Revised Project Proposal

I propose a summer project with four students for the summer, 2011, to continue to explore the control of small robots and to develop materials (handouts and laboratory exercises) for the use of robots in CSC 161. Of the four students, I propose that 2-3 students register for Mentored Advanced Projects (MAPs). The remaining 2-1 students will be first-year students and will register for 299 Directed Research. This work continues and extends part of my scholarly activity during my current sabbatical leave.

Background

In my proposal for my current sabbatical leave, I listed three likely topics as likely foci for my scholarship. The description of my third topic follows (with very slight editing at the end):

3. Exploration of the Use of Robots in CSC 161: In discussions leading to the department’s external review in 2007-2008, the department reorganized our introductory sequence. CSC 151 largely retains the same main content, but topics for CSC 152/201 have been completely reorganized to yield the new CSC 161/207. At the same time, we have added a multimedia theme for CSC 151, so that students can apply the problem-solving concepts of functional problem solving and Scheme to the interesting field of image processing. During our review, we considered adding robotics as a possible application area for the new CSC 161. Although this has had great success at Bryn Mawr, Swarthmore, and other colleges, our reviewers strongly suggested we not follow this approach until we had substantial time to work with the relevant robots and develop needed materials. This project likely would result in 30-35 laboratory exercises [and,] ... this might be consolidated in an extensive Web site, or it might yield a textbook.

In practice, my time during the summer and fall 2010 has been extremely productive. As part of my sabbatical activity, I have made some progress on my robots project:

- Although I was able to obtain an early version of the Scribblor robot, manufacture of this equipment was halted in March 2010 in anticipation of a new model. However, the new version did not arrive until January 12, 2011.

- I was able to obtain wireless communication equipment for the old Scribblor robot, and install it. After experimentation, I was able to install needed software on my personal Macintosh laptop, set up needed configurations, and establish connections between the Macintosh and Scribblor.

- Using a learning language (called the Python programming language), I was able to program the Scribblor to play a musical tune and to follow a path (marked with masking tape) in my lab.
This work provides a reasonable start, but several more essential steps must follow, and I hope to accomplish much of the following during spring 2011.

- Work from the Scribbler robot must be transferred to the new Scribbler 2 model. Since the new equipment has just arrived, it is difficult to know if this work will be easy or hard. For example, it is not known how well the old wireless communication equipment will work with the new robot.

- According to marketing information, the Scribbler 2 is supposed to work with the C programming language. However, the only known environments for the Scribbler worked only for C++. It seems likely that some development will be required so that the Scribbler 2 will work smoothly and easily with the wireless environment and C.

- A significant limitation of the Scribbler robot is that its processor can do only one thing at a time. Thus, in its current mode, when it travels, it must scan its environment, determine a direction for its next movement, move a short distance, and repeat. The Scribbler cannot look ahead to a later move until completing its current move. Thus, movement is quite jerky. The Scribbler 2 is supposed to support a time-sharing environment with which one would hope processing of the next move could take place during a current move. Such possibilities need to be explored.

If time permits, I also would like to experiment with other equipment, such as the Lego Mindstorms robot. As with the Scribbler and Scribbler 2, such work would involve substantial work on logistics and technical details.

Altogether, by the end of the spring semester 2011, I hope to have a basic understanding of a simple robot, its sensors, its control, and its programming environment.

**Proposed MAP Work for Summer 2011**

For summer 2011, I propose working with four students to greatly expand my experience with a robot, to expand technical capabilities of this platform (with the C programming language), and to develop extensive laboratory exercises and materials for students (e.g., targeting CSC 161).

Although courses at Bryn Mawr and Georgia Tech have used robots based in Python and courses at the University of Tennessee at Chattanooga have used robots based in C++, this work has not focused upon a programming environment in C. Further, students elsewhere have taken courses that focus on a single view of problem solving, whereas Grinnell’s introductory sequence emphasizes multiple view of problem solving (e.g., in CSC 151 and CSC 161). Thus, while experiments at other institutions suggest some possibilities for robotic control and use in courses, substantial modification and extension is needed for Grinnell’s environment.

The proposed project will benefit most from having several relatively experienced (i.e., MAP) students and one or two less experienced students (i.e., students completing their first year at Grinnell).

- Relatively experienced students (e.g., students who have taken CSC 213) will understand basics of multi-threading and parallel processing, which I hope will be one of the major foci of the summer work.

- Students who have recently completed CSC 161 will have a clear sense of the problems and issues facing introductory students — particularly students about to take CSC 161, and another major focus of this project is to develop materials for this audience.
Together, a mix of experienced students and rising second-year students will allow multiple perspectives, and allow the project to effectively address the diverse themes of the anticipated work.

