Computational Intelligence for Utilities

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Overview

- Modelling
  - Parameters
  - Agents
  - Models
- Other applications
  - Data analysis
  - Optimization

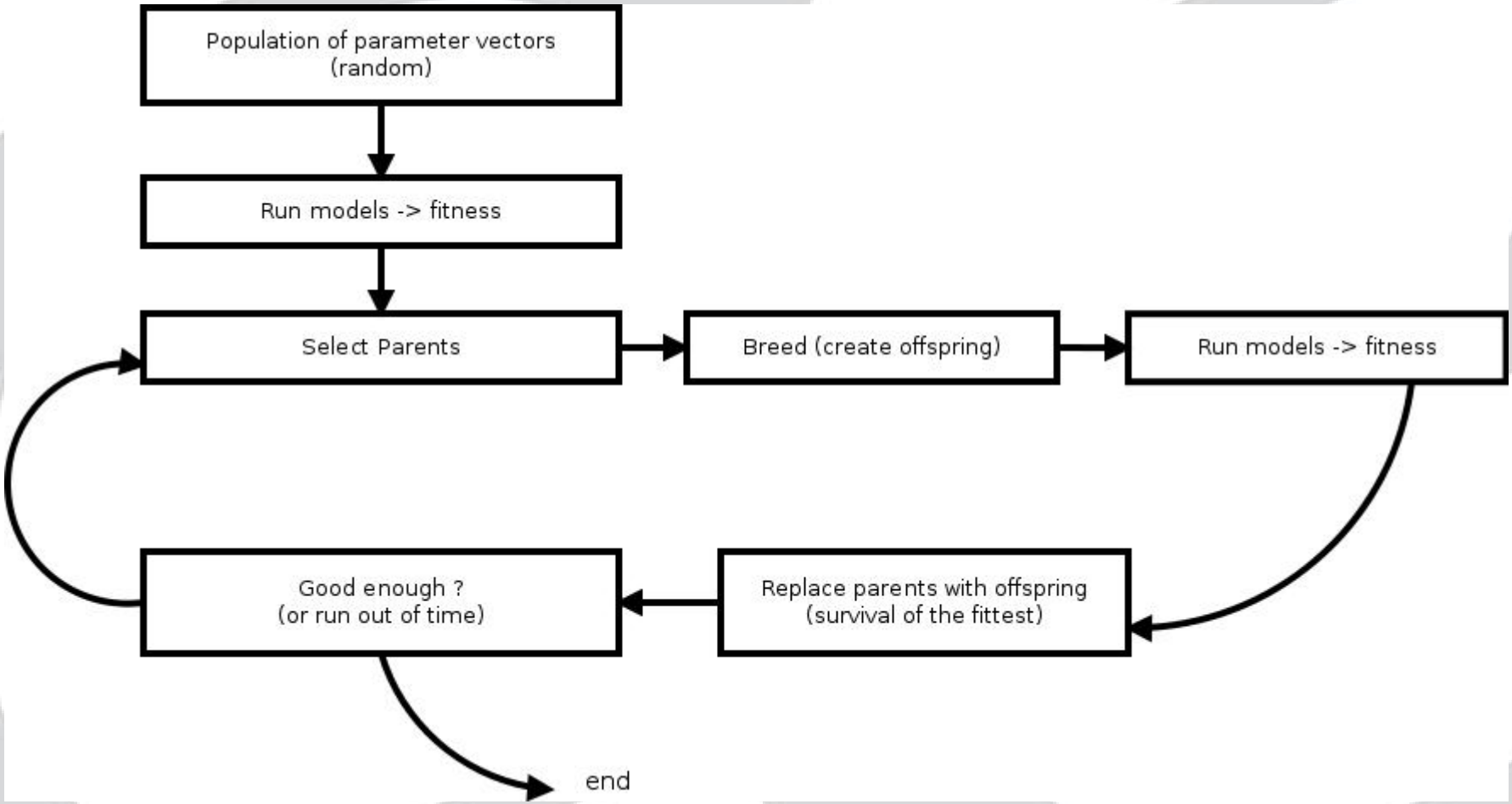
Model Creation

- Models are important
  - For understanding
  - For optimization
- Limited knowledge
  - Complex, non-linear interactions
- But:
  - Large amounts of data
  - Significant computational capacity

