Learning goals

1. Introduction

1. Recall Marr's three levels of analysis and an example thereof (barn owl)
2. Recall the Bayesian brain hypothesis
3. Explain what is meant by predictive coding
4. Explain the difference between Bayesian models and ANN models as methods to understand brain function

2. Theory

1. Understand the basics of Bayesian inference (prior, likelihood, posterior)
2. Be able to apply Bayes' rule and explain its components
3. Understand ML and MAP estimationKnow what is meant by Bayesian model comparison and write down the equation for the Bayes factor
4. Understand what a multilayer perceptron is
5. Be able to explain Q-learning, policy, action-value function
6. Explain how neural networks can be used to implement Q-learning

3. Models of memory

4. Neuromodulation

5. Bayesian connectomics

6. Optimal control

1. Understand which computational problems the brain has to solve in order to successfully execute a movement
2. Understand the optimal control model, including each of the elements and how they are linked to each other and its features and assumptions/limitations
3. Understand the state estimation (Kalman filter) model, including each of the elements

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4. Understand Optimal Feedback Control Theory, including each of the elements and how they are linked to each other and its features and assumptions/limitations
5. Be able to formalize an Optimal (Feedback) Control model by formulating the state equation, the measurement equation, the cost function, the state estimation and the control policy based on a Linear Quadratic Gaussian (LQG) controller
6. Be able to explain and interpret the differences between optimal control and Optimal Feedback Control (OFC)
7. Be able to make predictions for experiments that address neural responses or human behaviour from the three covered theories (Optimal control, state estimation, and Optimal Feedback Control)
8. Be able to design behavioural or (single-)neuron experiments to test predictions from the three covered theories (Optimal control, state estimation, and Optimal Feedback Control)
9. Be able to explain which brain areas are thought to play an important role in each of the components of the three covered theories (Optimal control, state estimation, and Optimal Feedback Control)

7. Reinforcement learning

1. Understand why we believe that Pavlovian conditionings is driven by error-based learning
2. Recall the equations and use these to explain the two basic features of the Rescorla-Wagner model
3. Understand the evidence is that midbrain dopamine firing reflects the reward prediction error
4. Explain the limitations of the Rescorla-Wagner model (ie. which phenomena it cannot explain)
5. Explain how temporal difference learning addresses these
6. Explain how goal-directed behaviour cannot be understood in terms of classic learning theory (ie. RW and TD learning)
7. Understand how goal-directed and habitual behaviour can be distinguished experimentally

8. Neural representations

9. Predictive processing