

## Big Data and AI Strategies

### Neural Network Explained: Part I

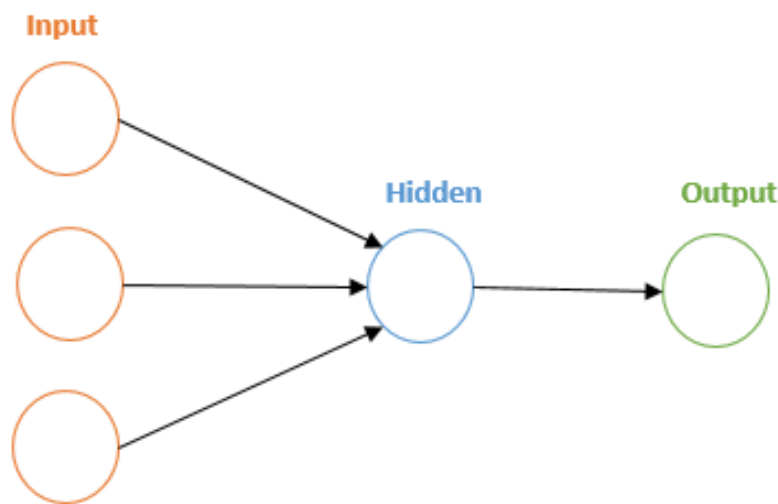
We are initiating a new series, Neural Network Explained, to discuss the application of a neural network in finance in a practitioner-friendly manner, without getting bogged down by the technical jargon (readers can find a technical introduction [here](#)). This note is the first installment of the series, and provides a high-level introduction to a neural network.

#### What is a neural network?

A neural network models the unknown function between the input and output variables via a highly flexible functional form. Unfortunately, much of the terminology comes from neuroscience, to the extent that terms like 'neuron' and 'activation function' obscure the actual meaning in the statistical modeling context.

When one searches for 'Neural Network,' one is likely to be greeted by an image similar to Figure 1. The nodes in the input layers represent the independent variables. There are three in this example (e.g., momentum, P/E ratio and volatility). The nodes in the hidden layer represent functions that perform computations on the input data. The results are then passed on to the node in the output layer, and combined to produce estimates for the dependent variable (e.g., future stock returns). Training refers to optimizing the model parameters to best fit the data.

Figure 1: A neural network with one hidden neuron and one hidden layer



Source: J.P. Morgan

A natural generalization is to have multiple nodes in the hidden layer and/or multiple layers. Doing so increases the model parameters and allows additional flexibility in fitting the data. A 'deep neural network' refers to one with multiple layers. The neural network can also have more than one node in the output layer, permitting multiple estimations to be performed simultaneously.

#### Why neural network?

From this author's experience, the vast majority of the problems one encounters in finance can be adequately addressed by linear models. Why do we have a need for neural nets? This is because, in addition to solving the remaining nonlinear problems, neural networks can potentially improve the solution to the existing problems that can be 'adequately' modelled linearly.

In the context of investing, we call this added value ‘computational alpha.’ Given the cost of computational power is becoming increasingly inexpensive, the return on investment on neural nets can be sizable even with moderate improvements in risk adjusted rate of return.

## Why now?

Neural network was first proposed in the 1940s. Why has it enjoyed such a massive resurgence in recent years? It has entered into the mainstream social consciousness as one of the most attention-grabbing AI achievements, such as image recognition and natural language processing have come courtesy of neural nets. The main reason for the breakthrough in these AI tasks is advances in both computer software and hardware. Open-source software libraries have made implementing neural networks much more efficient, and parallel processing and GPUs enable us to significantly cut down the computational time.

## What’s the catch?

If the aforementioned success sounds too good to be true, it probably is. Although neural nets, and specifically deep neural nets, offer extreme flexibility, the benefit is accompanied by a significant risk of overfitting and producing ‘artificial stupidity’<sup>1</sup>. To remedy the tendency to overfit, common solutions are computationally and/or data intensive. Computational costs are getting cheaper, but the requirement for data is much more difficult to overcome for problems in finance.

For instance, the neural networks used in the Gmail Smart Compose feature come with an average of 100 million parameters, and are trained on 8 billion English messages<sup>2</sup>. This is several orders of magnitude bigger than the common financial datasets. For comparison, S&P 500 daily returns dating back to 1928 contain approximately 23,000 observations. It is also safe to say that the English messages probably contain a lot less noise than S&P 500 daily returns. As such, whatever model that works for the Gmail Smart Compose is probably not going to work for predicting S&P 500 returns.

## What does it mean for investors?

Does that mean there is no use for deep learning in investing? No, it only means that simplistic attempts at transplanting models from computer science are unlikely to be successful. We need to be aware of the limitations of neural networks, and be thoughtful about adapting them to the problems we face. Of course, this is easier said than done. In future installments of the series, we will look to offer practical advice on this topic.

## Coming up next

In the next report, we will see in action how a simple neural net fits to data, and introduce some common architectures that we find to be relevant for finance applications.

<sup>1</sup> Murphy, C. M., G. J. Koehler and H. R. Fogler (1997) Artificial Stupidity: The Art of Raising a Neural Net’s IQ. Journal of Portfolio Management 23(2), 24 – 9

<sup>2</sup> Chen et al., 2019, Gmail Smart Compose: Real-Time Assisted Writing, retrieved from <https://arxiv.org/pdf/1906.00080.pdf>

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### Global Quantitative and Derivatives Strategy

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