EE 101 – Digital Control with Embedded Systems

The University of Vermont

Final Project – Search & Rescue Robot

Revision 3 Apr 2016

In this project you will use the robot platform to create an electro-mechanical search & rescue robot. The robot must be able to navigate through a series of obstacles (i.e. a tunnel of sorts) and find and rescue a victim (colored block) by moving it to safety (i.e. off of the robot area oval).

You will use your Arduino Uno board to interface to the robot shield to control two motors and to read some number of sensors – e.g. a color sensor, an infrared sensor, and other sensors as the team decides. You will create an algorithm to instruct the robot to navigate the obstacles and find and rescue the victim (i.e. colored block) and write all of the code needed to implement that algorithm. Structured coding techniques should be employed for the best score.

Items needed

- Robot Platform(s) (w/battery pack) – provided by team (including batteries)
- Arduino Uno board (or equivalent) – provided by the team
- YourDuino sensors, etc. as deemed necessary – provided by the team
- Any other materials / electronics used must be provided solely by the team

- Note: some additional electronics (e.g. robot shield, color sensor) MAY be provided – their use (if provided) is at the team's discretion and they **must** be returned in good working order

- Robot Arena – available in lab (oval track)
- Multiple colored blocks
- "Tunnel"

There are a number of documents posted on the class Bb including

- Motor controller documentation
- Robot shield schematic (if provided)
- Color sensor schematic (if provided)
- Infrared sensor schematic (if provided)

Additionally, you will likely find your previous lab work useful for utilizing other sensors. The intent of this project is for each team to research the provided materials as well as any other information they deem necessary to complete the task. Each team must develop their own unique algorithm / solution. No sharing or "googling" or plagiarizing or colluding others' work regardless of the format it may be available in or where it may be available.

Note: While some information related to the project may be discussed in class there is no plan to provide significant detail for every aspect of the project during class time.

Each team is ultimately responsible for developing their entire solution. Questions regarding any part of the project are always welcome and encouraged.

Grading

There are several components of the project. Each component is weighted as shown in the table below. Each team member will receive the same grade with the exception of teamwork.

Solution (i.e. does the robot rescue the victim): *(25 maximum)*

- There are three different colored blocks on the other side of the obstacle. Only the blue block is to be rescued (i.e. pushed off of the robot area oval). No other blocks may be removed from the arena.
- The time required to rescue the victim may also be factored in.
- The robot must leave the area after the victim as been rescued in somewhat of an opposite direction to that which the victim was freed. It does not need to re-navigate back through the obstacles.

Code / Algorithm: *(25 maximum)*

- Was structured coding techniques used?
- Is the code readable?
  - Is there good documentation in the code?
  - Is there good use of labels? Meaningful variable names, etc.?
- Is the algorithm efficient? Does it make sense for the problem?
- The code must be submitted during the final project evaluation but should the entire code should NOT be part of the oral presentation.
  - Key code segments may be appropriate to be included in the oral presentation.
  - Only the simple text file for the code is to be submitted.
  - Electronic submission required (sustainability don't ya know!).

Mechanical "Soundness" *(10 maximum)*

- Is the robot put together well?
- Is it neat? Is it self-contained? Is it stable?

Evidence of Teamwork *(15 maximum)*

- Is there significant information indicating that all members of the team participated in the overall project?
- During the presentation and periodic project quiz evaluations, it should be obvious how the team is working together and who is doing what on the project.

Oral Presentation

_____ *(15 maximum)*

- Is there a block diagram?
- Is there a flow chart showing the algorithm?
- Length (not too long / not too short)?
- Is the important information communicated?
- Are the slides organized, neat, to the point, not trivial?
- The presentation must be submitted at the final project review.
  - Power point or .pdf are the only acceptable formats.
  - Electronic submission required (sustainability don't ya know!).

Extra Features

_____ *(10 maximum)*

- Any innovative or unique features incorporated in the solution?
  - e.g. additional sensors or other features that make the teams' solution stand out from the others
  - note: a blinking LED will not be considered an extra feature

Project Description

You will create a robot that can navigate through an obstacle (i.e. a tunnel of sorts) and find a blue block and push it out of the oval robot arena using your own robot platform that is controlled by an Arduino (also supplied by you). Figure 1 illustrates a typical bare minimum block diagram of the robot system from the components that are to be provided by each team.

