



Mikkel Baun Kjærgaard

Associate Professor

SDU CENTER FOR ENERGY INFORMATICS
MÆRSK MC-KINNEY MØLLER INSTITUTTET

READ MORE: [HTTP://WWW.SDU.DK/OM_SDU/INSTITUTTER_CENTRE/CENTREFOREENERGYINFORMATICS](http://www.sdu.dk/om_sdu/institutter_centre/centreforenergyinformatics)

SDU CENTER FOR ENERGY INFORMATICS



Occupancy Team at SDU Center for Energy Informatics

Vision: *Sustainable Software-Defined Buildings which are Aware and Collaborate with their Occupants*

Occupancy Team:

Post Doc **Aslak Johansen**, PhD Student **Emil Holmegaard**, PhD Student **Fisayo Caleb Sangogboye**, PhD Student **Jakob Hviid**, PhD Student **Anooshmita Das** and Software Developer **Jens Hjort Schwee**.

25 people in the Center for Energy Informatics.

Current Projects:



IoTControl

Annex66

EnergiBH

ODEx: Open Data about Human Behavior

The vision of the project is to co-create new solutions for improving the built environment based on open data about human behavior.

Project period 2017-2019.

A primary goal is to foster spinoff projects in collaboration with external stakeholders including municipalities and companies.

Current partners in connected projects include: Odense Municipality, Vemco Group, UC Berkeley, LBNL, GeoFyn, Hesehus, Niko-Servodan, ...

Principal Investigator:



Mikkel Baun Kjærgaard
Associate Professor
Mærsk Mc-Kinney Møller Institute
Center for Energy Informatics

Participants:



Jasper Schipperijn
Associate Professor
**Department of Sports
Science and Clinical
Biomechanics**



