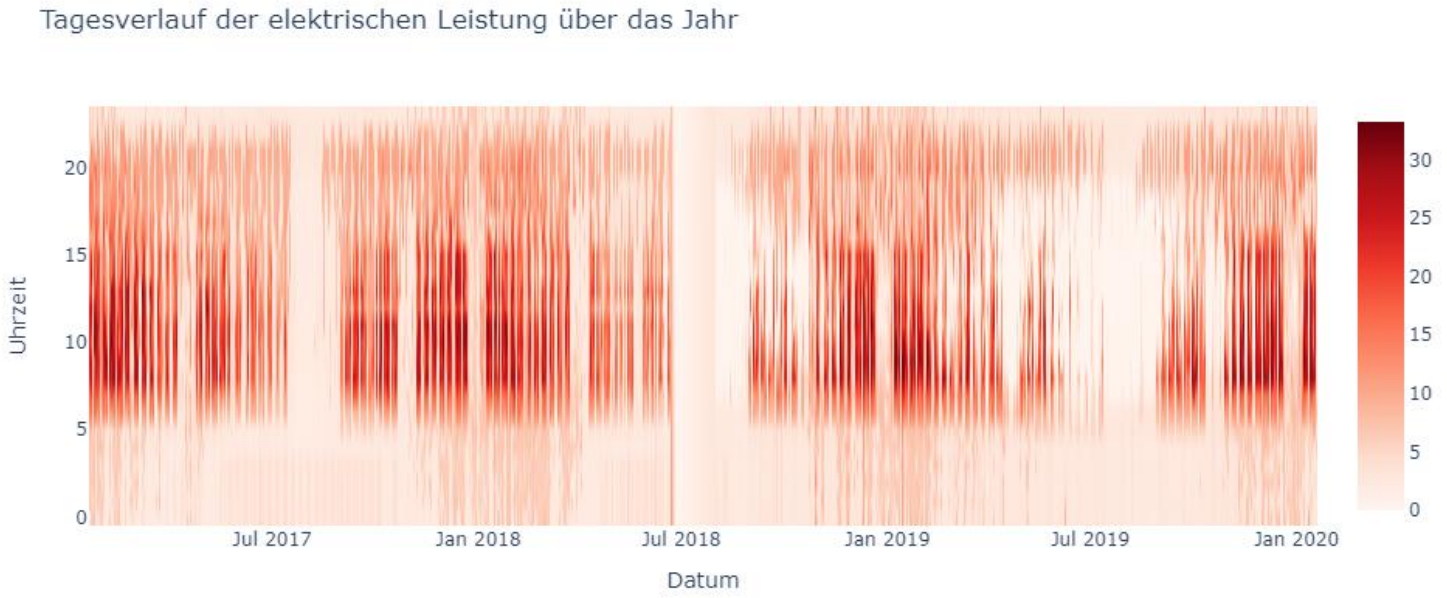


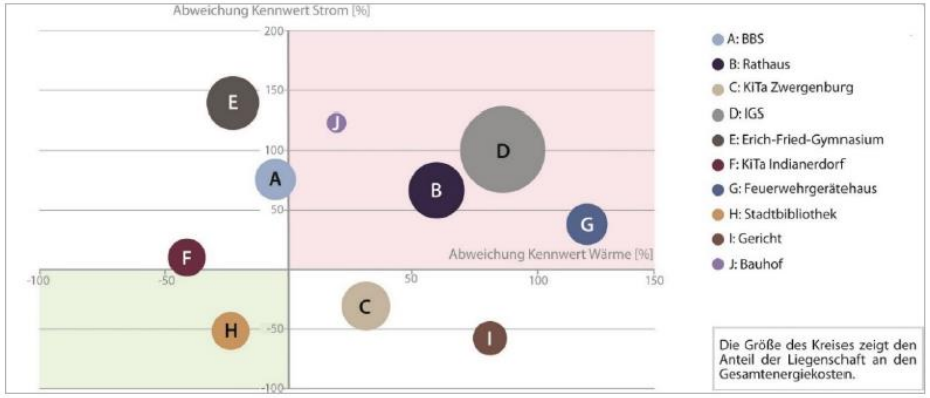


Abbildung 12: Strom-Wärme-Kosten-Diagramm

Musterenergiebericht mit Anleitung, Klimaschutz und Energieagentur, Niedersachsen

