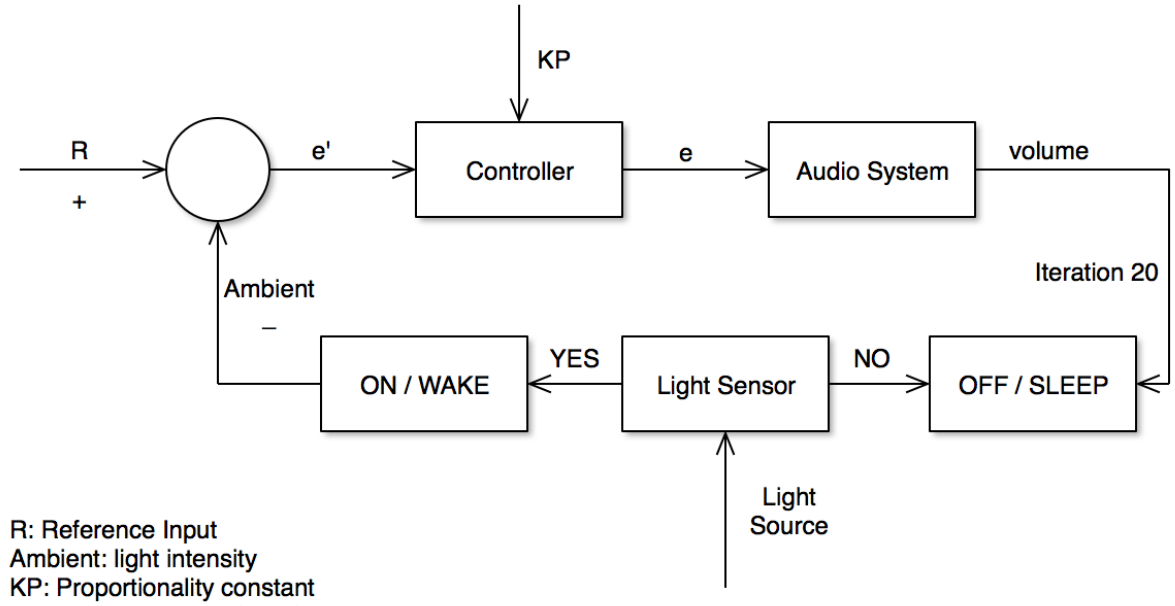
Braitenberg Vehicle-1

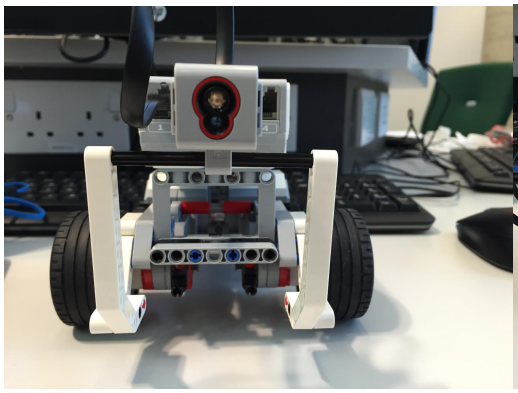
Design & Implementation

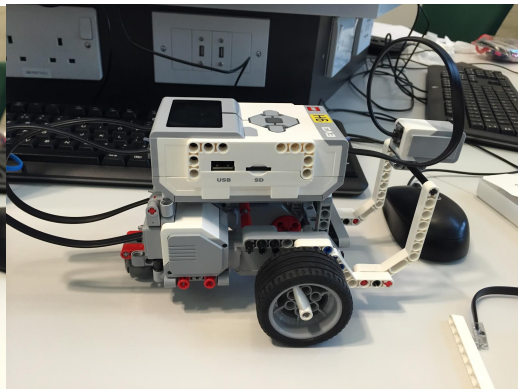
Negative Feedback Controller



R: Reference Input
Ambient: light intensity
KP: Proportionality constant
absError = Math.abs(error)
e' = R - Ambient
e = e' * KP
volume (HZ) = (R-absError)*1000

The following are photographs of the robot.





As shown above, the structure of the code is based on the main method “detectLight” in which the two motors are set to have the same speed. The error and volume of the speaker are then calculated. After 20 iterations, the robot’s behaviour changes and is set to sleep.

Evaluation

Question 1

A. R = 0, Error is negative so robot moves backwards. The lower the ambience the increased pleasure.
B. R = 2i, Error is positive so robot moves forward. The lower the ambience of the light, the decreased pleasure.
C. R = 5, Error is positive with continuous value of ~2.5. Robot moves fast due to increased effort, and has a tendency to overshoot desired ambience level.

Question 2

- **Slow-moving light source**
  Gradual change in speed. Pleasure levels were kept constant.
- **Fast-moving light source**
  Robot movements were "jumpy." Pleasure levels were not kept constant.

