

Neural sampling as neural dynamics

Tentative FYS5429/9429 project outline

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Background

- Many prominent neuro and cognitive scientists claim that brains essentially are prediction machines
- The idea that brains perform probabilistic reasoning is highly consistent with experimental findings
- **Bayesian brain hypothesis**
 - The brain maintains probabilistic models of the world
 - Performs (approximate) Bayesian inference for predicting current and future events based on experience
- **Neural sampling**
 - Neural activity is regarded as samples from internal probabilistic models
 - Sampling is implemented through the temporal dynamics of spiking neurons

Tentative project 1

- Explore neural sampling as neural dynamics
- Maybe use a Bayesian Recurrent Neural Network (RNN)?
 - RNNs achieve state-of-the art performance on a wide range of sequence prediction tasks
 - Bayesian RNN: parameters of the network (e.g. weights) represented as probability distributions rather than fixed values
 - Neural sampling implemented through using spiking computational units
- Challenges
 - Training spiking neural networks
 - Probably lots more...

Possible extension as project 2

- Explore neural sampling with energy-based neural networks
- Develop a Neural Sampling Machine (NSM)
 - Based on Restricted Boltzmann Machine (RBM) but with spiking neurons
 - Internal world model updated by minimizing the free energy calculated as the discrepancy between sensory input and predictions of that input (prediction error)
 - In neurobiologically plausible terms, this can be cast as predictive coding