EE 746: - Neuromorphic Engineering

Project stage II: - Coupling design for different kinds of optimisation constraints

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Background: -

When an input current is fed into a neuron, the membrane potential may oscillate between the threshold and the reset potential and hence the neurons can be represented by oscillatory devices. The unit of information is the phase of the neurons. Connectivity implies how the phases of the neurons interact each other. There are several models to depict phase synchronisation between oscillators - here we use the Kuramoto's model. The Kuramoto's model captures the homogeneous and weak connectivity forced by an external input. Two oscillators get connected on average only if the input has a frequency component of the difference of the intrinsic frequencies of the two oscillators as shown in Fig. 1

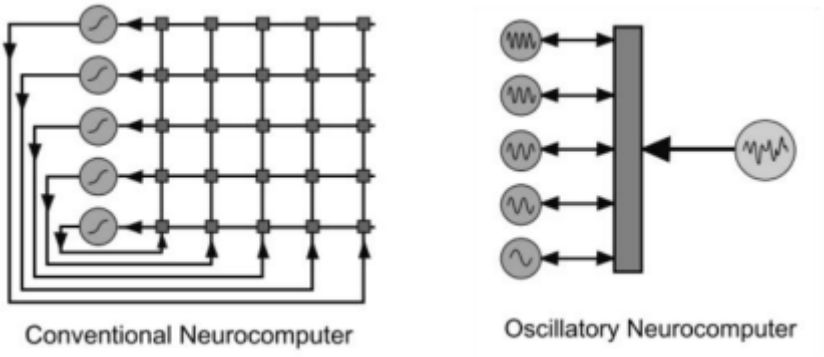


Fig. 1

The number of connections required in the form of n^2 synapses in a crossbar array can be done away with in a homogeneously connected system.

We have demonstrated the in-phase and out-of-phase nature of the neurons for generation of corrupted pattern as shown in Fig. 2 (This figure is from the paper. For actual generation of it please run main.m file.)

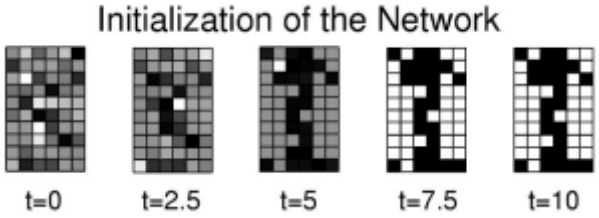


Fig. 2

Pattern Recognition: -

Thus, starting with this initial corrupted pattern and using the standard Hebbian learning rule, it is possible to demonstrate recognition by comparison with some memorized pattern with decreasing in accuracy of recognition with increase in the values of the patterns to be memorized. We are able to recognize the pattern using the above generated corrupted pattern and it can be seen from Fig. 3 (This figure is from the paper. For actual generation of it please run main_1.m file.)

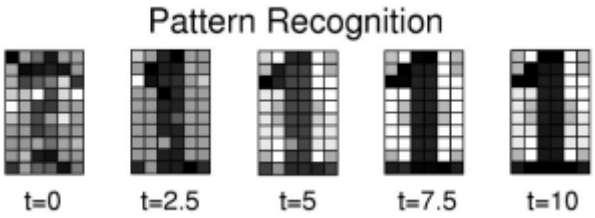
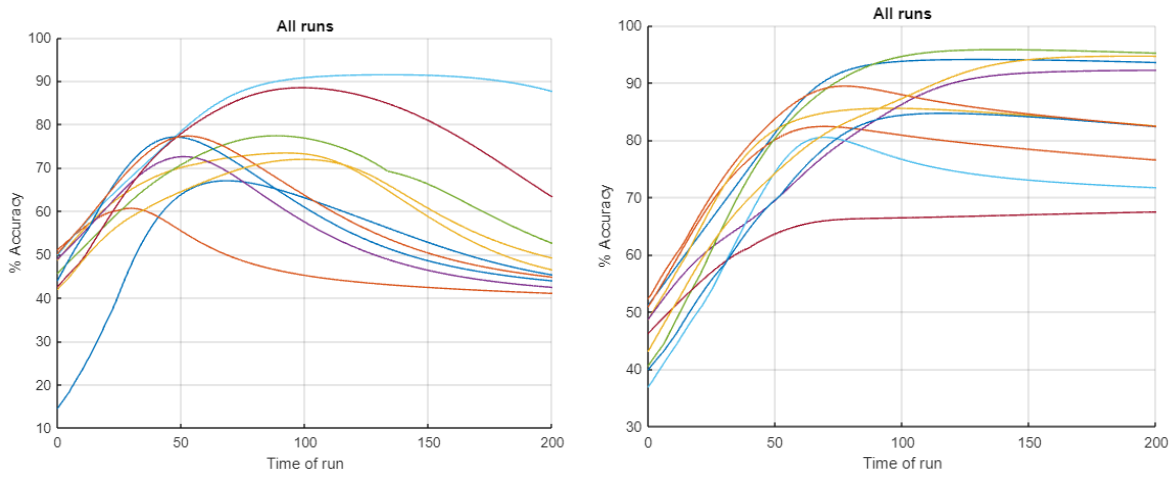


