Capturing uncertainties of household decision making with machine learning in an agent-based model

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Motivation

Precise modelling of uncertainties in energy system analysis is central for future energy systems. However, it is difficult to bring individual decisions to the system level. We combine the agent-based model AMIRIS (Schimeczek et al. 2023) with a stochastic optimisation and a diffusion model for three flexibility providing technologies, namely PV and storage, heat pumps (Sperber et al. 2020) and electromobility (Wulff et al. 2021). These three micro-models are aggregated with machine learning (ML) to fit the system level.

Methodology

Each micro-model generates a time series for the households' operating decisions by varying the input, such as different weather years and optimising individual costs. This is the basis for training a machine learning model to predict the aggregated load from thousands of household decisions (see Figure 1).

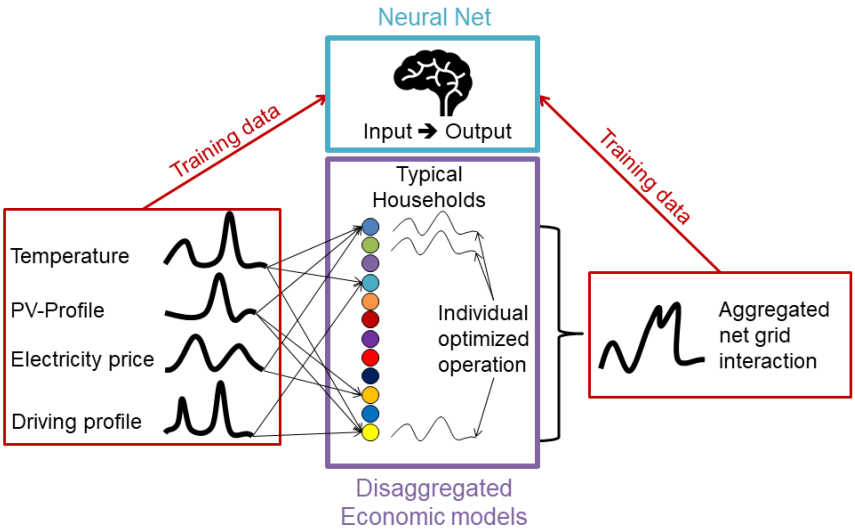

Figure 1: Aggregation of individual household decisions by machine learning to predict the total load

A separate diffusion model calculates the respective expansion dynamics of the three sectors. The supply side is modelled using a stochastic optimisation model (Rebennack 2014). It enables the portfolios of the operators of power plant parks in Germany to be modelled up to the year 2045.

The diffusion model, the stochastic optimisation, and AMIRIS are coupled to map the uncertainties of the expansion dynamics, the construction of power plants and the actor-based market behaviour. This makes it possible to integrate these uncertain individual decisions into a larger model at system level. This would otherwise be completely unfeasible for computational reasons.

Results

We will report on the individual results of all three models – PVS, heat pumps and electromobility. For example, the heat pump model shows a cost-optimised shift in electricity consumption without compromising thermal comfort (Sperber et al. 2020). The investment decisions of the coupled runs and the best ML model for the aggregated load are also presented. Overall, the model coupling shows that individual decisions and their uncertainties can be modelled very well in national energy system analysis simulations.

References

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