UNIVERSITY OF AMSTERDAM

Faculty of Science

Exam

Behavior-Based Robotics
Bachelor PsychoBiology

Regular Exam

Date: February 2, 2017
Time: 13:00-16:00
Place: H0.08

Number of pages: 8 (including front page)
Number of questions: 6

BEFORE YOU START

- Please **wait** until you are instructed to open the booklet.
- Check if your version of the exam is complete.
- Write down **your name, student ID number,** and if applicable the **version number** of the exam **on each sheet** that you hand in. Also **number the pages.**
- Your **mobile phone** has to be switched off and in the coat or bag. Your **coat and bag** must be under your table.
- **Tools allowed:** ruler, graphics calculator

PRACTICAL MATTERS

- The first 30 minutes and the last 15 minutes you are not allowed to leave the room, not even to visit the toilet.
- You are obliged to identify yourself at the request of the examiner (or his representative) with a proof of your enrollment or a valid ID.
- During the examination it is not permitted to visit the toilet, unless the invigilator gives permission to do so.
- 15 minutes before the end, you will be warned that the time to hand in is approaching.
- If applicable, please fill out the evaluation form at the end of the exam.
- You may answer the questions both in **Dutch** or **English**.

Good luck!

Intentionally left nearly blank. Great for notes!

Cartoon by S. Iwasawa from Pfeifer & Bongard: How the body shapes the way we think, MIT Press 2007.

Question 1

After the invention of Braitenberg Vehicles, they were actually created as true robots [1]. The researchers created six simple creatures with only one sensor and a rather limited electronic "brain". An example is the *Paranoid* creature, which drives straight until its protruding **threshold light sensor** enters a shadow. When this happens, the sensor's output switches from on to off, which the driving direction of the left motor, such that the left wheel reverses. At this point, the left and right wheels are driving in opposite direction, forcing the Turtle robot to pivot to the left (as illustrated in Fig. 1). It swings around to the left until the protruding sensor has swung back out of the shadow. At this point the left wheel returns its driving direction again and the Paranoid creature is driving straight again.

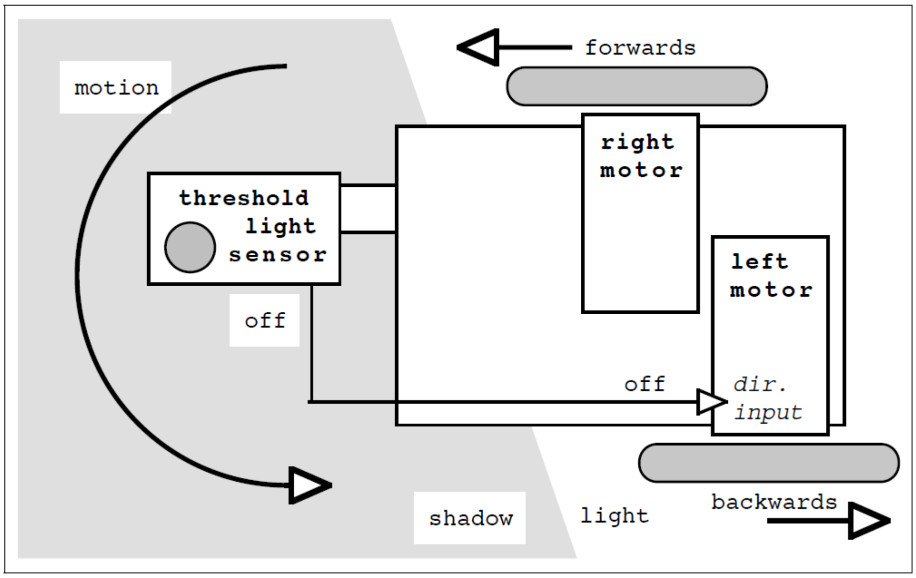


Fig. 1: The coupling of sensors and actuators for the Paranoid creature

Now it is your task to sketch comparable couplings between sensors and actuators for two of the three simple creatures. Next to the **threshold light sensor**, you also have the availability of a whisker (which change its output when a bending threshold is reached) and a **differential light sensor** (which has two outputs, indicating if there is more light received at the *left* or more light received at the *right*).

You can also make use of analog controls, such as a signal inverter and a memory element as a flip-flop.

These are the three creatures we like to see build:

Indecisive creature

If sufficient light is falling on the robot, the vehicle drives forward; otherwise it drives backwards. The result is a creature that finds shadow edges; it drives around until a shadow (table, hand) is cast over it. It directly runs back to the light, but there it is forced forward again, oscillating back and forth at shadow edges.

Dogged creature

This is a robot equipped with a front and back bumper. It runs either forward or backward. When either the front or back bumper is pressed, the robot changes direction. The result is a creature running quickly back and forwards between two obstacles.

Driven creature

The driven creature should move towards a bright light by successive right and left turn, wiggling its way towards light sources.