Artificial Intelligence in Public Sector

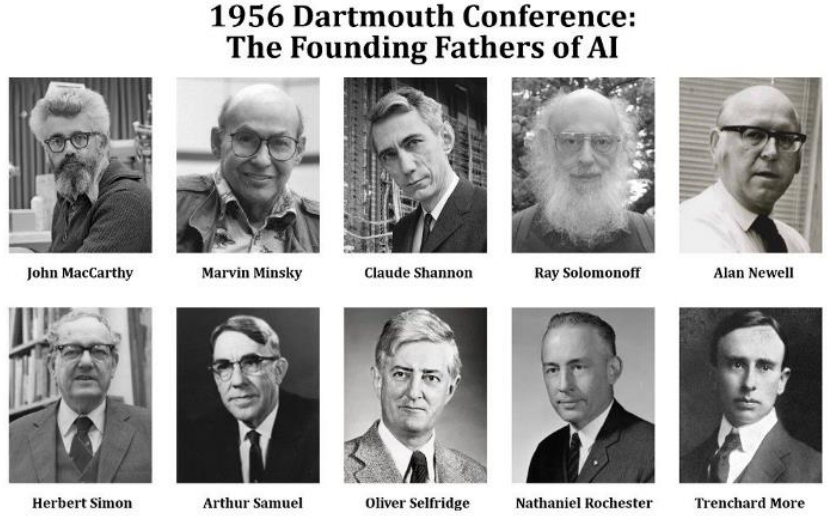
Applications of Artificial Intelligence to analyse and understand dynamics in municipal load consumption

Dr. Benjamin Adrian

Artificial Intelligence

… it is a vision, a huge field of research

Nature of human Intelligence	Disciplines of Artificial Intelligence
We communicate with language	Natural Language Processing
We memorize lessons learnt	Knowledge Representation
We draw conclusions	Machine Reasoning
We adapt our behavior	Machine Learning
We perceive our environment	Computer Vision
We move ourself and objects	Robotics



Founding fathers of AI. Courtesy of scienceabc.com

The following are some aspects of the artificial intelligence problem:

1. Automatic Computers

If a machine can do a job, then an automatic calculator can be programmed to simulate the machine. The speeds and memory capacities of present computers may be insufficient to simulate many of the higher functions of the human brain, but the major obstacle is not lack of machine capacity, but our inability to write programs taking full advantage of what we have.

2. How Can a Computer be Programmed to Use a Language

It may be speculated that a large part of human thought consists of manipulating words according to rules of reasoning and rules of conjecture. From this point of view, forming a generalization consists of admitting a new word and some rules whereby sentences containing it imply and are implied by others. This idea has never been very precisely formulated nor have examples been worked out.

3. Neuron Nets

How can a set of (hypothetical) neurons be arranged so as to form concepts. Considerable theoretical and experimental work has been done on this problem by Uttley, Rashevsky and his group, Farley and Clark, Pitts and McCulloch, Minsky, Rochester and Holland, and others. Partial results have been obtained but the problem needs more theoretical work.

4. Theory of the Size of a Calculation

If we are given a well-defined problem (one for which it is possible to test mechanically whether or not a proposed answer is a valid answer) one way of solving it is to try all possible answers in order. This method is inefficient, and to exclude it one must have some criterion for efficiency of calculation. Some consideration will show that to get a measure of the efficiency of a calculation it is necessary to have on hand a method of measuring the complexity of calculating devices which in turn can be done if one has a theory of the complexity of functions. Some partial results on this problem have been obtained by Shannon, and also by McCarthy.

5. Self-Improvement

Probably a truly intelligent machine will carry out activities which may best be described as self-improvement. Some schemes for doing this have been proposed and are worth further study. It seems likely that this question can be studied abstractly as well.

