A Bluetooth Based Local Positioning System

Ahuja, David Cooper, Andrew Hardy and Imran Kanji

Abstract --- **In this paper we present a new system for aiding blind students in finding their way around a university campus. The main idea is to use Bluetooth transmitters to indicate the current location of the portable electronic device of the user. The user would then input their desired destination using voice commands. The device then finds the best route to the destination and guides the user there using audio feedback. Transmitters placed throughout a building and a receiver integrated into a cell phone or PDA will allow the device to know its current location. The software used in the design consists of signal reception, voice recognition, path planning, and audio feedback.**

Index Terms -- **Bluetooth, Local Positioning System, Position Measurement, Radio Navigation**

I. Introduction

Local positioning systems are made up of a network of wireless devices that broadcast signals over an area of land. A receiver can be located anywhere within the coverage area of the network and would be able to determine its current location by comparing the received signal with a database which correlates the signals sent by the transmitters with a specific location. These systems can be implemented to help guide people unfamiliar with their surroundings around locations such as theme parks shopping malls and university campuses.

II. Conceptual Design/Methodology

A. Overall Design/Major Components

.The system consists of a receiver in the form of a cell phone or PDA as well as a network of transmitters placed throughout the coverage area. The user communicates with the receiver by using buttons as well as voice commands. The receiver uses information sent by the transmitters as well as a path finding algorithm. A block diagram of the design can be seen in fig. 1.

B. Transmitter Devices

The transmitter that has been chosen for the local positioning system is the BlueVOX-QFN it is manufactured by CSR [1]. These chips are a type two Bluetooth device with a maximum range of 10m [2] and are controlled using a RISC processor. These Bluetooth chips can be used to send a unique signal that can be received by any standard Bluetooth device. These chips will be wired into the power grid of each building on campus. Each transmitter or tag will broadcast a unique MAC address so that the receiver will be able to identify the transmitter it is currently receiving a signal from.

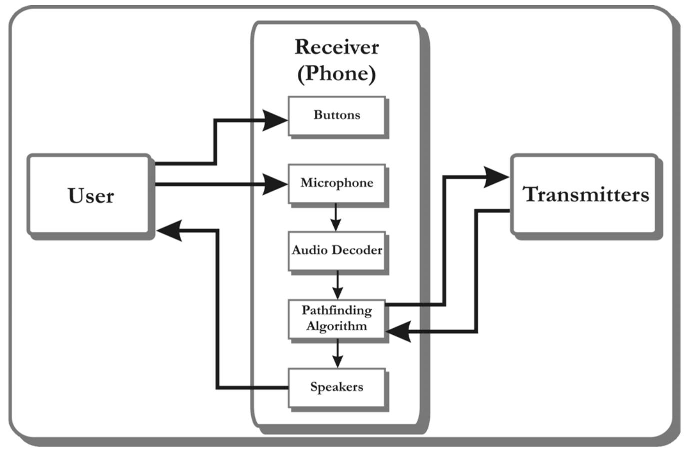

Figure 1: Block Diagram of Conceptual Design

C. Receiver Device

The receiver can be any Bluetooth enabled cellular phone or personal digital assistant that is capable of running programs coded using Sun Microsystems Java programming language. The specific library necessary to run the signal reception software for this system is the JSR-82 API which is part of the J2ME (Java to Micro Edition) Framework. The receiver must also be equipped with a microphone and speakers in order to implement the voice commands and audio feedback.

III. System Software

A. Signal Reception

Once the user begins running the program it will try to connect to any receivers in the area using the following java function: "LocalDevice.getLocalDevice().getDiscoveryAgent().startInquiry(DiscoveryAgent.GIAC,this)".

Once this is called the Media Control Access (MAC) Address of any transmitters in range are returned using the function "btDevice.getBluetoothAddress()". The receiver then searches through a database stored in memory in order to determine the current location of the user.