Jacob Buur
Professor
**Department of Design and
Communication**
SDU Design



Bent Ole Gram Mortensen
Professor
Department of Law

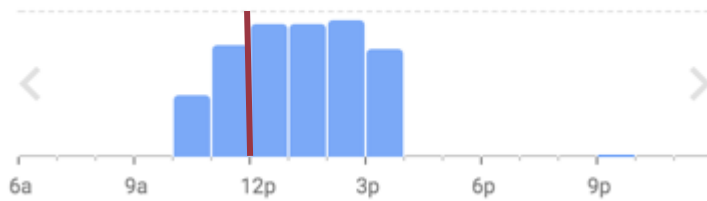


Bertil F. Dorch
Library Director
University Library

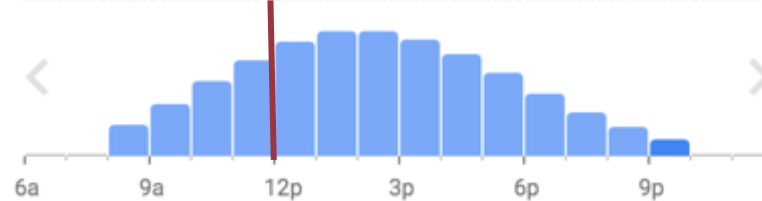
Open Data for Transparency

Google Maps Estimates for DOKK1

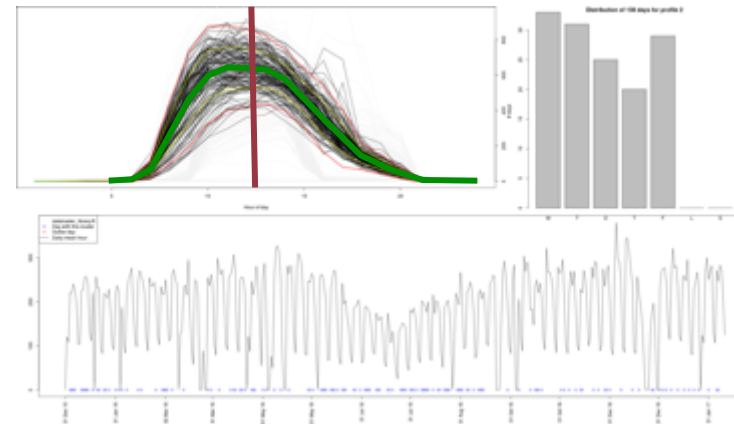
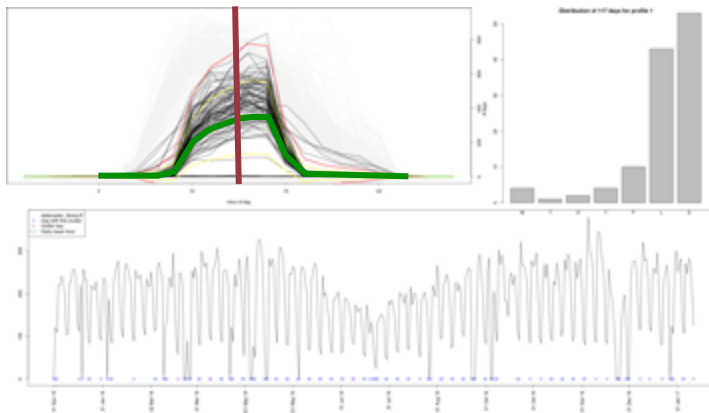
Popular times Saturdays ▾



Popular times Tuesdays ▾



DOKK1 Open Data Counts + PLCount + Data Mining



Why different?

- Data issue
(*smartphone biases*)
- Commercial reasons

**Open Data creates
Transparency!**

Data-driven Analysis for Multiple Users

Living Lab Building OU44 at SDU

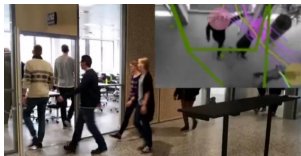


Sensors / Meters:

- Electricity meters (64)
- Heat meters (12)
- Water meters (4)
- Occupancy counters (17)
- CO2 (per room)
- Illuminance (per room)
- Temperature (per room)
- Humidity (per room)
- PIR (per room)
- Ventilation system (valves, temperatures)
- Heating system (valves, temperatures)
- Cameras across all entrances and floors



