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Smart Museum Design based on Indoor Localization

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Abstract –The current localization techniques heavily depend upon theGlobal Positioning System (GPS)technology. However, this technology has its limits in indoor locations. In places like malls and underground parking's, the GPS accuracy is greatly affected. Indoor localization requires higher accuracy and thus the use of GPS is not feasible in such scenarios. Smartphones contain multiple sensors and hardware such as GPS receivers, accelerometers, and gyroscope sensors. Moreover almost all the smartphones are equipped with Bluetooth and IEEE 802.11 connectivity. This paper explores the possibility of using the IEEE 802.11 signal strength and the Bluetooth signal strength combined with the smartphone sensors of the accelerometer to determine indoor location of the user.In this project, an indoor localization technique is proposed, for a scenario in a museum environment. Moreover after estimating the position, context based information will be provided to the user.

Keywords - *Indoor localization, Smartphone,Wi-Fi, RSSI.*

1. Introduction

In the past few years there has been a great advancement in localization systems. But these systems are only accurate in outdoor locations. The most prominent technology used in outdoor localization is the Global Positioning System. The GPS works on the basis of 'visibility' of the user. The user's smart phone must be in the range of the GPS satellites. Then only can the broadcast signal reach the satellite and the location can be identified. In places such as buildings and indoor facilities, GPS may be unavailable. Moreover GPS does not provide any knowledge of the user's location pertaining to a particular floor in an indoor facility.The limited range of GPS is not accurate to judge the persons location indoors. On an average, a person spends around 80% of time in indoor locations. There is a lot of demand to provide context based services to people. The peoples' demands for indoor location information are increasing. Today the size of building environments such as malls, airports and supermarkets has expanded to a great extent. Providing context based information to the user in such environments is highly beneficial. Indoor location knowledge can prove extremely useful in places such as hospitals and can aid the police,firefighters or rescue operation teams in completing indoor tasks. Thus an indoor positioning system can prove to be highly beneficial and has varied applications. Smartphones today contain various sensors and hardware which can be used for indoor localization. The signal strength of Wireless signals (Bluetooth& Wi-Fi) is used to determine the location of the user. The RSSI values of the Bluetooth and IEEE 802.11 access nodes can be combined with the sensor readings to determine the location of the user. The proposed system is based upon the fingerprinting technique. Initially in the training or the mapping phase, the RSSI values of candidate locations are recorded in the database. In the second phase the RSSI values are taken as input and using a suitable algorithm the approximate position of the user is determined.

In a museum scenario, the indoor location will be used to judge the proximity of the user to anartifact. The information of the artifact will be streamed live to the user's smartphone.

2. System Architecture

The system architecture has the following components. The database contains the trained dataset or the mapped values. The mobile application takes RSSI values from the Wi-Fi Access point and the Bluetooth Access points. The mobile application then sends them to the server. The server computes the nearest artifact and sends the artifact information to the application.

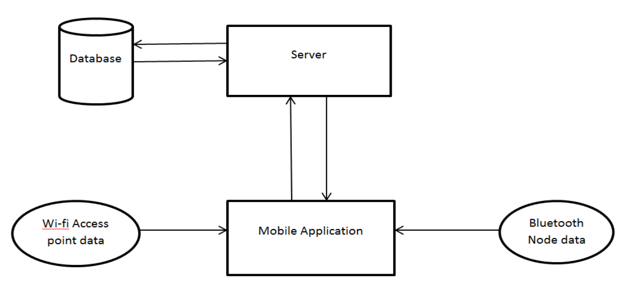

Fig 2.1 System architecture

2.1 Hardware Requirement

To employ Bluetooth beacons, we have proposed to use the Arduino Uno Bluetooth Module. Arduino is an open source computer hardware and Software Company, project and user community that designs and manufactures microcontroller based kits for building digital devices and interactive objects that can sense and control objects in the physical world.

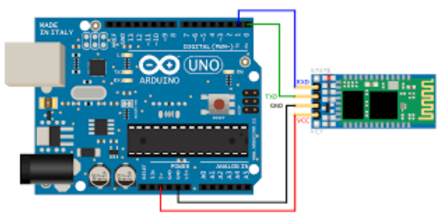

Fig 2.2Arduino board interfaced with Bluetooth Module

2.2 Software Requirements

- Java Development Kit (JDK) 7
- Android Development Toolkit (ADT)
- Java Runtime Environment (JRE) 6
- Android Debug Bridge (ADB)
- Android SDK
- Android SDK Manager

3. Proposed model for Application

To estimate the user's location, we have taken into account the Signal Strength of the Wi-Fi and Bluetooth Access points. The RSSI signal is used to indicate the power of the received radio signal. The smartphone identifies the name of the Access points and the RSSI value associated with it. Typically, the received signal strength indicator is a vendor dependent value. In a broader sense, higher the RSSI value, the stronger is the received signal strength. The smart museum system is based upon the fingerprinting technique. It consists of a training phase or amapping phase.

3.1 Training Phase

In the training phase,the artifact position in the museum is first identified. Accordingly, the RSSI values are monitored. RSSI values are highly fluctuating. Hence, during the training phase, the RSSI values will be recorded continuously for a fixed duration.The average of the recorded values will be calculated. This average value is considered to be ideal. The calculated average value will be stored in the database. Currently, we have proposed to use two Wi-Fi Access points and a Bluetooth Node.The database contains the values stored in the following tuple :(w1, w2, B ,ε)

(where w1- the RSSI value from the first Wi-Fi Access point, w2-the RSSI value from the second Wi-Fi Access point, B-RSSI - value from the Bluetooth Node and ε- the directional information obtained from the mobile sensors.)

3.2. Implementation

In the actual implementation of the application, the user must be present in the range of at least one access point. Only then, his location can be determined. The actual implementation takes place in the following steps.

- The user switches on the application from a device with Bluetooth and wireless receivers.
- The RSSI value of the user is retrievedcontinuously and is sent to the server. The server computes the location of the user using the training data set
- Information of the nearest artifact is sent back to the client application.

4. 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:

- 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.

- 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.

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. 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.

Important steps:

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.

5. Advantages and Disadvantages

Advantages:

- Implicitsystem: The user receives the artifact information implicitly.
- Additional hardware not required: The user does not require any external hardware. The location is estimated using the hardware present in smartphone itself.
- Can make use of available access points: The set-up is simple and already available access points can be used to determine the location.

Disadvantages:

- User smartphone must be Wi-Fi and Bluetooth enabled.
- The smartphone must always be in range of Wi-Fi or Bluetooth.

6. Future Scope

This system has a variety of applications in large buildings such as malls and airports. Context based information can be provided to the user accordingly.Currently the app is being developed for Android platform which can be then made available for Blackberry, iOS and
Windows.

7. Conclusions

We have studied various approaches to solve the problem of indoor positioning, and thus proposed an automated system for detecting user's location in indoor environments. By using Bluetooth and Wi-Fi routers, we have given a combined approach for effective indoor localization. The k-NN algorithm is used to find the location of the user by using Wi-Fi routers. This is done by obtaining a trained data set, which will be used to find the area in which the user is standing.

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