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Applications of Probabilistic Programming

Bayesian Linear Regression

linear_regression.ipynb

An AI to Help Reduce Heating Bills

Model Building Methodology

1. Understand the setting and the scientific question being asked of the data.

2. What are the sources of noise and imprecision in the process being considered.
    - What likelihood function is appropriate?
        - Are we making error-prone continuous measurements or are our observations discrete?
        - Do we know anything about the expected accuracy of the measurements?

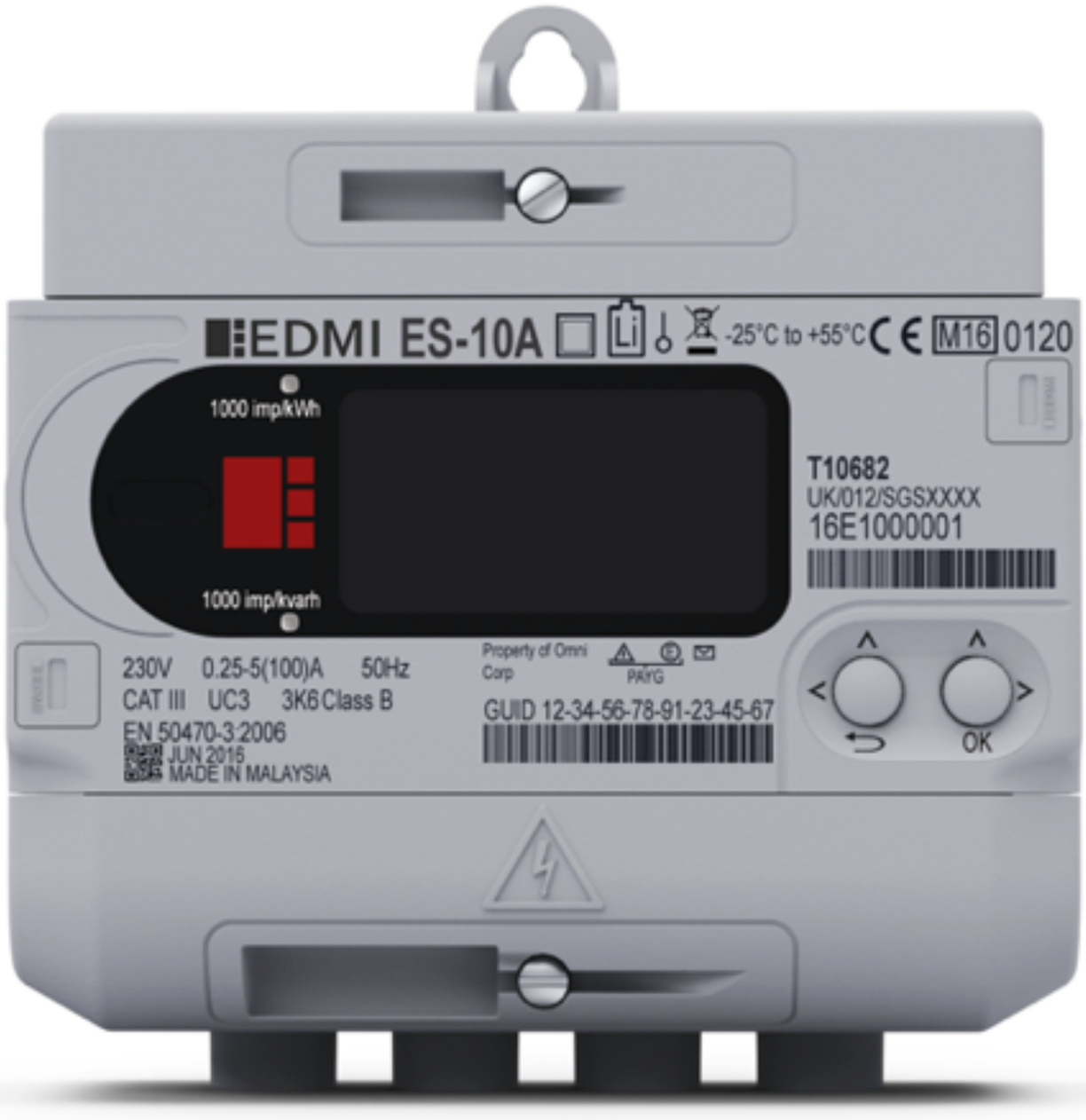
3. Think about what prior information is available.
    - How should that be represented within the model?
        - What prior probability distributions should we use?
        - Are random variable discrete or continuous?

Smart Grids and Smart Energy Systems

Imagine the possibilities: electricity and information flowing together in real time, near-zero economic losses from outages and power quality disturbances, a wider array of customized energy choices, suppliers competing in open markets to provide the world's best electric services, and all of this supported by a new energy infrastructure built on superconductivity, distributed intelligence and resources, clean power, and the hydrogen economy.

US Department of Energy (2009)

Smart Meters



24 hour consumption measurements

Opt-in 30 minute consumption measurements

In-home 10 second consumption measurements

An AI to Help Reduce Heating Bills

You are asked by an energy company to develop an AI to help their customers reduce their heating bills.

They want to be able to identify customers who are using too much energy for their home heating, either:

- Because they have their **heating** turned up **too high**.

