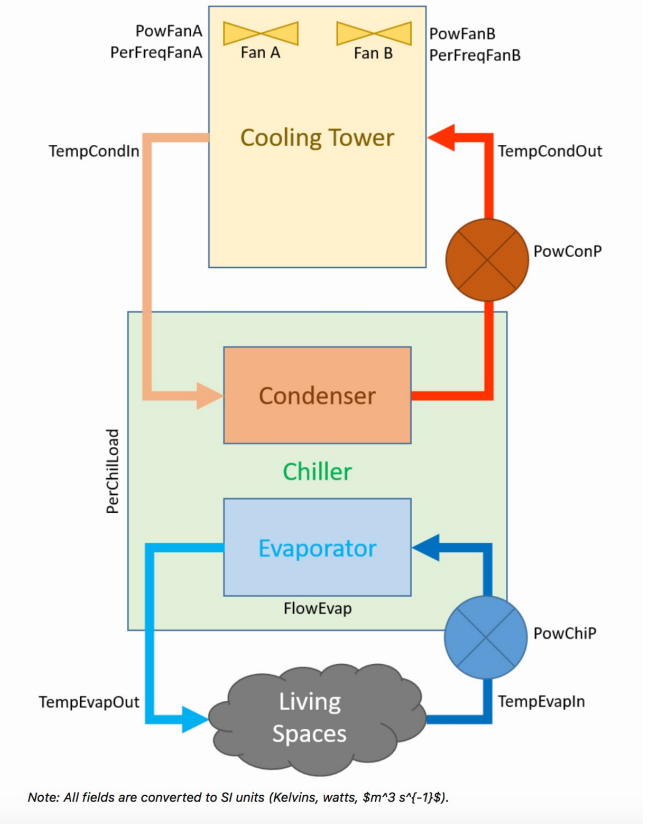
Anomaly Detection in a Cooling Tower System

