SPEECH BASED OBJECT TRACKING SYSTEM

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Abstract: - In daily life, we humans want to place things of importance, safely. Sometimes it is common for humans to forget the place of the object. We have proposed a system to track things, which consists of, a compact Bluetooth low energy (BLE) enabled module that can be attached to any object. The tracking module is linked to a mobile application through Bluetooth and enables the user to locate the objects using voice commands. The piezoelectric buzzer is attached to the target to indicate the location of the object. Multiple objects can be connected with the application and can be located using voice commands. Our system provides speech interface for finding various objects, and the use of semantic mapping to determine a single object with multiple name tags.

Key words: - Object tracking, Locating Object, Bluetooth Enabled Device, Android application, Smart Stock Verification System.

1. INTRODUCTION

In today's world, more and more sensors are becoming embedded in our environments to make our lives smarter. Systems designed to monitor the presence and movement of various objects in a given environment have been pivotal to the humans. In the current scenario, the primary mechanism for tracking objects in an environment involves the use of video surveillance systems. But without the deployment of a human operator to monitor the different objects around us, it is possible to track the presence and movement of objects using wireless technology [11].

There are many advantages of locating and tracking an object, in a variety of contexts such as monitoring the movement of luggage through an airport or a count check of various items in a warehouse. Sometimes, it is essential to use technology for stock management, quality management and checking in large factories and additionally, in case of emergency situations, to locate or alert workers when they are in the vicinity of moving machines. Currently, RFID which uses passive or active tags is the commonly used technique to track objects. But the RFID signal is disrupted by radio waves, and RFID sensors require extended configuration. When compared regarding cost, the Bluetooth module is much cheaper than the active RFID tags needed for indoor positioning [10]. Indoor Localization systems which use Wi-Fi tends to fall short of accuracy, and the cost of the setup is comparatively higher [10]. BLE (Bluetooth Enabled Device) has emerged as a technology to determine indoor and outdoor positions of a communicating device. Since automatic speech recognition systems have been on the rise in the present scenario, which adds the sophistication to use the machine by better interaction. Development in Human-Computer Interaction (HCI) needs the system to be user-friendly. Nowadays system like Alexa replaces personal assistant to do many assistantships with many applications. The intelligent object trackers add sophistications to the current scenario.

The field of object tracking has been extended to multiple objects using GPU processing, also has been deployed for tracking many sports personalities at a time. For instance, it may be used for capturing the reaction of multiple players like all fielders in cricket and all players in a football match at a specific example and sequence of instances may be quickly and accurately captured using parallel processing [14]. Interestingly the application in the object tracking field can be extended for tracking the mobile pattern of a person using his cell phone in a controlled environment using mobile application [9]. Continuing that, if the suspected persons are moving in an unauthorized place, an intruder alarm and an alert message has been activated [19]. In US patent filed in 2018, experimented with the system which displays multiple players in chronological and alphabetical order as well as record and replay the position of objects [18].

2. RELATED WORK

In our day to day life, we human often place things of importance in a safer place. Sometimes it is common for a human to forget where they kept it. It will be useful if we have a system to track the objects. This kind of application may be helpful in locating devices in warehouses and to track the moving objects, toys etc. Such type of object tracking systems are designed using an embedded target system with wireless technology such as Bluetooth, Wi-Fi, RFID, Infrared, IoT based systems are good [13, 15, 16]. The moving object also can be tracked and monitored continuously using video surveillance and image processing techniques [16, 17]. Some of the techniques and devices are discussed here. There are many systems exist by deploying Bluetooth technology for presence detection and identification, each using a different ow of control. For the location of objects, different sensors for indoor positioning and the peak relative received signal strength in a wireless environment (RSSI) value for localization alongside a WAN to collate the sensor data at a centralized server [1] have been used. A different concept has been tested by Fischer in their work "Bluetooth Indoor Localization System" [2]. In this work, to receive time differences, Bluetooth beacons were set up and time differences in the signals received were used to calculate position.

