Smart Approach for Finding Indoor Navigation Using BLE for Visually Impaired Person

Miss. Kalyani Mule
Department of Computer Engineering
Late G.N.Sapkal College Of Engineering,
Nashik,India

Prof. J. V. Shinde
Department of Computer Engineering
Late G. N. Sapkal College Of Engineering,
Nashik,India

Abstract

In day to day life, the problems faced by the visually impaired persons are increases due to the huge growth in urbanization in cities. Even normal person also gets confuse sometimes if they come across to the new locations, to handle this problem, in this paper, we have proposed a robust system which will gives help to user while navigating in huge complexes. This system uses BLE(bluetooth low energy) devices to communicate with the hardware present at user and then it will direct the route to the user. The process includes user interaction through voice for the input location after that system will find desired location of user by connecting the hardware to various BLE devices and depending upon the signal strengths from each BLE user will be get navigated. If the range of BLE devices get less than that means that user is going away from that BLE device and similarly if the range of particular device is getting increase then it means that user going towards the BLE device. Now to get accurate result we are implementing Three Dimensional Triangulation Technique where the hardware present at user will simultaneously connect with multiple BLE devices and then find the required route for navigation. Along with this we are providing IR(infra-red) SONAR sensors through which we can find any obstacle that comes between the user and its navigation. We have added buzzer and LED lights to notify the obstacle to others.

Index Terms— *Indoor navigation, BLE beacons technology for triangulation. Blind navigation, wayfinding, robotic navigation aid, pose estimation.*

I. Introduction

Indoor navigation technology is becoming practically available in different forms and quality. We cannot use GPS satellite technology to for indoor navigation and to reduce this problem we are using bluetooth low energy devices[1]. The global positioning system becomes major part of human life and every other person is dependent on the map for navigation. The first model of GPS has introduced in late 90’s. Today almost everyone has a device with positioning capabilities like a smartphone, tablet, GPS tracking device or a watch with built-in GPS. The GPS revolutionized outdoor positioning. Now 15 years later, the positioning technology goes indoor and new possibilities emerge for indoor use. Satellite-based positioning doesn’t work indoor, but other technological standards have emerged that make indoor positioning possible. Positioning indoor is more complicated than outdoor positioning using GPS because a certain infrastructure needs to be in place indoor. GPS signals don’t work indoors or in narrow streets as they tend to attenuate and scatter by roofs and walls. There is a common question that why anyone would even need a positioning system indoor. The answer lies within big buildings where some may spend enormous amount of time finding what they are looking for. Shopping centers, airports and museums are just some organizations where indoor positioning would bring great benefit to people. Can you just imagine that everybody would have an indoor map marked with their current position on a raspberry device? This would definitely revolutionize navigation indoor. Then, there are of course also benefits for organizations. With indoor positioning systems, organizations can deliver location-triggered content, location-based advertising and much more. Bluetooth Low Energy (BLE) signals from battery driven beacons are at the core of the indoor location technology. It’s one of the latest technologies that has emerged and become an industry standard available on most devices today. It uses so called BLE beacons (or iBeacons) that are inexpensive, small, have a long battery life and do not require an external energy source. The device detects the signal from the beacon and can calculate roughly the distance to the beacon and hence estimate the location. Geolocalization technologies have become an integral part of our daily lives thanks to the ubiquitousness of smartphones and GPS coverage. We use GPS powered services for requesting directions, sharing our location with friends and family, for giving context to photos and videos, and to trigger actions based on location. Reliable outdoor navigation is however one of the most beneficial applications of geolocalization technologies and providing a similar solution to indoor environments has been so far a long term goal. GPS is not a good choice for indoor localization because the walls and ceilings completely block the signal of the satellites employed by GPS. Moreover, the measurement error of GPS is too large for its usage in indoor environments where meters are significant and can place a user in the wrong room. Many technologies such as BLE (Bluetooth Low Energy), Wi-Fi and Electromagnetic Field have been tested to solve the indoor localization problem. Wi-Fi fingerprinting is known to provide accuracy of a few meters. However, it is a power-hungry protocol and access points are rarely deployed with the required geometry and density. In contrast, BLE has been designed to be a machine-to-machine energy efficient protocol, allowing devices with long battery lives, lower costs and maintenance.

