Rhodes University

Department of Computer Science

Honours Project Proposal

Integrating real-time image processing into rapid prototype robotics

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Project Title

Integrating real-time image processing into rapid prototype robotics.

Problem Statement

The incorporation of simple robotics in Computer Science education over the last twenty years has lead to a positive knowledge growth in specific fields of subject expertise. A sample of these subjects include embedded systems [2], cost-effective vision systems [8], micro-robotics [10] and the rate at which students can model and test programs [9]. It is worth noting that the outlined education tools use sophisticated programming environments, predetermined course objectives and rigid time frames - a necessity to achieve the ultimate goal of stimulating computational thinking [10]. On the other hand, this has left students with no time to experiment with robotics using their own methodologies and motivation.

Objective of this Research

The aim of this project is to successfully create rapidly developed robotics systems using at least two established teaching methods and incorporate an external field of knowledge into the system. The driving focus is to evaluate how an independently built robot can be used to solve a real world problem or perform a specific task without the constraint of specialized programming environments that limits experimental development. The goal is observe how these methodologies impact the performance of the robot, the difficulty of producing goal-driven robotics outside a controlled teaching environment and the complexity of integrating a useful subsystem.

Approach

To allow enough time to develop and experiment with rapid prototyping, with the volatile nature of software development in mind, this project will be replicating an existing robot that

was published on the Internet as an open source hobby kit in 2014 [5]. The original robot known as *PlotClock*, will serve as baseline for the prototype and will act as an initial milestone for the project. The *PlotClock* is a static program system, meaning it only follows predetermined instructions that it is hard wired to - this is where this project will improve the system by adding in an external field of knowledge: real-time image processing. By utilizing a webcam and simple artificial intelligence (AI) we hope to expand and improve the original design using the rapid prototype and goal-driven design paradigms. This improvement may not be relatively new in terms of robotic AI [4], but could would provide an interesting look into how such a system can be adapted to provoke solution refinement.

History & Background

The availability of low cost and easy-to-use products enables any teenager or adult with no formal engineering education to be able to create simple, quickly assembled robots to perform rudimentary tasks [6]. Younger roboticist are introduced to foundation robot-making using LEGO Mindstorm and its native NXT-G Visual Programming Language. Tools like LEGO Mindstorm and the Python-based Pyro are suitable as research-level robotics hardware and methodologies that are accessible to anyone within a computer science faculty who may not have robotics experience [3]. With this as a baseline, we hope to explore integrating a rapid prototype development cycle in conjunction with real-time image processing. The combination of the two fields allows for flexible designs to solve problems of varying degrees of difficulty.

A practical application for creating real-time image processing robots has always been to develop and understand AI research and the deployment thereof. There have been initiatives to promote such activities - for example, The Robot World-Cup (RoboCup), an attempt to foster AI and intelligent robotics research by providing a standard problem where a wide range of technologies can be integrated and examined [7]. By estimate, to create a highly advanced system like RoboCup would take more than a singular year production cycle. Investigating real-time image processing needs to be concise and within an achievable time frame of the Honours degree, therefore a smaller project with measurable results is desirable.

In February 2014 an Atmel based small-scale robotics project, using an Arduino Uno with ATmega based micro controllers, was designed with the simple task of writing the current time using a whiteboard marker on a surface and then with the same mechanic erase it [1]. With only three mechanical servos and a computer aided design 3D printed body, this small scale project would be an ideal way to test the true nature of rapid robotic prototyping. The self-named *PlotClock* will serve as a base model for this project, but the designer's direct open-source resources will not be used. The goal of this research is to replicate the design, report the ease of rapid prototyping and the difficulties of integrating the final design with real-time image processing.

Deliverables

This project promises to deliver the following products and all derivatives thereof:

- LEGO Mindstorm *PlotClock* (**LM-PlotClock**): a prototype *PlotClock* duplicate - a working model that will be used for mechanical experimentation.
- Embedded Image Processing *PlotClock* (**EIP-PlotClock**): an embedded *PlotClock* duplicate - the evolution of the original design with real-time image processing integration.

Extension, time-willing:

- A graphical art tablet integrated subsystem that would allow manual user-input plotting.