In some of the research work, Bluetooth technology was used along with RFID technology Real-Time Location Tracking [5]. These systems emphasize master-slave technique in an environment to create smaller regions called piconets and scatternets. The fixed devices in the environment are operated as the master units where each of the master units controls its slave units in the area. Some systems build tracking system using technology [8]. These kinds of system need a dedicated computer which runs the location determination algorithm emphasizes on WITS server to track an object using wireless fidelity. The server is capable of receiving tracking requests from WITS client. After receiving a request, it estimates its real-time location using tracking algorithm and returns the location information back to WITS client. For simplicity, the WITS client is installed in the user's mobile device. The received signal strength sends a tracking request to the WITS server and shows the estimated location on the map after receiving a reply from WITS server. As an additional provision, the WITS client can also register in the server that wants to. Furthermore, existing Bluetooth based object tracking system includes Chipola - a key ring style attachment for objects [6], Tile - a small square tracker capable of being stuck to objects and StickNFind - smallest IoT device which can be attached to other objects [20, 21]. Machine learning has also been employed for the object localization purpose" [3], where the machine learning/neural networks techniques are adopted along with RSSI values to know the user's position. Unsupervised machine learning has also been used for localization of objects based on Bluetooth. Now under the Global Positioning System Technology, the Android Mobile Phones [4], uses Transport Layer Security and GPS for localization purposes in the case 1 of road accidents. Machine learning also has been used to analyze the image and tracking a specific object/person. The system gets trained with images of a person/object and appropriately provide the location information [12]. Chipolo is a keyring style attachment for objects [5]. This system enables the user to attach this device to anything like a laptop case, keys or even with a pet (essentially any target system that can have a keyring hanging of it) and register it with the app. Once registered, the user can locate the object via Bluetooth using android or iOS phone. The application helps to locate the target and shows the distance and temperature of the object. Tile is a tiny tracker with many unique features to be attached to the destination device. Tile is used to find any equipment within 150 feet of mobile phone and may link to another mobile which has Tile application and search in the range of that phone too. That way the link proceeds. The disadvantages are the Tile works only with iOS and the battery isn't replaceable [10]. StickNFind is the smallest device if IOT which is small in size and comes with an adhesive side. StickNFind uses radar-style view and alerts the owner when he moves far away. Light and Sound makes the system detectable. The system is powered by a replaceable battery which may be used in wrist watches [11].

3. SYSTEM ARCHITECTURE

This application is aimed to locate the lost things and to ease stock verification, which has to be carried out frequently and periodically. There are many different technologies available for this job such as Wi-Fi, ultrawideband and IoT based tracking. Among these technologies, Bluetooth based monitoring is usually less expensive to deploy, and all smartphones can receive Bluetooth signals. In this paper, a Bluetooth Enabled Low Energy (BLE) device has to be attached to any device that has to be tracked. The system consists of many beacons that serve as fixed references, and a smartphone has been used as a searching agent. Results show that the system can locate any device in seconds. The number of objects connected to the phone is theoretically not limited, whereas the time delay to search an object increases in milliseconds as the number of bound devices increases.

The different objects in a given environment are linked to the mobile application through their Bluetooth modules, and all the Bluetooth modules in the environment are mounted on an Arduino Uno which is in turn attached to the object. The Bluetooth module, Arduino along with the piezoelectric buzzer is known as the object tracker.

Each Bluetooth module is identified with a name for the searching purpose. A separate mapping table is created for the list of Bluetooth modules associated with the objects along with their names. Hence, whenever the user wants to search for a particular object in the environment, he speaks the name of the object to be searched search for. The speech is converted to text, and the object's name is searched for in the mapping table for a match. The user can utter a synonym of that object too. We have semantically mapped one particular object to many identification tags. While registering for an object, the user has to provide allied names of that object. If a match is found, the MAC address of the Bluetooth module associated with the object is retrieved and using button automation; a pairing request is sent to that module. When the mobile and the Bluetooth module are paired, the piezoelectric buzzer at the object's end starts emitting the beacon signal. If the user has found the object, the user can stop the buzzing by just speaking the word 'stop'. Hence, the system is designed in such a way that whenever the user speaks through the communication module of the mobile application, the Bluetooth piezoelectric buzzer at the object's end beeps or stops beeping based on whatever the user has spoken. i.e. if the user has spoken the object's name and the object exists in the environment, then the piezoelectric buzzer at the object's end starts beeping or if the user has spoken 'stop', the beeping sound stops. The user can know an object's position just by speaking the name of the object to the Android mobile, as the Bluetooth HC-05 module allows our target to communicate with the smartphone.

