Data Analysis in the Smart Grid

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Next Generation Control Centres for Smart Grids

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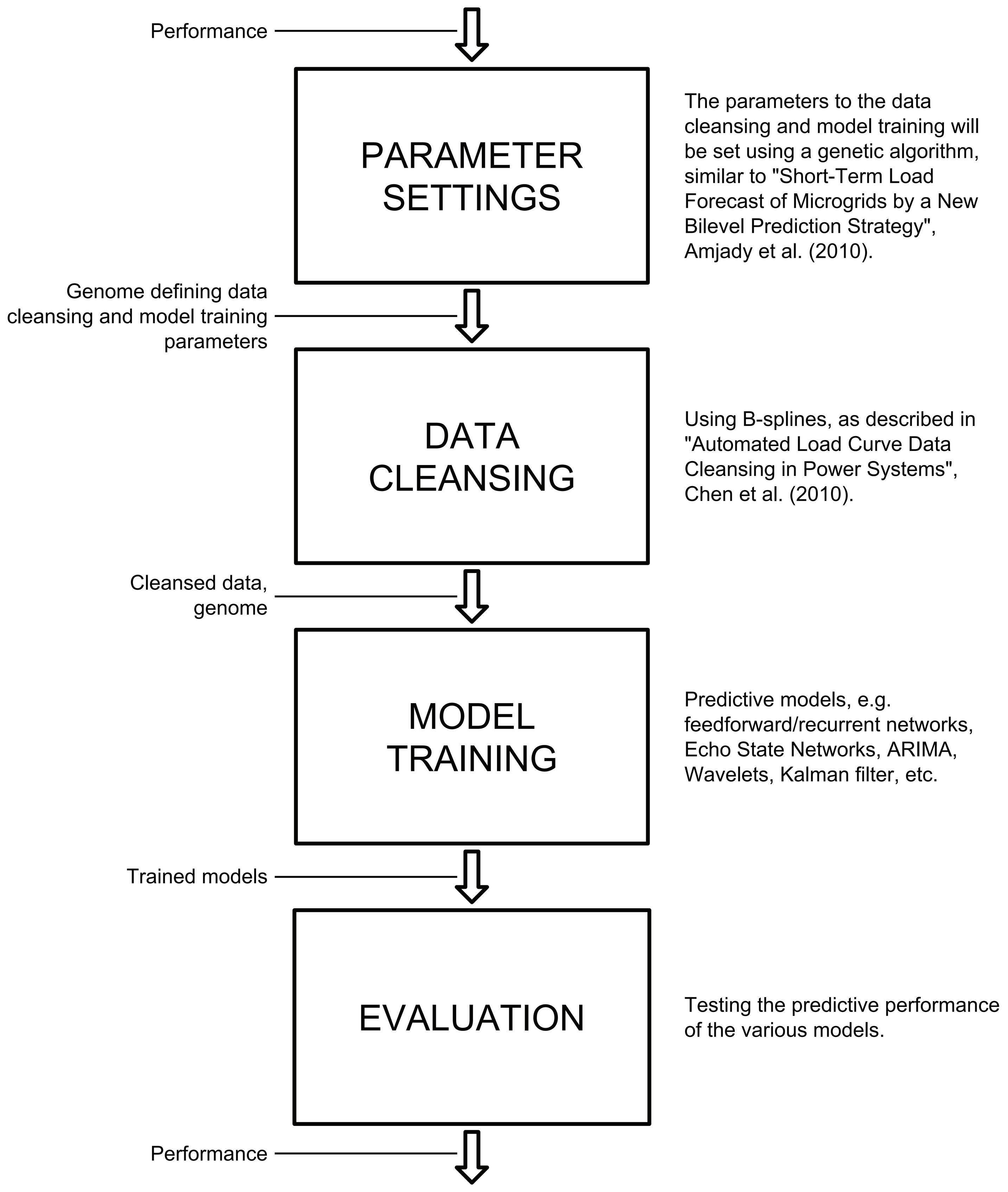
The next decade will see a complete transformation of the way we use, produce and relate to electricity: roof-mounted solar panels, electric cars and smart devices that pre-heat (or cool) your house when power is cheap are just some examples of the expected changes. The electrical grid infrastructure must undergo dramatic changes to support this development, with the rollout of smart meters with two-way communication capabilities as one of the most visible first steps.

