Report on Barrera and Weitzenfeld: Bio-inspired Model of Robot Spatial Cognition: Topological Place Recognition and Target Learning

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1 Problem

The problem addressed in this paper can be phrased as a question: "How do I know where I am?". The example used in the paper is a rat that finds its way through a maze. How does the rat know where it is if placed in a random location of a maze that it has explored before. The specific issue that is addressed is how to incorporate kinesthetic and visual information to form a spatial map while localizing yourself within this map.

2 Solution

The solution presented by the authors is inspired by experiments done on rats. The experiments showed that without spatial memory and cognition, rats are unable to use visual cues to locate a goal from a previously unvisited location. The solution that they implemented was fairly technical but can be summarized as follows: A cognitive model that starts with sensory inputs of kinesthetic information, landmark information, internal state and affordance information (amount that the rat can turn). The kinesthetic, landmark and affordance information is processed by a place representation network. The information from this processing as well as the internal state is used for reinforcement learning which is then used (along with the affordance information) to select an action (how far to move, how much to rotate and which direction).

The localization and mapping is done using two processing layers: one that builds up a current neuronal activation pattern from sensory input and another that stores the activation patterns of the previously searched locations. The current activation pattern is searched for in the stored activation patterns till a close match is found, whereupon the robot has located itself and can proceed to its goal.
3 What I learned

I learned that biological research can indeed inspire good solutions to current automation problems. The work that inspired this seems fairly primitive (destroying parts of the brain to see whether it is important for a specific task) but provided the authors with the right ideas to construct a working model of a creature that can map out its surroundings, locate itself within the map and find a target once it has done so. They also used off-the-shelf robotics and programming languages suited to neural network programming. This reduced the amount of effort needed to construct the experiment.

4 Work involved to implement the solution

The work involved programming a computer system (the Neural Simulation Language system) with the neural model described. Then connecting the system to the robot and programming it to control its motion (rotation and translation) and read its sensor (visual). The final part of the (experimental) work was constructing the maze and running the experiment. The results had to then be interpreted and analyzed before writing the paper.

5 Materials and Parts used

The main components of the experiment are the computer running the NSL system, the robot (a Sony Aibo) and the maze.

6 Critiques

The robot could only recognize a location that it had visited previously if it had stood directly next to it before. This is shown in the experimental runs starting at the further locations from the goal (D1 and D2). If spatial kinesthetic, landmark and affordance information can be used to map out an area then the distant L2 marker could have been noted in the training runs and recognized in the experimental runs.

One further critique is that they used an Aibo to provide sensory input but "dumbed down" the sensory input in such a way that they may as well have only used a computer, making the experiment cheaper.