# Abstract

The success of artificial neural networks or deep learning in solving many real-world problems have attracted interest from researchers trying to understand their working principles and optimize their performance. Dynamical system study on neural network demonstrates a transition from ordered phase to chaotic state in many real-world neural networks, with a transitional state in between called edge of chaos. I have been suggested that such critical point is associated with the optimal performances of the models in information processing. Further study into edge of chaos is often restricted to toy models of neural networks requiring the same number of input and output neurons, which is not commonly the case in real-world applications.

In this study, we used Denoising Autoencoder (DAE) in hope of solving some of the exist issues with edge of chaos approach, and better understanding the working principle of deep neural networks. DAE’s architecture ensures the same number inputs and outputs neurons while allowing for information extraction through the hidden state. Thus, this allows us to extend dynamical study results into DAE such as asymptotic distance, asymptotic Jacobian, Poincare plot, etc.

We use the Fashion-MNIST dataset with small noise added to the images at the input layer to simulate the function of a DAE. We found that DAE does experience the same order to chaos phase transition with a similar edge of chaos transitional state. However, this transition is not homogenous across all the training images, with some images transitioning into period cycles and chaos while others remained in the single fixed-point state as the network evolves towards the edge of chaos transition point. We also found the hidden state follows the same dynamical phases as the output neurons giving us a new way into studying various neural network architecture by employing them in the asymptotic activations of the encoder layers. This allows us to explore property of the hidden layers in more detail such as using them as embedding for other task such as classification. We can also use this architecture to explore other neural networks such as Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) Networks with their associated decoder and explore if they are approaching Self Organised Criticality as is the case in brain neural networks.