530.421 Mechatronics

Project 1: LightBots

Allison M. Okamura*
Department of Mechanical Engineering
G.W.C. Whiting School of Engineering
The Johns Hopkins University
http://www.me.jhu.edu/~allisono/courses/530.421/
Project announced: October 4, 2006
Project demonstration date: October 31, 2006
(Private evaluation session & Public showing, time TBD)
Project Report due date: November 1, 2006

Goal

To produce an "art machine" that will:

1. Engage the audience by displaying a motion-generated light show *in a dark room*, and
2. Changes its response based on some external input from the audience, such as sound or human proximity/motion.

The projects will be viewed and enjoyed not only by your fellow 530.421 students, but also by interested people who may know a little about art *and* the technology involved. Also, the behavior of your Lightbot will be captured for posterity using video recordings and/or long-exposure photography. You should keep this in mind when designing the project.

The machines will be displayed and demonstrated on the lab benches in Wyman 140. You will also submit a report detailing the sensors, actuators and control of your device.

The underlying purpose of this project is to give you some experience with designing and building an electromechanical/robotic device. This will involve working with sensors, actuators, circuits, and microprocessor or DAQ-board control.

Specifications

- Each team of *two* will design and construct a machine. We encourage interdisciplinary teams. Your teammate does not need to be a previous lab partner.
- The machine's behavior will be initiated by the pressing of a single button. Once triggered, the machine should react by generating an interesting visual display

---

 Thanks to Joan Freedman and Christopher Vee (JHU Digital Media Center) for their contributions to the conception of this project.

through motion. The process should run for a minimum of 10 seconds and a maximum of 60 seconds.

- The machine should be *safe* for use in a darkened room. This means that it must not apply so much force as to injure a person. Also, the base of the machine must be fixed to the table.
- The generation of the light show must use at least *two* sensors and *two* actuators.
- The entire operation of the machine *must* take place in a space no larger than 3 feet wide, 2 feet deep, and 3 feet tall.
- The Lightbot's performance will be judged with the lights off, but the system should be crafted well enough that it has a pleasing appearance even with the lights on.
- The machine can use existing equipment in the Wyman 140 lab, such as the power supply and computer. You may use any microprocessor or data acquisition board desired, such as the Basic Stamp or NI-DAQ PCI-6014.
- While it is normally not good practice, the finished circuitry may be constructed on a proto-board. (Wire-wrap is also acceptable, but more difficult to debug.) This has been done to allow you to spend the maximum time to spend on your project, without having to learn electronic prototyping or wait for printed circuit boards to be manufactured.
- Your team may not spend more than $80 on the materials included in the final version of your device. You may use any sensors and actuators already available in the lab (these are not included in the $80 cost), BUT you must return then unbroken at the end of the project.

Note the following safety requirements:

- The machine must be safe for both users and spectators
- No toxic materials, and no liquids.
- No part of the machine may become ballistic outside the size envelope outlined above.
- No pyrotechnics or fire of any kind!

Evaluation

Each LightBot team will receive four grades:

1. **Concept (20%):** This will be based on the technical merit of the design of the machine. Included in this grade will be the appropriateness of the solution, as well as innovative hardware, and use of physical principles in the solution.

2. **Implementation (25%):** This will be based on the prototype displayed at the evaluation session. Included in this grade will be evaluation of the physical appearance of the prototype and quality of construction. We will not presume to judge true esthetics, but will concentrate on *craftsmanship* and *finished appearance*.

3. **Performance (40%):** Based on the results of the performance testing during the evaluation session. Does it work? Is it reliable?

4. **Report (15%):** Project report requirements are described in a separate document. This report is due to the instructor's office on Wednesday, November 1, 2006 (the day after the demonstration). One report per team. You should also turn in a self and partner evaluation form.

Performance testing procedure: All machines will be tested by the instructor pressing the designated button on the machine, initiating the process and observing the response. Each team should prepare a verbal, 30-second (no more) presentation to introduce the machine. This presentation should highlight the basic functionality and unique features in the design.

Checkpoints

Your project should meet a series of minimum levels of design/functionality by the end of the following lab sections:

Thursday 10/5 or Friday 10/6: Single motor trajectory control, evidence of brainstorming
Thursday 10/12 or Friday 10/13: Response to button press, fairly complete mechanical design ideas, light show materials purchased
Thursday 10/19 or Friday 10/20: Mechanical prototype complete, all final materials purchased
Thursday 10/26 or Friday 10/27: Preliminary LightBot complete

You must continue to attend the lab sections throughout the project period. We will provide instructions on the use of the NI-DAQ PCI-6014 board and control software and laser cutter at the lab sections. In addition, this is one time when you can be guaranteed to receive help from the TAs in the lab.

