Smart Buildings: Sustainability and Efficiency

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Sponsor: Siemens | **Mentors:** Kenneth Cossaboon, Byron Burns

Understanding The Problem

- The present-day approach to building maintenance is expensive and disruptive.
- The fault detection system for VCU building operations is simple and rule-based.
- Siemens provides HVAC equipment like sensors, valves, and damper actuators for VCU building automation systems.

Solution: Predictive Maintenance

Our predictive maintenance model will:

- Use operational data of a laboratory HVAC system in VCU COE West Hall
- Flag data anomalies that could indicate system malfunctions
- Predict remaining useful life of HVAC components (e.g., Fan Coil Unit and Supply Air Box)

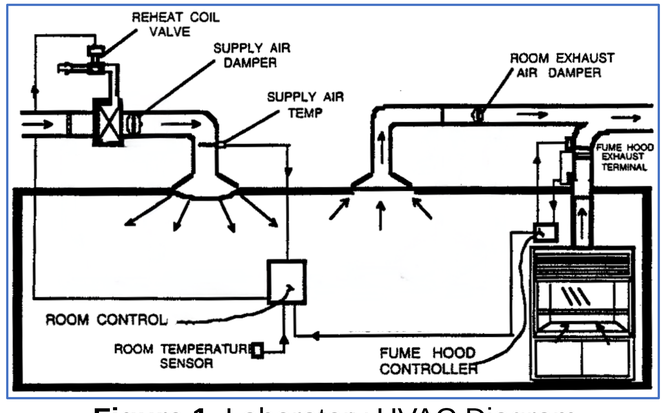

Figure 1. Laboratory HVAC Diagram

Data Visualization

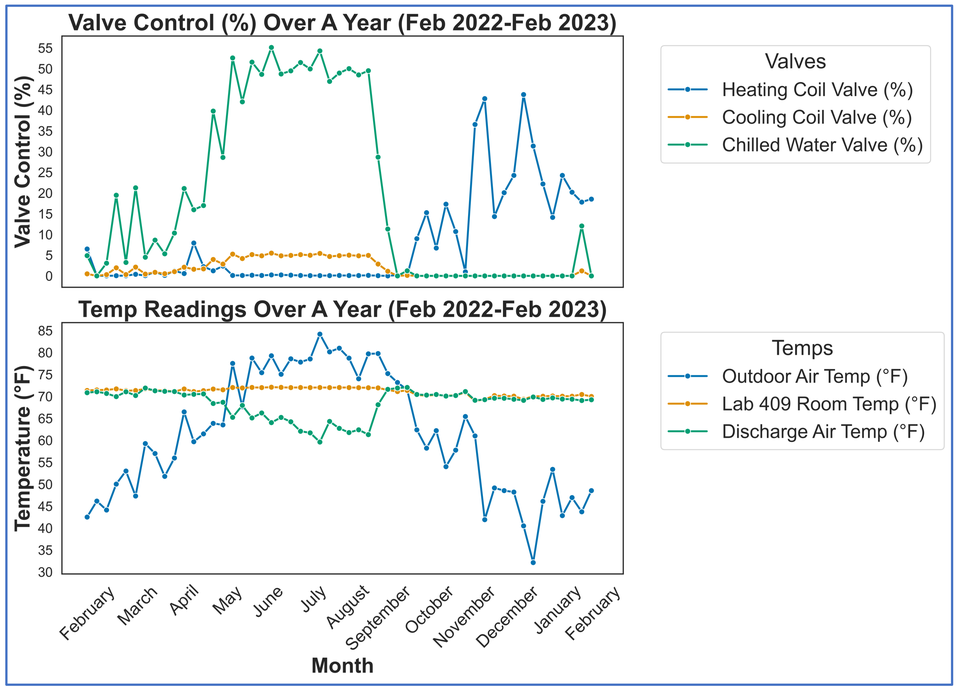

Figure 2. Year-Long Operation of a Fan Coil Unit (FCU)

- As shown in the graphs above, specifically in the top graph of Figure 2, knowledge of an area's seasons helps us predict which valve will be used and how much. We can then set a baseline of operation, which allows us to flag potential anomalies as they occur.
- Heating Coil Valve (%) (top graph, Figure 2) and Outdoor Air Temp (°F) (bottom graph, Figure 2) have an inverse relationship. This is normal system behavior. Gathering observations like this is critical to building a correlation matrix as shown in Figure 3. These types of correlations will then be used to help build the neural network.

Correlation Analysis

$$\text{Pearson's Correlation} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

$\bar{x}$ = mean of variable x and $\bar{y}$ = mean of variable y

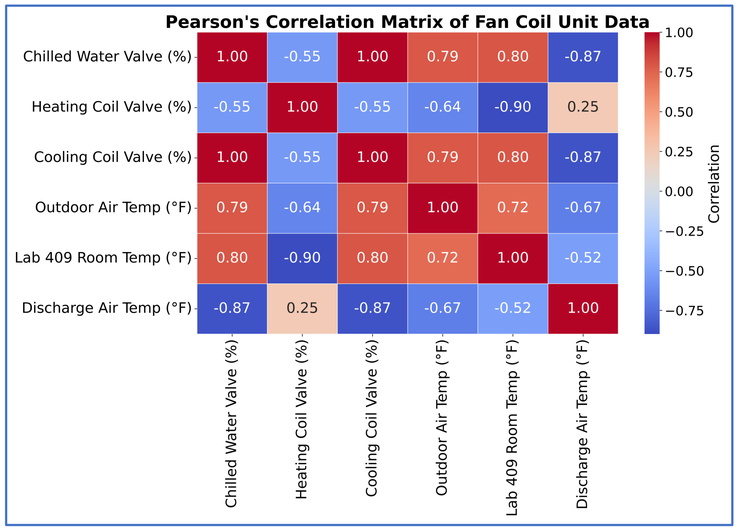

Figure 3. Linear Trends in Fan Coil Unit Data

- The correlation matrix helps identify strong relationships between FCU variables. This establishes normal system behavior—i.e., the foundation for anomaly detection and equipment lifespan prediction.

Project Progress And Next Steps

Project progress so far:

- Collaboration with mentors to understand HVAC systems, data collection, data cleaning, handling of missing data, and correlation analysis

Next steps include:

- Further preprocessing using feature selection and extraction algorithms, feature engineering, and neural network architecture design