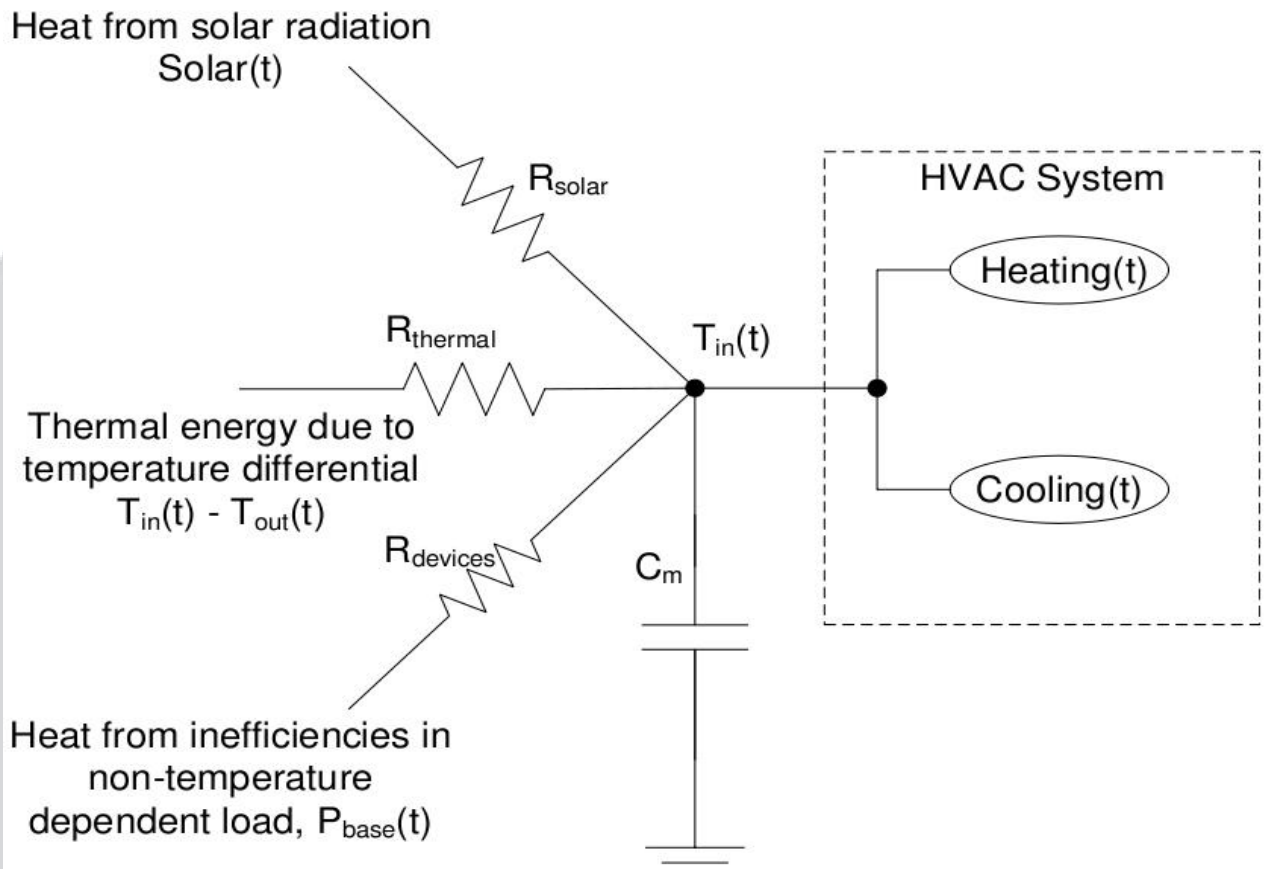
Modelling 1: Parameter Estimation

- Given: a model with model parameters, and a series of observations
- Task: determine model parameters so that the model fits the data

