THE APPLICATION OF COMPUTER VISION TO ROBOTICS AND MULTIMEDIA ART

Richard Weiss

e-mail: weissr@evergreen.edu
campus phone: 360-867-6871

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A. Statement of proposed activity.
One of the central problems in robots has been coordinating robots, so that they can work together to accomplish a common task. Thanks to a Plato Royalty Equipment Grant, Evergreen will soon have 15 Scribbler robots, each of which will have a camera and a Bluetooth transmitter and receiver. The first part of my research plan is to apply computer vision to allow these robots to cooperate by sensing and communicating with each other. For example, simple types of cooperation include swarming and flocking behavior. This work will involve processing images taken by each robot to recognize the positions of other robots in its vicinity and sending this information to those neighbors. In addition, there is an interdisciplinary and educational component. I would like to integrate robotics, computer vision and media arts because I believe that this is a way for a broader community of students to understand computer programming and computer science. In order to facilitate collaboration with students and faculty in the media arts, I will transfer some of my work on the Scribbler and other small robots [Weiss and Overcast] to more flexible Arduino systems, which include a processor, stepper motors and ultrasonic sensors. These have been used for interactive art installations. The multimedia Lab at Evergreen has Max/MSP and Jitter, which is a software programming framework. This can be used for programming the Arduino robots as well as creating audio and video pieces which integrate input from a variety of sources, including microphones and cameras . I will put together some kits, hardware and software, which I will share with students and faculty to give them easier access to using robots in their artwork. One of the most important outcomes of this work is that it will facilitate the collaboration of computer scientists and media artists both in terms of projects as well as curriculum development.

B. Purpose and scope
One of my primary goals is to explore the connection between my work in computer vision and image processing on the one hand and robotics and interactive multi-media on the other. Many of the problems are similar. Although some artists have used motion sensors to trigger motors, the ability to recognize people as moving objects and communicate with them introduces many more possibilities. One such application suggested by Beatriz Flores-Gutierrez is to use the sensory information to control the projection of images onto a computer screen. Another application is to use the Scribbler robots to make drawings based on visual cues. It would be possible for the Scribblers to recognize hand gestures and translate them into simple commands such as “draw a square” or “draw a circle” or even imitate a person's path walking through a room. Detecting the presence of humans and human motion is the subject of active research in the computer vision community, and I plan to investigate that and apply some of those results. However, these are both very ambitious projects, so I am starting with robots recognizing and communicating with other robots. This can be controlled to a much greater extent, since the robots can have known colors and shapes. Ultimately, I would like to build tools which would allow robots to interact with people based on visual cues.

C. Professional Agenda:
I spent 15 years doing research in computer vision at the University of Massachusetts, Amherst, and I have returned to that work, especially in the last few years encouraged by some of my experiences at Evergreen. Recently, I have been collaborating with a colleague at Microsoft on a project to measure radial distortion in cameras and use that for estimating the distances to objects in the scene. That work has a very narrow focus, and does not address some of my broader interests, such as how computing technology affects culture and society.

I participated in the summer institute on experimental multi-media organized by Ruth Hayes and Peter Randlette. This experience was very important in highlighting the connections between robotics, multimedia and computer vision. I have also talked with Beatriz about using computer vision in her work. Jean Mandeberg has expressed an interest in combining robotic motors with her use of fine metalwork. It would take a significant amount of effort to adapt techniques in computer vision and robotics for such projects. I intend to develop tools and a methodology which would facilitate this collaboration. This type of research and development is not supported by the traditional funding sources for computer vision, such as the National Science Foundation. On the other hand, once I have developed these tools I would be in a position to apply for NSF funding to develop interdisciplinary curricular modules based on these tools.

It has become clear to me that in order to continue my research at Evergreen, it must be integrated into some of the programs that I teach, and the combination of computer vision, robotics and multi-media is an exciting way to accomplish that. My discussions with faculty in the SI Planning Unit and with Ruth, Beatriz and Jean have convinced me that there is an opportunity to do that here. In the future, I would like to create an interactive piece that is interesting from an artistic and cognitive perspective and which would engage the viewer/participant. My idea is to explore the idea of creating a robot that could crudely imitate human motion and seeing how humans would react to that.

I also have other research goals in computer architecture and computer security, and I hope to integrate those in the future, as well. However, I feel that given my experience, focusing on computer vision and robotics now will be the most productive direction, and could serve as a foundation to allow students at Evergreen to study artificial intelligence through robotics in the computer science curriculum.

D. The benefits from this activity:
I will produce tools which would facilitate my collaboration with faculty in the arts. In addition, these tools will be made available to the Evergreen community, students and faculty, as well as the Max/MSP and Jitter community at large. My experience from this project will help me to collaborate with faculty to provide interdisciplinary programs which integrate computer science, mathematics, and the media arts.

E. Dates and length of request:
I would spend four and a half weeks working on this project between June 18, 2009 and Sept 7, 2009. Based on past experience, it would take me four weeks to accomplish the tasks that I describe below. Given the expected level of funding, I picked tasks which I thought I could accomplish and which would be the most useful to me and other faculty. I think that the time frame works well in that if I were to spend less than four weeks, I would just be at the point of formulating the problems and solving some, but I would probably not produce software that others could use.

F. Detailed plans:
I would spend 4 weeks during the summer on the following activities:
Weeks 1-2:
I would combine motion segmentation algorithms with object recognition for to allow a Scribbler robot to locate and identify another robot in its vicinity. There are several algorithms for estimating motion in image sequences. I have worked on some of these in the past [Anandan and Weiss].
Week 3:
I would examine the modules for motion detection that have been written specifically for Jitter, and I would transfer the algorithms I implemented to that environment.

Week 4-end
I will examine and test algorithms for human motion detection. The goal of this phase of the research is to allow the application to find out about the location and activities of the viewer. The research content of this work is adapting and combining existing algorithms in computer vision to a new domain. I would also be programming an Arduino diecimila to process an image and send signals to a stepper motor, which would be part of the Arduino kit.

Budget: $4105
Salary: $4000 for four weeks of work. Having this funding means that I would not have to take other jobs during the summer, and I would have time for this project.
Equipment: $55 for the Arduino diecimila processor, $50 for additional accessories, such as ultrasonic sensor. Lab stores already has Logitech webcams which include a microphone. I will also have access to the Scribbler robots with Bluetooth adaptors, which will be purchased with the Plato equipment grant.

Bibliography
R. Weiss and I. Overcast, “Finding your botmate: criteria for evaluating robot kits for use in undergraduate computer science education”, Journal of Computing Sciences in Colleges, Vol 24, No. 8, 2008, pp. 43 -- 49.

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