6. Abstractions

A number of types of ``abstraction'' can be distinctly defined and several others less distinctly. A direct attempt to classify these and to describe machine methods of forming abstractions from sensory and other data would seem worthwhile.

7. Randomness and Creativity

A fairly attractive and yet clearly incomplete conjecture is that the difference between creative thinking and unimaginative competent thinking lies in the injection of a some randomness. The randomness must be guided by intuition to be efficient. In other words, the educated guess or the hunch include controlled randomness in otherwise orderly thinking.

https://web.archive.org/web/20070826230310/http://www-formal.stanford.edu/jmc/history/dartmouth/dartmouth.html

Artificial Intelligence in Germany

Public Administration

National focus on AI set to:

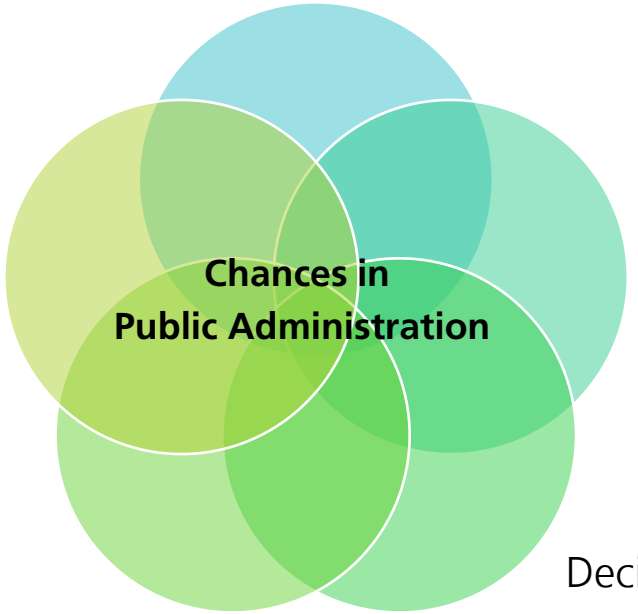
- Industry 4.0
- Healthcare
- Energy

Front Office

- Chat Bots / Interactive forms / Knowledge Graphs
- Stay in Contact via Mobile Apps
- Planning Visitor Distributions

Real-time Control

- Fraud detection
- Alerting
- Energy Management
- Traffic control



Back Office

- Tenders
- Planning infrastructure refurbishment
- Database creation

Robot Process Automation

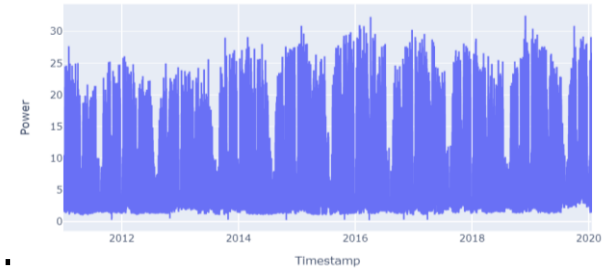
- Tax return
- Digital services

Decision Support

- Energetic refurbishment
- Communal Sentiment analysis
- Rapid/Continuous Polls
- Reports and Dashboards

