### Artificial Neural Networks algorithm

Motivated by the structure of the neurons of the human brain, ANN is a method that is considered valuable for forecasting in the case that having a large number of predictors (Elliot et al., 2016). Furthermore, ANN itself requires a large sample dataset, which is adopted well by Google Trends data, to perform the powerful value for prediction (Woloszko, 2020). The difference between PCA and dynamic factors of ANN is the non-linear approach (Elliot et al., 2016). It reduces the dimensionality to a number of intermediate components in the middle layer before making a prediction (Woloszko, 2020). With the multi-layer structure, ANN can avoid overfitting. It has an ability to deal with the extremely large sample with high dimensions, even the number of predictors is higher than the number of the observations (Csaji, 2001). Therefore, this algorithm has been increasingly applied in academic research in recent years, especially with the rapid improvement of media (Elliot et al., 2016; Aiken, 2000; Jena et al., 2020; Malte, 2018; Loerman & Benedikt, 2019).

A neural network is fundamentally operated by an information-processing called as a *neuron*. The model of a neuron (basic form of an artificial neural networks) has five main elements: *input signals*, which are predictors of this thesis, are maybe plural; *synapses or connecting links*, which is variables value, show the strength of the connection of each input signal to a neuron; an *adder* takes a weighted sum of input signals; an *activation function* for optimizing the weights, or by other works are limiting the neuron output; an *external bias* is included in the model to increase or decrease the net input of the activation function; and *output*, which is outcome variable of this thesis. The model of a neuron is delineated by figure 3.1.

Figure 3.1 The model of a neuron

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Input signals

X1

X2

Xn

**.**

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Synaptic weights

Summing junction

Activation function

Y

Output

φ(.)

Bias (b)

The model of a neuron can be described in mathematical term by:

|  |  |  |
| --- | --- | --- |
|  |  | *(3.3)* |

Where is input signals, are the synaptic weights of the neuron, *b* is the bias, is the activation function and is the output of the neuron. Following Woloszko (2020), the model of this thesis uses "relu" activation function.

The neurons in a layered neural network are organizational layer form. At least, a layered neural network has two layers: an *input* layer and an *output* layer. Layers which are between input layer and output layer called as *hidden layers*, whose have *hidden neurons* or *hidden units* that are computations nodes. The neural network having the input of the neurons of each layer is the output of the preceding layer only, not vice versa, called *multilayer feedforward architecture* (figure 3.2). As said by Csaji (2001), by adding more hidden layers, high-order statistics may be extracted by computing the network. By other words, in a rather loose sense, although it is potentially *local* connectivity due the extra synaptic connections and the extra dimension of neural interactions, the network is able acquires a *global* perspective. The neural network of this thesis uses two hidden layers of 300 and 10 neurons.

Figure 3.2: Multilayer feedforward architecture

The main concern of this method is their black-box nature, which is addressed by machine learning interpretability techniques presented below.