Coursework

Title: *A Subsumption Architecture Implementation on LEGO Mindstorms EV3 Robots*

Hand-in: Programs AND Written Reports will need to be submitted online via Moodle by **Monday 25th November (Week 10) at 3pm UK time.**
Note that also, all Lab Sheets must be assessed during the official Computing and Practical sessions prior to the above deadline at the very latest. It is the students' responsibility to submit Lab Sheets for assessment in good time to enable in-class marking.

Late policy: The deadlines above are absolute. Late submissions of either Programs or Written Reports are subject to a 5% deduction of the overall coursework mark per 24 hours. Note that this also applies for weekend days.
Any lab sheets not assessed by the deadline will be marked as 0.

Informal Description

The coursework task is to program your robot to:

- start somewhere within the race-track
- wander around to find the line
- follow the line around (both clockwise and anti-clockwise)
- detect and avoid any obstacles in the path
- attempt to identify the longest straight of the race-track
- halt the robot in the middle of the longest straight

This must be implemented using *Brooks' subsumption architecture*. Programs will be demonstrated in the laboratory session(s) of week 10 and an implementation report must be written. Note that your solution should be working on any track under a variety of lighting conditions. **Leveraging the characteristics of a given track to the best level possible while achieving robustness in the proposed solution is a core aspect of the assignment.** Hint: application of algorithms and mechanisms reviewed in the module may help to achieve this.

Behaviour Details

Level 0 (*forage*)

Description	performs a fixed/random wander pattern ("looking" for the line)
Applicability	always
Suppresses	none

Level 1 (*follow*)

Description	when the light sensor detects the line, then drive forward, steering left or right as needed to stay on the line as smoothly as possible
Applicability	when light sensor detects the line, or wandered slightly off line
Suppresses	*forage*

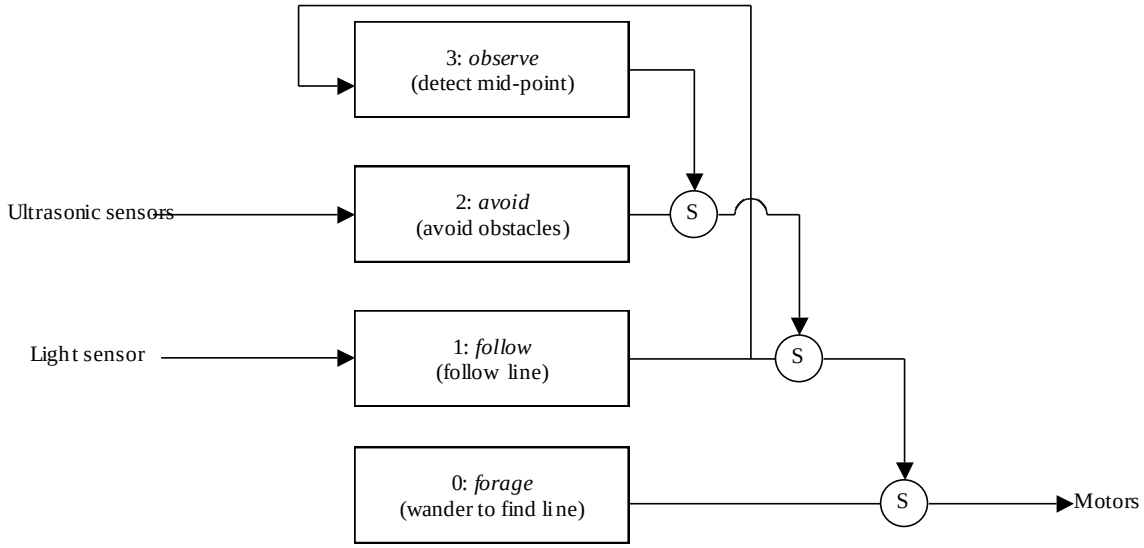
Level 2 (*avoid*)

Description	when ultrasonic sensors are triggered, back up slightly, turn away from and go around the obstacle (to proceed line following…)
Applicability	when ultrasonic sensors are triggered
Suppresses	*line*, *forage*

Level 3 (*observe*)

Description	watches *follow* behaviour's motor commands and tries to identify the middle of the longest leg of the track; when at the centre of this point, then halts the robot
Applicability	when *follow* behaviour is outputting
Suppresses	*avoid*, *follow*, *forage*

Outline Subsumption Model



Laboratory Observation

You will work on the program development and implementation in your assigned laboratory group. You are strongly advised to prepare your programs, enter, and compile them prior to the lab session; you can then use the lab time to observe, test and debug your robot behaviour. *There will be **no** access to the robots outside of normal timetabled lab and practical sessions (i.e. 2 x 2 hours per week)*. Lab supervisors will be keeping attendance records and records of effort for each session – any unequal attendance and/or effort within pairings will be noted and may be used to adjust individual marks.

