SRI RAMACHANDRA
INSTITUTE OF HIGHER EDUCATION AND RESEARCH
(Deemed to be University)

INT400-INTERNSHIP3

ECOSTRUXURE POWER- THERMAL MONITERING SYSTEM

Schneider Electric

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Overview

- The Thermal Monitoring System project aims to create a comprehensive solution for collecting, cleaning, preprocessing, and analyzing thermal data from client sites.
- The system starts by gathering thermal data from various sensors and ensuring its quality through validation and correction.
- Appropriate transformations are applied to prepare the data for analysis.
- Machine learning models are trained to distinguish between thermal and non-thermal data, with the performance evaluated to ensure accuracy.
- The project includes refining the system to enhance its effectiveness and responsiveness to thermal anomalies.

Domain Introduction - Data Science

- Data Science is an interdisciplinary field that combines statics, machine learning, and data processing to extract insights and knowledge from data.
- Key activities include data collection, cleaning, exploration, modeling, and interpretation to turn raw data into actionable insights.
- It utilizes various methods such as statistical analysis, algorithms, and programming languages to analyze and visualize data.
- Applied across industries like Electrical, Finance, healthcare, marketing, and technology, make predictions and support decision-making.
- Continously advancing with developments in artificial intelligence, big data technologies, and computational methods, driving innovation and efficiency in data analysis.

Problem Statement

- The problem at hand involves monitoring the thermal health of assets to detect anomalies and ensure optimal performance and safety.
- The collected data is carefully preprocessed to ensure accuracy and consistency, which involves cleaning the data, normalizing features, and properly labeling each event

Objective

AUTOMATE MONITORING

Develop a system that continuously collects and analyzes temperature data at regular intervals to automate thermal condition monitoring, eliminating the need for manual checks.

ENHANCE ACCURACY

Utilize machine learning to preprocess and analyze the data, accurately detecting and classifying thermal anomalies to improve the reliability of temperature assessments.

IMPROVE RESPONSE

Provide timely alerts and notifications for abnormal thermal conditions to enhance operational efficiency, safety, and prevent potential damage or failures.

Literature Survey

Reference	Authors	Year	Title	Summary
[1] **Y. H. Choi, H. K. Kim, and J. K. Park**, "Real-time thermal monitoring system for smart buildings," **IEEE Trans. Ind. Appl.**, vol. 55, no. 2, pp. 1010-1017, Mar. 2019.	Y. H. Choi, H. K. Kim, J. K. Park	2019	Real-time thermal monitoring system for smart buildings	The paper presents a thermal monitoring system utilizing IoT devices for real-time temperature data collection in smart buildings, improving energy efficiency and occupant comfort.
[2] **S. A. C. Williams and M. L. Jones**, "Development of an integrated thermal monitoring system for industrial applications," **IEEE Trans. Ind. Electron.**, vol. 66, no. 7, pp. 5404-5412, Jul. 2019.	S. A. C. Williams, M. L. Jones	2019	Development of an integrated thermal monitoring system for industrial applications	This study describes a thermal monitoring system designed for industrial environments, emphasizing the integration of sensors and data analytics to monitor machinery and prevent failures.
[3] **M. T. Johnson and L. R. Davis**, "Wireless thermal sensing and monitoring system for environmental applications," **IEEE Sens. J.**, vol. 18, no. 4, pp. 1723-1730, Feb. 2018.	M. T. Johnson, L. R. Davis	2018	Wireless thermal sensing and monitoring system for environmental applications	The paper explores a wireless thermal sensing system focused on environmental monitoring, using low-power sensors to provide accurate temperature readings for various environmental conditions.
[4] **R. P. Singh and N. K. Gupta**, "Advanced thermal management and monitoring systems for electronic devices," **IEEE Trans. Electron Devices**, vol. 67, no. 5, pp. 2231-2238, May 2020.	R. P. Singh, N. K. Gupta	2020	Advanced thermal management and monitoring systems for electronic devices	This research introduces advanced techniques in thermal management and monitoring for electronic devices, highlighting new methods to prevent overheating and enhance device reliability.

Tools and Technology

PYTHON

- **Python 3.8.0:** The programming language and version used for implementing the data collection, preprocessing, and machine learning model.
- **PyCharm:** The integrated development environment (IDE) used for coding, debugging, and managing the project. PyCharm supports Python development with features like code analysis, version control, and project management.
- **Git:** For version control and managing code changes, integrated with PyCharm.

