State of the Art in Visualization for Building Systems

September 25, 2019

Lyndsey Franklin, Yi Huang, and Dustin Arendt
Agenda

• Survey of relevant literature

• Exploration with Tableau (exploratory data analysis platform)

• Exploration with CHISSL (interactive machine learning)
Literature
A Systematic Review of Visualization in Building Information Modeling


URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8674573&isnumber=4359476

- Results from a survey of visualizations in current Building Information Modeling practice
- Taxonomy of main application areas
  - Information: Scope, Schedule, Cost, Sustainability, Facility, Risk, Resource, Supply Chain, Security, Mechanical, Quality
- 200+ papers surveyed
Simulation and visualization of energy-related occupant behavior in office buildings


DOI: [https://doi.org/10.1007/s12273-017-0355-2](https://doi.org/10.1007/s12273-017-0355-2)

Fig. 11 The interface of the visualization model in AnyLogic (Note: the lighting illuminance is only for the daylighting and doesn’t include the artificial lights)
Enabling Complex Building Energy Visualization by Integrative Event-Driven Data Provisioning

doi: 10.1109/NetSys.2015.7089085

URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7089085&isnumber=7089054
A Visualization Tool for Building Energy Management System


doi: 10.1109/iV.2015.15

URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7272573&isnumber=7272518

Figure 1. Snapshots of the presented visualization tool for building energy management. Long-term polyline chart is clickable so that users can specify blocks of the building on the particular day. The energy consumption and other values corresponding to the clicked position are displayed in one-day polyline chart. The values of each block, each day are divided into the meaningful number of patterns so that users can interactively focus on specific patterns.
Chasing the Negawatt: Visualization for Sustainable Living


DOI: 10.1109/MCG.2010.50

Figure 3. The Adaptive Living Interface System (ALIS) Dashboard provides access to high-level information regarding home energy use.
Chasing the Negawatt: Visualization for Sustainable Living


DOI: 10.1109/MCG.2010.50
Time-pie visualization: Providing contextual information for energy consumption data


URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6676549&isnumb er=6676523

Figure 6. A prototype implementation of time-pie visualization, showing the proportions of energy usage by five different offices in a 24-hour period.
TimeNotes: A Study on Effective Chart Visualization and Interaction Techniques for Time-Series Data


DOI: [10.1109/TVCG.2015.2467751](https://doi.org/10.1109/TVCG.2015.2467751)
Automated daily pattern filtering of measured building performance data


https://doi.org/10.1016/j.autcon.2014.09.004
Tableau
Data Prep for Tableau

- Each row is a a timeseries for a measurement on a specific day
- Meta-data: feature name, unit, etc.
- Derived data: min, max, quartile edges
Tableau Visualizations

**zone temp_max**

Date

- Max: 69.800 - 77.600

Weekday of Date

- Sunday
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday

Sum of Max (color) broken down by Date Week vs. Date Weekday. The data is filtered on Unit, Category and Feature. The Unit filter keeps AHU1. The Category filter keeps VAV100. The Feature filter keeps ZoneTemperature.
Alternate Data Prep for Tableau

- Each sensor reading is a row
  - Timestamp
  - Metadata: building, unit, etc
  - Features: Temperature, Air Flow, etc.

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<th>ZoneCoolingAirFlowSetPoint</th>
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Tableau Visualizations

Zone Temp vs Zone Air Flow by VAV
Tableau Visualizations

Zone Air Flow vs Zone Temp by Day of Week and VAV
CHISSL
Necessity of Large, High-Quality, Labeled Datasets: Machine Learning’s “Elephant in the Room”

• Because, crowdsourcing requires
  ▪ A well defined task
  ▪ Users with expertise
  ▪ A large population

• Alternatives may not be satisfying
  ▪ Active Learning
  ▪ Visual Interactive Labeling
### CHISSL—Rapidly Organize Data and Build Models

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CHISSL Applied to VOLTTRON
Univariate time series

1-minute samples

Normalized

Featurized
### CHISSSL Applied to VOLTTRON

**Univariate time series**

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**flattened**
CHISSL Applied to VOLTTRON User Interface
CHISSL Applied to VOLTTRON
Post-hoc Findings

Patterns found:
• Spring vs Summer weekdays
• Weekends & Holidays
• Monday (Summer)
• Anomaly 1, Anomaly 2, Anomaly 3
Future Applications of CHISSL
CHISSL is on GitHub!
github.com/pnnl/chissl

Thank you