Question 3

With a higher Kp, the error was also higher. Therefore, the robot moved faster to correct it, overshot its desired ambience and lowered its pleasure.
For a low Kp, the robot moves at a reasonable speed. Pleasure was kept high and constant.

Question 4

With the light sensor pointing backwards or to the side, the robot failed to pick up varying ambience levels. As the ambience level was constant, so were the error and pleasure levels.

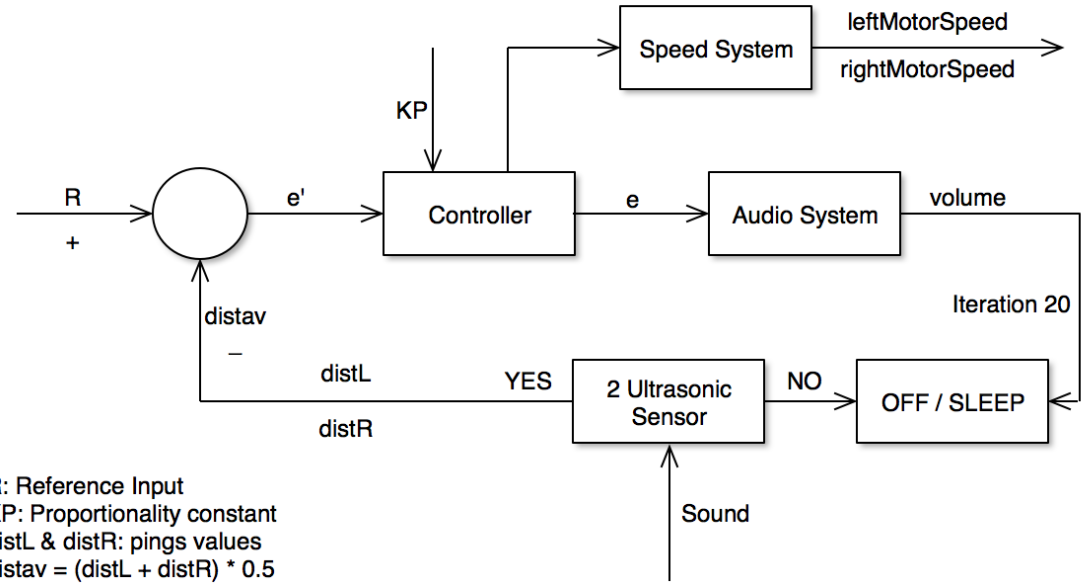
Question 5

By reversing the polarity of the motors, instead of reducing the error margin it accidentally increased it. Therefore, the robot progressively lowered its pleasure.

