for location tracking. Geo-fencing shows maximum security results when coming or going out of the virtual zone. The GPS-based geo-fencing location tracking system has been successfully built. However, this system can be made more powerful by using a more precise GPS unit.

The proposed system is successfully developed with precise design, flexibility and customizable.

7. FUTURE SCOPE

System can be further modified to use a more precise GPS module for getting a more accurate location. A mobile application can be designed to make the location details available on it and actions can be taken accordingly. According to the application, we can add features required to the system.

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