Robot Project

Mechatronics Microcontroller Project MXEN2002

A catastrophic accident has caused the ACME laboratory to become flooded with radiation. A human rescue team is on standby, but radiation exposure must be limited by a carefully targeted rescue.

You must design and build a semi-autonomous robot, which would be capable of entering the laboratory to identify the location of the victims for the subsequent rescue operation.

There are two zones in the laboratory. The first zone has restricted communication, meaning robot operation must be autonomous except for a “pause” function, allowing victims to be identified. The autonomous zone is a flat-floor single path maze with no dead-ends. The second zone permits full remote operation, and may include various obstacles and mobility challenges, including inclined floors (up to 10°) and small steps and obstacles (up to 3cm).

For this task, you will have the following components available:

- An Arduino Mega board, which you will configure for low level robot control.
- A robot base, consisting of a base plate, two DC motors and a caster wheel
- A position or a continuous rotation servomotors.
- 1 or 2 analog joysticks
- Up to three Sharp range sensors (a mix of 30cm range and 80cm range subject to availability)
- H-Bridge motor drivers
- A 9V battery (student provided) and connector

To represent controller-robot communications, all drive signals for the robot (button pushes, joystick signals) must be passed via a serial communication channel (see Lab H).

The preconfigured Arduino board will need to be programmed, but should not be rewired without permission (it needs to be reused by other groups). This board is the “remote controller” board, and should be used to drive the robot, and also to relay information from the range sensors.

The robot will commence operation at the entrance of the “autonomous zone”. When autonomous mode is activated, the controls may not be touched except to pause the robot until the robot emerges from the autonomous zone (otherwise penalties will apply). The robot is then operated under remote control for the remainder of the operation.

The project is worth 50% of your final grade, with 20% being achieved through technical demonstrations and the neatness and presentation of your circuit and robot, 10% through the presentation of functional, well structured and thoroughly commented code, and 20% through a project report which describes your robot, and details the design, testing, evaluation and performance of each sub-system.

Technical Demonstration

Each team should be able to demonstrate the following technical tasks, using a single built robot with an Arduino controller, and a single program. The technical demonstrations will take place during the lab sessions in the final teaching week of semester.

- Each team has a built robot, with a board wired up for h-bridge (motor control), 8 flyback diodes correctly oriented, 1 servo, and up to 3 sensors. A joystick or two would also be mounted on the robot (assuming a second controller board is not available).
- The circuit should be neat, compact, and with some colour coding of wiring (power, ground, signal at least). The likelihood of short-circuits (e.g by diode leads touching) is minimised.
- A program is provided and demonstrated, which is well structured and commented, and uses descriptive variable names. Control signals should be passed via a loopback communication channel (e.g Serial 2).
- Robot driving control with smooth differential drive using one joystick.
- Servo control with one (different) joystick channel.
- Calibrated sensor readings printed to serial terminal or LCD (with range in mm or cm and units given).
- Limited demonstrations of autonomous capability:
  - Autonomous mode is started and stopped with a push button (or joystick select)
  - An object in front of the robot causes the robot to turn in auto mode
  - When travelling a straight corridor in auto mode, direction adjustment is evident (this can be tested with robot suspended and moving objects closer or further from sensors)

The only changes permitted to the circuit between demonstrations are if there are limited components (e.g if only one joystick is available, moving the joystick channel to demonstrate servo control).

Project Report

The project report is a formal document which describes your robot, and details the design, testing, evaluation and performance of each sub-system. The project report is a group submission, in the week following the final teaching week. As a rough guide, the report should be at least 4-5 pages per group member.

Common material (including diagrams and code) between different groups is not acceptable, except where they are obtained from the same public source (e.g sample code provided) and properly referenced.

The report should:

- Describe the task that needs to be completed
- Describe the system that has been designed to solve the task
- Outline the process required to get to the final system, including any key tests or calibrations which were required
- Highlight any innovative features of your design
- Reference any external sources of material, including code snippets.
- Reflect on the performance of the robot, outlining the system components which worked well or not, and highlighting any improvements which could be made to the system.

You must include:

- A fully labelled **schematic diagram** which shows the interaction between sub-systems (Arduino, joystick, sensors, motor controller, motors, servo)
- Fully labelled **circuit diagrams** for each electronic sub-system
- Any relevant **calculations** for key parameters (such as PWM base frequency, duty cycle, joystick mixing)
- One or more **flowcharts** showing the flow of program control (the flowcharts should be presented such that the program logic is apparent to the reader as easily as possible)
- A **description of the logic** employed in the autonomous navigation (where this was attempted), preferably in an easy to read graphical form (flowchart or state transition diagram): note this logic should be described even if there were limited or no opportunities for testing
- An **outline of the communication protocol** implemented

Code

A complete printout of your program code should be provided in an appendix of the report, with context highlighting and indenting. The code must be presented as readable text (not as screenshots or images).

The code will be marked for clarity, structure and style. It should include relevant comments for every line or block of code, it should include descriptive variable names, and it should be functional (i.e it should achieve the technical requirements).

You should present the code as if handing it over to a client. In other words, other people should be able to easily read, understand and modify your code.

Project Marking: (total 50 marks)

Functionality and Design (20 marks):

- Robot is complete and well built, the electronic layout and breadboard is neat, with some use of colour coding for the wiring **(4 marks)**
- Smooth differential drive is achieved using 1 joystick **(4 marks)**
- Smooth control of the servo is achieved using 1 joystick channel (separate to motor control channel) **(4 marks)**
- Calibrated sensor values are formatted and displayed on the serial terminal (units given in mm or cm) **(4 marks)**
- Limited autonomy demonstrations: **(4 marks)**
    - Autonomous mode is started and stopped with a button press (or joystick select button)
    - Robot turns to open direction when an obstacle is placed in front
    - Robot adjusts direction when driving a straight corridor

Project Report: (20 marks):

- Task description **(2 marks)**
- Schematic diagram **(2 marks)**
- Brief overview of subsystems including calculations and communication protocol **(4 marks)**
- Circuit diagrams **(4 marks)**
- Flowcharts or other descriptions of logic (including autonomy) **(4 marks)**
- Overall structure and quality of writing **(4 marks)**

Code (10 marks):

- Code appears to achieve the requirements of the project task **(2 marks)**
- Code is well structured and consistently indented **(4 marks)**
- Code uses descriptive variable names, and is well commented; unexplained constant values are avoided **(4 marks)**

Example arena layout:

This is an example of the area layout that would be used to test the robot if we were not restricted in our use of the laboratory. It may give you some idea of how the autonomous part (in particular) is intended to look.