ENEL350 Project 2 – Robot Maze Solver

Background:

Robot line followers are often found in modern factories. The robots are used to perform multiple carry and delivery tasks. However, the lines may end up creating a form of maze that the robots must be able to handle.

The project at hand, while using a line following robot to work through a maze, is not intended to directly mirror the usual industrial application. It is intended to offer design experience in analogue and digital electronics, embedded programming, and hardware implementation, with a well defined set of operational requirements. As a design/product usually needs to perform within a competitive market, some credit for this project will be allocated to the robots that are able to out-perform others.

Project description:

This project requires the design, construction, and report of a line-following robot maze solver. The robot will be placed at the start of an assessment line-maze (line width is 30mm) constructed out of a standard set of shape units printed on A3 size paper (straight through, 90 degree turn – either direction, T-sections, and cross). The joining of shape units will be made with 18mm wide white insulation tape, which will leave an 18mm wide white gap in the line. The maze will have a single true exit where the maze end is defined by a grey cross-line (an example maze is shown in *Figure 1* – note, the maze configuration used for assessment will be different). A .pdf file with all standard shapes is provided for your use (printouts of the grey cross-line maze ends will be made available for grey-level consistency).

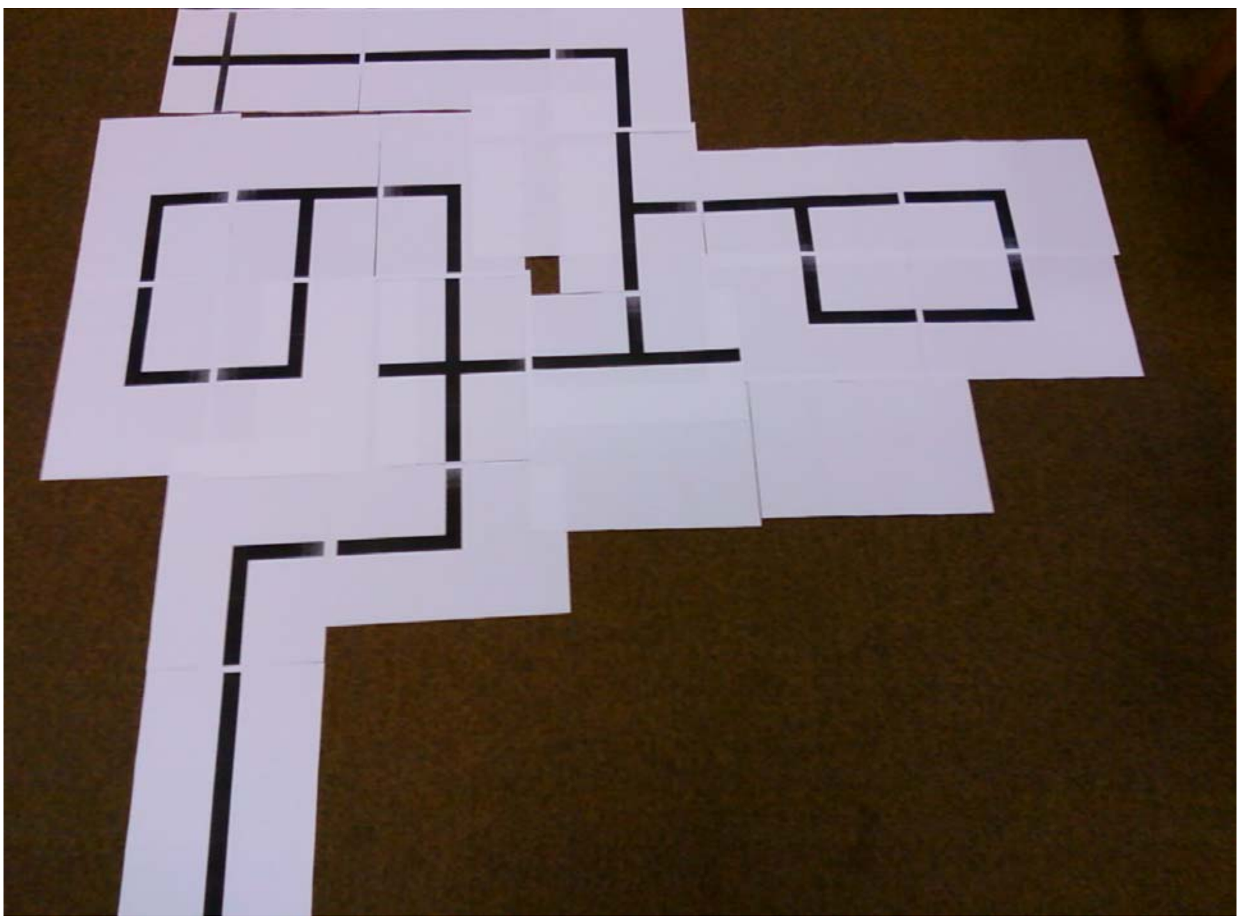

Figure 1. Example maze. Note the "false" dead-ends (no grey cross-line), and closed loops that may exist, as well as the white line-gaps created by the joining insulation tape.

