Advanced Methods of data analysis

Examples from previous years

Tools and companies in this area

Homework

Review of work to date
Advanced Methods
Scatter Plots show how heat use varies with outdoor air temp water and electricity use do not.

- Identify characteristics and simple control strategies (signatures)
- Daily values
- Grouped by workday / weekend
- Show correlations among parameters
- Note that scatter plot can suggest causality … but not prove it!
Scatterplots show data where trend lines can summarize data.

Daily Values

- Water
- Electricity
- Heat

Trend line

Scatterplot Consumption
- Identify characteristics and simple control strategies (signatures)
- Daily values
- Grouped by workday / weekend
Carpet plots are an alternative display technique for time series data

Carpet can show comparable time period patterns

Time series shows values
Carpet Plot Basics

Carpetplot Consumption

- Each pixel width shows one day
- Each vertical band has one “pixel” per sample within a day
- Enable easy identification of operation and / or occupancy schedules

Example of Hourly Water Use

No water use in middle of night

Note vertical stripe that goes into what is normally low water use period. Anomaly?

Holiday period
Carpet Plots: Utilities

Carpetplot Consumption
- “stapled” plots for comparison of patterns
- Easy identification of operation and / or occupancy schedules
This Carpet Plot illustrates that the base Lighting Load is \( \sim \frac{2}{3} \) of the peak load.
Carpet Plots highlight a leaking valve in an AHU

- Carpetplot **Air Handling Unit**
  - Distinct weekly operation pattern
  - Delta T at heating and cooling coil at the same time!
  - Simultaneous heating and cooling! (evtl. Control valve of cooling coil is leaking)
  - In winter: When SUP fan is not operated $T_{SUP}$ increases to 40-50°C?
  - Still unresolved because of organizational reasons)

---

Carpetplot:
- $dT_{CC}$
- $dT_{HC}$
- $dT_{SUP-EXH}$
- $T_{SUP}$
- $OAT$
Carpet Plot of Heating System data

Carpetplot Heating Circuits

- Pumps were operated constantly at 100% ①
- In Dec 08 an operation schedule for the pumps was introduced ②…
- …but mixing valves were still open during nights③
- Adjusted in April 09 ④
Best Practice Display from CEE 243
AH74 – CORE Broadview highlights issues

- Yearly variation in space air temperature: 63°F to 80°F
- (B): Unusual spikes in space temperature to 80°F in January 2010
- (A-C) What is the relationship, is there a relationship?
AH74 – CORE detailed view examines issues

- **Inconsistency**: Core cools above 74°F; spikes in space air temperature in middle of the night in January instigate cooling and do not correspond to OAT
- **Hypothesis**: Occupancy, space use, or ventilation changes could be cause of spikes
Figure 2: Supply air temperature for Zone 1 of SF1 as OAT varies from November 4, 2009 through April 22, 2010. Note the extreme fluctuation in supply air temperature and lack of correlation to OAT, while space air temperature is extremely constant.
A technique for illustrating system energy flows

**SET POINT:**
- **Zones 1-4:** 66°F - 72°F
- **Zones 5-6:** 66°F - 70°F
- **Supply fan & Return fan:** Always On
- **Heat Exchanger:** On when OAT <52°F or >76°F

The thickness of the red band represents the energy in the system—the band thickens when energy is added, and it thins whenever energy is removed.
Cooling Tower efficiency: Supply and Return water difference

• The Functional Intent (green line)
  Cool the water to be provided to the chillers, then difference of supply and return water temperature must be negative.

• Non-functional regions (red circle)
  • One above the target temperature
  • Big variability of cooling (Yellow arrow)

• Hypothesis
  • One time maintenance, cooling towers off for the upper region malfunction
  • Check the variability of the cooling tower

SYSTEM OVERALL:
• Check Manufacture Variability
• Further analysis may include fans and pumps status (now has poor data)
What do the regions 1-4 suggest?
Example Tools and Companies
Advanced Energy Management at Intel

Intel Scheme Architecture

Retriever File
- Run weekly to gather data from SQL databases and Intranet website

Overspend League Table

XSD Plot
- Analysis tool
- Consumption v's driving factor

Courtesy of Intel
Modern Tools: Lucid Design Group

http://www.luciddesigngroup.com/kiosk/features.php

Social networking for buildings
Modern Tool and Companies

• http://www.pulseenergy.com/

• http://www.scientificconservation.com/
  offers predictive diagnosis based on measured past performance
Whole Building Diagnostician

- Compares against empirical model of building
Conclusion

• Best Practice Data Display

• Reviewed Best Practice Performance Analysis

• Techniques for Performance Analysis

• Now apply to Y2E2
Other

• http://www.computerworld.com/s/article/9215504/22_free_tools_for_data_visualization_and_analysis?taxonomyId=18&pageNumber=10