Evolutionary Model Inversion

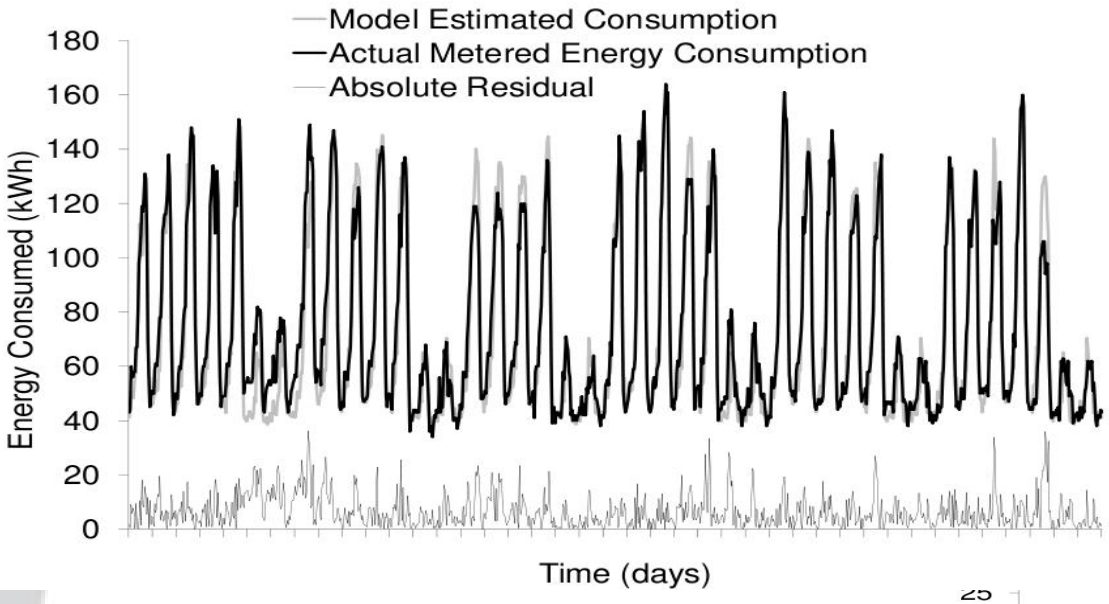


Example: Thermal Building Model

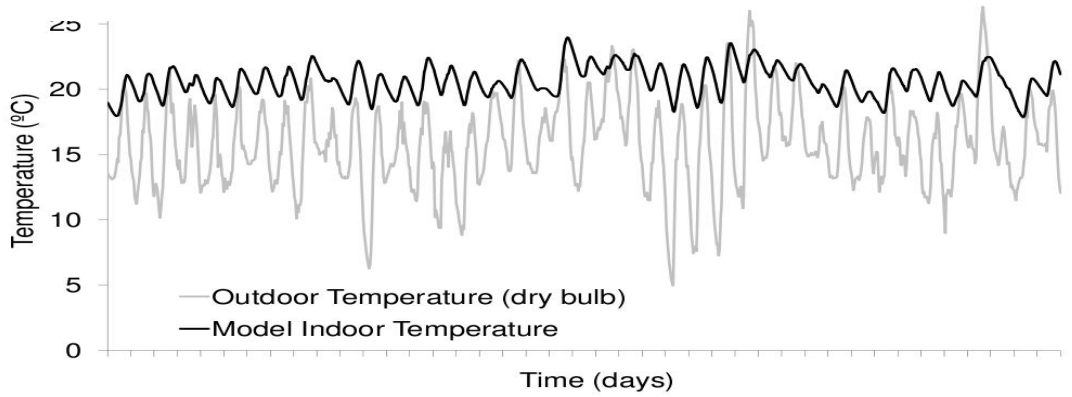


- T_in(t): hidden variable
- 10 + 3 * 24 * 7 params
- Fitness: mean abs error

Results



(Schnier/Bowers/Wright)



Also: superplastic-damage constitutive equations (Lin/Cheong/Yao)
Callibration of water runoff models (Nazemi/Yao/Chan)

Modelling 2: learning behaviour

- Given: agent model structure, framework for interaction
- Task: determine a set of behaviours for agents