Your robot will be timed over two runs through the maze (time stops when robot **stops** after detecting the grey cross-line), and the fastest of the two times will be used for ranking purposes with respect to the other timed robots. Failure to reach the end of the maze (time limit of 5 minutes) will constitute a major failing of the operation such that no more than 5 marks can be given for "Function" (see assessment breakdown below), and those 5 marks will be allocated on the basis of how well the robot is able to achieve specific operational tasks (following the line, turning at corners and junctions, detecting dead ends and grey cross-line). Robots that can complete the maze will automatically receive 5 marks for function. The remaining 5 marks will be allocated linearly in half-mark increments based on timed ranking, whereby the best times get 5 marks, and the worst times get 0.5 marks.

Being constructed from standard A3 printer paper connected by tape, the assessment maze surface may not be completely flat when laid out on a flat surface. Also, the background lighting conditions may be different depending on how much sunlight there may be at the time of testing. These practicalities should be considered in your design.

You will be working in groups of 4 people. Team up with 3 other people in the class and submit your group list (names and standard University computer username) on the Departmental on-line booking system for ENEL350 (instructions on page 4). This task must be completed by **4pm this Friday 7 May**. Partial groups will also be accepted in the database and extra group members will be allocated. If you cannot find a group to be a member of, notify Dr Gaynor of this situation by email (also by 4pm this Friday), and you will be allocated to a group.

As with any design process, there are limitations on use of hardware and components. You are allowed to use components stocked by our electronics store up to a budget limit of $25 (an ENEL350 card will be available to list components you use). This is a virtual budget, so you do not actually pay any money for this project. Your group will be supplied with two motors, a dual gearbox, two wheels, and a battery holder at the end of the **Wednesday 12 May** lecture (tutorial). Sensing of the line must be achieved optically, preferably using three QRD1114 proximity optocouplers (also supplied, at a budget cost of $1.50 each). Use of more than 3 optocouplers will result in 2 marks off (out of 30) per extra optocoupler (likewise use of less than 3 optocouplers will gain 2 marks per optocoupler less). The microprocessor to be used (processing sensor input, pwm generation for the motor drivers, etc.) is the Atmel Atmega-8 (the same one used in ENEL206). You are required to develop a single PCB (single-sided and not included in component budget). It is strongly recommended that you keep to using through-hole components (not surface mount).

Each group will be required to design and build the hardware (including the PCB and computer interface cable), create the microprocessor software, and produce a report. While aspects of circuit simulation would be seen as good design process (and considered favourably in marked assessment), mixed-signal (analogue and digital) simulation is not easy to perform and it is not specifically required for this project. The completed hardware/software and report submission deadline is **Monday 19 July**, (4pm for the hardware, 5pm for the report - details on page 4). **No late submissions will be accepted.**

PCB's are to be laid out using Altium, TINA, or Protel and the appropriate format file submitted by email to Nick Smith (n.smith@elec.canterbury.ac.nz - Room A118b, in the Electronics Workshop) **BEFORE 3pm Monday 31 May** (failure to meet this deadline will incur a **penalty of 20% per day late**). It is up to you to make sure the PCB layout and file format is correct for the Electronics Workshop to use. If using Altium or Protel, then save as .pcb (binary 3 format setting – note: polygon fills do not port across into this file format). If using TINA, save the PCB layout as a .pdf, setting the page size to A5. **Be warned**, leaving submission of your PCB to the deadline will mean that you do not receive the board (which will require drilling by your group) until Friday 4 June, which is the last Friday of semester! Groups that submit PCBs with such substantial layout errors that make it impractical to attempt to fabricate will be notified, and depending on how long it takes your group to fix the errors and resubmit the layout, you may not receive your completed PCB until some time during the mid-year lecture break.

Hardware Testing

Your hardware will be tested for function on an assessment maze during a session starting at 2:10 pm in the Machines lab, **Wednesday 28 July** as per detailed in this project information document. Your attendance is not compulsory. If your hardware fails to work completely during testing, your group will be allowed just 1 extra hour to work on the hardware/software to sort out any problems (time by specific arrangement via email correspondence). The hardware will then be re-tested and given a final mark.

