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Models of Neural Systems, WS 2009/10
Project 5: Reward-related learning in animals
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Background

Obtaining natural rewards (food, water, sex) is essential for the survival of animals. Learning to obtain rewards is therefore a very important task for the brain. It has been shown that dopamine neurons in the brain play a crucial role in processing reward-related information. In this project you will employ a variant of reinforcement learning to model the firing rate of dopamine neurons in reward-related learning tasks. Further, you will examine the utility of the modelled dopamine signal for decision making. To do so, you will implement a decision-making module and compare your model with animal behaviour.

Reinforcement learning and dopamine cell activity

Dopamine neurons have a low baseline activity (only about 5 Hz), but exhibit brief phasic bursts (up to 100 Hz) when the animal receives a reward. Importantly, dopamine cells are only active if the reward was unpredictable. If there is some cue that predicts the reward, dopamine cells respond with a phasic burst to the occurrence of the cue instead.

1. Read some of the relevant literature. This includes (a) the original paper describing the so-called temporal-difference (TD) reinforcement-learning algorithm (Sutton, 1988), (b) papers on dopamine responses in primates (Schultz et al., 1997; Morris et al., 2005), and (c) papers that use the TD algorithm to model dopamine cells (Montague et al., 1996, Pan et al., 2005).

2. Implement the TD algorithm as described in Pan et al. (2005) and reproduce the dopamine cell activity in a classical conditioning paradigm.

3. Examine the effect of changes to the paradigm. For example, let the reward occur in only 50% of the trials. Can you think of any other interesting changes to the experimental paradigm?

Model animal decision making

Unlike in classical conditioning, most tasks require that the animal performs a correct action in order to obtain a reward. So far, you have seen that the dopamine signal is useful to learn to predict future rewards. Here, you will examine its aptitude for learning to choose the right action.

1. Implement a decision-making module as described in Rose et al. (2009).
2. As above, think of some interesting variations to the experimental paradigm. Can you make predictions for how animals should act in the task you modelled?

Create labeled figures for all your main findings and a write a brief summary of your findings.

Literature

P.R. Montague, P. Dayan, T.J. Sejnowski (1996). A framework for mesencephalic dopamine systems based on predictive Hebbian learning. *Journal of Neuroscience* 16(5):1936-47.

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