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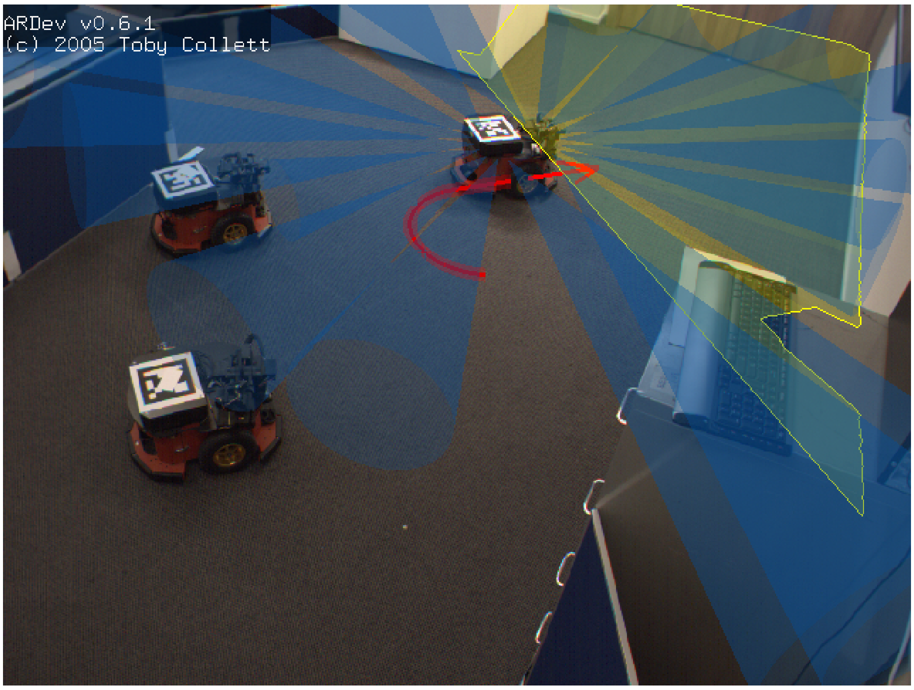

Augmented Reality Visualisation for Mobile Robot Developers

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Abstract

Developer interactions with robots during the testing and debugging phases of robot development are more complex than and distinct from general software application development. One of the primary differences is the need to understand the robot's view of the environment and the inconsistencies between this and the actual environment. Augmented reality (AR) provides an ideal way to achieve this, allowing robot program data to be displayed in context with the real world. This allows for easy comparison by the developer, highlighting the cause for any bugs in the robot behaviour. An AR debugging space is created in this work that allows the developer to have this enhanced understanding of the robot's world-view, thus improving developer efficiency.

Over the past decade robots have begun to move out of industrial assembly lines and into environments that must be shared with human users. Many of the tasks that we wish robots to perform in these environments require close interaction and collaboration with human users. The move away from the constrained environment of a production line means that the tasks required of robots are more varied, their operating environment is far more complex and unpredictable, and safety can no longer be achieved through isolation of the robot.

The result of these influences has been to change robot programming from a simple task of instructing the robot to perform a sequence of steps to an open ended challenge of specifying dynamic interactions that robot developers are still coming to terms with. Robot development is more than just design and code entry and a broader approach to improving robot development is needed. One of the founding principles of this thesis is that robot development should be approached as a human-robot interaction issue, this particularly applies to the testing and debugging phases of the development.

The nature of the robot platform, the tasks the robot is required to perform and the environments that robots work within are significantly different from those of the desktop application. Hence robot developers need a tailored tool chain that focuses on this unique combination of issues. Current robot programming research is dominated by robot APIs and frameworks, leaving support tools to be developed in an ad hoc manner by developers as features are required. This leads to disjointed tools that have minimal feature sets;

tools that generally have poor portability when applied to other robot developments. This work examines the needs of the developer in terms of a general purpose robot visualisation tool.

One of the fundamental requirements of a general purpose robot visualisation tool is that a set of stock visualisations must be available for the developer. A prerequisite to providing these is to have a set of standard interfaces to provide the visualisations for. The open source robot framework Player/Stage was used throughout this work to provide standardised access to robot hardware. As part of this research the author has contributed heavily to the Player/Stage project, particularly as one of the key developers of the 2.0 release of Player. This new release simplifies Player development and increases the ease of maintenance of Player drivers and the efficiency of the server core.

To evaluate the benefits of AR visualisation an intelligent debugging space was developed, which runs as a permanent installation in a robotic development lab providing an enhanced view of the robot's behaviour to the developer. The space is capable of automatically detecting the presence of robots and displaying visualisations of the standard interfaces of the robot, such as its sensors and effectors. The debugging space also allows the developer to create custom renderings, leveraging the developer's ability to determine the most salient items of their code and display these.

A set of representative case studies was carried out using the debugging space for testing and debugging. These studies showed that AR provides an opportunity to understand the type of errors that are encountered during debugging. Debugging is essentially a process of elimination and by understanding the type of error developers can quickly eliminate large sets of potential bug sources, focusing on the sections of code that are causing the bug and therefore substantially reducing debugging time.

The implemented system also shows that AR provides an important stepping stone between simulation environments and the real world.

This thesis contributes the novel approach of applying AR to developer interactions with robots. The use of AR has been shown to have significant benefits for the robot developer, enhancing their understanding of the robot's world-view and hence reducing debugging time. As part of the work a flexible AR visualisation tool was developed with close integration to the Player/Stage project. This tool creates an intelligent debugging space where developers can exploit the benefits of the AR visualisation with minimal overhead.

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