The Motor Controller is an Arduino shield that has a TB6612FNG integrated circuit (IC). This IC can be used to provide the current drive and other controls for two small motors. The datasheet for this device can be found on the class Bb.

IR1 and IR2 are infrared sensors that are loaned to your team from the instructor. They can be used to detect white or dark objects (to mention just a few of its capabilities).

CS is a color sensor that you can build from the components in the Arduino kit (or may be provided to you by the instructor). This color sensor can be built just like the one that was done in one of the class labs.

Other sensors will likely be needed depending on your solution to the project. It is "assumed" that each team will show a complete detailed block diagram of their final system during their oral presentation.

There are three different colored blocks that the robot may encounter – red, green, and blue. Only the blue block is to be pushed out of the oval arena. Neither of the other two blocks may be disturbed.

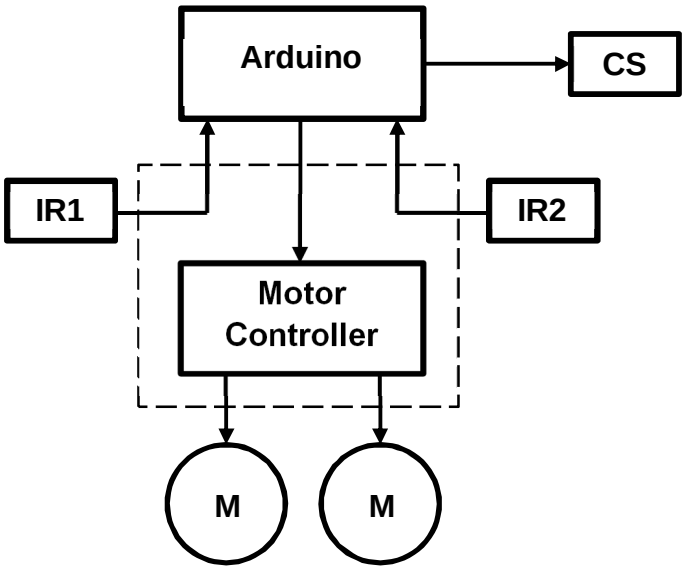

Figure 1 - Line Follower Robot Block Diagram

Procedure

Unlike other labs you have done in this course, the project is somewhat open ended in that you, as an engineering student, will provide the entire solution. All algorithms, code, electrical connections, mechanical assembly, etc. are to be developed and implemented as part of the project. No detailed instructions or information will be given. Of course, questions related to the project or components will be answered.

Each teams' method to create their robot must be their own. A rough outline of the work required is provided as an aide below. A team's solution may or may not include each of these steps. Other steps may be necessary depending on the team's solution to the project.

- assemble the robot as deemed by the team to implement the best techniques needed for their algorithm
- write code to operate the interface to the motor controller and drive the motors
- determine any differences in motor drive speed and develop methods as needed to compensate them (i.e. does one have more torque and that other?, does one spin faster / slower than the other for a given speed setting?)
- write code to collect data from the infrared sensors
- determine the infrared sensors sensitivity to light and dark in various lighting conditions such that they can be used to detect the white and black of the arena
- write whatever other code is needed for whatever other sensors, etc. the team decides to utilize
- develop an algorithm to control the motors from data from the infrared sensors and other sensors
- test and modify the algorithm as needed to enable the search and rescue robot to operate autonomously
- other work to provide the required solution

