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Computational Biology Homework 3

1 Introduction

This project focuses on building and analysing the performance of a Hopfield Network for learning images of digits. Such a Network is a weighted click graph that is used as a model for network memory. This document describes the application and evaluation proposed.

2 Methods

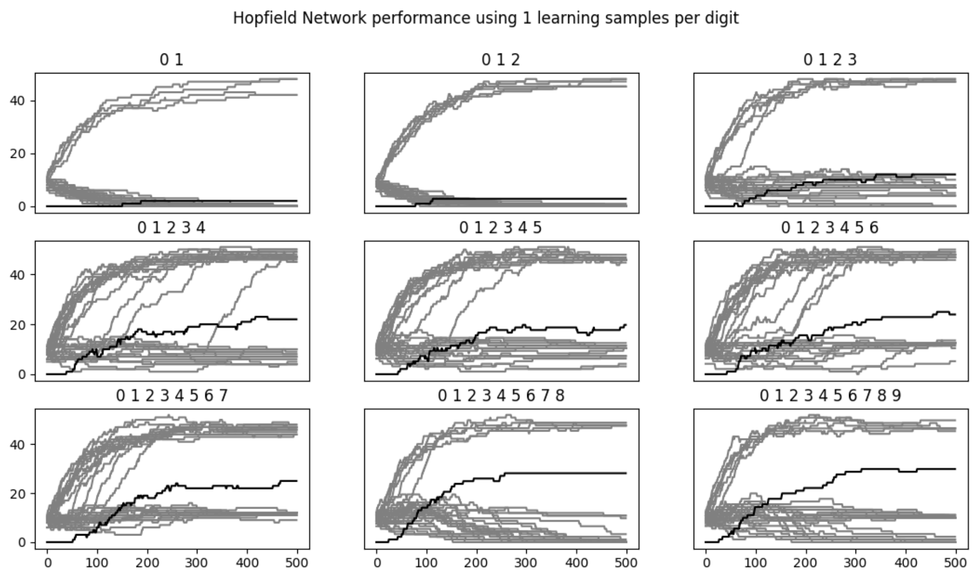
The digits are represented as images of 10x10 with binary values. They are fed to the network as 100 bit arrays. The network has a learning period where it adjusts its weights between its 100 nodes. The second procedure it performs is a form of evaluation where it transforms a given 100 bit input into a “recognizable” array.

To test the network's performance we transformed the original images that it learned by 10% then evaluated them. The evaluation result (recovered image) was then compared to any of the images learned by the network. The similarity by them was calculated using levenshtein or editing distance. Besides checking if the network transformed the input to a recognisable image we also need to test if the transformation corresponds to the intended initial digit that was modified.

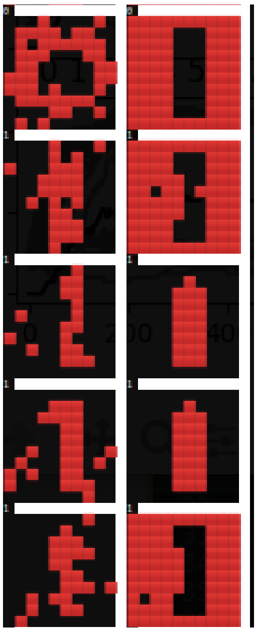
3 Results and Homework Questions:

3.1 How many digits can the network learn?

Below is a collection of graphs that show experiments in which the network was taught a variable number of digits. Each experiment shows the recovery of 30 modified samples fed to the network after it learns each of the digits. The grey lines represent the result of the similarity metric to the learned set. The black line represents the total error of identification. A good Network transforms the input to a learned digit (convergence of the grey lines) and more importantly to the correct digit (low error rate represented by the black line).