RUBIN ZOU

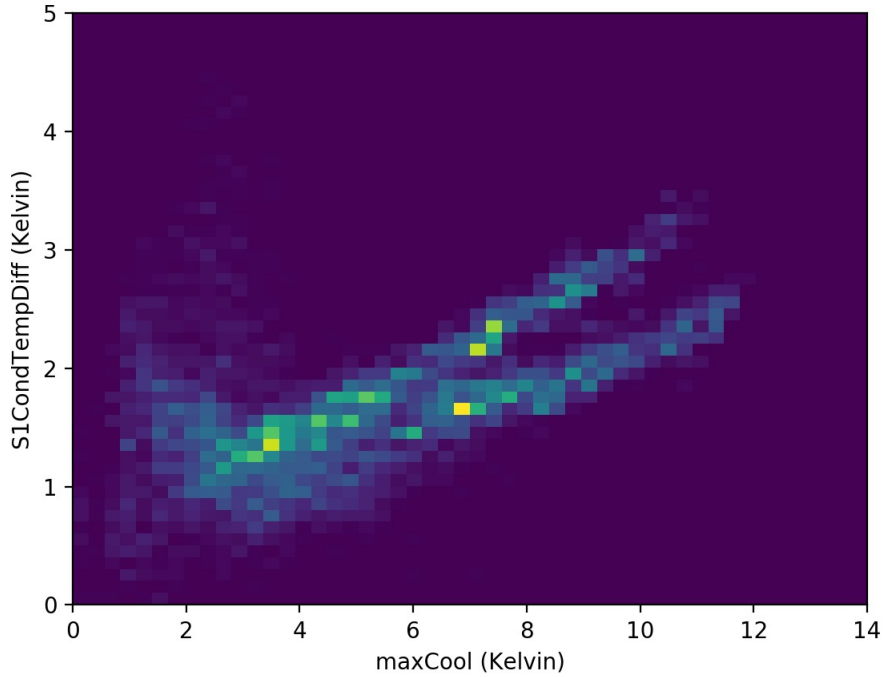
Problem

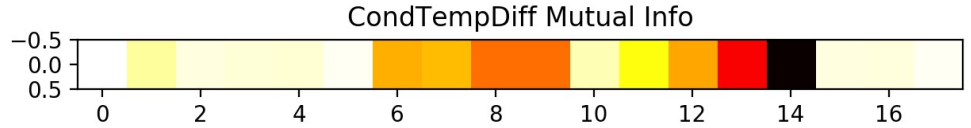
- The goal of the project is to develop methods for detecting anomalous behavior in a cooling tower system, with a focus on the condenser loop.
- Our methodology adopts a data-driven approach, but we use knowledge of the physics of the condenser loop
- Approach is to use segments of data to characterize the nonlinear nominal behavior among the loop variables
- Continued monitoring of the condenser loop variables can help detect faults when anomalies are observed.
- Data from 2018, 2019, and 2021 was explored.



Data extraction and Pre-Processing

- Bad data, Noise data, and irrelevant data removed
- Analyzed how Different variables correlated and affected each other.