DATA PROCESSING LIBRARIES

- **NumPy:** For numerical operations and handling large arrays of temperature data.
- **Pandas:** For data manipulation, cleaning, and preprocessing.
- **sklearn:** For data analysis, including a wide range of algorithms for classification, regression, clustering, dimensionality reduction, and model evaluation.

VISUALIZATION TOOLS

- **Matplotlib:** For plotting and visualizing temperature data and analysis results.
- **Plotly:** It supports a wide range of charts types.

Methodology

DATA COLLECTION:

Data Acquisition: Temperature readings are gathered from the sensors(TH110) with the help of Ecostruxture Asset Advisor Expert system and stored in a structured format.

DATA PREPROCESSING:

Data Cleaning: Remove any noise, handle missing values, and correct errors in the collected data.

Normalization: Standardize the data to ensure consistency and improve the performance of the machine learning model.

Feature Engineering: Extract relevant features from the raw data to enhance the model's ability to identify thermal anomalies.

MODEL DEVELOPMENT:

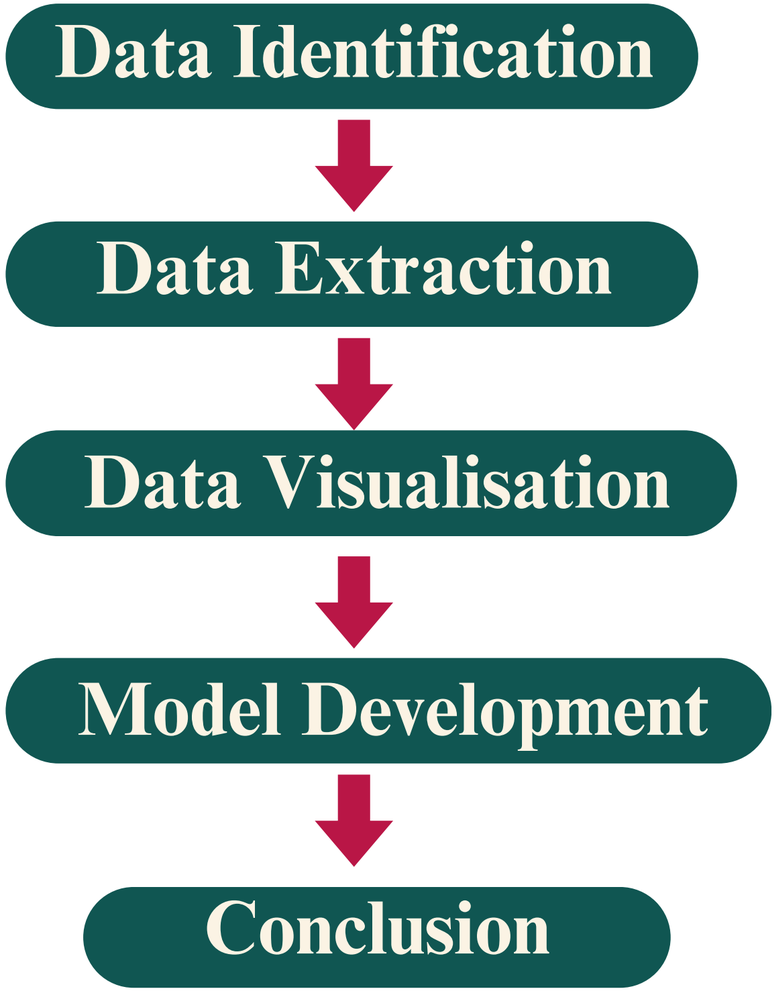
Algorithm Selection: Experimented with different Unsupervised algorithms (Local Outlier Factor (LOF), K-Means, One-Class SVM) and LSTM model for prediction.

Model Training: Train the machine learning model using historical data with labeled thermal events to learn patterns associated with anomalies.

Model Evaluation: Assess the model's performance to ensure it meets the desired performance criteria.