Braitenberg Vehicle-2

Design & Implementation

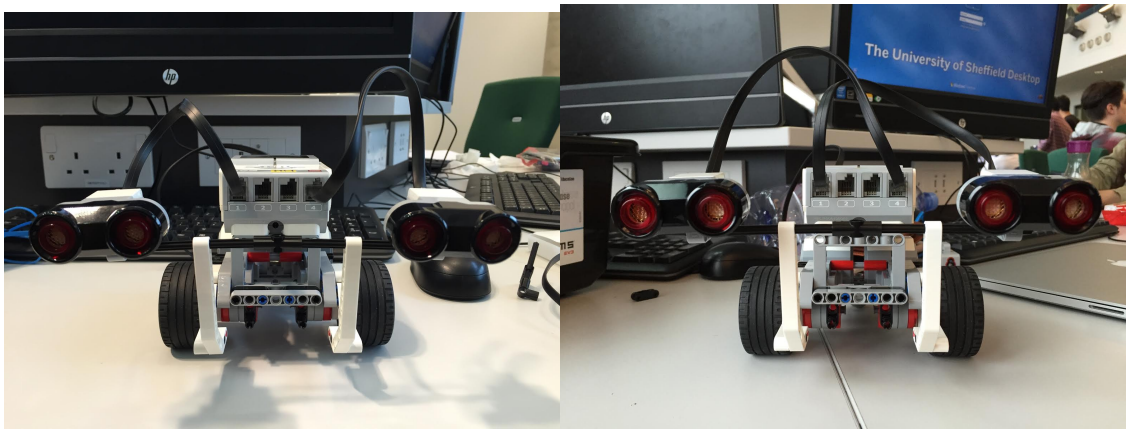
Negative Feedback Controller

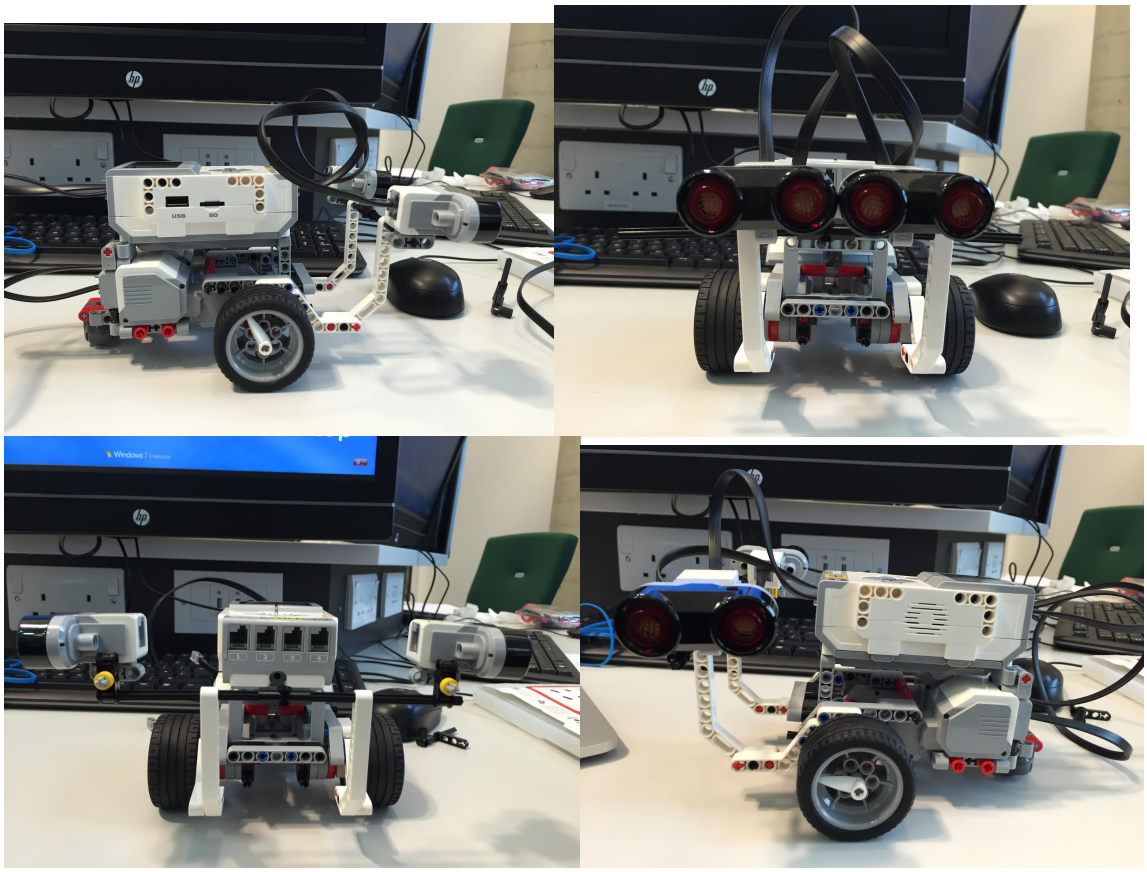


R: Reference Input
KP: Proportionality constant
distL & distR: pings values
distav = (distL + distR) * 0.5
e' = R - distav
e = e' * KP
volume (HZ) = (R-absError)*1000
leftMotorSpeed = ROBOT_SPEED (set) * distL
rightMotorSpeed = ROBOT_SPEED (set) * distR

The structure of the code is included in the above diagram.

The following are photographs of the robot.





Evaluation

Question 1

The robot did exhibit similar behaviour. In our experiments, we found setting R = 2 and Kp = 1 maximised pleasure.

Question 2

Vehicle-2a Fear	Vehicle-2b Aggression
1. If the connections are not crossed, then it speeds up and turns away from stimulation (Ipsilateral excitation). 2. If the stimulation is directly ahead, the vehicle may hit the source. Otherwise, it would turn away from stimulation.	1. Crossed positive connections mean that the robot will turn towards the side with the greater stimulation (contralateral excitation.) 2. If the stimulation occurs one side, it would veer towards with increasing speed. 3. If the stimulation is directly ahead, the vehicle moves directly towards it as before.

Interpretation: Fear & Aggression are anthropomorphic descriptions for the vehicle's movement. Vehicle-2a seems restless in the object's vicinity avoided it and speeds up while exposing to more stimulations. Vehicle-2b was excited by the object and aggressively moved towards it and possibly hit and destroy the source with high speed. Therefore, it can be said Vehicle-2a is fearful and Vehicle-2b is aggressive.

Question 3

Both sensors were detecting a lot of the same signals, so the robot's motors were constantly competing resulting in a high error value and low pleasure value.

