6.836 Embodied Intelligence–Research Assignment 1

Massachusetts Institute of Technology

Due: Friday February 22nd, 2002

This is a **graduate** class, not an undergraduate class. As such, the research assignments are much more open ended; there will not be much hand holding, and there definitely will not be great levels of clarification of precisely what is wanted. It is up to you to figure out something reasonable that gets at the underlying issues, and at the same time do some thinking. Mechanical problem set problem/solution matching is not what we are looking for here. The purpose of these research assignments is to get you thinking about some of the underlying issues.

The problems require some thinking but not much writing. I don't expect more than a page for any one of them.

This first research assignment can be handled in a boring way or you can have some fun. It is up to you to find any extra resources that you might want to bring to bear on these problems–the course web page `http://www.ai.mit.edu/courses/6.836` has some Braitenberg simulators on it under the handouts link.

Braitenberg uses exquisitely simple vehicles to illustrate concepts such as psychology, cognition, and free will. You will be analyzing in a virutal world. State any assumptions you are making about this world, e.g., friction, light source characteristics, etc. We are looking for both a quantitative analysis of the vehicles as well as a qualitative assessment of their behaviors.

Problem 1.1 Consider modifying each of the four Braitenberg vehicles $2a$, $2b$, $3a$, and $3b$ so that the connections between the sensors and the actuators are non-monotonic. Design vehicles which (a) circle a single light source, and (b) go back and forth between two light sources. Given that there can be no time dependencies within these vehicles, is it possible to design one that can (c) go in a figure eight with a single light source at the center of one of the lobes? If so, do so, otherwise explain why not. Different assumptions about the physical realization of the vehicles may lead to different answers.

Problem 1.2 Add a light source to the top of the Braitenberg vehicles so that other vehicles can sense their presence. Analyze the behavior of a pair of $2a$ vehicles otherwise alone on a flat plane. Repeat your analysis for pairs of $2b$ vehicles, pairs of $3a$ vehicles, and pairs of $3b$ vehicles. What if you start mixing vehicle types—can you find interesting predator/prey relationships?

Problem 1.3 How do things change in problem **1.2** if the light is not omnidirectional, but is visible only over some angle range in the front of the vehicle instead?

Problem 1.4 In problems **1.2** and **1.3** the light sources were always on. Now suppose that the total light level measured by the two front pointing sensors of a vehicle must exceed some threshold for the vehicle's light to turn on. How do pairs of vehicles interact now? (Your answer should cover the four pairs from problem **1.2** with omni-directional light, and the four pairs from problem **1.3** with restricted light.)

...see over...

Even if you used one of the simulators for the previous problems it is going to be harder to use it for the next three, as you would need to do a lot of hacking. So it is probably better to think of these as just paper problems.

Problem 1.5 Consider a Braitenberg-like vehicle with two actuators and an array of three range sensors in front. The sensors point $0°$, $-30°$, and $30°$ from straight ahead. They each return the range to the nearest obstacle in that direction (up to some maximum value). For the moment ignore these sensors. Build a network of augmented finite state machines (from chapter 2, or the lecture of February 15th) that makes the vehicle wander around randomly, perhaps bumping into things. You can assume that the AFSMs have access to a wire that produces a new random number periodically. In building the network, you will have to specify a reasonable interface to the actuators and fully specify each of the AFSMs.

Problem 1.6 Now add an obstacle avoidance layer to the network of problem 1.5. You will have to specify a reasonable interface to the sensors to do this. The new layer should only interact with the existing random-move layer of the previous problem through suppression and inhibition.

Problem 1.7 In problem 1.6 the time periods used in the AFSMs will depend on the nominal velocity of the vehicle, the scale of the vehicle, the update rate of the sensors, and the maximum range of the sensors. Pick one of your time constants and discuss the qualitative nature of each of these dependencies.