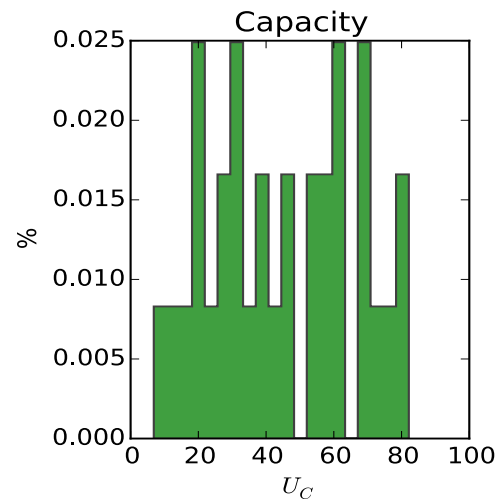
Occupancy counter camera



Real-time occupancy counters

Planning

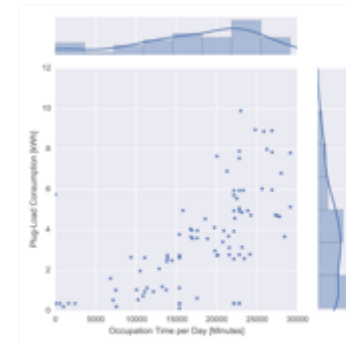
Utilization of Room Capacity



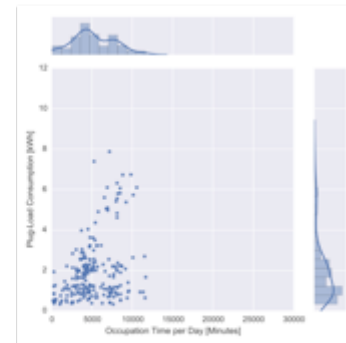
Data:
Room Counts
Teaching Schedules

Building Operation

Electricity Consumption for Student Laptop Recharging



(a) Classrooms

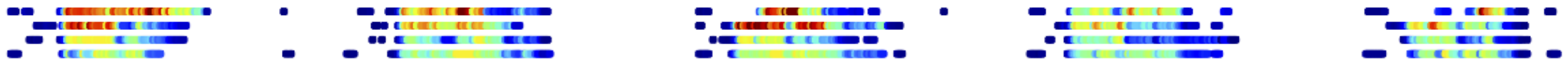


(b) Study zones

Data:
Room Counts
Room Plug-Load Consumption

Privacy Sensitive Data

Example: Counts for five weekdays for four lecture rooms:



Linkage attack based on schedules enable you to quantify attendance to individual lectures (Low attendance, do people leave during lecture, are lectures shorter than scheduled, ...)

Hard for domain expert to spot possible linkage attacks which calls for general mechanisms to protect data.

Project Plan

Activities

A1 - Methodology for open data about human behavior

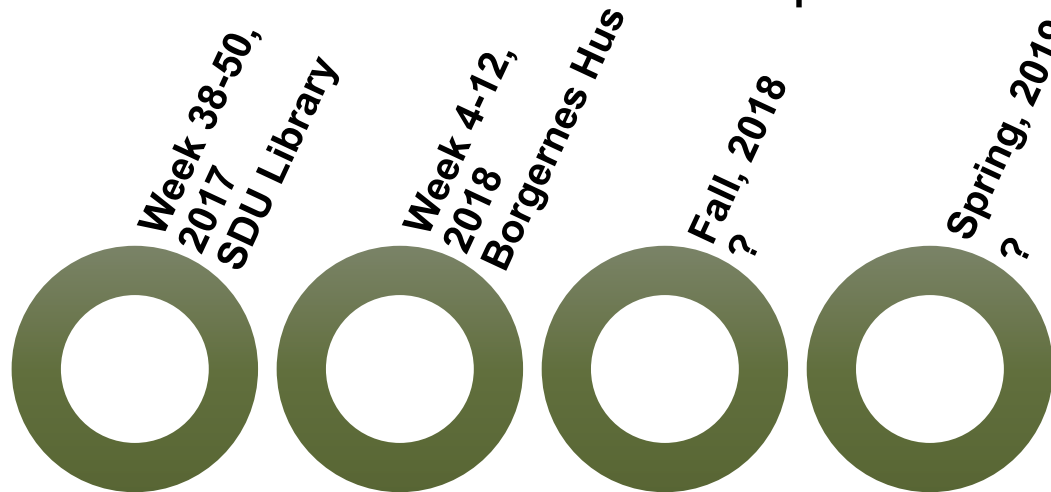
A2 - Open data collection by stationary and wearable sensors

- **Stationary: People counting, WiFi and environmental conditions (Temperature, Humidity, CO2 and Noise)**
- **Wearable: Dedicated research devices with high robustness (GPS, acceleration, Bluetooth positioning)**

