RESEARCH PROPOSAL

INVESTIGATION INTO WIRELESS LOCATION SERVICES AND AUTONOMOUS NAVIGATION USING THE LEGO™ NXT

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March 2, 2009

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1 Statement Of Problem

Recent research has been directed into the development of autonomous systems capable of navigation of autonomous vehicles in different environments. One of the major problems in the development of self navigating autonomous systems is the establishment of positional information for the said system [4]. This constraint has lead to a stunted growth of development in this area. Thus the demand is for dynamic methods of detection of positional information relation to a mobile device while stationary as well as in motions as well as for software that is capable of interpreting and using such information as data for an autonomous vehicle.

2 Research Objectives

Based on the above problem statement the following objectives are presented:

2.1 Primary Objectives.

- Investigate and develop a positioning system that can locate a small mobile device.

- Obtain acceptable accuracy with the above system.
- Design and program a small autonomous vehicle to use positional information for navigation purposes in a small scale environment.

2.2 Secondary Objectives or Future Works

- Implementation of object and obstruction traversal for the autonomous vehicle.
- Implement real-time positional tracking.

3 Background

3.1 Position Based Services

Recent studies have shown an interest in the development of position based services [4]. These systems are often used in large stores for the purpose of advertising and the proposal of real-time guidance systems [6]. With the increasing sophistication of wireless networking technologies there has been a significant increase in the inclusion of wireless technology in the infrastructure of networks[4].
One of the most popular methods of localization of wireless devices is triangulation using the Received signal Strength Indicator (RSSI) from 3 or more devices, giving a reasonably accurate relative position [6, 4]. GPS is effectively being used to locate automobiles in a outdoor setting, but most GPS devices can not receive signal indoors meaning alternate technologies need to be considered [4].
Mobile localization is the concept of tracking and keeping a ongoing estimation of the position of a mobile device [4] . With access to more powerful systems and better hardware there is a current push for the development of perfectly autonomous systems capable of self navigation [7].

3.2 The LEGO^{TM} NXT Intelligent Brick

The LEGO ^{TM}NXT contains a central processing unit that has been labeled by the designers as the Intelligent Brick and features a 32bit ARM7 micro-controller processor, 256K Flash Memory and 64K RAM memory both running at 48MHz [5]. The Intelligent Brick is also fitted with a embedded bluetooth device designed for interfacing with other bluetooth devices. The device can maintain up to three connections but can not support simultaneous data transfer from multiple sources [5].

3.3 Bluetooth

Blutooth is a universal radio based networking tool for small ad hoc networks and designed to provide an alternate to wired networks [1]. Operating in the 2.45 GHz frequency band that is license free and thus open for any device to use. Achieving a transmission rate of 1 Mb/s [3]. The protocol also utilizes

Gaussian frequency shift keying (GFSK) modulation using time-division duplex (TDD) schemes for full-duplex operation at 625 microsecond time frames [3].

4 Design Considerations and Implementation

4.1 Local Positioning System (LPS)

The wireless positioning system will be bluetooth based to take advantage of the the built in bluetooth V2.0 device in the intelligent Brick of the LEGO^{TM} NXT. The objective being to use several identical wireless bluetooth devices (referred to as beacons) to locate the NXT Brick and report the location of the Brick to a workstation. The system will be modeled on GPS.
Two implementations will be attempted, a workstation based localization system that uses the bluetooth beacons to locate the Brick and then relay that information back to a workstation and a Brick based system where the NXT intelligent brick itself preforms the localization using the built in microprocessor. The latter implementation being limited by the capabilities of the Intelligent Brick. Real Time tracking of the object movement will also be attempted.

4.2 Autonomous Navigation

A coordinate based location system needs to be developed for the LEGO^{TM}NXT that allows the unit to autonomously move from one specified location to another by the plotting and calculation of a trajectory vector. This can be combined with the above Local Positioning System to locate the NXT and then allow the calculation of a vector to another position relative to the bluetooth beacons.

4.3 Other Design Considerations

Different programming environments need to be assessed for this research. The proposed language for the development of any NXT based software is NQC or RobotC. JAVA while compatible with the NXT and having extensive bluetooth libraries is not recommended as JAVA applications exist at too high a level of abstraction to allow the access to the signal strength of any linked bluetooth devices [2].

5 Project Time-line

The following time-line is proposed as in Table 1

Table 1: Proposed time-line of project

Time Allowed	Activity
2 March 2009	Proposal Submitted
3 March 2009	Seminar Presentation
3 March - 3 April 2009 (4 weeks)	Reading of Literature and familiarization with the NXT
4 April - 1 May 2009 (4 weeks)	Coding and testing of LPS
4 May - 29 May 2009 (4 weeks)	Write literature review and design and build NXT robot
1 June 2009	Literature Review Due
1 June - 26 June 2009	Coding and testing of NXT navigation Software
26 June - 17th August 2009 (7 weeks)	Integration of LPS and navigation Software and Testing
17 August 2009	Start writing up thesis
17 - 21 August 2009 (1 week)	Code Inspection Week and evaluation of project
1 September 2009	Display Poster
14 September 2009	Submit First Draft Paper
21 September 2009	Submit Final Paper
28 September 2009	Submit first chapter drafts for thesis
2 November 2009	Seminar for completed project
9 November 2009	Hand in project

6 Possible Extensions

6.1 Local Positioning System

The implementation of real time positional tracking systems can be extended for the tracking of persons or devices around an indoor environment. For example a blind employee around a workplace can be warned of doors and static obstructions or the tracking of convicted criminals in a prison environment. LPS may have many implications in security. .

6.2 Autonomous Navigation

The proposed project here can be extended further by the addition of object traversal and recognition allowing the NXT to recognize different obstructions and try to traverse them. Generating new navigation information as it does so. Another possible extension is for the system to learn from instructions and in future avoid them entirely.

References

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