Artificial Neural Network Applied for Development of Blackout Scheduling System in an Emergency Situation

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Abstract: On March 11, 2011, an earthquake with magnitude of 9.0 has occurred in the Tohoku region. It was the largest earthquake ever recorded in Japan and a colossal earthquake fourth largest in the world since 1900. Tsunami generated by this earthquake and several ten square kilometers inland from the coast was flooded. Tsunami Wave in some areas was with the height of 40.1 meters and approximately 19,000 people were lost their lives or missing due to this disaster.

Tokyo Electric Power Company (TEPCO) at Fukushima Daiichi Nuclear Power Station was hit by this Tsunami approximately one hour after the earthquake and as result the cooling system of was drawn and all power supply were stopped. Then meltdown occurred in Unit 1 and Unit 3 and the reactor building was blown away by the hydrogen explosion with leakage of large amount of radioactive materials. Therefore in order to solve the power shortage in entire power system including nuclear, thermal, hydro, substation and transmission facilities in TEPCO territory, rolling blackouts were conducted from March 14. Rolling blackouts are an intentionally engineered electrical power shutdown where electricity delivery is stopped for non-overlapping periods of time over different parts of the distribution region. It’s a measure used by an electric utility company to avoid a total blackout of the power system.

In the rolling blackouts, TEPCO territory was divided into five groups, in which the sum of the demand of each group approximately equal and each group are constituted by various regions in order to prevent the neighborhood densely. Blackouts were rotated from noon till evening (2-3 hours per group). TEPCO also subdivided each group into five; however there were no concrete idea and it was hard to how whether this kind of break-down really works or no. For example, due to distribution network congestion, power companies do not fully understand the supply area of each substation. Therefore, there are two areas where blackout is not done once and it’s excessive, resulted in giving people distrust. Distrust, such as stopping etc. had a significant impact on transportation and it caused a major economic damage.

In this study, we tried to develop a blackout scheduling based on artificial neural network to overcome the problems in present insufficient blackout scheduling system and have a smooth and stable system for the future emergency situation. In our developed system, fair scheduling is considered in case of power shortage in the household, commercial and industrial sectors.

This blackout scheduling system has three main blocks. The first block determines the amount of power shortage at each hours, the second block determines the amount of power saving by sector in Tokyo metropolitan, and the final block determine the area to be considered for blackout. The first block is performed to predict the hourly power demand in TEPCO territory using Radial Basis Function Network (RBFN) of neural network. The total demand classified as household, commercial and industrial using the statistical data such as number of households and offices and schools are used for training the RBFN. The final block is determined the area of blackout to maintain the balance between supply and demand. In order to do that, there is a need to predict the electricity demand at each substation. However, considering the distribution substation of TEPCO, it is required a forecast of at least 80 substations. Different RBFN neural networks are designed for predicting 80 substations with different selection of substations in the group. As decision criteria of blackout area, in order to reduce the economic impact and avoid excessive blackout, the area of blackout are selected based on the sum of power demand of area of blackout and the amount of power shortage to be approximately equal. Then given the constraints of the blackout will not occur a second time during the one cycle in the same group to protect the fairness of scheduling in the groups. In the short-term demand forecasting in TEPCO territory, we have obtained a high accurate prediction with Mean Absolute Percentage Error (MAPE) of less than 3% which make this system applicable for real emergency situation in case of any disaster in the future.