Evolutionary Agent Modelling

- Iterated Prisoner's Dilemma

	Co-Operate	Defect
Co-Operate	3 - 3	0 - 5
Defect	5 - 0	1 - 1

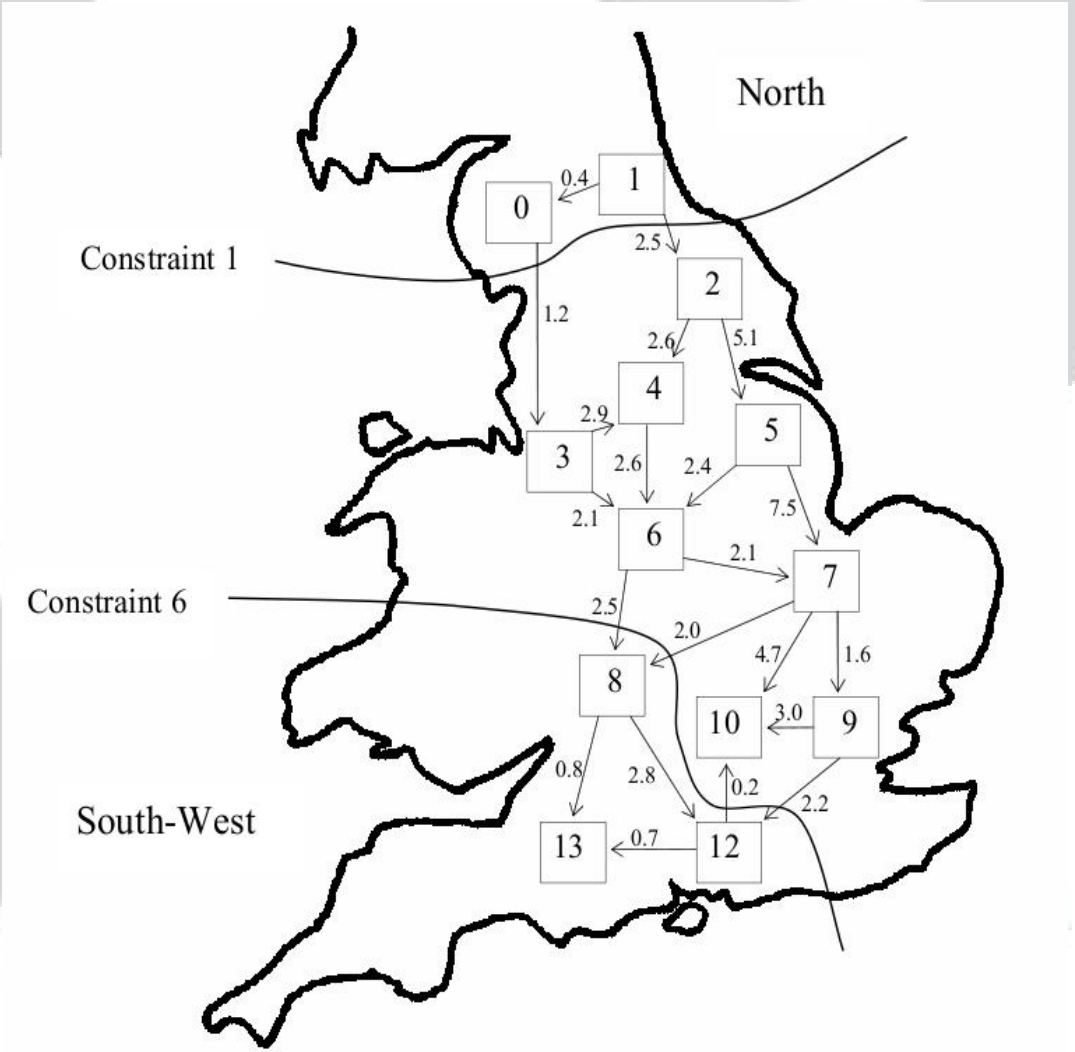
- Evolve agent strategy (decision table)

(Darwen/Yao)

Agent-Based Energy Market Model

- Market Power
  - Not bidding real costs
  - Abusing constraints
- Agent based model
  - 'Learn' greedy bidding strategies
  - Different scenarios

