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Denoising diffusion probabilistic models applied to energy forecasting in power systems

Transition towards a carbon-neutral society by 2050 is one of the greatest challenges of this century. This goal will necessarily lead to a progressive increase in the part of renewable energy in the global energy mix. However, renewable energies are much more subject to uncertainty than conventional power plants. This uncertainty raises new challenges for the integration of renewable energy in the energy mix. Probabilistic forecasting has emerged as a solution to some of those problems as it provides a way to reduce this uncertainty.

This thesis aims to apply a new deep learning approach to the task of probabilistic forecasting. It is based on *denoising diffusion probabilistic models* (DDPM), a recent type of deep generative model. This new type of method has recently shown outstanding results with image generation. A lot of focus has been given to those models by the computer vision community. On the other hand, really few have been given for other types of applications such as time-series forecasting, and they have not yet been applied in the power system community at all.

In this thesis, the first implementation of DDPM for conditional probabilistic forecasting applied to power systems application is presented. Then, a demonstration of the competitiveness of the developed method is realized. This is done by comparing the quality and the value of the predictions with other state-of-the-art deep generative methods, namely, generative adversarial networks (GAN), variational auto-encoder (VAE), and normalizing flows (NF). One big advantage of the methods implemented through this thesis is the fact that they are able to deal with conditional data. The forecasts are weather-based forecasts and depend on external conditions instead of just relying on historical values. The empirical comparisons are realized across three different datasets from the Global Energy Forecasting Competition 2014. The assessment considered the quality of the generated forecasts as well as the actual value of using them. This thesis shows that not only DDPMs are competitive with other state-of-the-art deep generative models, but they are able to consistently outperform them.