ELECTRICITY LOAD FORECASTING USING STRUCTURED NEURAL NETWORK

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Overview

Using the neural network to forecast is not that special in recent. In electricity load forecasting studies which is one of the most general and important topic, neural network models such as nonlinear autoregressive network with exogenous inputs, radial basis function network, and, recurrent neural network are used. But it was very hard to find the studies which considered structure of layers in neural network. All studies we reviewed use only one layer which includes all variables used in their study, or as many independent layers as the number of variables. We focused on how the method of connection of each layers effects to results. Let's suppose there are two variables and two input layers for each variables, then three methods of connection can be possible; each independent layers connected to first hidden layer, an input layer is connected to the other input layer which is connected to hidden layer, reverse direction of second connecting method. We came up with an idea that the concept of causality in econometrics could be brought in to solve this problem.

We examined our hypothesis by forecasting Korean electricity load. Electricity market in the world faces huge changes because there were big influential events like the Paris agreement and the development of energy storage system which has economic fesibility. Korean electiricity market is also needed to be redesigned because it uses coal to operate its base load. Coal which is unfavourable for greenhouse gas emission accounts for about 30% of total generating. Therefore, accurate forecasting is needed because it could be helpful to plan a efficient and economic generation schedule including matintenance so that this could be used to minimize the impact of the redesigning electricity market. To forecast load, we used hourly load data and hourly temperature data from 2012 to 2014 year in Korea and forecasted 3 time points to represent one day.

Methods

Aritificial Neural Network (ANN)

Neural network is a computational model imitated from the human brain. There are many nodes like neurons in brain and these nodes have their own weights. Each input goes through the nodes and transfer function in single layer and then moves to another layer. This process is repeated to the final layer which is called output layer and output can be calculated by going through the activation function.

In the actual process, there could be more than one variable and then we could set the layers for each variable. When there are 2 variables, we can design the structure of layers like Figure 1. Each layer of Figure 1 shows the brief concept of ANN and Figure 1 shows one example of layer connection when there are 2 variables. They are independently connected to the output layer which calculates output. As we mentioned above, there are two remaining methods of connection between layer 1 and layer 2; layer 1 can be connected to layer 2 and then layer 2 will be connected to output layer, and vice versa. We tested that whether their method of connection can effect to the results of simulation or not.

Causality

Causality is similar to the concept of cause and effect, but a more appropriate term for causality is precedence. If variable 1 precedes variable 2, we can say that variable 1 causes variable 2. The direction of causality can be estimated by the vector error correction model (VECM). Equation 1 shows the VECM model with variable *x* and *y*.

$$\begin{aligned} \Delta x_t &= a_1 + b_1 z_{1,t-1} + A(L)\Delta x_t + B(L)\Delta y_t + e_{1,t} \\ \Delta y_t &= a_2 + b_2 z_{2,t-1} + C(L)\Delta y_t + D(L)\Delta x_t + e_{2,t} \end{aligned} \tag{1}$$

Where, L is the lag operator, z_{t-1} stands for the error correction term, e_t refers to the white noise. *A(L), B(L), C(L), D(L)* are stationary polynomial. In equation 1, we can estimate the direction of causality by testing statistical significance of parameters. If b_1 is statistically significant, *y* causes *x* and if b_2 is significant, *x* causes *y*.

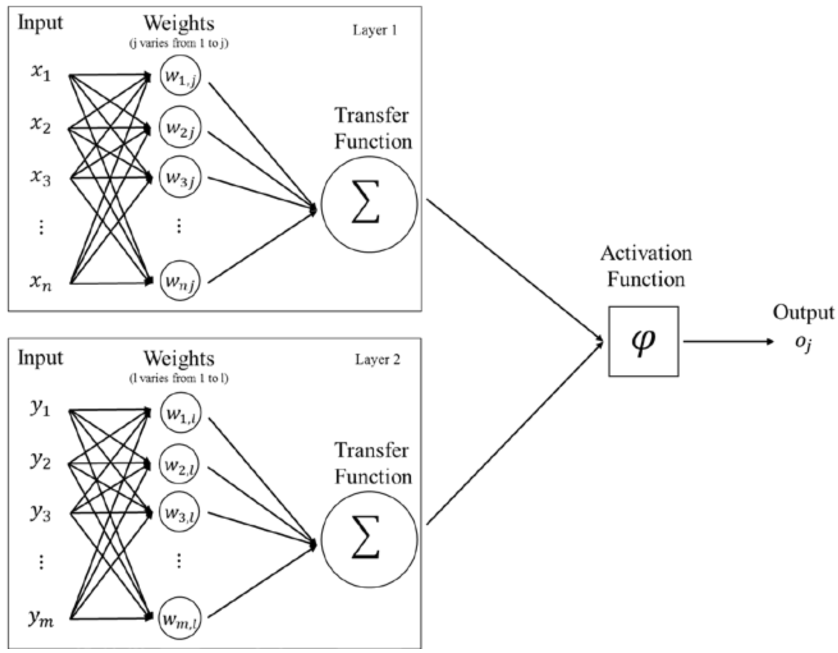

Figure 1. Flow of ANN with 2 variables

Results

We designed the layer structure based on the results of causality test and the result that temperature causes load. Therefore, we guessed the case that the layer including temperature data is connected to the layer including load data would perform best forecasting results. We compared 4 cases of structure; single layer including both data is connected to output layer. 2 layers including each variable is independtly connected to ourput layer, a layer is connected to the other layer which is connected to output layer. Table 2 shows the results of load forecasting, these values are the average for the results of 28 points which means average of each hour for 28 days.

Table 1. Forecasting results of 3 hours.

	Single layer			Dependent layer			Load causes Temp.			Temp. causes Load		
Hour	1h	6h	12h	1h	6h	12h	1h	6h	12h	1h	6h	12h
MAPE	0.55	1.05	3.42	0.68	0.77	3.22	0.54	0.56	3.23	0.52	0.51	2.93

Conclusions

We tested our hypothesis that the method of connection of layers effects to the simulation results. According to our study, layer structure reflecting the relationship of variables, which is expressed by causality in our study, could increase the performance of forecasting.

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