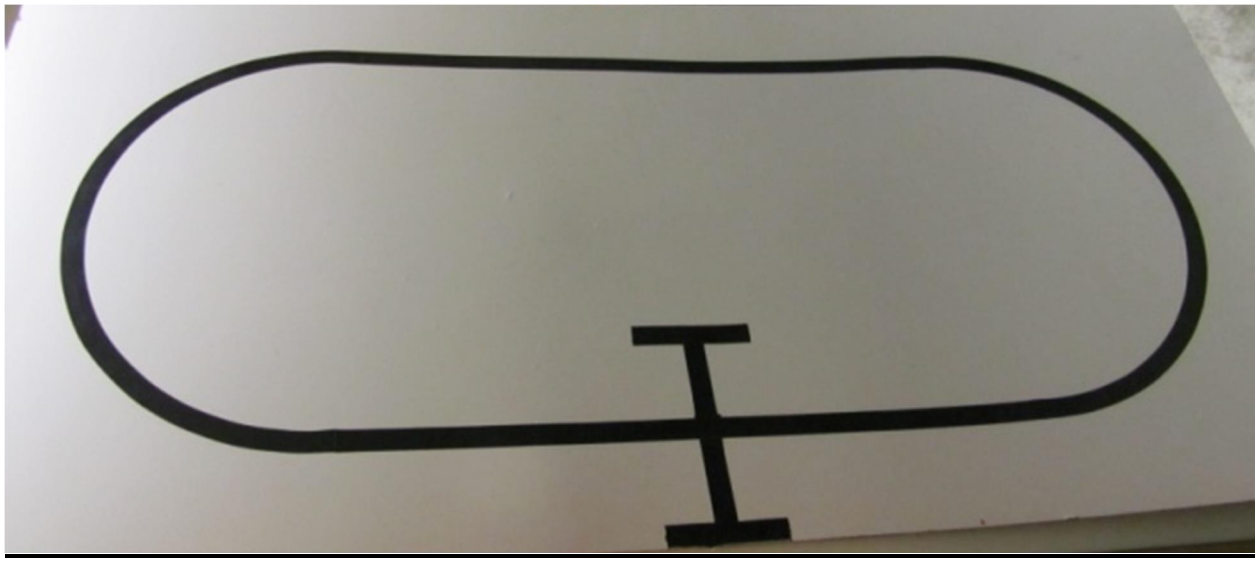

Figure 2 – Robot Arena

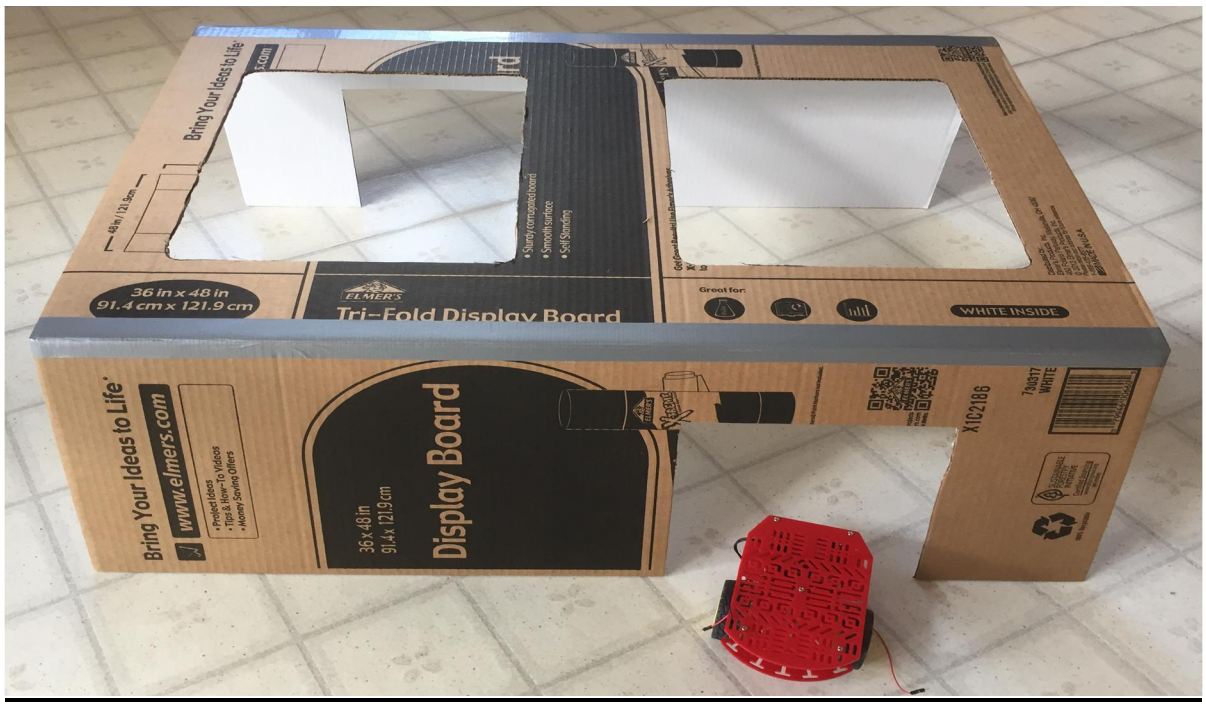

Figure 3 – Obstacle that Robot Must Navigate Through

The obstacle that the robot must navigate through is shown in Figure 3. The openings for the robot are approximately 12" by 8". The openings on top of the obstacle are intended for observation purposed only.

The project will be graded as detailed above. The following additional information is provided.

Solution: The three blocks will be placed completely at random inside the oval robot arena on the opposite side of the obstacle to the starting position of the robot. The robot's starting point will be determined by the instructor. It is assumed that the robot will have a random starting position and orientation.

The robot must navigate through the obstacle. It may not go around the obstacle. It may not move the obstacle. It may not damage the obstacle.

Once robot has cleared the obstacle it should be able to find the blue block and remove it from the oval arena. The blue block will be considered removed from the arena whenever 100% of the block is outside of the black oval. No other blocks may be disturbed.

After the last block is removed, the robot must also exit the arena in a different direction from that which the blue block was removed.

Code / Algorithm: The class lectures have discussed structured coding. The code for this project should use good structured coding techniques. It is also considered good coding practice to provide adequate documentation in the code (i.e. comments). Additionally, code can be made more readable with good use of labels, meaningful variable names, proper indentation, etc.

e.g. analogWrite(MOTOR1, SPEED) is much more readable than analogWrite(3, 0x57).

It is EXPECTED that structured coding techniques will be used as has been presented continuously throughout the lectures. It is also EXPECTED that each team's code will be clearly documented (i.e. commented).

Mechanical "Soundness": Since this course is "electronics for mechanical engineers", it is expected that good mechanical principles will be used to assemble the robot. e.g. the robot should be neatly assembled and pieces should not be falling off or dragging, etc. while it operates.