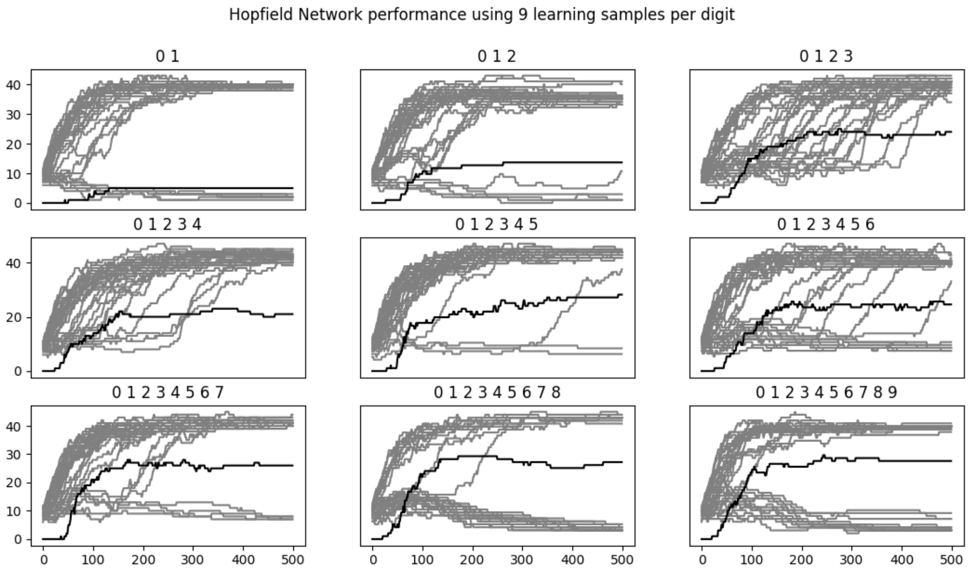


It is important to note that many images converge to digits that are not at all similar to the input while most converge downwards to similar digits. The network has a low error rate only after learning 4 digits. For more examples the inputs converge to incorrect numbers.
The following image shows transformations performed by a network with a library of 2 digits. The example contains errors, correctly recovered digits and inverted correct digits. This is a common phenomenon when using a set of (1,0) weights instead of (1,-1).



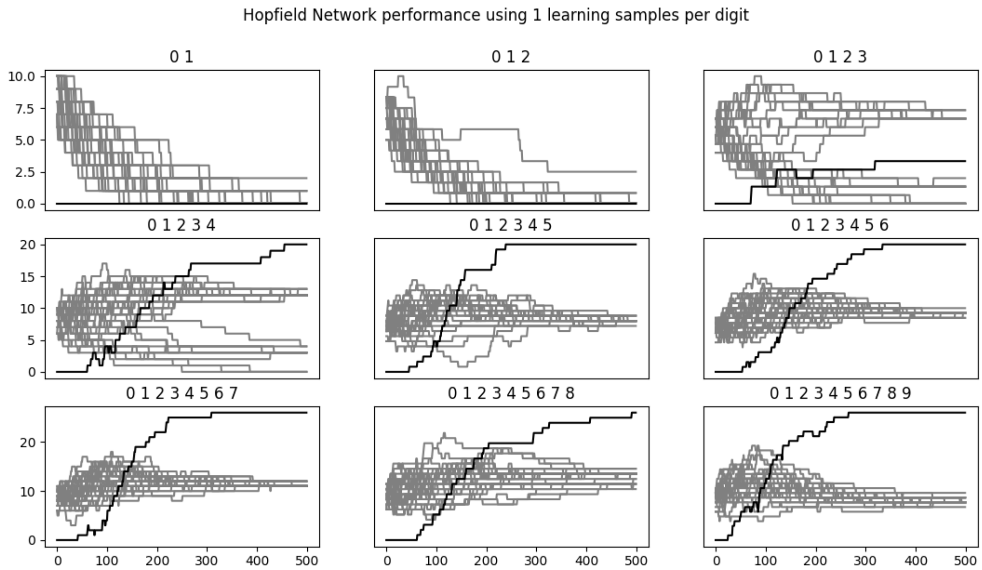
3.2 Create a 3D graph to represent the error across learning experiments.

3.3. Using 9 replicas for each number learned to the network. Does the performance improve?



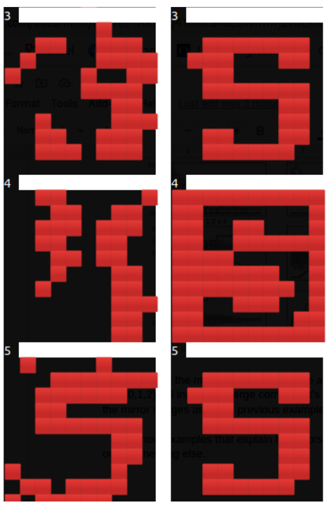
The network does not improve. It increases the error rate and the noise in the model.

3.4 Changing the binary encoding in the weighting method from (1,0) to (1,-1) what are the results?



This improves the model significantly. If we analyse the graphs that learned libraries (0,1) and (0,1,2), all inputs converge correctly. It's important to note that inputs do not converge to the mirror images as in the previous examples.

3.5 Show examples that explain the errors. Are the inputs converging to incorrect images or to something else.



Above there are examples where a 3 is converted to a 5. A 4 is converted incorrectly to an inverted 5 and a five is correctly recovered to a 5.