Exploring improvements of wind power forecasts using Convolutional Neural Networks and Time Series Analysis

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Electric power is commonplace in our daily lives. It is used to power our cell phones and even cars. There are multiple approaches to producing electric power, among these is wind power. Due to wind power being an intermittent power source, meaning that the production output is sporadic, making accurate forecasts is a challenge. These forecasts are necessary for supplying power to the grid. This thesis explores the concepts of Time Series Analysis and Convolutional Neural Networks to improve existing power forecasts.

Wind power is seen as a clean power source as it does not lead to emissions of carbon-dioxide during power generation. For a power source to be used in the electrical grid it is preferable for the production to be plannable in advance. This way power production can be fitted to match the power consumption. Wind power is not plannable but forecasts regarding the production levels can be made so that other power sources may be planned. This is all done through the complex mechanisms of the energy market.

This thesis works with a case study regarding a wind farm managed by Axpo Nordic. Axpo Nordic is an energy trading company that, among other endeavors, manages wind farms. To trade on the so-called spot market, forecasts for power output are made. As wind power output is highly correlated to wind speeds, weather forecasts are an important factor in the models for these forecasts. This thesis works with creating models for improving those forecasts.

Two models were created based on the Kalman-filter and Convolutional Neural Networks. The Kalman-filter is an algorithm that was first presented in 1960 and was used for trajectory estimation in the Apollo program. Convolutional Neural Networks are based on newer technology and are related to Artificial Neural Networks. These are inspired by the neurons in the brain and the synapses between them. This way they can be used to solve complex problems and for example be used for prediction generation.

The models created incorporate an input which very likely was not used in the original forecast. That input is recent production data. This is oftentimes not used as an input due to data errors and that in many cases, there is no advantage to using it. The advantage of using recent production data is that consistent prediction errors may be detected.

This leads to the result in this thesis. In case of long periods of systemic forecast errors (which can be the result of an inactive turbine), using recent production data as an input may be beneficial. The Convolutional Neural Network handled this better than the Kalman-filter.