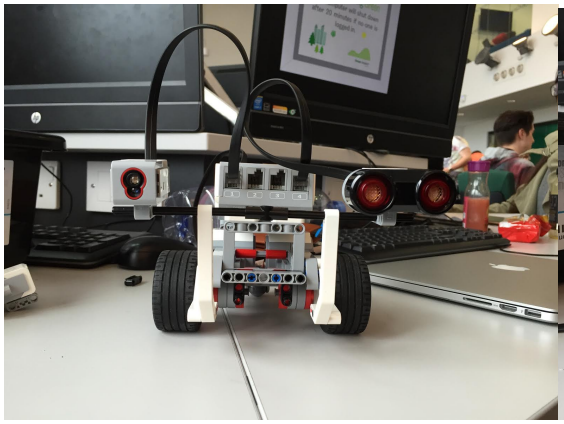
Question 4

The sensors detected different signals, but the robot failed to find a balance. Therefore, error stayed high and pleasure was low.

Braitenberg Vehicle-3

Design & Implementation

The following are photographs of the robot.



Evaluation

Question 1

The robot did exhibit similar behaviour. Vehicle-3a had a strong attraction to the object, whereas Vehicle-3b moved away from the object and explored for stronger sources. Setting Kp = 1 maximised pleasure.

Question 2

Vehicle-3a Lover	Vehicle-3b Explorer
1. Vehicle-3a orients towards source and comes to rest facing it. 2. Uncrossed inhibitory connections give ipsilateral inhibition. As soon as the stimulation is strong enough, vehicle would be exerted sufficient inhibitory activation.	1. Vehicle-3b comes to rest facing away from the stimulation. 2. Crossed negative connections give contralateral inhibition. It slows down on seeing light, but then turns away and speeds up again.

Note: For both Vehicle-3a and Vehicle-3b, there need to be some constant positive signal to the motors as well, which gets inhibited by the effects of the stimulus.

Interpretation: Vehicle-3a is obsessed with the source and would attempt to stay close to it. Vehicle-3b however, although liking the source, attempts to find a more gratifying resource. In conclusion, vehicle-3a is a lover and vehicle-3b is an explorer.

Vehicle-3c Evaluation

Vehicle-3c uses a light sensor and an ultrasonic sensor. Without stimulation, its motors and movements are inhibited. Vehicle-3c has two possible conditions. When no light is shined on it, it has a stable status and keeps a constant distance away from wall. However, when a light is shined on it, it veers towards the wall. Considering the different values detected by the vehicle, it's possible to say it has some form of "knowledge" of its likes and dislikes. Instead of storing the values in the explicit storage which can be manipulated by the vehicle, it is attributed to the vehicle by an outside observer; the ultrasonic sensor. Attributing the values (knowledge) to the vehicle is a more appropriate way to describe its behaviour, whilst it has nothing to do with the vehicle's internal structure.

Conclusion & Further Discussion

Summary

1. The early Braitenberg vehicles indicate how much cognitive movement could be obtained with limited reactive, dynamic parameters in a particular environment (light & sound).

2. By varying the type of sensory-motor connections, it would generate widely diverging behaviours.

3. Implementing inhibitory connections (i.e. an element of choice) could enormously extend the amount of possible vehicle commands.

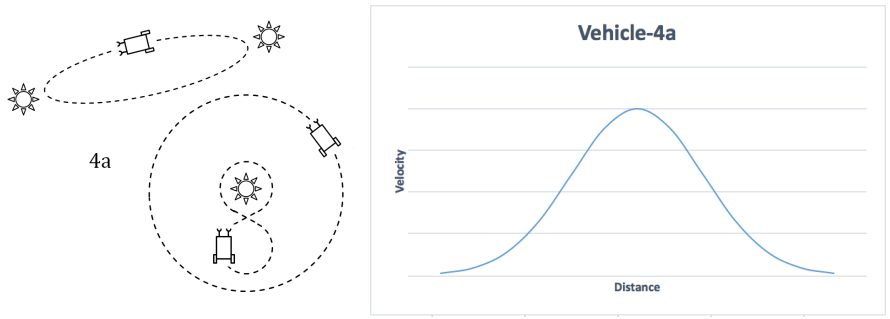
Further Discussion

Vehicle-4a (Improved version of Vehicle-2b.)

Background

As in vehicle-2b, a distance sensor is stimulated. However, in this example there is a global maximum where the robot can no longer move faster. If the maximum is breached, the vehicle turns away, decreasing the stimulation and therefore its speed.

Implementation



Reference: Wikipedia

As the background described, the graph followed the expected trend and produced a gaussian distribution.

Conclusion

Vehicle-4a would move faster due to the stimulation to an individual sensor, but once the stimulation becomes too strong, lower its speed, circle back and turn back again. This would repeat in a cycle.

In conclusion, if a vehicle possesses nonlinear and complicated sensory-motor connections, possible responses would be continuous, discontinuous or a combination of both. It's difficult to predict the motions of the vehicle. Experimentation is likely necessary.