RESEARCH PROPOSAL
ARToolkit Based Robotic Direction With Visual Real Time Localization

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1 Statement Of Problem

Relaying of commands to robotic systems is often a complex and unintuitive task for users to understand, often requiring extensive training or tutorial. One such complication of commands for robotic systems is that such commands are often positionally context sensitive. The controller is required to know the location of any robotic system and be capable of issuing commands to the robotic system to achieve the desired task.

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 [2]. 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 motion as well as for software that is capable of interpreting and using such information as data for generation of commands and instructions for a robotic system.

2 Research Objectives

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

2.1 Primary Objectives.

- Investigate and develop a visual positioning system that can locate and track in real time small visual markers in three-dimensional space.
- 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.

3 Background

For this project and understanding of positional based systems and the LEGO^{TM} NXT will be required.

3.1 Position Based Systems

Recent studies have shown an interest in the development of position based services [2]. These systems are often used in large stores for the purpose of advertising and the proposal of real-time guidance systems [1]. 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[2].
One of the most popular methods of localization of wireless devices is latigation using the Received signal Strength Indicator (RSSI) from 3 or more devices, giving a reasonably accurate relative position [1, 2]. 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 [2]. Mobile localization is the concept of tracking and keeping a ongoing estimation of the position of a mobile device [2].

Another alternative is vision based triangulation using referential points. Visual localization using camera systems has become popular due to simplicity and the availability of camera technology [4]. By having multiple cameras a know distance away from each other a point can be mapped in 3 dimensional space, provided both cameras can detect it and have a suitable reference to compare it against [4]. Visual

technologies are already quickly replacing the traditional lazer and sonar sensors used for obstruction detection [4].

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 ARToolKit

The ARToolKit is a framework for creating augmented reality applications and includes computer vision algorithms for overlaying of three dimensional virtual objects on real markers. The ARToolKit is powerful enough not only to provide six dimensional but also offers support for multiple camera inputs with the intention of providing a good metaphor for a tangible interaction with the computer [3].

4 Design Considerations and Implementation

The proposed design is as follows:

4.1 Visual fiducial Marker Tracking

Two cameras will be employed to track the robot in a small environment. The cameras will track small fiducial markers on the LEGO^{TM} NXT as well as markers placed in the environment by the user. The markers need to be distinct and easily identified and will serve as the metaphor "preform indicated action here". The system needs to track each marker and relate the function of the marker. Certain markers will be used to track the robot, while others will be used to issue commands to the system, there needs to be a distinct difference between them.

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 position of fiducial markers.

4.3 Other Design Considerations

Different programming environments need to be assessed for this research. The proposed language for the development of this system is the C# or visual basic Microsoft robotics studio. The C++ ARToolKit can be wrapped into C# and used as a .NET service.

5 Project Time-line

The following time-line is proposed as in Table 1:

Table 1: Proposed time-line of project

Time Allowed	Activity
27 June 2009	Start Implementation of System
3 July 2009	Implemented Framework and Camera Input
10 July 2009	Interpretation of positional information of markers
17 July 2009	Integration of NXT into the system
24 July 2009	Vector path planning for NXT
24 July 2009	Submit work in progress paper
14 July 2009	Extensions to System and Testing
4 September 2009	Conclude Testing and begin Writing up
13 September 2009	Submit Full Paper
6 November 2009	Submit Completed Thesis

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. Local positioning systems 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.

6.3 Virtual Reality Control from generated Actual Realities

A possible extension exists of virtual reality based control of robotic systems, where commands to a virtual system are translated to commands in an actual environment. The challenge lies in the overlaying of the two realities.

References

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