Suggestions

We understand that the project definition is probably a bit more open than you might be used to. To help you get your creative juices flowing, we offer some reflections that you might want to consider:

- Art can be geometric.
- Art can be abstract.
- Art can be interactive.

We encourage, and hope to foster, a wide range of solutions to this problem. This will make for the most enjoyable presentation for your audience. The tasks of being triggered, creating some kind of light show, and responding to external input represent the basic functions that all machines *must* provide. It may help to think of your device as a *light machine* rather than an *light robot*.

While the emphasis in this class and *Robot Sensors and Actuators* has been on the use of sensors, actuators, electronics, programming, and control, don't forget the mechanical aspect. Make use of techniques demonstrated in the rapid prototyping lecture (e.g., foam core, laser cutter). Do not attempt to make an unnecessarily complex device. Get something simple working first, and then *carefully* add bells and whistles as time permits. Your machine must be rugged enough to survive your testing as well as "testing" by the audience. Functionality is judged on the day of the demonstration, not the night before.

Materials

You are limited to an expenditure of $80 per team of two ($40/person) for purchased materials and parts used in the construction of your final project. You may use any item already available in the lab (these are not included in the $80 cost), BUT you must return then unbroken at the end of the project. Examples of available items include: A breadboard, a Pittman motor with optical encoder, an LCD display, a ultrasonic transducer with circuit board, a stepper motor with control circuit, wire kit, amplifiers (low-power and power). If these items are damaged or destroyed, you will be charged their cost for replacement. If you wish to keep your device at the end of the project, so it is *highly* recommended that you purchase all your own hardware and circuitry. That way all you would need to purchase in order to keep it running is your own microcontroller/DAQ board and power supply.

Some suggestions for purchasing items online:

- Digikey is an online electronics store (http://www.digikey.com/)
- Mouser is an online electronics store (http://www.mouser.com/)
- Tower Hobbies sells RC Models and parts (http://www.towerhobbies.com/)
- Parallax makes the Basic Stamp and thus sells many easy-to-integrate components, including sensors and servo motors (http://www.parallax.com/)
- You can also get free samples shipped (often overnight) from companies like National Semiconductor, Texas Instruments and Analog Devices.
- Jameco Electronics sells electronic and mechatronic components (http://www.jameco.com/)
- McMaster-Carr sells mechanical parts (http://www.mcmaster.com/)
- When ordering chips, note that you usually want to order them in DIP (Dual Inline Packaging) configuration. If you purchase surface mount, you will curse yourself as you try to solder it onto reasonable wire.

Some suggestions for local electronics:

- Radioshack is located in the Rotunda (http://tandy.know-where.com/RadioShack/cgi/site?01-2903)
- Baynesville Electronics is located in Towson (http://www.baynesvilleelectronics.com/)

Mechanical construction should be done as *simply as possible*. I particularly encourage the use of foamcore, glue guns, acrylic, and acrylic "cement". Foamcore can be cut using an X-acto knife or similar. Glue guns and glue are available in Wyman 140. To cut acrylic, you can use the laser cutter in Wyman Park Building. You will be introduced to this device during the last formal lab session. If you need help with simple machining tasks, such as tapping a hole or cutting a shaft, see the TAs.

Don't Forget

- The specifications listed in the project description. Meeting these specifications is more important than flashiness. Start conservatively.
- Design your subsystems on paper first, before constructing any circuitry or hardware.
- The TAs, Brian and Bob, will be in the lab during the normal section times. Allison will also stop in frequently, especially during the last week of the project.
- When debugging, first make sure that you know what each part of your circuit/program *should* do. Then test each subpart separately to determine if it is doing the right thing.
- You must leave the lab in *pristine condition*. Mike Johnson and Bob Blakely have worked extremely hard to provide us with this resource. You should carefully package and store your project materials in a box underneath the supply bench or in a corner of the lab, or take it home with you. We will have a record of who was in the lab at any given time. Poor lab maintenance will affect the participation portion of your grade (10% of your total course grade). If the lab is already in bad shape when you walk in, use the phone in the room next door to notify the instructor or lab managers immediately (Allison Okamura is at 6-7266, Mike Johnson is at 6-6752, and Bob Blakely is at 6-8660).