- Or because their home is **poorly insulated** and uses a lot of energy to maintain a comfortable temperature.

An AI to Help Reduce Heating Bills

Each home has a **smart meter** that measures the daily total electricity used by the home.

Electricity is used for running household **appliances** and for **heating** the home.

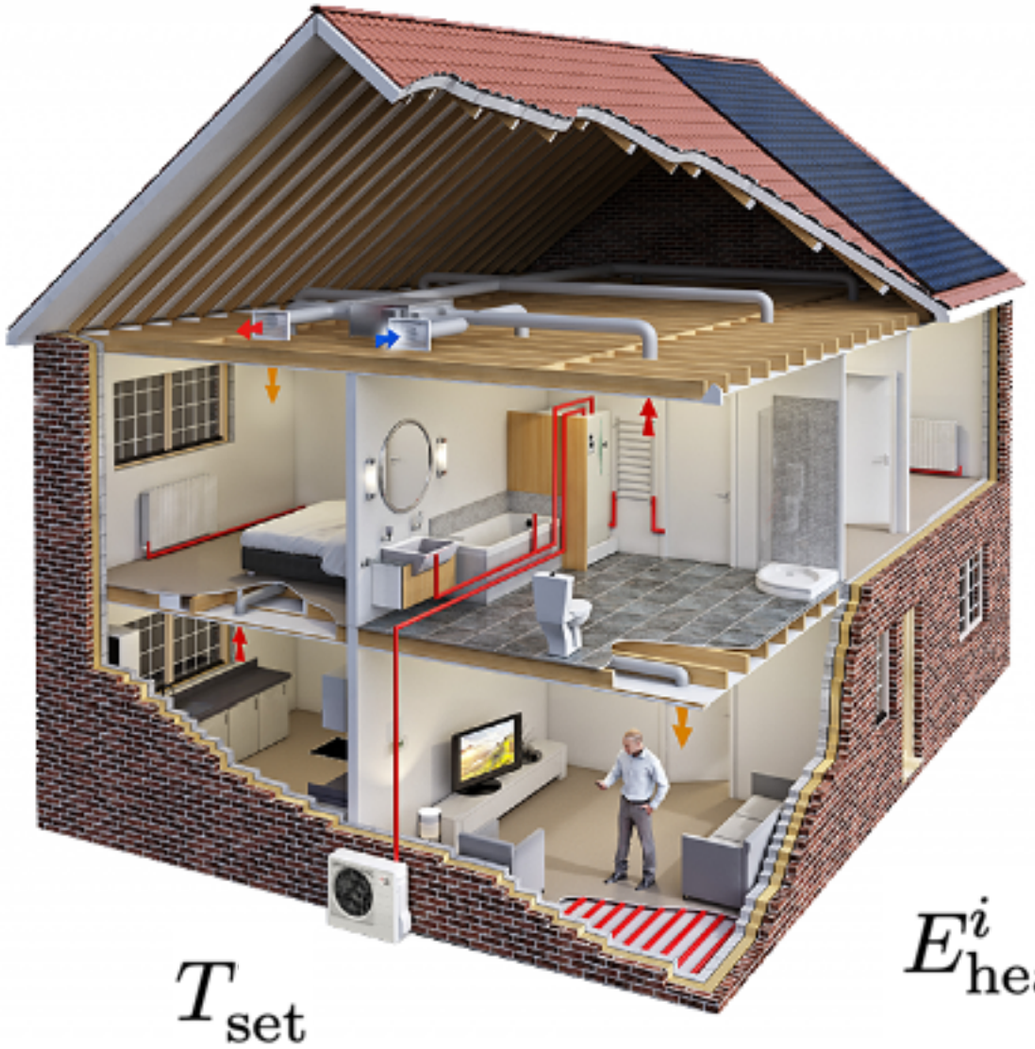
The heating is only on during the winter months when the external temperature drops below the **thermostat set point** temperature.

Heat leaks from the home at a rate that is proportional to the difference between the **internal temperature** and the **external temperature**.

The amount of electrical energy used by the heating system each day matches the amount of heat energy that leaks out of the house.

An AI to Help Reduce Heating Bills

T^i_{ext}



T_{set}

$$24 \times \text{HPLC} \times \left(T_{\text{set}} - T^i_{\text{ext}}\right)$$

E^i_{heat}

$$E^i_{\text{heat}} = 24 \times \text{HPLC} \times \left(T_{\text{set}} - T^i_{\text{ext}}\right)$$

Heating off $\quad E^i_{\text{meter}} = E^i_{\text{app}} \qquad T^i_{\text{ext}} > T_{\text{set}}$

Heating on $\quad E^i_{\text{meter}} = E^i_{\text{heat}} + E^i_{\text{app}} \qquad T^i_{\text{ext}} \leq T_{\text{set}}$

An AI to Help Reduce Heating Bills

You will be provided with **external temperature** data (°C) and the **daily electricity consumption** measured by the smart meter (kWh) from five houses.

Design a robust probabilistic model that captures the features of this data.

Use the model to estimate:

1. The thermostat set point temperature of each house [°C].
2. The heating power loss coefficient of each house [kW/°C].

Houses 4 and 5 present additional challenges and will require a more sophisticated model.

home_heating_ai.ipynb

Next Time

Methodology and Describing Models Mathematically