Also: Competition Modelling

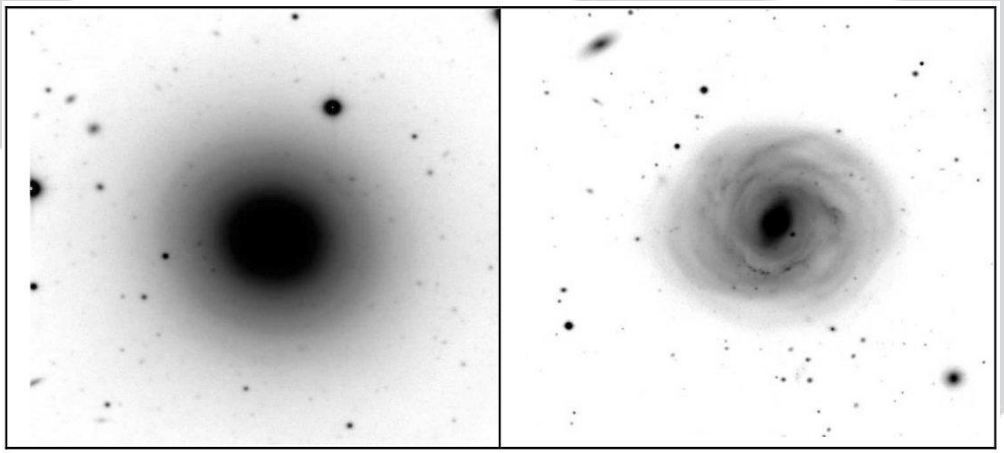


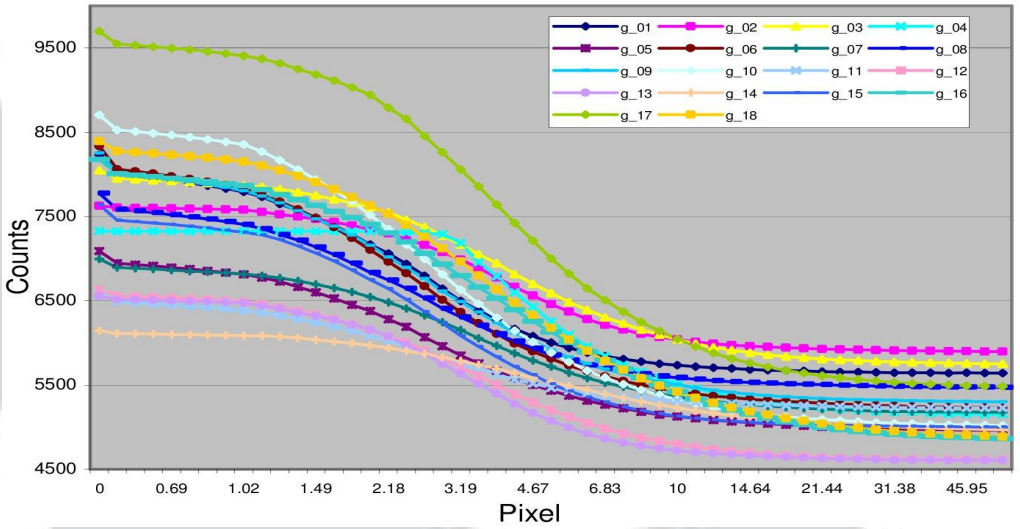
Modelling 3: Inventing the Model

- Given: a set of series of observations
- Task: find the underlying model

Example: Galaxy Modelling

- Elliptical and Spiral Galaxies
- Given: brightness profile
- Task: find a model





Traditional Approach

- Guesswork...
  - Hubble's law:
    - Physically inspired
    - Bad fit...
  - De Vaucouleurs law:
    - No physical interpretation
    - Reasonable fit

$$I(r) = \frac{I_0}{\left(\frac{r}{a} + 1\right)^2}$$

$$I(r) = I_e \mathrm{e}^{-3.33 * \left(\left(\frac{r}{r_e}\right)^{1/4} - 1\right)}$$