The project *Next Generation Control Centres for Smart Grids* is a long-term effort to investigate how the distribution grid control centres can be modernized, and better suited to meet the above challenges. More specifically, our group is interested in how applications that make use of sensor data can contribute to efficient grid operation. In particular, we are looking for ways to take advantage of AMI data beyond simple metering and billing.

Background and Methods

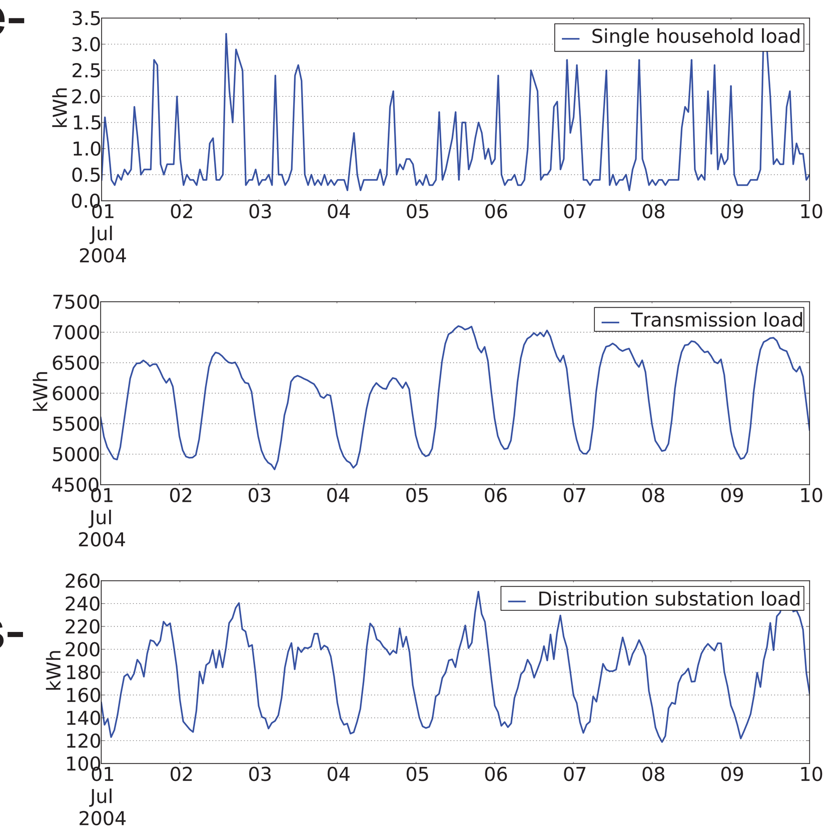
Short-term load forecasting is important for power producers and vendors, as well as for planned outages to ensure grid stability. Short-term load forecasting is not yet routinely performed at the distribution level. This is particularly relevant in Norway, where we have numerous small distribution system operators (compared to the rest of Europe), coupled with a rapidly increasing penetration of both small-scale hydro-electric power and electric vehicles.

We have focused on 24-hour load forecasting based on AMI data. In order to compare different forecasting methods, we have developed a framework for parameter optimization. Using an evolutionary algorithm, our system performs an explorative search in the parameter space of each forecasting model. Various forecasting models are employed, including ARIMA, wavelets, ANNs, echo state networks, etc. Prior to forecasting, the data are cleansed and seasonalities are removed.