4. DESIGN AND IMPLEMENTATION

To develop a system which is aimed to locate any valuable item, by attaching a tiny embedded system on it. In this work, we have developed a small, compact Bluetooth enabled the device that can be connected to any valuable items. With the mobile application, the target system can be located in seconds by ringing. The specialty of our device is we made the system to be interactive so that voice commands may be added and dynamic, so may be attached to any object and reconnect it with another one. The system enables to register with the allied names of an object. Bluetooth enabled low energy device has been used to construct this system.

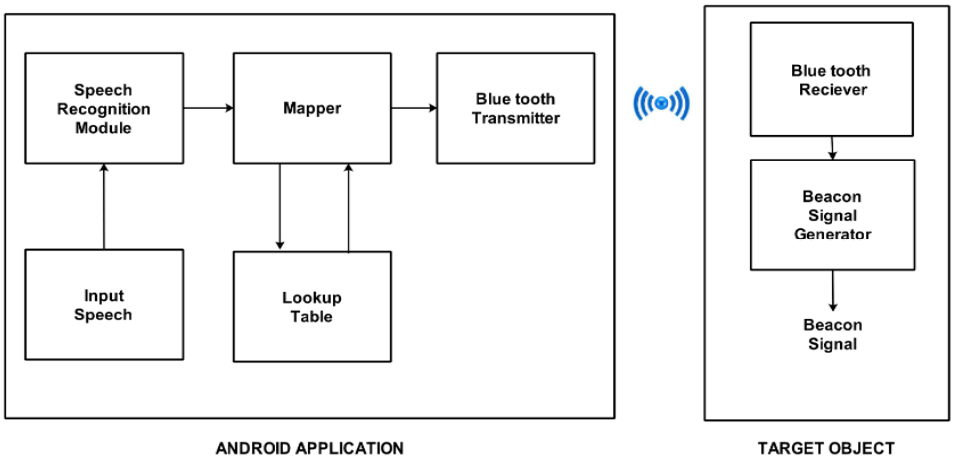

Figure 1. System Design

The system is proposed to track any device using Bluetooth enabled android mobile. The application will be installed in the Android phone, and the hardware component is attached to the object. This will enable the user to locate the devices through voice commands. The object name must be spoken to track the object. The spoken word will be converted to text using Google API and that text is mapped in the table with its corresponding tracker name, and the mac address is retrieved. Then the Bluetooth connection is established between the mobile and the object tracker. Once the Bluetooth is connected, the speaker will produce sound. This will enable the user to track the object. The system structure diagram shown in figure 1 depicts how the actual system works. The design of the proposed system has been implemented using the following modules.

- Speech Recognition Module
- Mapper

- Object Linker

4.1. SPEECH RECOGNITION MODULE

Speech recognition is the ability of a system to identify spoken words and convert them to a machine-understandable format. In our system, the speech recognition module used here is Google API to build speaker independent, vocabulary independent speech engine. Google APIs is a set of application programming interfaces (APIs) developed by Google which allows communication. Google builds an acoustical model, based on Google customer interaction. Hidden Markov Model (HMM) acts in the ASR technology block using acoustic models. Google API enables developers to convert speech to text by applying powerful neural network models in an easy to use API. An android application uses Google APT for Speech recognition, once speech is converted into text, the corresponding mac address is retrieved from mapping table and the connection got established. Whenever a user wants to track the object, the user can speak the object name which will be recognized by the Google API and converted to text. Google speech engine dynamically updates its acoustical and language model from time to time when additional users use these services.