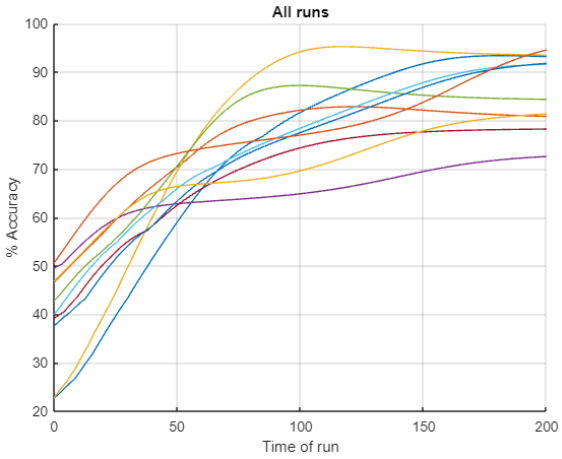
Fig. 3

Accuracy of the Model: -

If we talk about the accuracy of the model then we can see like the model is able to produce the accuracy up-to 95% for different runs as it can be seen from Fig. 4 is because of the learning rule is unable to treat all the starting points identically in terms of recognition accuracy. Also, we can see like when we run the recognition for shorter duration of time then we are able to get higher accuracy and if we go on running the process for longer duration of time then the accuracy falls but if we run the simulation by decreasing the number of memorized patterns then we are able to observe the saturation of it over time and the accuracy increases above 95%.



(a) (b)



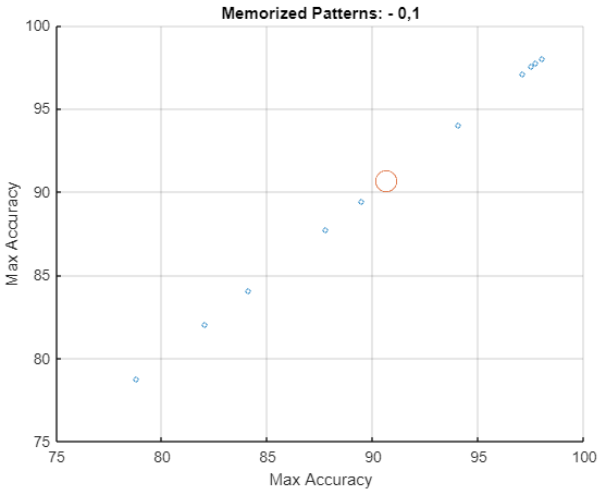
(c)

Fig. 4 (a) Accuracy over time when memorized patterns are 0,1,2,3. (b) Accuracy over time when memorized patterns are 0,1,2. (c) Accuracy over time when memorized patterns are 0,1.

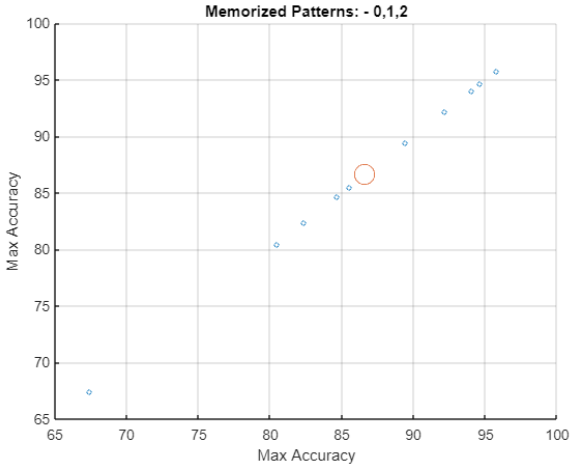
Fig. 4

Response of model for number of memorized patterns: -

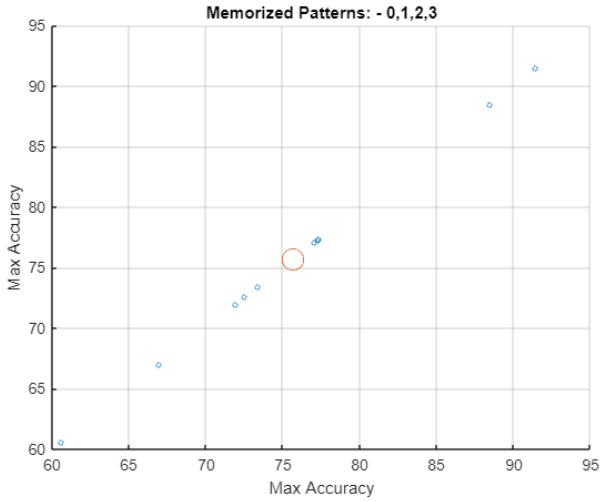
If we memorized minimum number of patterns then the accuracy of the model is high but if we go on increasing the number of it then the accuracy falls down. So, if we try to stick with minimum number of patterns to be memorized then the we are able to get much out of the model with higher accuracy within same interval of time because with minimum number of memorized patterns the model is becoming more confident about the recognition and hence gives the higher accuracy but with more numbers, the confusion increases and it becomes less confident about the recognised pattern and tend to produce less accuracy because of more comparison along all the patterns. The maximum obtained accuracy of the model in comparison with different memorized patterns is presented in Fig. 5.



(a)



(b)



(c)

Fig. 5 (a) Accuracy for memorized patterns 0,1.

(b) Accuracy for memorized pattern 0,1,2.

(c) Accuracy for memorized pattern 0,1,2,3.

Fig. 5

Now, if we observe Fig. 5 then we can conclude that for (0,1,2,3) memorized patterns the model is able to produce the maximum accuracy of around 76% only, for (0,1,2) it is giving around 87% and in last for minimum number of memorized patterns (0,1) it is giving higher accuracy of around 92%. Hence, we can comment like if we make use of model with minimum number of memorized patterns then we can obtain maximum accuracy in case of pattern recognition.

Reference: -

[1] More from the internet mainly GitHub for learning purpose.