Evolutionary Approach

- Evolve complete formulas
  - Genetic programming
- Simplify
- Parameterize

$$f_{g1} = \frac{a+b}{c+r}$$

$$f_{g2} = a' + \frac{b'}{b'+c'*r^2}$$

Li/Yao/Frayn et al

Data Analysis 1: Outlier Detection and Classification

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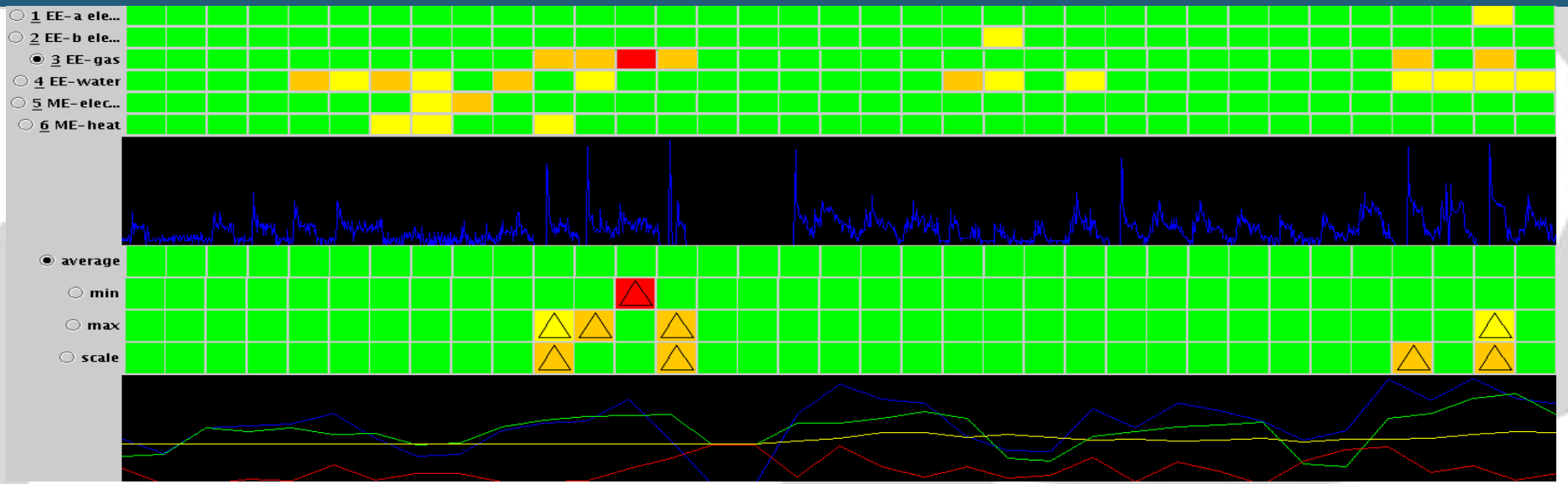
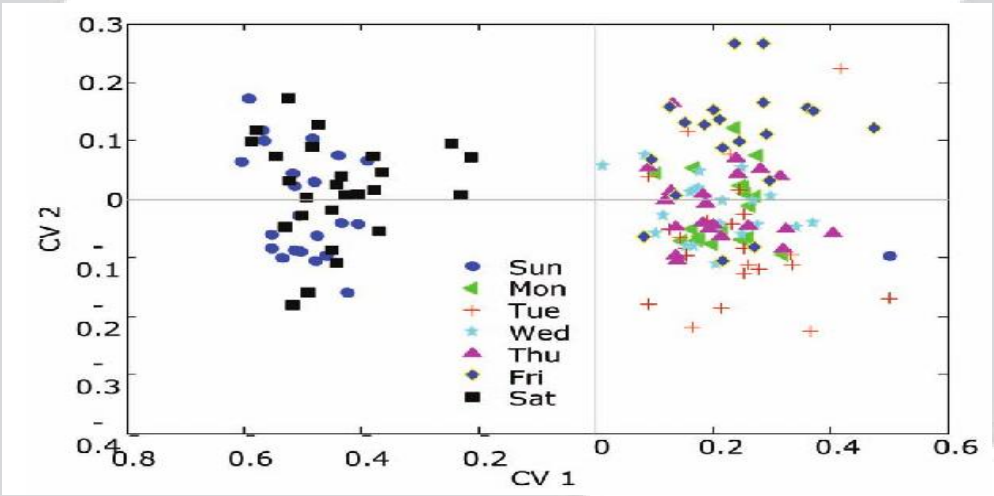
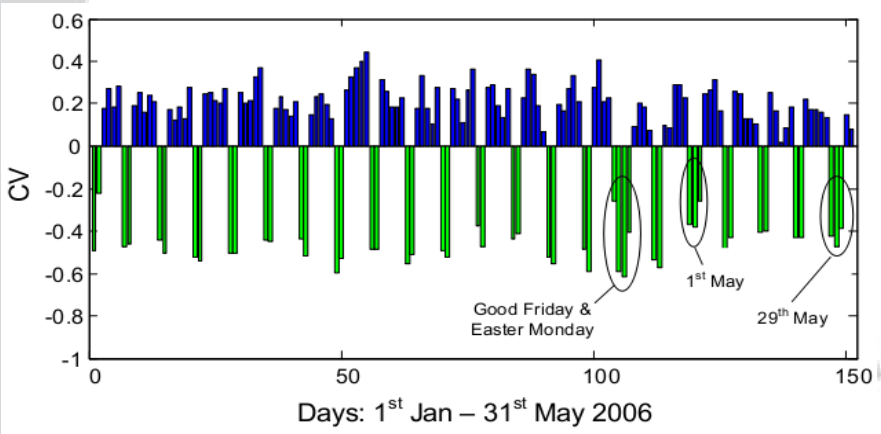
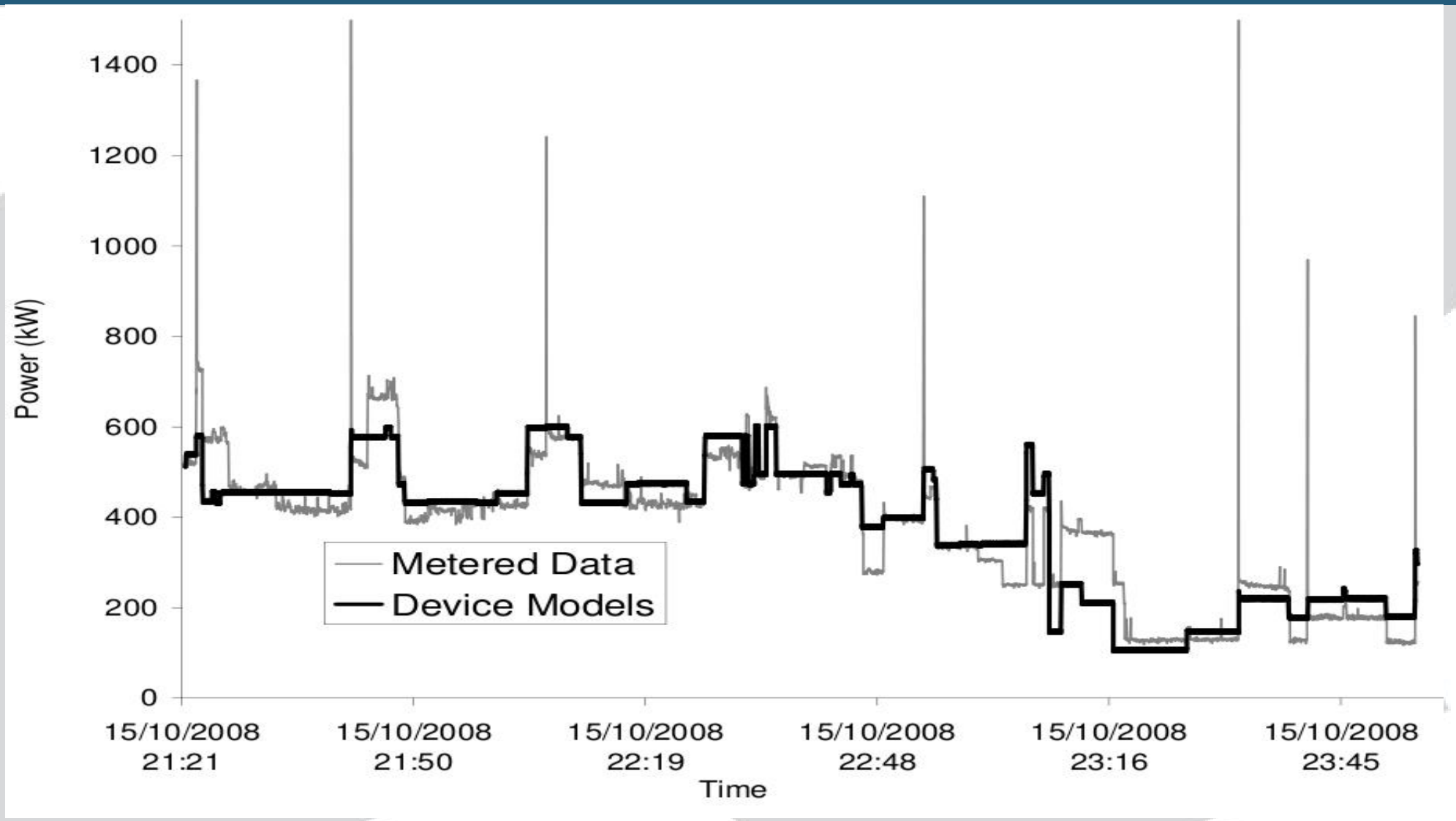