4.2. MAPPER

Mapper is user-defined module used to map the keyword spoken with the respective Bluetooth module name. Look up table is referred each time when the voice command is given. The voice command is converted into text and using mapping table, the corresponding Bluetooth device mac address is returned to make the connection with the module of the tracker. The user can define multiple names for a single object. The names of a single object are kept in a list. The semantic mapping may be designed with automatic mapping to the different synonyms of the same object when it is registered. But we allowed the user to provide the synonyms, since it may be noun or nickname as per the user wish. When the system tries to map automatically, there may be the wrong synonyms. For instance, object key may get the semantic mapping to the solution, clue or lead etc. When the user defines the allied names to an object like puppy doll it may like puppy, dog, brownie as he wishes. A number of the allied name can increase the search time of an object, thus as of now we have fixed it as three but can be configured with more names. Table 1 shows how the objects are mapped to different Bluetooth modules. This effort is to make the system to be user-friendly. Now every object can be searched by object name, instead of the module name.

Table 1. Look up Table

OBJECT NAME (Every Object name/Synonym is attached with the allied names list)	BLUETOOTH MODULE NAME
Key	One
Wallet/Purse	Two
Document/File	Three
Specs/Spectacle	Four
ID card/Tag	Five
Pen drive/USB	Six

Look up table is referred each time when the user speaks out voice command. The corresponding row is retrieved, and the name of the Bluetooth module is sent to get paired with android mobile. The Bluetooth module comes with default name HC-05. We change the Bluetooth name for convenience using AT command [7].

4.3. OBJECT LINKER

This module is responsible for establishing a connection between the tracker and Android mobile. The object tracker is composed of Arduino UNO, Bluetooth module and speaker. When a voice command is given, the tracking app in mobile phone, the speech wave gets converted into text. The mapping modules map the text into mac address. Now the communication modules establish the connection with the tracker using Bluetooth API and mac address. The Bluetooth device emits Beacon signal which actuates speaker in the target. If the object is not found in the mapping table, an error message is displayed in the Android phone, and the user needs to try again. This module is actively available, listening for Bluetooth signal.

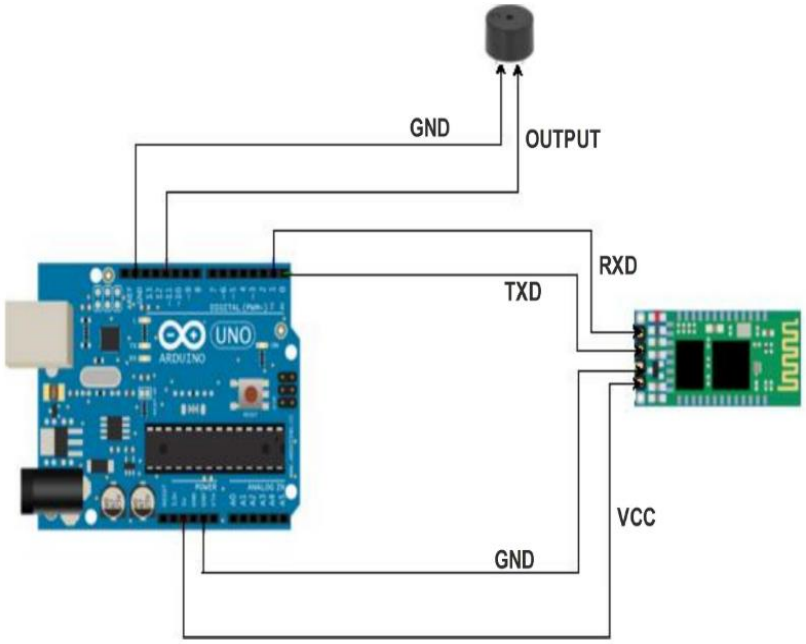

Figure 2. Connectivity Diagram

4.4. HARDWARE CONNECTION

The target system is designed with Arduino UNO, connected with Bluetooth transceiver. HC-05 Bluetooth module has a range of 9 meters, and it is relatively cheap. Fig 2 shows the connection diagram of Arduino UNO with Bluetooth module HC-05, speaker. Figure 3 shows the pin configuration of connection details.