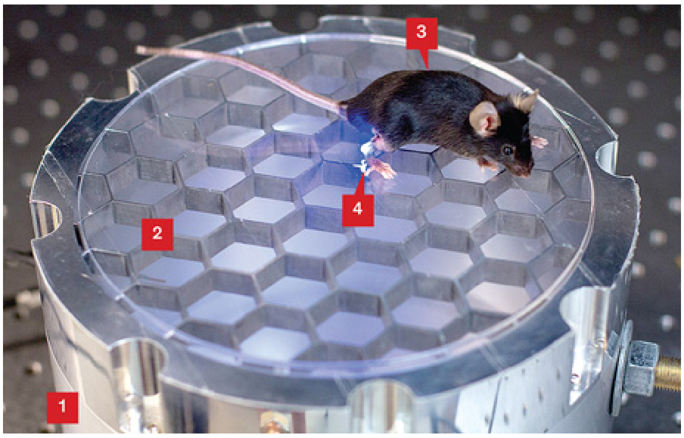
Sketch, describe and explain your designs!

Question 2

Geneticists are able to deposit genes of algae species, which encode for light-sensitive proteins, into specific clusters of neurons in a mouse brain. With this modification, specific neural “circuits” could be switched on, allowing to observe the effect on the animal’s behavior. Yet, the type of behaviors that could be studied where limited due difficulty to get the light into the brain. Until recently the solution were to use tiny fiber-optic cables or small implanted devices which were energized by a bulky battery-pack.

This solutions stresses the animal, which can alter the outcome of behavioral experiments. Tethered, its movements are limited, which makes it difficult to perform maze experiments In addition, it changes the animal appearance, which prevents normal social interactions with other mice.

Recently, a method was designed to wirelessly energize the implants of a mouse by radio waves [2]. This is not as simple as it sounds, because to keep the receiving coil small enough, the transmitting structure needs to be close to the animal. If the structure just emits its waves everywhere in the maze, a lot of energy is wasted, which generates a lot of heat. Aiming the waves at the mouse, requires active tracking of the animal. Instead the engineers designed a resonance chamber with an open grid. The waves are trapped in this chamber, until a mouse takes a step and releases the energy at that specific cell of the grid (See Figure 2).



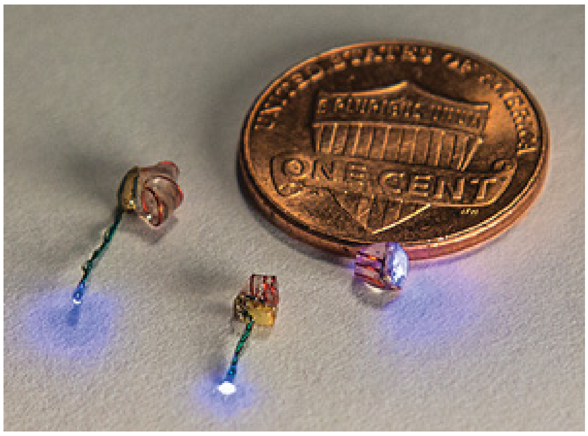


Fig. 2: (a) A wireless mouse (Courtesy Austin Yee). The implant of the mouse is energized by radio waves in resonance to the mouse body. The grid at the top [2] prevents the waves from escaping the resonant chamber [1]. Yet, every point of contact [4] allows the waves to escape the resonant chamber and resonate within the body of the mouse, which allows to energize implants like a tiny LED device. (b) Wireless powered LED device which allows to stimulate genetically altered neurons in the brain.

Which sort of social behavior experiments would you design if you would have access to such an experimental setup. Would you try to study flocking, foraging, consuming, grazing or transport? **Explain your argument for choosing one of those tasks and give a design of an experiment that you would perform with those wireless controlled mice. Make sure that in your arguments you include the social interaction between mice and the amount of space your experiment needs (there is still a limit on the size of the resonant chamber).**

Question 3

Cognitive science is shaped by a sequence of emerging paradigms. Each change is driven by the explanatory need to address previous shortcomings in explaining cognition by appealing to a more inclusive set of determining factors. Froese summarizes this history in the following figure:

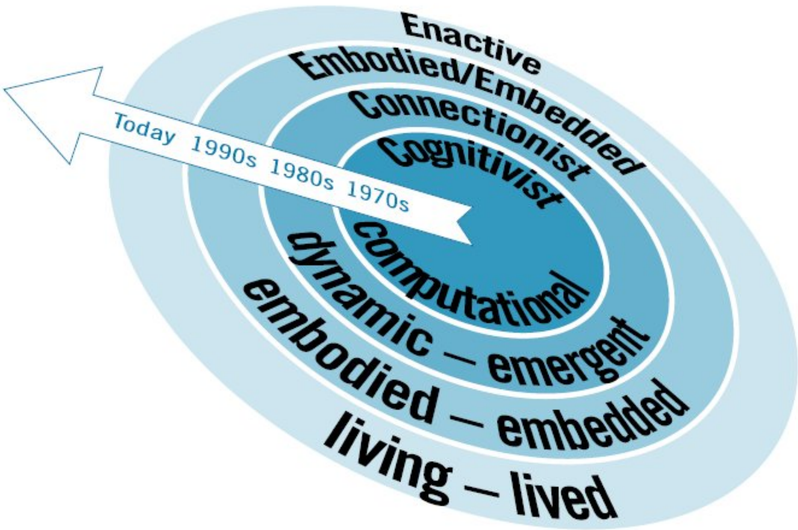


Fig 3: A history of ideas in Cognitive Science (Courtesy Froese [3])

a) Indicate for each of the 1970s, 1980s and 1990s a typical cognitive scientist who represents the computational, emergent and embodied paradigms.
b) Indicate for the emergent and embodied paradigm which previous shortcomings are addressed.
c) **Bonus:** indicate which shortcoming of the embodied paradigm the enactive paradigm addresses.

Question 4

Suppose you have a sweet-pepper harvesting robot with a mobile base and an arm (see Fig. 4).

Fig 4: A prototype of the Sweeper robot from Wageningen University

A behavior called *Pluck* controls the arm. *Pluck* uses a camera tuned to the spectral signature of ripe peppers to servo on and pick the fruit. Another behavior called *Nav* uses a differential GPS system to navigate from one plant to another. *Nav* outputs commands for the base, Pluck for the arm. If *Nav* and *Pluck* are the only two behaviors, does your behavior-control system require a coordination module which performs arbitration? Is this situation changed if the arm is extended while the base is in motion? Draw a simple behavior diagram to describe the working of the system. Include any other (perceptual) behaviors you feel the system would need.

Question 5

Suppose you were to construct a library of potential fields for the five primitives potential fields *uniform, perpendicular, attraction, repulsion* and *tangential* (see Fig. 5):

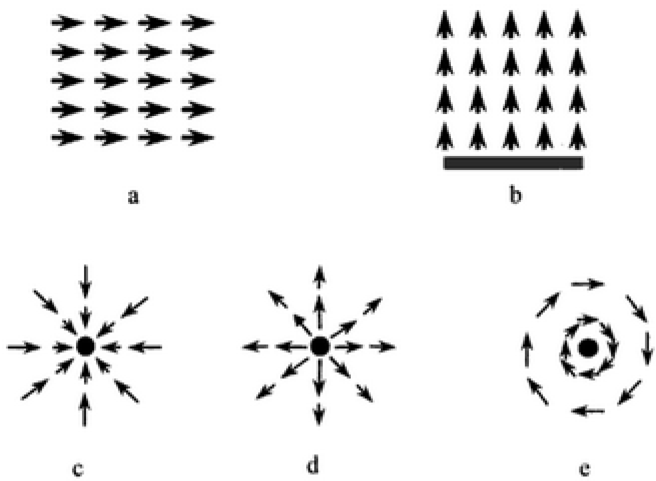


Fig 5: Five primitive potential fields (courtesy Robin Murphy [4])

Your library consist of five Python function, which will have a number of arguments.
What parameters would you include as arguments to this function to allow a behavior designer to customize the effect of the fields?

Question 6

Some robots are clearly bioinspired, such as the eight-arm robot developed in the OCTOPUS project (see Fig. 6):

Fig 5: Octopus-like eight-arm robot (courtesy C. Laschi & London Science Museum [5])

This robot is able to perform a crawling behavior by actuating two of its eight arms [5]. During crawling, each of the two arms are used to push the body forwards in a four-phase cycle: shortening, attaching to the ground, elongation, and detaching. In the article is claimed that for an octopus-like robot, one DoF is enough to obtain the four phases.

Explain how one degree of freedom (DoF) should be interpreted for an octopus-like robot. Does this mean that a robot can move in only one direction?

References

[1] David W. Hogg, Fred Martin and Mitchel Resnick, "Braitenberg Creatures", MIT Media Laboratory Epistemology and Learning Group memo No. 13, June 1991.
[2] A. Poon, "A new kind of wireless mouse," in IEEE Spectrum, vol. 53, no. 12, pp. 26-32, December 2016.
[3] Froese, T. (2010), "From Cybernetics to Second-Order Cybernetics: A Comparative Analysis of Their Central Ideas", Constructivist Foundations, 5(2), pp. 75-85.
[4] Robin R. Murphy, "Introduction to AI Robotics", MIT Press, 2000.
[5] C. Laschi and B. Mazzolai, "Lessons from Animals and Plants: The Symbiosis of Morphological Computation and Soft Robotics," in IEEE Robotics & Automation Magazine, vol. 23, no. 3, pp. 107-114, Sept. 2016.

You reached the end of the exam!