This proposed work has several vital benefits:

- Feedback from our external reviewers and others suggest that each person coming to robots typically encounters different problems and challenges — particularly in getting started. By working with four students, I would likely expand my understanding of what technical challenges to expect with a broad range of users.

- With four assistants, I can experiment with a much wider range of sensors and controls than I would have time for on my own. For example, a Scribbler 2 and its communication hardware has a video camera, two proximity sensors (checking different nearby locations), three light sensors, and two line-following sensors. With my simple experiments with the Scribbler, I could utilize only the camera in a simple way. Having four more people on the team would greatly expand the range of possible activities and experiments.

- Working with several students might allow substantial experimentation with multi-tasking, so that processing on several tasks can proceed concurrently rather than in sequence. Multi-tasking has the potential to allow smooth movement of a robot, instead of the current jerky motion. Without student help, work in this area will likely be quite limited.

- Working with students would allow me to obtain student perspectives on topics that are difficult and other topics that are reasonably straightforward. Such insights are important in planning materials and laboratory exercises for courses.

- By the end of the summer, I would like 30-35 laboratory exercises and supporting materials for CSC 161. Although I expect to write much of this, I hope four student assistants can write drafts of some labs and provide feedback on other materials.

Overall, four MAP students this summer could have a significant impact in moving this project along from initial stages of research to completed laboratory exercises, supporting materials, and possibly a textbook.

**Time Line**

Although details of a schedule will depend upon many factors, the following time line seems a plausible first draft.

- Prior to Summer 2011: Install software on a Scribbler 2 robot; establish wireless communications on a Scribbler 2 robot; port current software from the Scribbler robot to the Scribbler 2 environment; develop a basic C environment for use with the Scribbler 2; duplicate and translate initial programs for the Scribbler (in Python) to work with the Scribbler 2 (in C)
- Week 1: Experiment with basic properties and controls for the Scribbler 2
- Week 2: Modify existing programs for the Scribbler 2 to yield refinements and extensions of movement
- Weeks 3-4: Document processes required in getting started; experiment in use of multiple sensors
- Week 5: Continue programming with multiple sensors; experiment with multi-threading
• Weeks 6-7: Continue work with multi-threading; 
organize Web site for materials; 
write basic guide for programming with sensors; 
outline initial topic plan for 30-35 labs; 
write draft of 1 lab
• Week 8: Wrote basis guide for multi-threading; 
polish initial lab; 
write drafts of 4 new laboratory exercises (2/student)
• Week 9: Refine draft labs; 
write drafts of 4 additional laboratory exercises (2/student); 
plan Poster; 
consideration of research or conference paper
• Week 10: refine and complete Web site; 
complete Poster; 
planning of MAP presentation (to be done in fall)

Outcomes
The goal of the project is to complete these products:
• Software for controlling a simple robot to perform several tasks 
  § Software for moving a robot along a path 
  § Software to allow a robot to run a maze 
  § Software to allow a robot to accomplish 3-4 additional tasks
• Documentation in using the robot 
  § Basic guide for the use of sensors 
  § Basic guide for multi-threading
• User documentation, so the system can be used by others in future years 
  § Plan for 30-35 laboratory exercises 
  § 8-10 laboratory exercises completed (student written; faculty reviewed) 
  § about 20 laboratory exercises completed by faculty
• A research Poster

I am hoping this project, combined with my sabbatical work, will be adequate to allow me to use small robots in CSC 161 in fall 2011. If this project progresses well, I would hope to have laboratory exercises and supporting materials in place for use in the classroom laboratory.

Also, depending upon the success of the project, the team might consider writing a paper on this project. Some possible places for publication and presentation would include the 43nd Technical Symposium on Computer Science Education, scheduled for Raleigh, North Carolina, in March 2012, and the April 2012 meeting of the Consortium for Computing Sciences in Colleges for the Central Plains region.

Finally, if work on this project works well in the classroom, I may explore combining materials into a textbook and approach publishers with a proposal. All this, of course, depends upon how my experiments and development progresses with small robots.
Conclusion

Although robotics is an important subject area within computer science, exploration of these machines requires substantial time, energy, and insight. Work can draw upon much theory and research, but robots also have mechanical and electrical attributes that yield practical problems. Following the advice of our external reviewers, I am devoting considerable time during my current sabbatical leave to delve into this area. The proposed MAP with four students for this summer would extend this work, provide an opportunity for new areas of exploration, identify new practical problems and considerations, and allow the development of numerous laboratory exercises for future use. Depending upon the success of this work, this scholarship also might lead to a full textbook on the subject, aimed at introductory students.

Sincerely yours,

Henry M. Walker