4.5. RANGING AND SERIAL PROTOCOL

The HC-05 Bluetooth module covers 9 meters (30ft) of signals and works both as a master or as a slave. It communicates through serial communication. The HC-05 uses BLE technology standard for communication.

BLE is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices and building personal area networks (PANs). The Serial Port Protocol module 1 (SPP) is used to send and receive bursts of data between the mobile device and the Bluetooth module. This profile is based on ETSI 07.10 & RFCOMM protocol. It emulates a serial cable to provide a simple substitute for existing RS-232, including the familiar control signals. It is the basis for DUN, FAX, HSP and AVRCP. SPP maximum payload capacity is 128 bytes. Serial Port Profile defines how to set up virtual serial ports and connect two Bluetooth enabled devices. Since there is no restriction on the number of objects in this system, a given environment can have any number of objects within the given range. But all the objects in the environment should be within the range of the system. When the objects go out of range of the system; the mobile application finds difficulties in establishing communication with the Bluetooth module even though the user has spoken the name of the object he wants to find correctly.

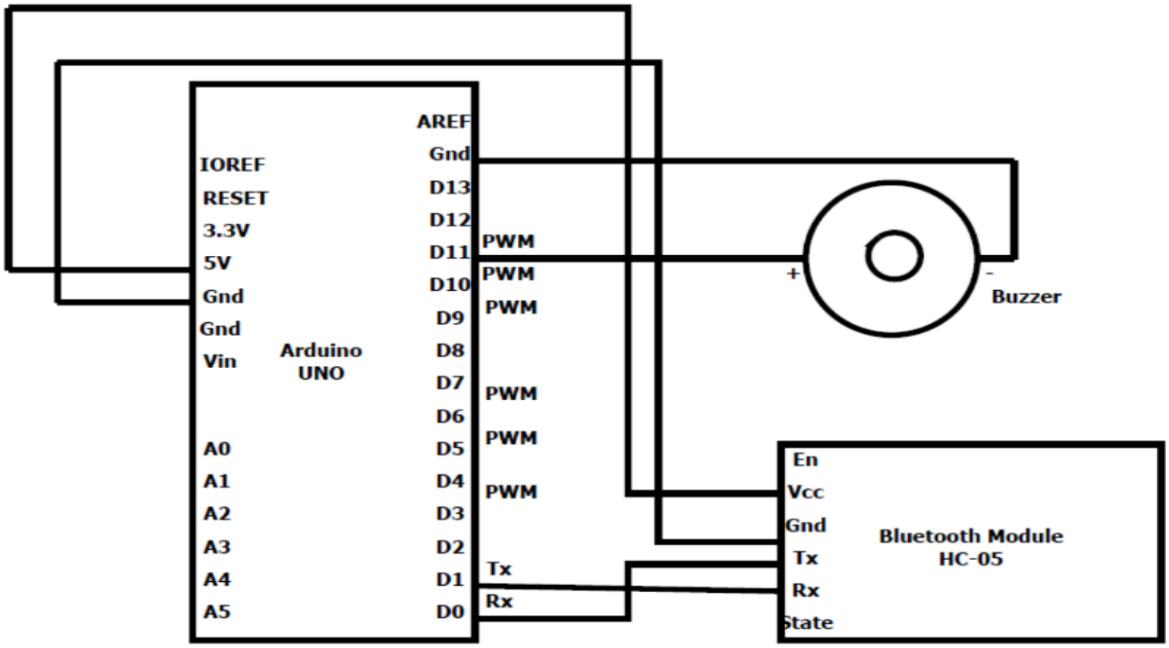

Figure 3. Pin Diagram

4.6. MOBILE APPLICATION

The mobile application is designed using Android Studio and the Android SDK. The Android SDK is setup and is checked if it is below the phone's operating system level. The required buttons are added in the primary activity, and the mapping table is created using JavaScript. Initially, all the Bluetooth modules associated with the objects are stored individually in the mapping table. If the mapping table containing the list of objects in an environment is maintained in the mobile application itself, keeping track of the total number of objects in the environment and appending the list will be more comfortable. Now, button automation is introduced to make sure that the mobile application checks the mapping table for the corresponding object and sends a pairing request automatically to the corresponding Bluetooth module after reading in the user's voice. Also, to stop the buzzing of the piezoelectric buzzer once the object has been found by the user a 'stop' button is designed in the mobile application. For speech recognition, Google Speech API is used, which is vital for recognizing the object which the user wants to search for. The mobile application is tested, and we arrive at an application with a communication module.

4.7. OBJECT LOCALIZATION USING SPEECH RECOGNITION