Analysis of municipal load consumption / production

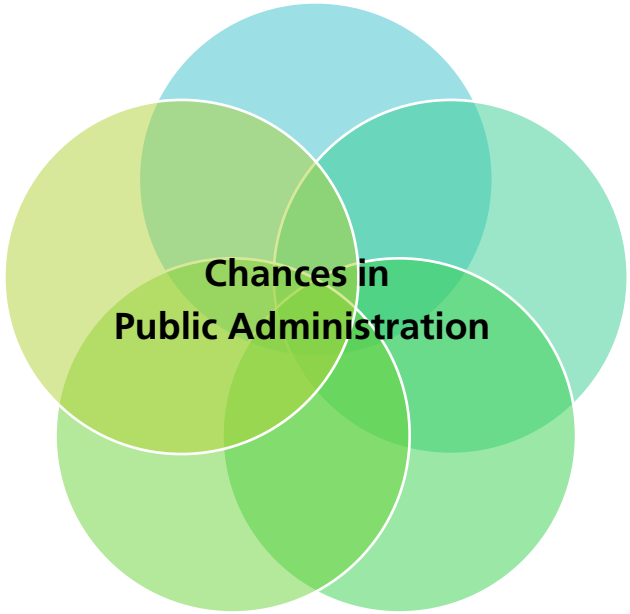
Public energy management



- Decompose load curves into seasonal load profiles
- Identify potential savings via
  - energy reports
  - comparison of similar municipalities
- Simulate effect of potential refurbishment
- Identify change points in load profiles to
  - alert on defects or misconfiguration
  - see effect of altering usage profile
  - validate effect of refurbishment