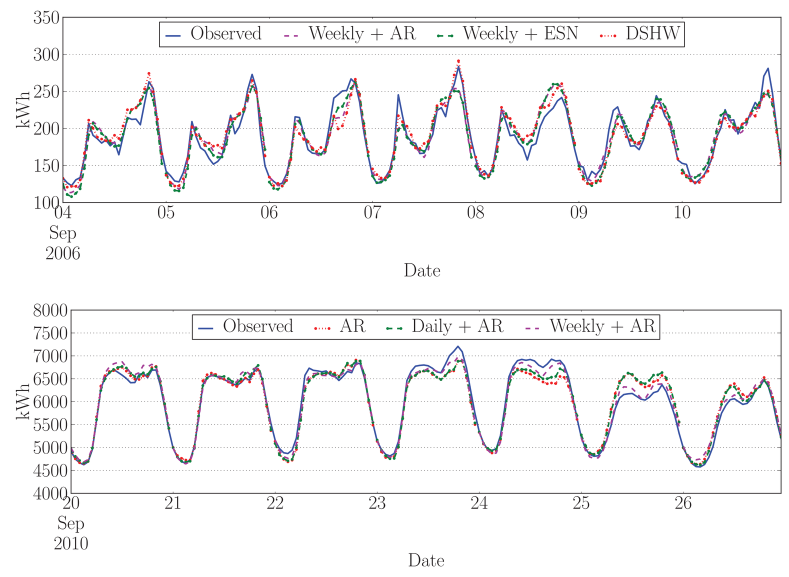
Experiments and Results

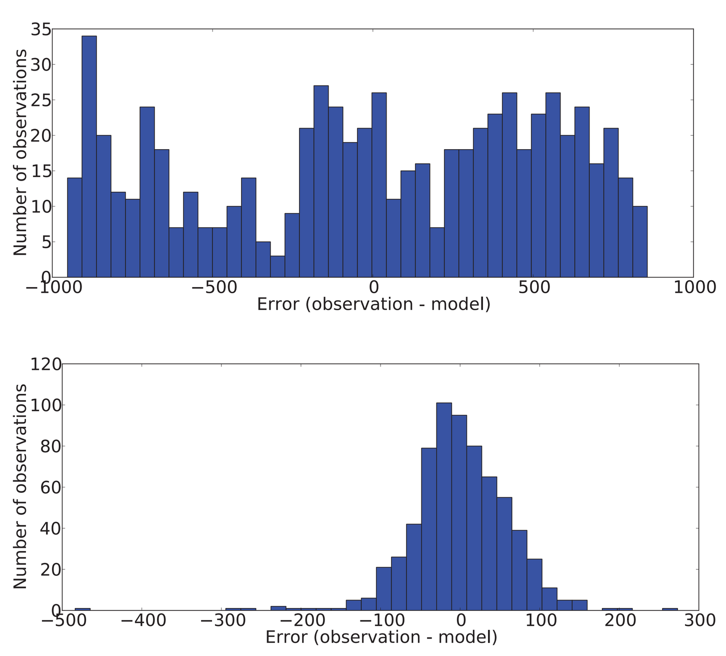
In order to investigate how forecasting methods originally applied at the transmission level would scale down to the distribution grid, we optimized load forecasters on different levels of data granularity: end user, distribution substation level (~150 end users) and transmission. The signal characteristics for each of these levels vary greatly.

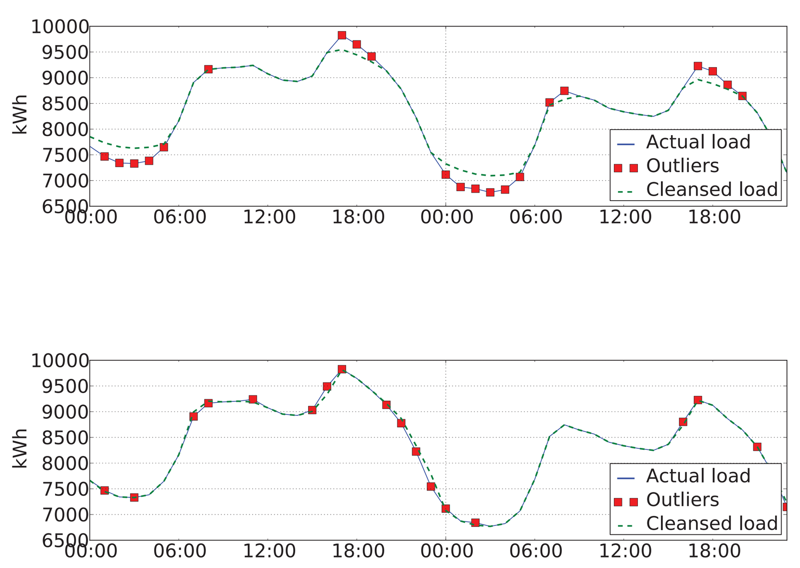


Several different forecasting models were evaluated, including linear autoregressive (AR), echo-state networks (ESN), wavelet-based predictors, and a case-based reasoning approach (CBR). These are all data-driven models that take advantage of covariates such as weather data, in addition to the load time series. Moreover, they must all be described with a set of parameters that need to be found by the GA.

Our experiments show that the framework successfully parametrizes each model to the dataset at hand. Moreover, a non-parametric removal of seasonality yields improvements in both cleansing and forecasting accuracy.







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