II. Review of Literature

In the existing systems, we are having the navigation using the Depth Camera Sensor, using that depth camera continuous images are get captured and gets processed for the finding out the distances between user and obstacles or to navigate the user to desired location. But it has some serious drawback as the data collected from the camera has big size and it needs to process as well as that needs to compare with previous images to predict the output, this is not best possible solution available due hardware in capabilities in real world. Also the accuracy of camera images decreases during night or in foggy seasons, to overcome this major drawback in proposed system we have introduce BLE based navigation system. The existing systems uses 6-DOF pose estimation (PE) system. The Pose Estimation system has two graph SLAM processes to minimize the incremental pose error of the device. In these two steps initially, the floor plane is extracted from the 3D camera's point cloud and hence creating a landmark node into the graphical representation of for 6-DOF SLAM to reduce roll, pitch and Z errors. X. Qian and C. Ye has propose a new 3D object recognition method. The method segments a 3D point set into a number of planar patches and extracts the Inter-Plane Relationships (IPRs) for all patches. Based on the IPRs, the method determines the High Level Feature (HLF) for each patch. W. Burgard present an approach to simultaneous localization and mapping (SLAM) for RGB-D cameras like the Microsoft Kinect. Our system concurrently estimates the trajectory of a hand-held Kinect and generates a dense 3D model of the environment. G. Osborne present a robot-assisted wayfinding system for the visually impaired in structured indoor environments. The system consists of a mobile robotic guide and small passive RFID sensors embedded.

Existing system uses 3D-Camera's for continuous location and depth finding which is not feasible solution as the output may vary depending upon the lightning condition of indoor architecture and also it has the to calculate the location from processing the images which can errors due to the camera direction.

III. System Analysis

Street navigation systems that rely on Global Positioning System (GPS) satellites are used by many people every day. Unfortunately, this kind of technologies can only be used to navigate in open spaces and are not available indoors. It is because of this that indoor navigation techniques using Wi-Fi and Bluetooth signals, along with effective positioning algorithms, have been an object of study in recent years.

Ideally, deploying an indoor navigation system must be easy and cost effective. Most of the time, signals received from Wi-Fi devices present in a building are used as reference, however, these are not meant to be used for this purpose. It is because of this that other technologies better suited for indoor navigation, such as Bluetooth Low Energy (BLE), may be a good alternative.

BLE is a subsystem of the traditional Bluetooth technology capable of broadcasting data using a minimal amount of power. This makes it ideal for devices operating on small batteries which need to function uninterrupted for long periods of time. For the purpose of indoor navigation,

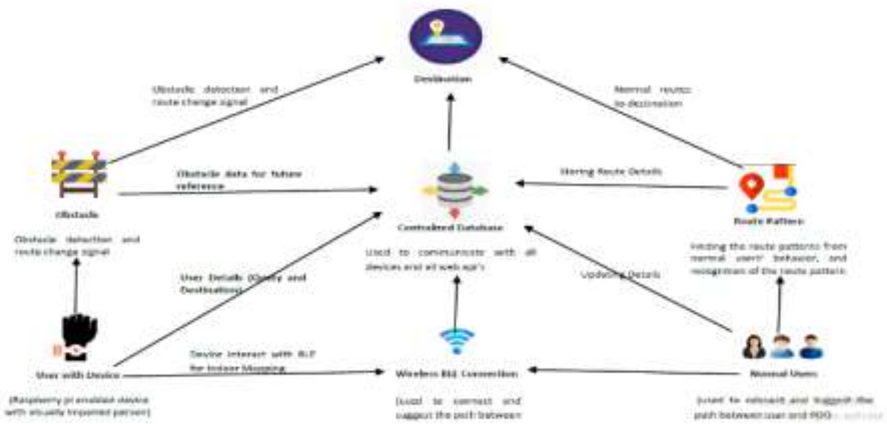

Fig. 1. System Architecture

BLE devices known as beacons seem to be the best choice. Beacons are small devices that broadcast packets of data in short time intervals. These packets contain information about the beacon, as well as telemetry readings commonly used in distance calculations. Raspberry Pi devices such as tablets and smartphones can be used to pick up BLE signals and read the broadcasted data, which in turn can be used on indoor navigation applications.