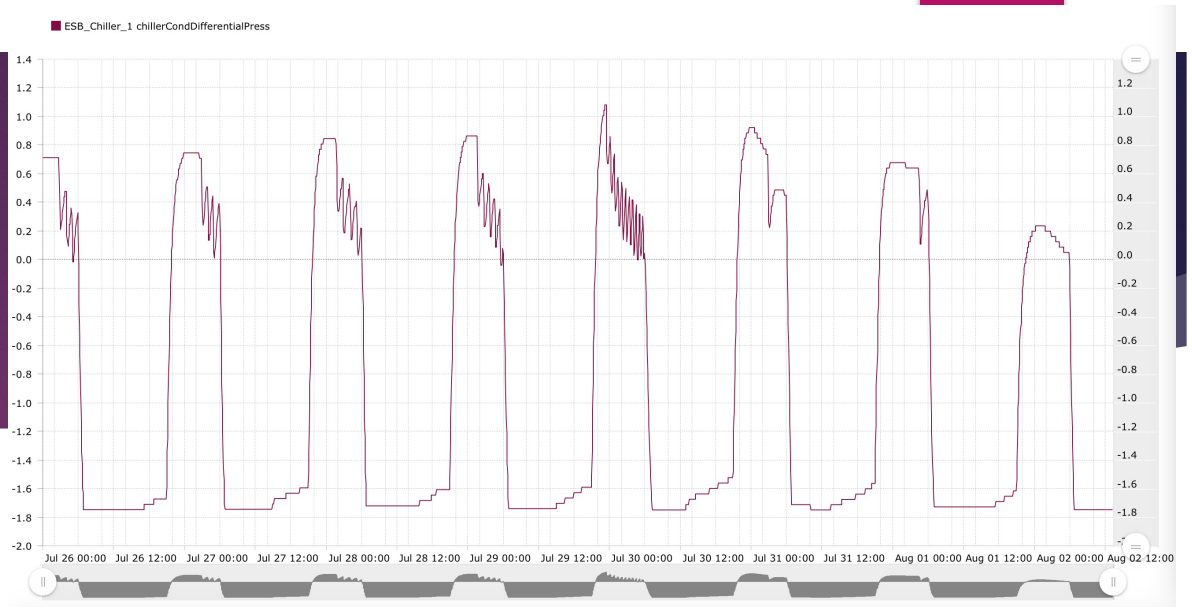


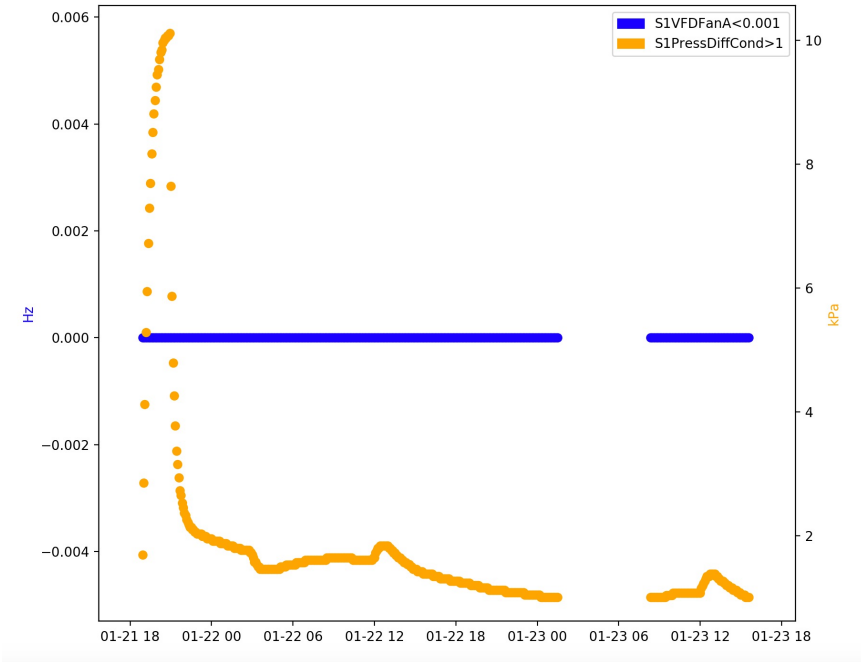


0 = S1CondTempDiff
1 = TempAmbient
2 = TempWetBulb
3 = PerHumidity
4 = S1TempCondIn
5 = S1TempCondOut
6 = S1PowFanA
7 = S1PowFanB
8 = S1VFDFanA
9 = S1VFDFanB
10 = S1PressDiffCond
11 = S1PowChil
12 = S1PowPump
13 = DaySin
14 = MonthSin
15 = effCool
16 = effCoolNext
17 = maxCool

Analysis

- Certain variables that displayed unusual behavior in certain time periods were analyzed.
- Certain behaviors were deemed to be normal behavior or human-caused behavior, while others were possible anomalies.





Prediction

- Algorithms including SVM, MLP Regressor, Neural Networks, and XGBoost were used to create prediction algorithms for the temperature difference across the cooling tower.
- Algorithms were tested on data from different years, as well as modified equalized data sets.

Regression: MLPRegressor

- Hidden layers: (32,32)
- Learning_rate: 1e-3

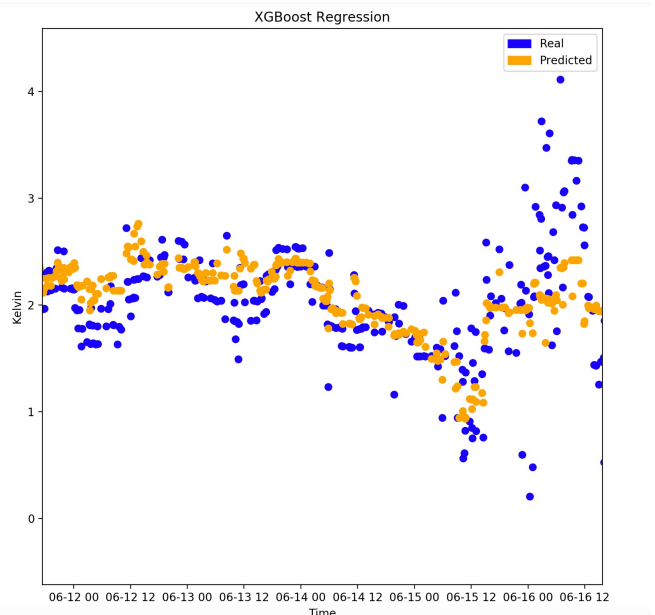
- Random state = 1
  - Regular R^2: 0.617
  - Equalized R^2: 0.727

- Run 50 times, random state not set
  - Regular R^2: 0.746
  - Equalized R^2: 0.450

Regression: SVM

- Kernel: rbf

- Regular R^2: 0.873
- Equalized R^2: 0.705



Next Steps

- Try to obtain better data for certain variables, such as those which should vary but do not.
- Improve the prediction algorithm.
- Use clustering algorithms to enhance predictions and detect anomalies.