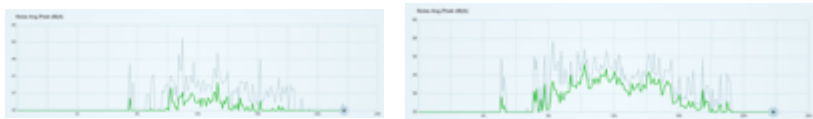
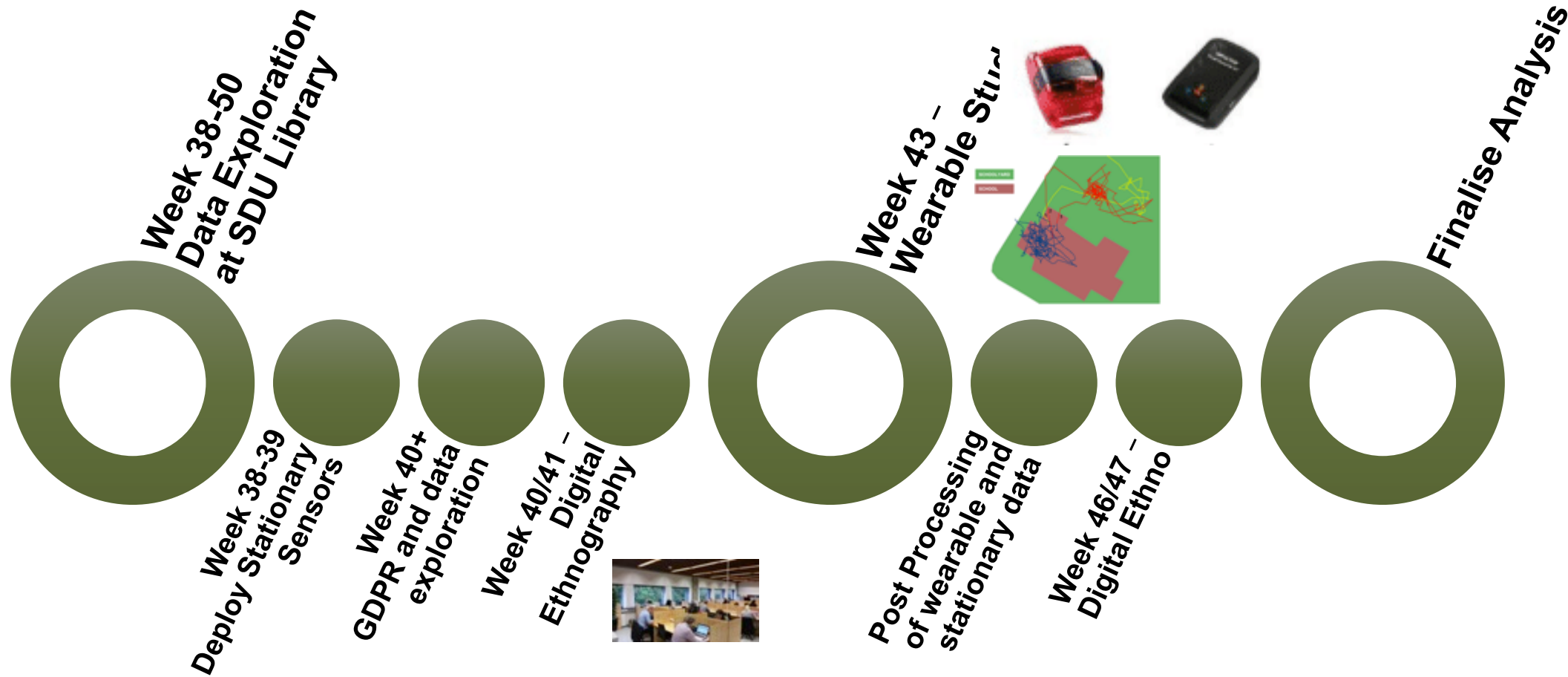
A3 - Software tools for trajectory and place data about human behaviour

A4 - Domain demonstrations for smart buildings

Activities linked in a number of data explorations:

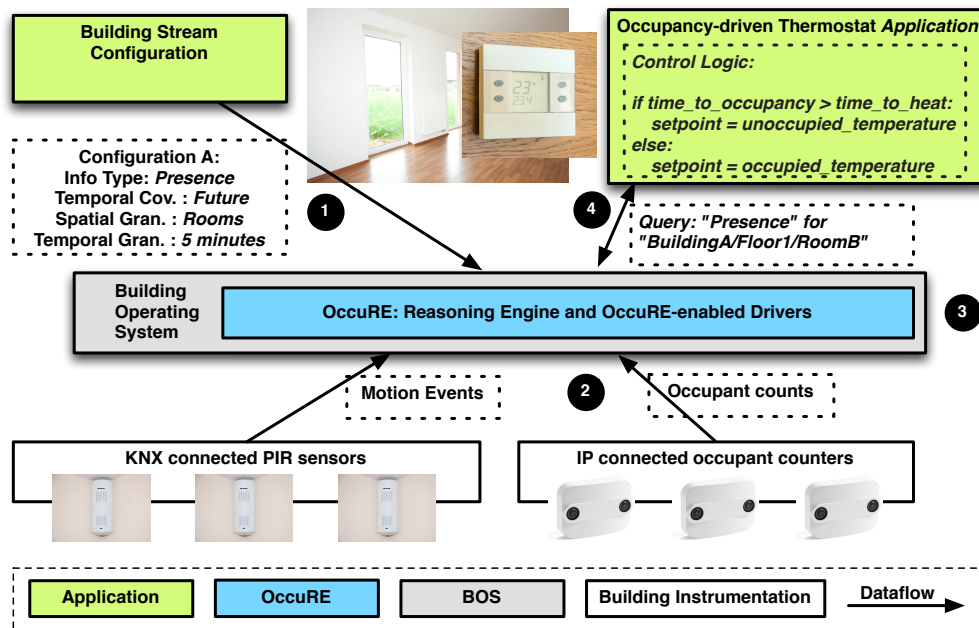


Data Exploration at SDU Library



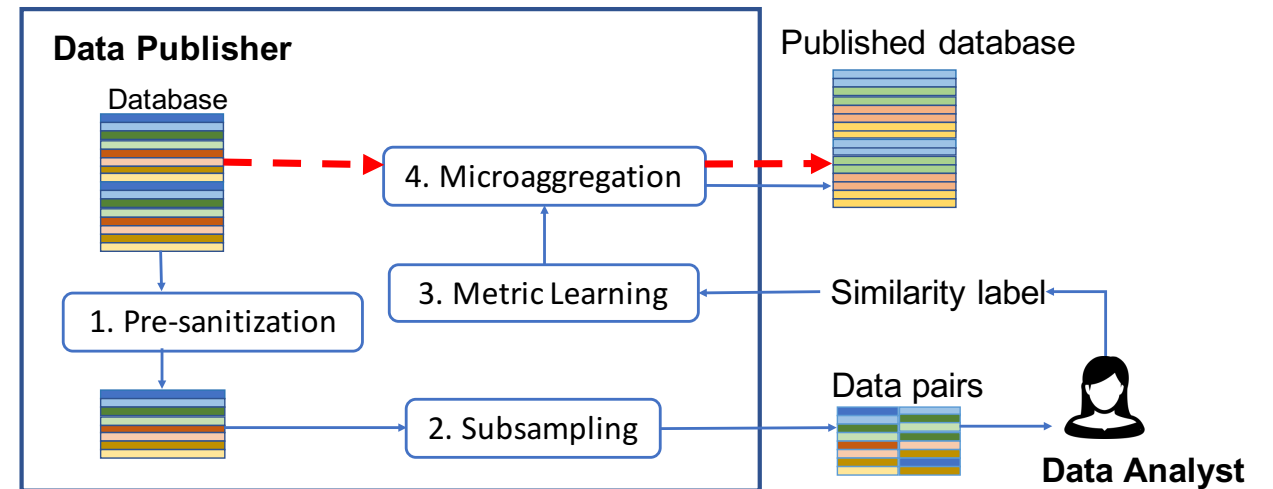
Technology View

OccuRE: Platform for Analysis of Occupancy Data



Kjærgaard et. al.: OccuRE: An Occupancy REasoning Platform for Occupancy-Driven Applications. CBSE 2016: 39-48, ACM.

PAD: protecting anonymity in publishing building related datasets



Ruoxi Jia, Fisayo Caleb Sangogboye, Tianzhen Hong, Costas Spanos, and Mikkel Baun Kjærgaard: PAD: Protecting Anonymity in Publishing Building Related Datasets. BuildSys 2017, ACM

ODEx: Open Data about Human Behavior

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