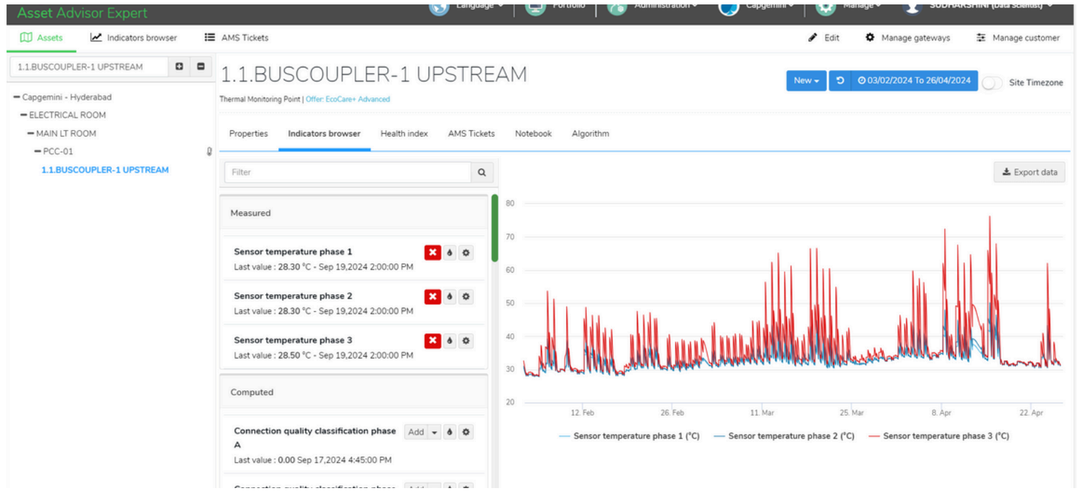
Integration: Combine the data collection, preprocessing, and machine learning components into a cohesive system.

WorkFlow


Data Identification
Data Extraction
Data Visualisation
Model Development
Conclusion

Work Flow

Export_date	Custome	Customer_ID	Customer	Site_name	Site_ID	SE_Accoun	Asset_name	Asset_ID	Ticke	Ticket_name
09-09-2024 20:44	38TEC_ficti	0cb0e5e8-e75f-4	Factory	Mohamed ELS	03142129-997d-4590-9c		Mohamed ELSHEIKH	03142129-9	291909	MV Panel (Sirius) has not been created due to
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Aarti Industries Limit	e2fa78a1-0	268003	Communication issue in Aarti Industries Limite
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Aarti Industries Limit	e2fa78a1-0	304159	Communication issue in Aarti Industries Limite
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Circuit Br	423c84bc-e	236581	Cicruit-breaker open
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Circuit Br	423c84bc-e	236869	Cicruit-breaker Incomer-1 Circuit Breaker in si
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Circuit Br	423c84bc-e	236940	Cicruit-breaker open
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Circuit Br	423c84bc-e	236942	Cicruit-breaker open
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Circuit Br	423c84bc-e	236945	Cicruit-breaker Incomer-1 Circuit Breaker in si
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Circuit Br	423c84bc-e	236961	Cicruit-breaker Incomer-1 Circuit Breaker in si
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Circuit Br	423c84bc-e	237279	Cicruit-breaker open
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Cubicle	9e4ce145-9	236582	Communication loss on temperature sensor
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Cubicle	9e4ce145-9	237446	Control on temperature for \"Cable 1 Tempera
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Cubicle	9e4ce145-9	237447	Over-temperature on circuit-breaker connecti
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Cubicle	9e4ce145-9	237448	Over-temperature on circuit-breaker connecti
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Cubicle	9e4ce145-9	238257	Control on temperature for \"Cable 1 Tempera
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Incomer-1 Cubicle	9e4ce145-9	238261	Excessive temperature discrepancy between c
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Trafo Outgoing-1 Cir	6db44271-4	236580	Cicruit-breaker open
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Trafo Outgoing-1 Cir	6db44271-4	236596	Cicruit-breaker Trafo Outgoing-1 Circuit Break
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Trafo Outgoing-1 Cir	6db44271-4	236944	Cicruit-breaker open
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Trafo Outgoing-1 Cir	6db44271-4	237280	Cicruit-breaker open
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Trafo Outgoing-1 Cul	d2ebb91d-6	236951	Communication issue in Trafo Outgoing-1 Cub
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Trafo Outgoing-1 Cul	d2ebb91d-6	236959	Communication error with the protection rela
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Trafo Outgoing-2 Cir	022525a2-d	236583	Cicruit-breaker Trafo Outgoing-2 Circuit Break
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Trafo Outgoing-2 Cir	022525a2-d	236584	Cicruit-breaker open
09-09-2024 20:44	Aarti Indust	b8a2201f-e1e4-4	Customer	Aarti Industrie	e2fa78a1-071f-40c8-a16		Trafo Outgoing-2 Cir	022525a2-d	236595	Cicruit-breaker open