Requirements & Resources

Hardware requirements:

- Access to a x64 based PC.
- (LM-PlotClock) A LEGO Mindstorm NXT Intelligent Brick.
- (LM-PlotClock) LEGO Technic Parts.
- (EIP-PlotClock) An Arduino Uno with ATmega328 chip.
- (EIP-PlotClock) Three Pro 9g servos.
- (EIP-PlotClock) Project mounting and wiring components.
- (EIP-PlotClock) A Webcam.
- Black Bullet-tip Whiteboard Marker.
- (Extension) Graphical art tablet and stylus.

Software requirements:

- *Windows* 7/8.1/10 Professional.
- *Linux* Ubuntu 14.04 or newer.
- LEGO NXT-G Visual Programming Language IDE.
- *Python 2.7* for Linux and Windows.
- *Microsoft Visual Studio 2013* for Windows C Programming.
- Any *C* compiler.

Project Milestones & Initial Schedule

Essential Milestones & Deadlines

Deadline	Completed Objective
Monday, 2 March 2015	Written formal project proposal
Tuesday, 10 March 2015	Seminar 1: Project proposal presentation
Friday, 29 May 2015	Literature Review
Tuesday, 28 July 2015	Seminar 2: Oral presentation
Monday, 14 September	Short Paper
26–27 October 2015	Seminar 3: Assessed oral presentation
Friday, 30 October 2015	Final Project & documentation
Friday, 6 November 2015	Research website updates
TBA, ±18 November, 2015	Deliver final research Oral Examination

Initial Project Work Schedule

Duration	Due Date	Activity
4 Weeks	*Monday, 30 March 2015*	Research material
<1 Week	*Friday, 3 April 2015*	Design research website
<1 Week	*Wednesday, 8 April 2015*	Construct LM-PlotClock
2 Weeks	*Friday, 17 April 2015*	Complete LM-PlotClock
2 Weeks	*Friday, 1 May 2015*	Construct EIP-PlotClock
4 Weeks	*Friday, 29 May 2015*	Research & Write Literature review
6 Weeks	*Monday, 20 July 2015*	Examinations and Field Trip.
5 Weeks	*Friday, 30 August 2015*	Complete EIP-PlotClock
2 Weeks	*Monday, 14 September 2015*	Write Short Paper
7 Weeks	*Friday, 30 October 2015*	Complete project & Write Long Paper

References

[1] Plotting time with an arduino uno. `http://blog.atmel.com/2014/02/20/plotting-time-with-an-arduino-uno/`, February 2014. Accessed: 2015.03.01.

[2] Bridget Benson, Arash Arfaee, Choon Kim, Ryan Kastner, and Rajesh K Gupta. Integrating embedded computing systems into high school and early undergraduate education. *Education, IEEE Transactions on*, 54(2):197–202, 2011.

[3] Douglas Blank, Lisa Meeden, and Deepak Kumar. Python robotics: An environment for exploring robotics beyond legos. In *In Proceedings of the SIGCSE Conference*, pages 317–321. ACM Press, 2003.

[4] James Bruce, Tucker Balch, and Manuela Veloso. Fast and inexpensive color image segmentation for interactive robots. In *Intelligent Robots and Systems, 2000.(IROS 2000). Proceedings. 2000 IEEE/RSJ International Conference on*, volume 3, pages 2061–2066. IEEE, 2000.

[5] Abe Connelly. A clock that plots time. `http://hackaday.com/2014/02/13/a-clock-that-plots-time/`, February 2014. Accessed: 2015.03.01.

[6] David Cook. *Robot Building for Beginners*. Technology in Action. Apress, January 2002.

[7] Hiroaki Kitano, Minoru Asada, Yasuo Kuniyoshi, Itsuki Noda, Eiichi Osawa, and Hitoshi Matsubara. Robocup: A challenge problem for ai. *AI magazine*, 18(1):73, 1997.

[8] Juan F. Martin and Luciano Chiang. Low cost vision system for an educational platform in artificial intelligence and robotics. *Computer Applications in Engineering Education*, 10(4):238–248, 2002.

[9] Fulgencio Soto, Pedro Snchez, Antonio Mateo, Diego Alonso, and Pedro J. Navarro. An educational tool for implementing reactive systems following a goal-driven approach. *Computer Applications in Engineering Education*, 22(4):764–773, 2014.

[10] Teruya Yamanishi, Kazutomi Sugihara, Kazumasa Ohkuma, and Katsuji Uosaki. Programming instruction using a micro robot as a teaching tool. *Computer Applications in Engineering Education*, 23(1):109–116, 2015.