You should work on the first two behaviours, *forage* and *follow*, in combination with an appropriate *(subsumption) architecture*, first. These will be reviewed at an interim demonstration (see below), after which you will receive feedback. You will then spend the remainder of the time improving the existing solution (if necessary), and implementing the higher two behaviours, *avoid* and *observe*.

Interim Demonstration

At the start of your lab session in **week 6** you will be asked to demonstrate the progress achieved so far. As a minimum you are expected to have implemented functioning *forage* and *follow* behaviours with significant progress towards their concurrent/parallel operation based on a subsumption architecture. This interim demonstration does not carry specific marks, but is an essential component of the coursework. Past experience has shown that students who fail to engage in the laboratory sessions, fail to obtain feedback or fail to attend lectures (which provide the core material required in order to complete the coursework) struggle to pass the module.

Final Demonstration

Source code for your robot is to be handed-in by the specified deadline (see Coursework above). A lab session after the assignment deadline will be used for demonstration of your robot and a mini 'viva'. Your robot will be pre-loaded with your handed-in code and each team will have 10 minutes (strictly timetabled) in which to demonstrate their robot working:

- the robot will be started at a random point within **a** race-track
  (automatic calibration of the light sensor is allowed, **and is strongly advised!)**
- obstacles will be placed at random positions to test obstacle avoidance
- all obstacles will be removed for at least 2 minutes for the robot to 'observe' and halt

After this demonstration, each person will have a brief (~5 minute) individual viva.

Written Report

An individually written implementation report is also to be handed-in by the deadline, containing:

- a brief introduction (½ page maximum, incl. figures) outlining which behaviours have been implemented and how
- a detailed and concise description of each behaviour implemented (3 pages total maximum, incl. figures) – individual behaviour diagrams (e.g., FSM's) should be included. Specific emphasis should be given to HOW a behaviour was implemented (e.g., was a specific algorithm used?).
  (Note: If you choose to include behaviours BEYOND the predefined behaviours, each behaviour will need to be clearly detailed and documented.)
- a detailed description of how the behaviours interact (via the arbiter task) (½ page maximum, incl. figures) – a block diagram (as *subsumption model diagram* as above, with more detail) should be included
- personal reflections (½ page maximum) discussing your contribution to the groupwork
- discussion and conclusions (½ page maximum, incl. figures) summarising achievements, limitations and possible improvements

Note: Writing a concise and professional report is a core part of the assignment (this includes formatting, cover sheet (not included in page count), etc.). The total number of pages for your report cannot exceed 5 pages (with a minimum page margin of 2.5cm on each side, single line spacing and a minimum font size of 12 in Times New Roman font). If your report is longer, any material that goes beyond the page limit will be disregarded.

Assessment Criteria

The practical implementation is marked as a pair-group; the written report is marked individually. Laboratory attendance and/or effort, and individual demonstration viva performance may both be used to modify the individual's pair/group mark.

Practical Implementation (50%)

1st	*forage*, *line*, *avoid* and *observe* behaviours robustly implemented with accurate and reliable location of mid-point
2:1	*forage*, *line* and *avoid* behaviours robustly implemented, with an *observe* behaviour attempting to locate the mid-point
2:2	*forage*, *line* and *avoid* behaviours robustly implemented over multiple randomised run conditions
3rd	*forage* and *line* behaviours robustly implemented over multiple randomised run conditions
F	failure to successfully implement *forage* and *line* behaviours using subsumption architecture

Written Report (50%)

1st	an excellent, well-written report demonstrating extensive understanding and good insight
2:1	a comprehensive, well-written report demonstrating thorough understanding and some insight
2:2	a competent report demonstrating good understanding of the implementation
3rd	an adequate report covering all specified topics at a basic level of understanding
F	an inadequate report failing to cover the specified topics