Front Office

Real-time Control



Back Office

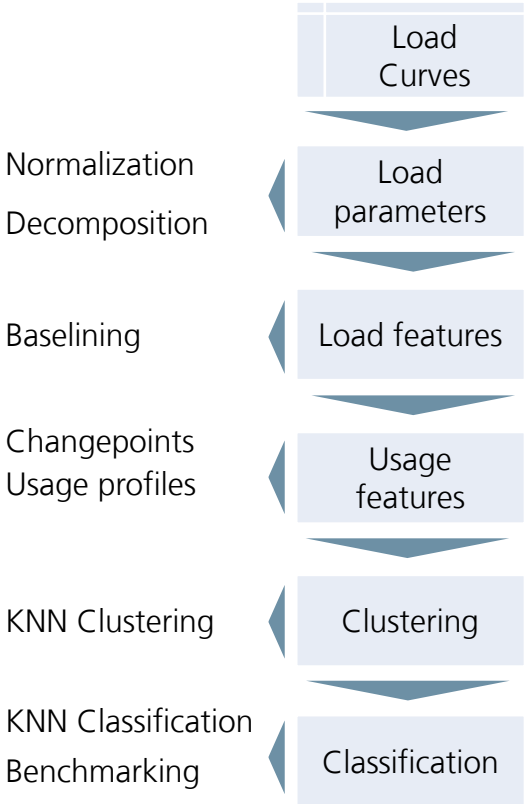
Robot Process Automation

Decision Support

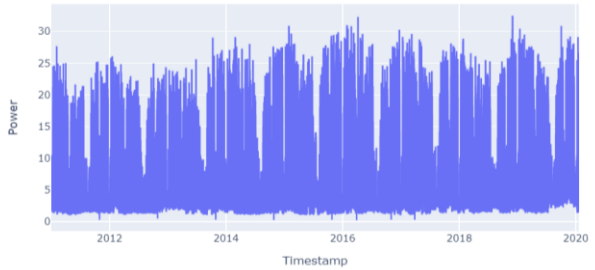
Analysis of energy consumption data

Use Cases

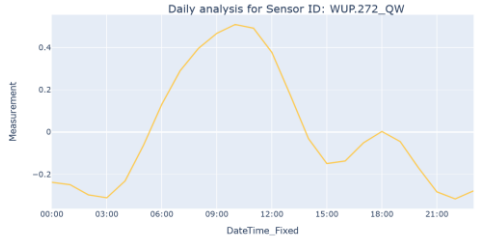
Workflow



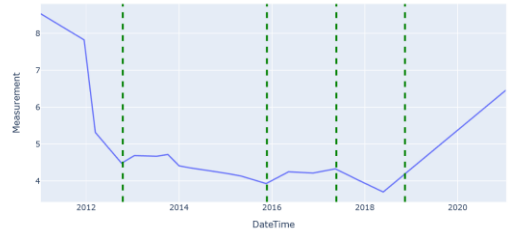
Load Curve of a school



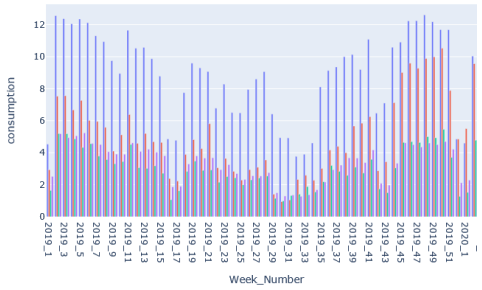
Saisonal components



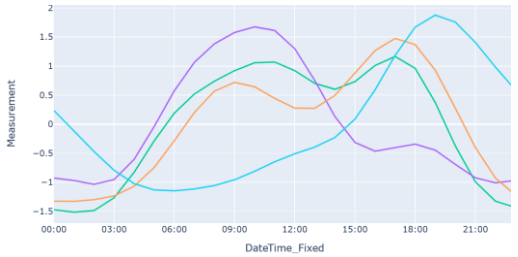
Change points



Benchmarking



Saisonal load profiles



Load performance categories

Decomposition of load curves

The Basement

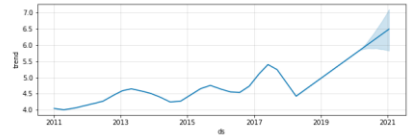
General additive Model (GAM) decomposes load curves:

$$\hat{y} = g(t) + s(t) + h(t) + \epsilon_t$$

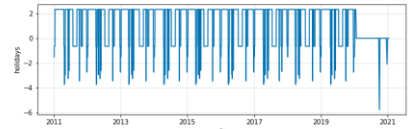
- Piecewise linear or logistic **trend**:
  $g(t) = (k + a(t)^T\delta)t + (m + a(t)^T\delta)$, $a_j(t) = \begin{cases} 1, & \text{if } t \geq s_j, \\ 0, & \text{otherwise.} \end{cases}$
- **Periodic changes** in terms of saisonalities (several partial Fourier Series):
  $s(t) = \sum_{n=1}^{N}(a_n \cos\frac{2\pi t}{p}) + b_n \sin\frac{2\pi t}{p})$ period p (e.g., yearly, weekly, daily)
- **value-discrete varying part** (e.g., holidays, temperature, daylight):
  $h(t) = z(t)r_i$

δ, m, k are optimisation variables and therefore found by a solver.