The popularity of beacons, as well as indoor positioning systems that rely on them, has increased notably during the last couple of years. Beacons are cheap when bought in large quantities and easy to set up. In addition to this, Apple and Google have developed dedicated beacon protocols which make managing and communicating with these an easy task.

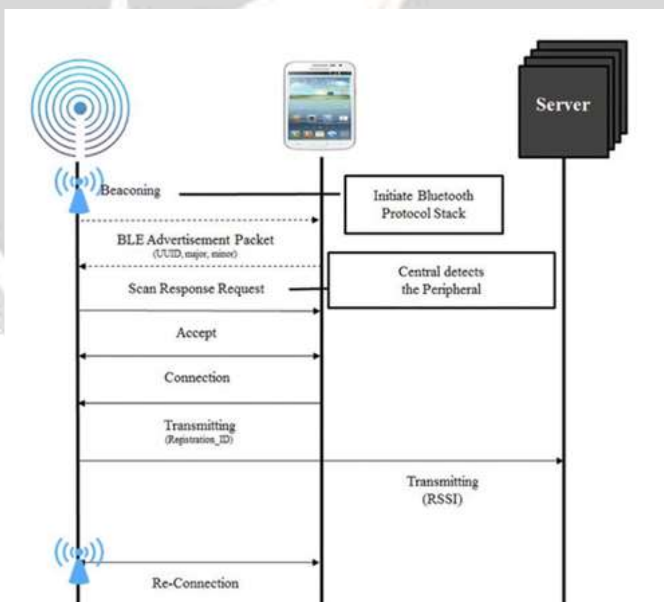

Fig. 2. Data Flow with beacon, user device, and server

For this project, an raspbian application that helps users navigate inside a building and receive contextual information, was developed. This application relies on information gathered from beacons and sensors integrated into the Raspberry Pi device to function. The main reason for developing this application is to better understand indoor navigation and show how smartphones can be used for this purpose. To evaluate the performance of the proposed 3-D positioning system, we perform the experiment with BLE beacons, smart phone, and server computers as shown in Figure. 2. It shows the signaling process among beacons, a user (smart phone), and a server to perform the proposed positioning system. In the experiment, the server draws and expresses a sphere, which is based on the measured beacons and shows the location of a moving user. RSSI is used to measure distances between a user device and a beacon. The server is implemented with script-based Node.js to provide accessibility and light-weight management for the beacons and raspbian data. The server has two functions. The first function is to express the measured beacon on the web screen, and the other is to show the actual location of a moving user in the expressed screen. The user device app is implemented with a smart phone using the raspbian OS. Since lower version of raspbian OS does not support BLE, we use a smart phone that supports the latest raspbian version. The user device can communicate with beacons through this app. Advertising packets, which are periodically transmitted by beacons, are scanned by the user's Raspberry Pi device. When the scanning process is completed, the device receives the request of a response and makes a connection with a beacon. In connection state, the proposed method in app measures the distance depending on the signal strength of the advertising packet.

In the actual implementation of the application, the user must be present in the range of at access point i.e. in it connected with BLE devices. Only then, his location can be determined. The actual implementation takes place in the following steps.

1. User is the location with BLE integrated complex.
2. Automatic voice input for the desired location after connecting with the BLE devices.
3. Once user input validated then system will process the path to navigate.
4. System will calculate the distance between each BLE device and user.
5. After user movement it will relocate the user current point using three-dimensional triangulation technique.
6. System will follow the step 4 and step 5 till user gets its desired location.
7. Meanwhile system is continuously recognizing the obstacle that comes in while navigating with the user.

