The Interlock House Environmental Control and Alert System

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About the House...

“...we set out to create a house that demonstrates how existing principles of passive design, along with concepts of community interface and spatial organization, could allow a house to "interlock" with the environment, its occupants, and surrounding development. We wanted to show that a solar-powered home does not require revolutionary technologies.” –solard.iastate.edu
Purpose of the Alert System:

• Identify errors in data for research
• Provides parameters for operating the house
• maximizes energy efficiency
• Identify malfunctioning sensors or equipment in the house (ex. Hot water tank)
Types of Sensors in the House

• Air temperature
• Relative Humidity
• Wind speed and direction
• Solar irradiance
• Illuminance
• Water Flow
• Energy Usage (Wh, A, V)

Omega SA1-T-SC adhesive thermocouple
Temp: -60 to 175º C
Sensor Examples

Vaisala HMP60
Relative Humidity: 0 to 100%
Temp: -40 to 60º C

Vaisala HMT333
Relative Humidity: 0 to 100%
Temp: -70 to 180 ºC

LI-COR LI-200
Pyranometer
Irradiance: 0 to 3000 W/m²

CSI_RM Young 03101
Anemometer
Wind Speed: 0 tp 50 m/s
Equipment...

- Inverters
- Hot water tanks
- Radiant floor
- A/C and ERV (Energy Recovery Ventilation)
- Solar Panels
- Evacuated Tubes
- Appliances
Mechanical room before May of 2013
Historical Data

Why use historical data?
• Helps us find usual trends

• Allows one to monitor the building performance as it progresses over time.
Distributions from JMP

• Great for:
  • Showing the range of data in a set of data
  • Allows for one to look at where most of the recorded data occurs for the set
  • Gives a statistical analysis of all the quartiles

• This allows you to get a rough approximation of the max and min just by looking.
**Distributions**

**SunspaceMid_pctRH_Avg**

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**Quantiles**

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<tr>
<td>0.0%</td>
<td>minimum</td>
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**Summary Statistics**

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<td>Std Err Mean</td>
<td>0.0454952</td>
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<td>Upper 95% Mean</td>
<td>46.567568</td>
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<td>Lower 95% Mean</td>
<td>46.389225</td>
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<tr>
<td>N</td>
<td>43117</td>
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Distributions from JMP

• Some set backs:
  • Distributions do not have time associated with it
  • Many times looking at the range does not help significantly for tell us the true max and min (outliers)

• And when we identify them we need a way to select them out

• Doesn’t allow ones to know the exact nature of problems/ outcomes or result
Specific example

Solar Water Heater
Sensors within the system
Using r to select for times of the outliers

• R is handy for the manipulation of data in any way one might want to see it handled, graphed, averaged, summed, to find standard deviation, whatever your heart desires.

• Here we want to use R to select for the values of the Solar Water Heater which have values above 39
  • Corresponding times are associated with that selection.
Something we would not expect.

Something we would expect.
The correlation

• Looking at the correlation between each of the variables becomes noticeable on graph however R provides a way for giving simple correlation values for input variables
Simple correlation

\[ r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}} \]

r values range from -1 to 1
Correlation coefficient (r value)

• ±1 = would mean perfect negative/positive correlation
• ±0 to .3 = would mean weak correlation
• ±.3 to .7 = means moderate negative/positive correlation
• ±.7 to 1 = represents strong correlation

• You can find more specifics on correlations on: http://www.dmstat1.com
Correlation of

To Solar Tank sensor °C to:

- From DHW Tank sensor °C: -0.1995947
- From Radiant Floor °C: 0.517184
- Mechanical Room Temp °C: 0.4488417
- Radiant Floor pump L/s: N/A
- DHW Tank pump L/s: N/A

Dec 31 2013
Looking Further

• Errors with the thermocouple
  • Possibly we need to look further back in time

• When considering the mechanical system of a building there is some lag in response time for heating and cooling

• i.e. a pot takes time to boil. This is not instant,
From 10:21am to 10:36am

Correlation of

To Solar Tank sensor °C to:

From DHW Tank sensor °C  
0.8948234

From Radiant Floor °C  
0.5044277

Mechanical Room Temp °C  
0.3314604

Radiant Floor pump L/s  
-0.663206

DHW Tank pump L/s  
-0.6564266
Correlation of
To Solar Tank sensor °C to:

From DHW Tank sensor °C
0.8572375
From Radiant Floor °C
0.8457842
Mechanical Room Temp °C
-0.3719189
Radiant Floor pump L/s
-0.8285808
DHW Tank pump L/s
-0.8202768
From 9:59 to 10:51am

Correlation of

To Solar Tank sensor °C to:

From DHW Tank sensor °C
0.6736574

From Radiant Floor °C
0.1548516

Mechanical Room Temp °C
-0.04545742

Radiant Floor pump L/s
-0.6387423

DHW Tank pump L/s
-0.6324385

From 9:59 to 10:51am
What is wrong with the thermocouple?

• The system,
  • Water flowing back from within the pipes heating up water
  • Seeing as this only happens for a brief period of time maybe the shutting valve for the solar water heater intake had a problem closing
  • Maybe there was a problem with the sensor itself
  • Helps to show what sensors might be most involved
Protocol for examining raw data

• Taking information from source, in our case the data logger.

• One needs to have an understanding of the system they are working with to know what possible outcomes might be.

• Choosing a software that one knows in order to parse, order and sort information wanted based on outliers in raw data. Using JMP’s graphs, box plots etc.
Protocol for examining raw data Continued

• Then analyzing the data- if it makes sense to correlate to sets of data/variables in the data set this should be done.
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Links

• Correlation coefficient:
  • http://www.dmstat1.com/res/TheCorrelationCoefficientDefined.html

• Downloading R(both are needed):
  • http://cran.r-project.org/bin/windows/base/
  • http://www.rstudio.com/products/rstudio/download/

• R tutorial:
  • http://www.cyclismo.org/tutorial/R/