A mobile device's microphone can capture audio input or transmitted from a pre-recorded audio file. Multiple audio encodings are supported, including FLAC, AMR, PCMU and Linear-16. Hence, by exporting this API to the mobile application, we can achieve high levels of accuracy even in noise-prone environments which is beneficial to the user. Also, once the speech is recognized, the mapping table is used for finding out the concerned Bluetooth module associated with that object and a pairing request is sent to that Bluetooth module. Once, the module receives the pairing request, pairing is established automatically, and the piezoelectric buzzer starts buzzing. Hence, the API is integral in the mobile application used for speech recognition.

4.8. HARDWARE AND FIRMWARE

The hardware of the system consists of Arduino Uno's, Interface cable, HC 05Wireless Bluetooth RF Transceiver Module, Arduino compatible piezoelectric buzzers, batteries and connecting wires. The piezoelectric buzzers were mounted on the Arduino's to obtain the object's location accurately. The Arduino, piezoelectric buzzer and the Bluetooth module collectively are known as object tracker in this system. To keep the setup minimalistic, the connecting wires used are thin in length. The HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it an excellent solution for wireless communication. This serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and

baseband. It uses CSR Bluecore 04 External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). The module also has a typical 80 dBm sensitivity, programmable input /output and a UART interface with programmable baud rate. The unique ability of this module is to permit the pairing device by default.

5. RESULTS AND DISCUSSION

The objects were randomly arranged in a 20*20 room and tested for their response time once the user has spoken the object's name using any android phone.

5.1. RESPONSE TIME

The time taken to recognize the speech and map to mac address and the establishment of the connection to the appropriate tracker and getting a response from object tracker are the turnaround time of the process. This turnaround time is presented as response time in the following table. Speech recognition speed depends on the network speed. The proposed design can control the rest of the parameter. By assuming constant time for Speech to text conversion, the time taken for reaching an object is analyzed and presented here. From the above results, we can infer that the time is taken for each object to respond to the user's search request increases as the number of objects in the environment increases but the time taken to produce buzzing sound by the piezoelectric buzzer 1 is uniform. This is because of the deployment of good search algorithm when the search is performed in the mapping table to send a pairing request. Hence, as the number of objects increase, the system traverses through a greater number of objects to find the correct match.

The time complexity = O (n + e) + C

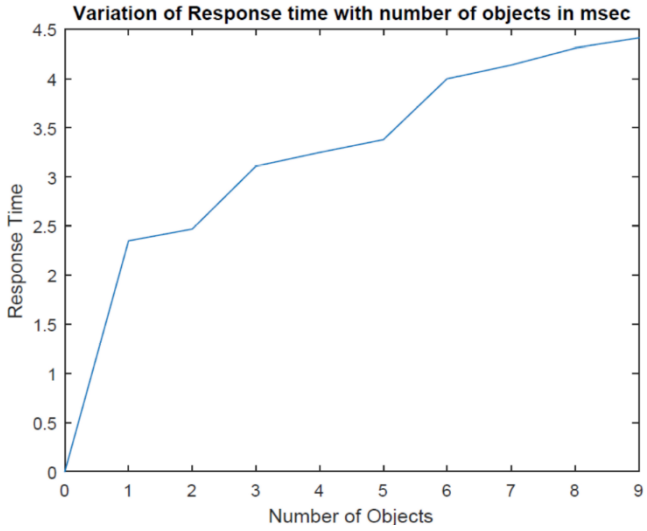

Figure 4. Response time of target object Vs number of objects connected to the application