IV. Algorithm

Algorithms 1: Fast SLAM Algorithm

Input: Current location from BLE.
Step 1: Extract from the environmental sensors characteristic points.
Step 2: Spike (Distances Measure Set from the beacon to the user location)
Step 3: RANSAC (Random Sampling Consensus- using k-NN verify distances)
Step 4: Scan-Matching (match with stored details)
Step 5: Geometric polygon extraction (Path / route mapping for specific location or point of interest POI)
Output;
Location distances of POIs from user current location.

Algorithms 2: k-NN Algorithm

In pattern recognition, the k-Nearest Neighbors algorithm (or k-NN for short) is a non-parametric method used for classification and regression. In both cases, the input consists of the k closest training examples in the feature space. The output depends on whether k-NN is used for classification or regression:

Step 1: In k-NN classification, the output is a class membership. An object is classified by a majority vote of its neighbors, with the object being assigned to the class most common among its k nearest neighbors (k is a positive integer, typically small). If k = 1, then the object is simply assigned to the class of that single nearest neighbor.

Step 2: In k-NN regression, the output is the property value for the object. This value is the average of the values of its k nearest neighbors.

Step 3: k-NN is a type of instance-based learning where the function is only approximated locally and all computation is deferred until classification. It can be used to assign weight to the contributions of the neighbors, so that the nearer neighbors contribute more to the average than the more distant ones.

Step 4: The neighbors are taken from a set of objects for which the class (for k-NN classification) or the object property value (for k-NN regression) is known. This can be thought of as the training set for the algorithm, though no external training step is required.\\ Step 5: The k-NN algorithm is used to determine the nearest artifact from the user's location. The user's current RSSI values are queried and the current values are compared with the training set database. The k- nearest neighbor algorithm will be implemented on the training dataset to find the artifact having RSSI values nearest to the user's parameter.

VII. CONCLUSION

An indoor location-based control system that provides services by estimating user's indoor locations has been implemented in this study (First scenario). The system consists of a localization server, service-provision client and user application. The server estimates the location by using trilateration and COG calculation for the hexagonal indoor spaces. The service-provision client is an element that provides services based on the location information acquired with the webcam-based indoor monitoring program. The user application delivers the RSSI data to the server. By integrating communication technology with Bluetooth Beacons and the proposed system, a real time service similar to that offered by black boxes can be provided to users so that it will be helpful in avoiding disputes over navigation service or cost savings. A method that facilitates system extension in various indoor spaces by partitioning an indoor space into several hexagonal basic unit spaces was proposed as well. For the estimation of indoor locations, the trilateration and COG calculation based on the RSSIs of the Bluetooth signals in a WLAN environment were used. The characteristics of wireless signals were studied, followed by investigation of causes of inaccurate location estimations. The key to a robust localization system is the accuracy so that we have proposed a method that selects the target of trilateration within the hexagonal basic unit space to increase the accuracy. However, we found that the methods proposed through the experiments conducted here were insufficient to provide useful services as they did not provide an adequate level of accuracy. The implemented system provided an accuracy level of approx. 74\% when the margin of error was 1 m. The other 14\% were found to be far apart from the actual locations such that the accuracy can be improved up to 88\% if the system can estimate locations more precisely. Therefore, we propose using the technology based on the cumulative probability distribution. It is expected that the locations will converge to exact coordinates as the indoor location data piles up, dismissing the distant coordinates. The indoor location-based control systems with an increased accuracy will provide more useful services to the users. Providing an indoor navigation service to the people who cannot acquire any visual information due to visual impairment can be a good example. Thus providing location based information in raspbian application can provide batter experience to user. Location awareness in raspbian application can provide much value to smart phone for better user experience and productivity. In our project we implemented indoor navigation application for college campus. Since application uses Bluetooth Low Energy signals, therefore it consumes less battery power. In our project we have implemented more accurate cost efficient approach to indoor navigation.

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