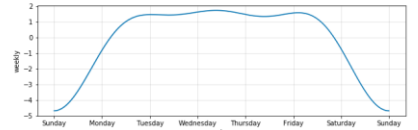
trend



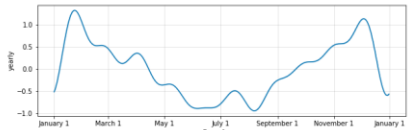
holidays



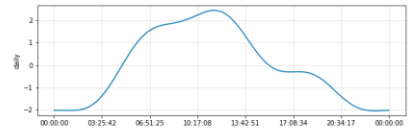
weekly



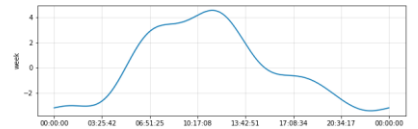
yearly



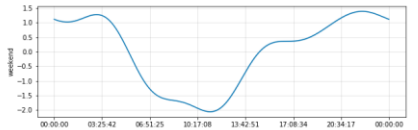
daily



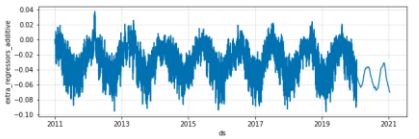
work_daily



weekend_daily



temperature

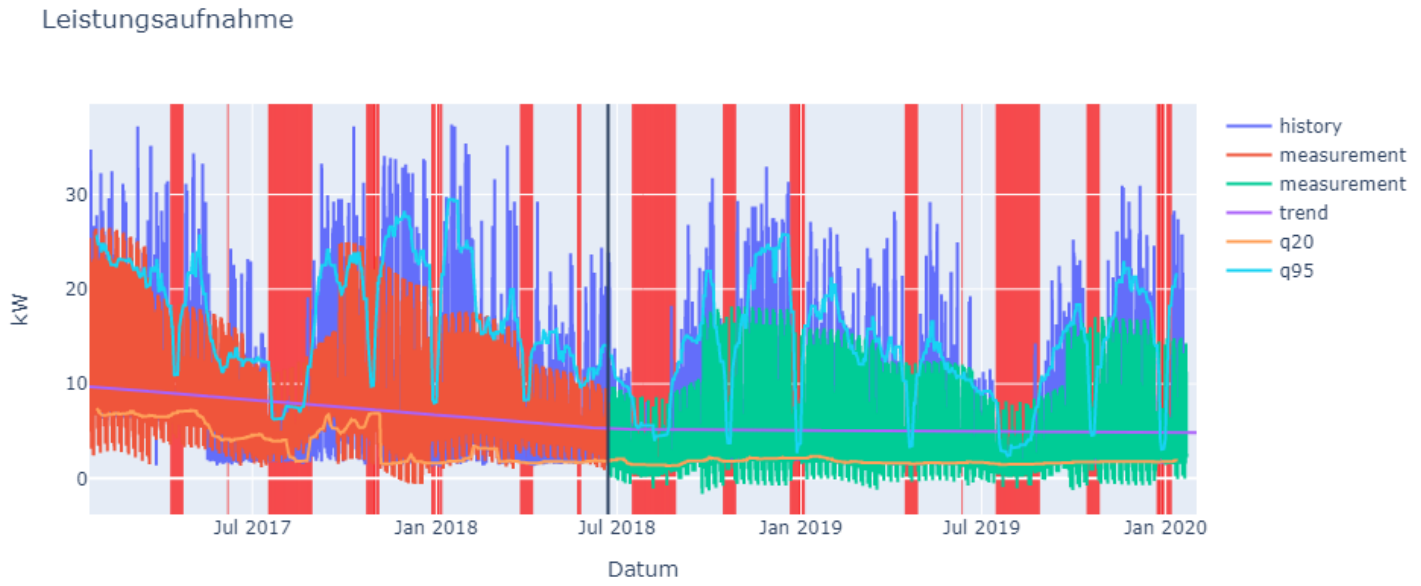


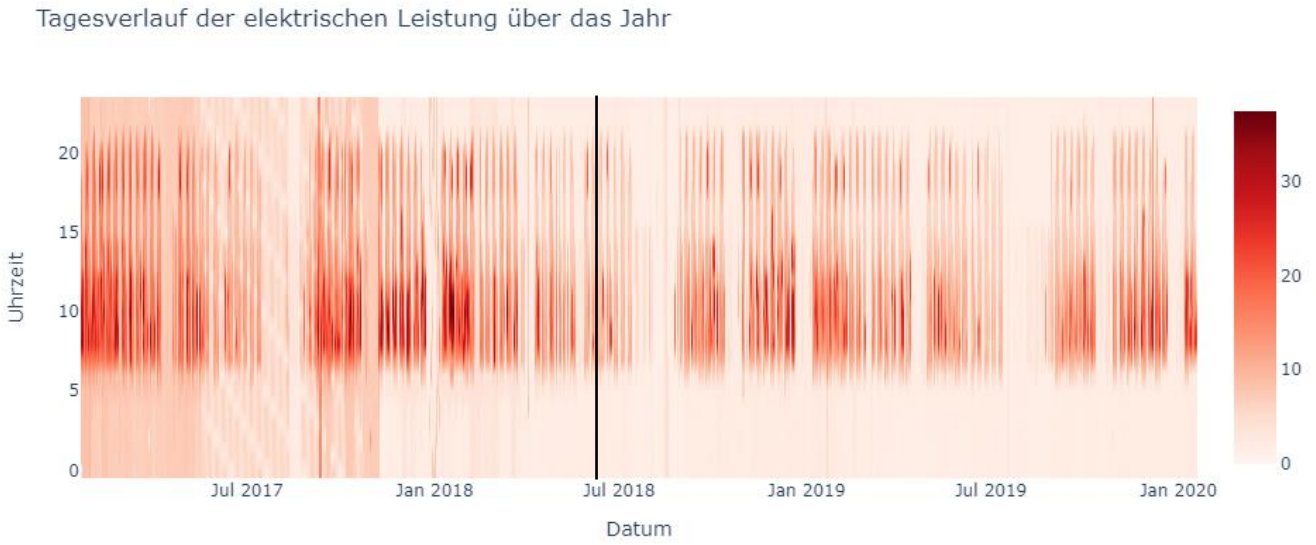
Goal: Identify changepoints

From load data to changepoints

Reasons for Changepoints

- energy-saving measures
- change of heating control
- additional consumer
- change of usage
- system failure





Example research task: Segmented regression and postprocessing

Goal: Finding minimal number of optimal changepoints:

The original model uses a high number of change point event events

$a(t)$ is defined over the time range

- Taylor, Sean & Letham, Benjamin. (2017). Forecasting at scale. 10.7287/peerj.preprints.3190v2.

