FYS5429 Project Report

Janita Ovidie Sandtrøen Willumsen

https://github.com/jovidie/FYS5429

(Dated: March 20, 2024)

I. INTRODUCTION

In neuroscience, machine learning has become useful tool. It allows us to investigate several hypotheses, before testing the the most promising ones in animal models. This process can speed up the time of testing, while reducing the number of animal lives spent. It is, however, important to build efficient models, as energy resources are still limited.

One machine learning method is artificial neural network. It was inspired by the synapses in the brain, and has been found useful in neuroscience. One interesting circuit to investigate, is the entorhinal-hippocampal circuit, which is thought to be vital in navigation [4, 5]. Using biological plausible conditions, the neural network can learn how to path integrate [2].

The aim of this project is to train a model to learn trajectories, by taking velocity data as input. Since the trajectories are time dependent, the model has to take in sequential data, I will implement the model using a recurrent neural network.

II. PROJECT PLAN

1. Decide on theoretical background, such as articles and machine learning methods.

2. Decide on environment setup and generate synthetic data using `RatInABox` [3]

3. Set up vanilla RNN using `PyTorch` [1], and experiment with parameters.

4. Expand experiment to include more complex environments, and/or objects in the environment, and train the model. Test the model on both seen and unseen environments, and compare performance.

III. PROGRESS REPORT

I researched the use of neural networks, specifically recurrent neural networks (RNN), and decided to look more into path integration. As a main article I will focus on the work of Banino et al. in [2].

To generate synthetic trajectories of an agent moving in an environment, similar to a rodent exploring a new environment, I used a package called `RatInABox`. I started with a default square environment of 1×1 meter, and an agent with no bias toward walls. With this setup I generated a dataset containing velocity and position.

Next, I started building the RNN model. I did some test runs using a basic RNN from PyTorch, however, it was not able to learn the correct path. I continued building a vanilla RNN using the module class provided by PyTorch, and set up a model which was able to predict similar trajectories as the labeled trajectories.

So far I have tested the model using a hidden layer with 7 and 10 neurons, increasing the number of neurons also increase the accuracy. I have also tested with different number of epochs, batch sizes and learning rates during implementation. Figure 1 shows the current model predictions.

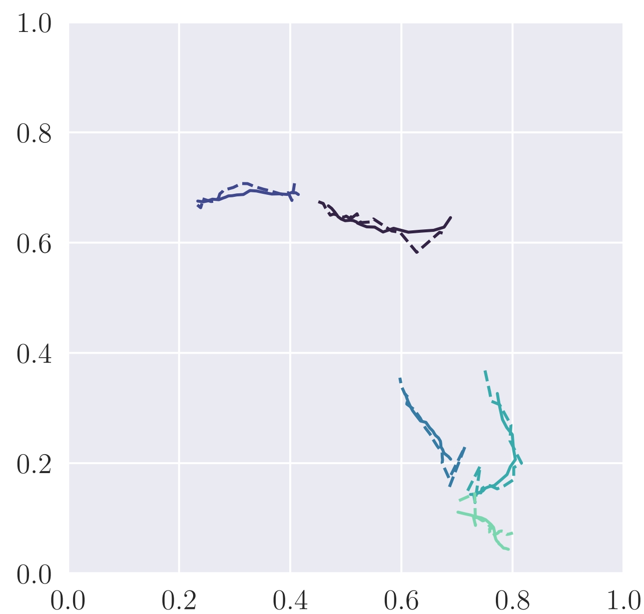

Figure 1. The model have been trained on 5 different sequences, each with 19 time steps. The original trajectories, are plotted in solid lines, and the predicted trajectories in dashed lines.

IV. FUTURE WORK

The next step is to tune the model, and investigate different parameters such as learning rate and optimizers. Continuing, I will experiment with different environments, and agent biases. And if time allows, I will test the model on unseen environments. In addition, I plan on training a model on synthetic and test it on experimental data.

[1] Pytorch documentation.

[2] Andrea Banino, Barry Caswell, Benigno Uria, Charles Blundell, Timothy Lillicrap, Piotr Mirowski, Alexander Pritzel, Martin J. Chadwick, Thomas Degris, Joseph Modayil, Greg Wayne, Hubert Soyer, Fabio Viola, Brian Zhang, Ross Goroshin, Neil Rabinowitz, Razvan Pascanu, Charlie Beattie, Stig Petersen, Amir Sadik, Stephen Gaffney, Helen King, Koray Kavukcuoglu, Demis Hassabis, Raia Hadsell, and Dharshan Kumaran. Vector-based navigation using grid-like representations in artificial agents. *Nature*, 557(7705):429–433, 2018.

[3] Tom M George, William de Cothi, Claudia Clopath, Kimberly Stachenfeld, and Caswell Barry. RatInABox: A toolkit for modelling locomotion and neuronal activity in continuous environments. 2022.

[4] Torkel Hafting, Marianne Fyhn, Sturla Molden, May-Britt Moser, and Edvard I. Moser. Microstructure of a spatial map in the entorhinal cortex. *Nature*, 436(7052):801–806, 2005.

[5] John O'keefe and Lynn Nadel. *The hippocampus as a cognitive map.* Oxford university press, 1978.