Li/Bowers/Schnier

Data Analysis 2: Disaggregation



Optimization of Complex Systems

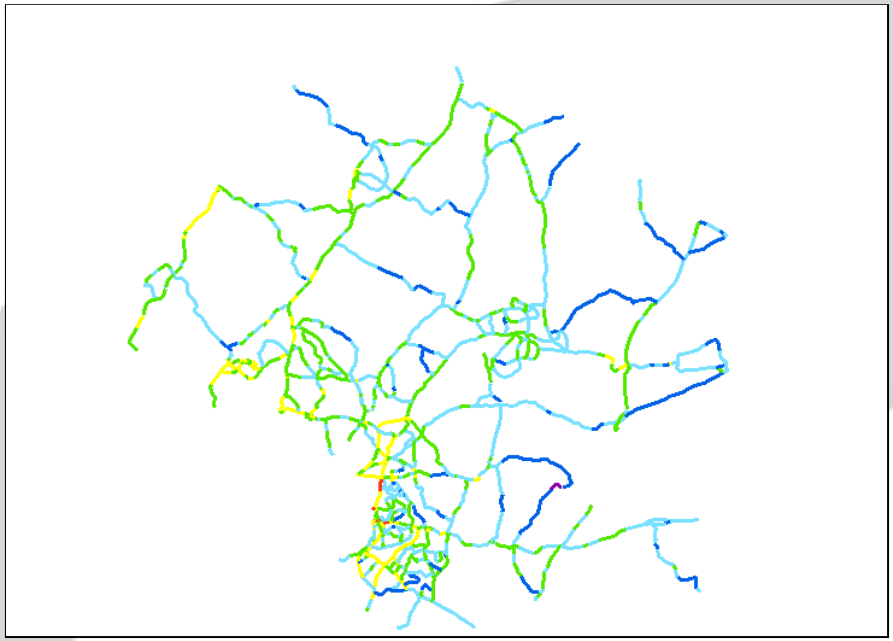
- Highly constrained
- Highly non-linear
- Multi-objective
- Incomplete knowledge

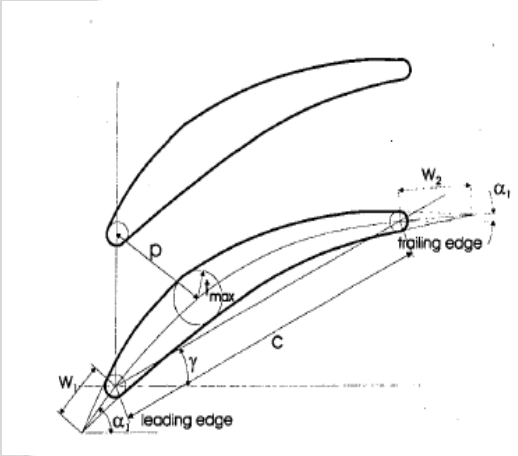
- Growth, Development
- Robustness, Breaking Models

Examples

- Logistics: Gritter Routing

(Handa/Chapman/Yao)





- Design: Turbine Blades

(Zhang, Yao, Schnier)

Summary

- Data + Computational Power
  - Data-driven modelling
  - Use and analysis of sensor data
  - Make sense of complex systems
  - Optimize complex systems