Better Approach:

- For a given number of breakpoints a series is estimated piecewise by linear regression
- Find optimal number of changepoints by iterating over a desired metric (here R^2)
- Reduce number of breakpoints by applying an additional time-threshold

$$y \approx \alpha x + c + \beta(x - \psi^{(0)})H(x - \psi^{(0)}) - \beta(\psi - \psi^{(0)})H(x - \psi^{(0)}) + \zeta\,.$$

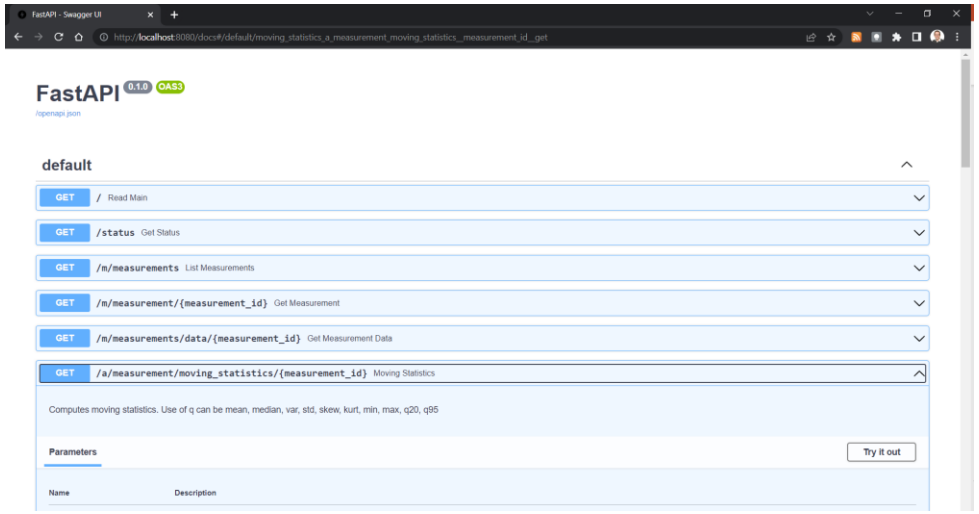
Estimating regression models with unknown break-points, Vito M. R. Muggeo, 08 September 2003
https://joss.theoj.org/papers/10.21105/joss.03859

Analysis of energy consumption data

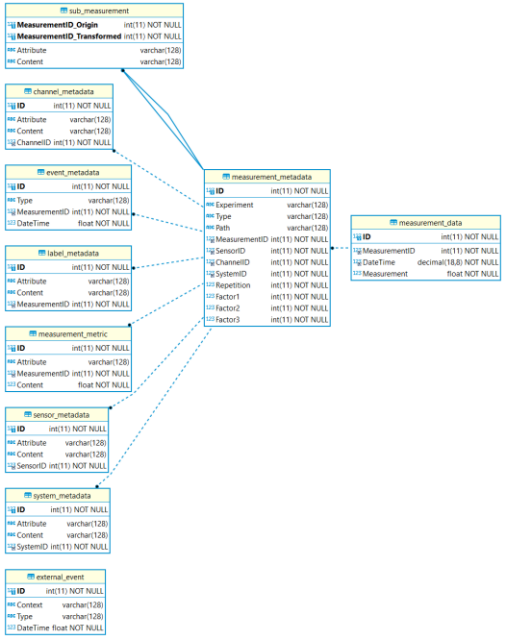
Building an application

Web Dashboard

REST Services



ORDB Storage



Thank you for having me