B. Voice Commands

Due to the fact that most real time voice recognition software is still fairly unreliable, for this design will use a voice comparison system. This system would require the user to provide a sample sound byte for several commands when they first begin using the system. Once that has been completed the user can repeat any of the pre-recorded commands and the system will compare the input with the recordings in the database.

Once a successful match has been made the software will be able to execute the desired command. A list of the voice commands used in the system is included below in table 1. In addition to those commands the system will also accept the numbers zero through nine as input so that the user can specify the room number they wish to travel to.

Table 1: Supported Voice Commands And Their Purpose

Keyword	Purpose
Yes	To answer questions
No	To answer questions
Location	To request current Location
Route	To request entire route
Room	To request directions to a room Followed by a number(s)
Exit	To request directions to an exit Followed by a number(s)
Hallways	To request directions to a hallway Followed by a number(s)
Pause	To pause and un-pause the program
Destination	To repeat the destination entered

Once the user has performed a voice input and a successful comparison has been made by the software the system will repeat the commands entered and ask the user for a "yes" or "no" confirmation that the correct command has been entered into the system. This implementation does not require a lot of memory on the cell phone to store the voice commands and has the benefit of providing a quick and accurate way for blind users to interface with the system.

C. Audio Feedback

Due to the fact that this system is being specifically designed for blind users it does not require a graphical user interface. Instead the user will be guided through the system operation by being given audio feedback when necessary. When the system is started it will begin by asking the user to input their desired destination. The software will then repeat the command it believes to be correct and ask the user for confirmation. The system will then update it current location as the user moves through the building and guide the user down the correct hallways and into the correct rooms by telling the user to turn left and right where appropriate. If the user misses a turn or for some other reason strays from the path provided by the program the program will recalculate the optimal path to the destination and inform the user to turn around.

D. Path Planning

The path planning algorithm used in this system has been developed using several widely used path finding algorithms [3]-[5]. It will basically begin by searching for the destination in the current hallway first; the program would sequentially check all connecting hallways. The algorithm will continue searching adjoining hallways until the destination node is located. Once this is done it will guide the user down the most direct path down the hallways towards the destination.

E. Signal Conflict Resolution

The user may cross through an area which is covered by multiple transmitters and therefore receive multiple signals. If this is the case, the system will check if at-least one of the multiple signals is on the current path. If it is, then the system guides the user as planned. If the user happens to enter an area were there is no signal coverage the system assumes they are still in the last transmitters range and does not provide directions until another signal is detected.

IV. Discussion

This system design has met or exceeded all of the criteria and constraints outlined in the design proposal and should be able to be easily implemented as a fully functioning navigation system for blind university students. One aspect of the system that could be improved upon that was not foreseen at the earlier stages of the design process is the fact that with the current implementation the system requires around eight seconds to receive the MAC addresses of the surrounding transmitters. This may cause a slight decrease in the accuracy of the system as the user could travel a long way in that time and the system may not indicate to the user the proper location to turn down a new hallway, for example. This problem could be worked out by further optimizing the java code to perform a quicker transmission alternately a update to the Java Bluetooth libraries could address this issue.

Acknowledgement

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References

[1] BlueVOX QFN Press release (February 12, 2007), CSR [Online]. Available: http://www.csr.com/pr/pr274.htm

[2] Bluetooth Basics (February 12, 2007), Bluetooth SIG [Online]. Available: http://www.bluetooth.com/Bluetooth/Learn/Basics/

[3] Dechter, Rina; Judea Pearl (1985). "Generalized best-first search strategies and the optimality af A*". Journal of the ACM 32 (3): pp. 505 - 536.

[4] Hart, P. E.; Nilsson, N. J.; Raphael, B. (1968). "A Formal Basis for the Heuristic Determination of Minimum Cost Paths". IEEE Transactions on Systems Science and Cybernetics SSC4 (2): pp. 100-107.B. Smith,

[5] A* Path Finding For Beginners, Patrick Lester (Updated July 18, 2005), visited, march 15 2007. Available: http://www.policyalmanac.org/games/aStarTutorial.htm