Project Management

The report **MUST** contain a section dedicated to project management. It is recommended that groups use MS Project or similar software. The beginning date will be the day this assignment brief is received (5/5), and the final date will be your hardware and report submission date (19/7). Work breakdown structure, durations, linkages, project milestones, and critical path should be considered. Budget and labour allocations must be included.

This section will make up 20% of the report mark. **Important note:** Failure to include a project management section in the report will result in the loss of 50% of the marks allocated to the report (leaving a maximum mark of 5).

Important Considerations and Restrictions:

- Departmental intranet on-line resources for the Atmel Atmega-8 microprocessor can be found at www.elec.canterbury.ac.nz/intranet/dsl/p30-avr/index.html.
- Numerous optical sensing, and motor driving circuits can be found on the internet. It is perfectly fine to use these circuits as reference material to help you with your design. Please remember to reference the circuits you use for circuit design help in your report.
- Use robust design techniques for the microcontroller software.
- The motors are only 3V rated, so if using four 1.5V batteries (6V), this must be considered to avoid burning out the motors (no new motors will be supplied).
- **Single-sided** PCB (**maximum** size of 100mm x 140mm). PCB artwork **must** comply with the attached instruction set. Surface mount components are not recommended for this project.
- In this project, there are elements of analogue electronics, microprocessor hardware/programming, PCB construction, and potentially computer system programming. You should form a group that has a good mix of electronics/software skills and interest.
- Use of stocked components and parts available from the Departmental Electronics Store **ONLY** (although I do have a limited number of L2930D dual full-bridge motor drivers you can use at a budget cost of $4 – only 1 per group). You are strictly not allowed to use any non-electronics store parts/materials apart from cardboard and tape to construct your robot from. You should make sure components you intend to use can be quickly re-ordered if stocks run out (some components in the Store are obsolete and no longer available for re-ordering). Components/parts budget per group is strictly limited to $25 (excluding PCB, motor, gearbox, and wheel costs). List all components used on the green ENEL350 card with your group number in the Store (see Dudley Berry for instructions).

Assessment Breakdown (out of 30 total):

Hardware (20):

Circuit design	5
Software design	5
Function	**10**

Report (10):

Abstract:	0.5
Introduction:	1
Project Management:	2
Design Description:	2
Design Results:	2
Discussion & Conclusions:	1.5
References:	1

Submission Details

Completed hardware/software must be submitted to Dr Gaynor's office **between 3pm to 4pm** on **Monday 19 July**. Please supply detailed instructions on how to start your robot for testing purposes. The completed report must be converted to .pdf format and emailed to **enel350assignment@elec.canterbury.ac.nz before 5pm on Monday 19 July**. Name your file as "350project2groupXX.pdf", where XX is your group number (group numbers less than ten use 01, 02 – 09 format). **No late hardware/software or reports will be accepted.**

On-Line Group Booking Instructions

From www.elec.canterbury.ac.nz click "Resources and Facilities" then click "Booking System for laboratories, projects, electrical and mechanical workshop courses"

At the prompt enter the following for your username:

ENG\xyz123 and your normal password

Look under ENEL 350
NOTE: The first one in a group to put their name in the on-line system will book the entire group (reserve it) and then that first person has to release the remaining spots (click again on each position in the group) so that the remaining group members can enter their names.

If you have problems with your group booking, contact Florin Predan, florin.predan@canterbury.ac.nz.

PCB ARTWORK CHECKLIST

Listed below are the critical through-hole component PCB workspace settings
that **must** be configured before you place any tracks (try to use Typical as much as possible).

Parameter	Typical	Minimum
Snap Grid	**25 mil**	
Track width	**40 mil**	30 mil
Component Pads	**80 mil**	60 mil
Vias	**80 mil**	60 mil
Clearances	**40 mil**	30 mil

Listed below are the **absolute minimum** surface mount component PCB workspace settings around each surface mount component. Revert to "Typical" through-hole settings as closely as possible to each surface mount component. **Surface mount components are not recommended for this project**

Parameter	Minimum
Track width	**12 mil**
Component Pads	**12 mil**
Clearances	**12 mil**

Increase Pad size to accommodate components pins/legs that are larger than 0.8mm.
Polygon plane connections to any Pad must be virtually solid (for low resistance and good thermal relief).
Text strings should be at least 60mil Height & 20mil Width.

Final PCB must include the following:

A border to be used as a cutting guide once PCB is etched (100mm x 140mm **maximum**).
Label the PCB.
Remember to mirror the bottom layer text.
Your Group number.