Evidence of Teamwork: Since this is a team project, it is expected that the work be done by ALL of the members of the team. As such, it should be easy to demonstrate what work was done by whom. This evidence should be featured during the oral presentation along with other aspects of the project evaluation.

Oral Presentation: Each team will demonstrate their robot performing the given task. During the demonstration they will also give an oral presentation showing slides that discuss each of the grading aspects as well as whatever other information they deem important to secure a grade that reflects their efforts.

Extra Features: Teams are encouraged to provide any innovative or clever additions - electrical or mechanical - to their robot. (e.g. in previous years, one team tried to implement a bulldozer "shovel" to remove the blocks). The more innovative the extra features, the more points that will be awarded.

Note: While the project is open-ended, teams are encouraged to ask relevant questions and seek advice as needed to obtain whatever additional information they require to successfully complete their project.

IMPORTANT: Periodic readiness checkpoints we conducted via quizzes to insure that each team is making steady progress throughout the project work time.

e.g.

- a quiz to demonstrate the robot's ability to move
- a quiz to demonstrate the robot's ability to act on the black or white area of the arena

- a quiz to demonstrate the robot's ability to find a block
- etc.
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These quizzes will be administered during the class lab time but will be counted as a class quiz (i.e. not a lab score, nor as part of the final project score – a quiz score).

The scope and number of quizzes are TBD but will be announced in advance. Quiz scores are pass / fail only (i.e. 0% or 100%). Team members must be present during the quizzes and all team members must be able to answer any questions related to the quiz task.

The projects will be demonstrated and oral presentations given during the final exam time as scheduled by UVM. Early project demonstrations / presentations may be available upon request.

It is sincerely hoped that you will not only learn an awful lot from this opportunity but that it will be fun and inspire you to more engineering challenges that use electronics to control your mechanical projects. 8-)