Where n is the number of objects and e is the number of synonyms per object. The best-case efficiency of the system is 1, and the worst-case efficiency is n, where 'C' is assumed to be constant time (It varies depends on network speed, consumed by Speech Engine but it is not tunable by app). The experiments have been repeated by adding many modules and the response time is noted. The variation of time concerning many objects are plotted in the graph and shown in Figure 4.

Table 2. Response Time of Target (Considering 3 objects in search list)

NAME OF THE OBJECT	BLE MODULE	RESPONSE TIME
FILE (First Element)	1	2.31 Sec
POUCH (Second Element)	2	2.50 Sec
WATCH (Third Element)	3	3.10 sec

The table 2 shows the response time of the application in one instant when three objects are linked to the application. This system uses piezoelectric buzzer because it is a loudspeaker that uses piezoelectric effect for generating sound. The initial mechanical motion is created by applying a voltage to a piezoelectric material, and this motion is typically converted into audible sound using diaphragms and resonators. Compared to the other speaker designs, the piezoelectric speaker is relatively easy to drive. Usually, they operate well in the range of 1-5 kHz and up to 100 kHz in ultrasound applications. They are resistant to overloads that would typically destroy most high-frequency drivers, and they can be used without a crossover due to their electrical properties. Piezoelectric speakers can have extended high-frequency output, and this is useful in some specialized circumstances.

5.2. COST ANALYSIS

Regarding cost, when we compare all the existing systems with this system, the price is less as almost every person in today's world possesses a smartphone. So, only the Arduino and the Bluetooth modules constitute the cost of the whole system. The RFID sensors are expensive, and in the case of multiple objects, the cost of the system rises. The same problem arises when it comes to an Object tracking system using Wi-Fi as we need to use a Wi-Fi router. In some object tracking techniques, the deployment of a server to store object's location related data may be necessary. It again adds on to the cost of the system. Hence, this system is cheaper when compared to the other existing object tracking systems. At present, since there is no positioning service in Bluetooth technology, we used a simple technique used to find the position of the object in this work is the emission of sound from a piezoelectric buzzer at the object's end whenever the user has searched for an object.

6. CONCLUSIONS

The proposed system is built to make people convenient for searching objects. The objects are searched by giving voice-based commands so that user need not operate the phone much. Whenever user gives the voice command, it is converted to text and searched in the mapping table. If it is available in the table, it matches with the tracker name and connects to Bluetooth based on the mac address of the tracker. After the Bluetooth is connected, the data will be received, and the buzzer emits a noise which will enable the user to find the object. This can be used by anyone who often places things somewhere and faces difficulty in finding them.

Multiple users were allowed to test the system in different environments. Irrespective of the environment, the response time from each object i.e. the time is taken for the piezoelectric buzzer at the object's end to start buzzing was found to be very less. The system has a simple configuration and hardware setup and the cost of the entire system is very cheap as the system makes use of Bluetooth low energy modules and Arduinos. The system also can be extended a little for an inventory-based system for managing stock in medium and large-scale environments. Hence, this system provides a user-friendly object tracking method which has proved to be efficient in small-scale situations.

In future, if the system designed to have localized speech engine, so that the necessity of internet connection and delay 1 in connection with Android speech engine may overcome. An extension of this work would also be the management of objects using an inventory system wherein the inventory would be deployed in a cloud-based environment for the administrator to keep track of the stock related data. It would be a system where all the stock associated data are updated in the inventory by the administrator and any person handling the inventory system can search for stocks using voice commands. Accommodating Bluetooth low energy into such a system provides a stock management solution at a little cost.

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