Data Identification

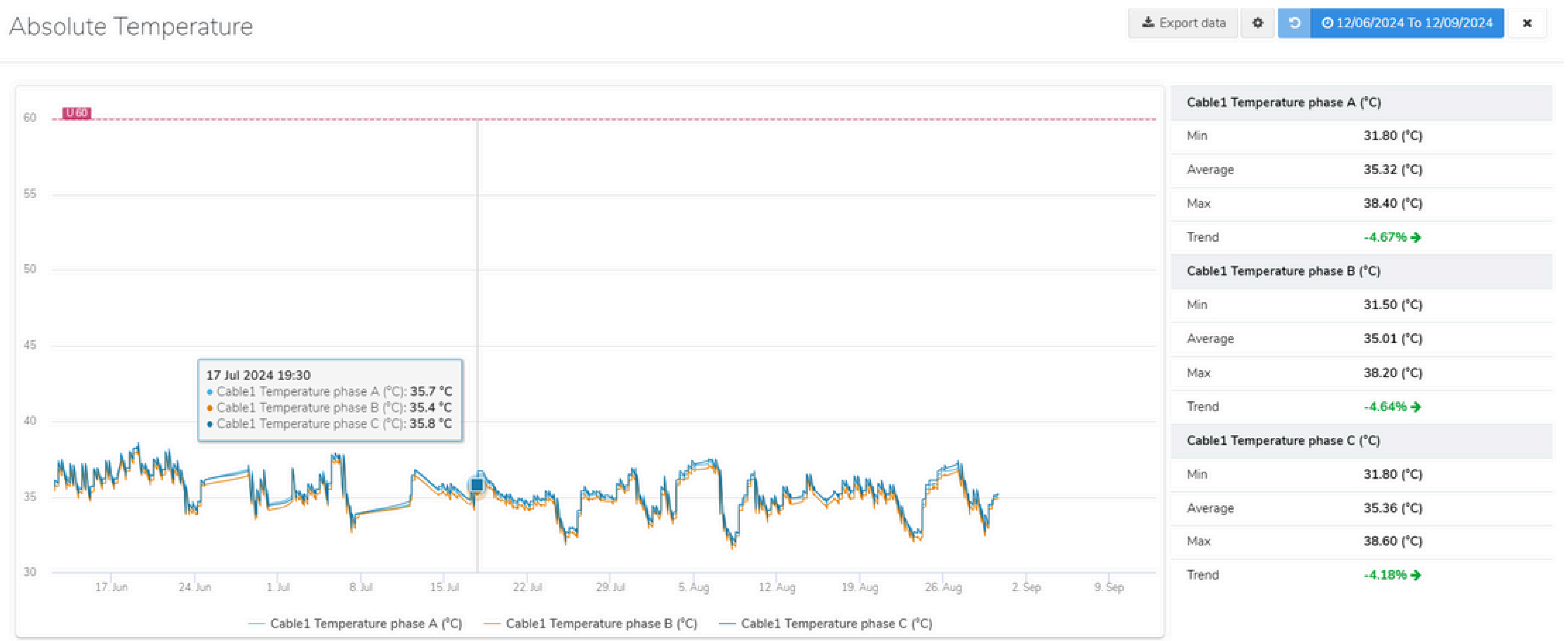
- A list of required data to be extracted from Ecostruxure Asset Advisor to perform our analysis.
- For instance Temperatures only, Temperature and current in the busbar , ambient temperature, Humidity, Sites characteristics etc.

Data Extraction

- Data is extracted from the Ecostruxure Asset Advisor by matching the ticket creation date and the date on which the event has occurred.
- The collected data is then grouped into different events like Overheating, Communication loss and overheating due to Ambient Temperature.

Work Flow

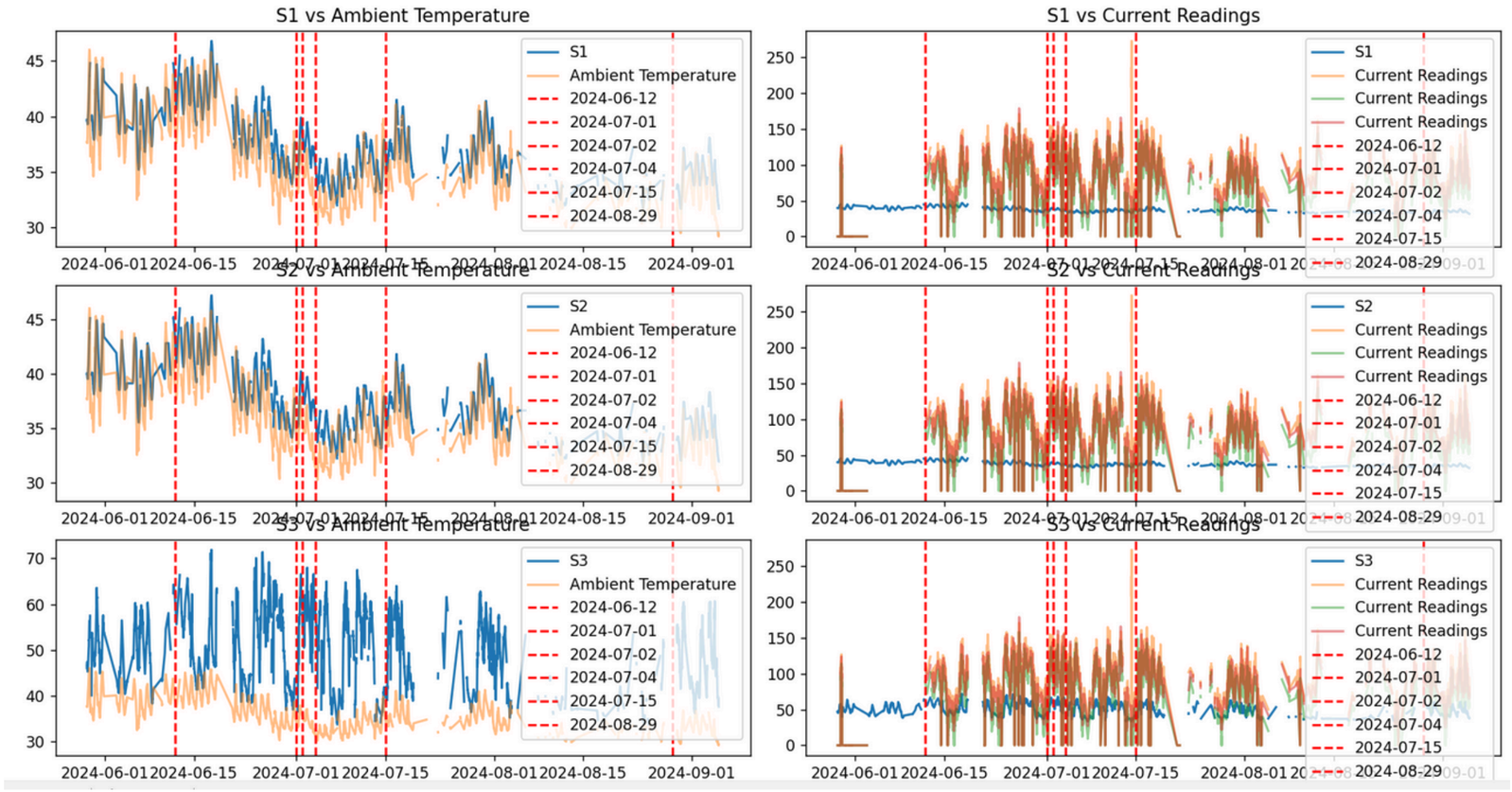
Capgemini	Capgemini -Noida	Sasikumar Alagarsamy	2.1.FEEDER-2 MAIN INCOMER UPSTREAM
Capgemini	Capgemini -Noida	Sasikumar Alagarsamy	2.1.FEEDER-2 MAIN INCOMER UPSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	2.3.CHILLER-1 DOWNSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	2.3.CHILLER-1 DOWNSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	2.3.CHILLER-1 DOWNSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	2.3.CHILLER-1 DOWNSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	2.3.CHILLER-1 DOWNSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	2.3.CHILLER-1 DOWNSTREAM
Capgemini	Capgemini -Noida	Sasikumar Alagarsamy	2.3.FEEDER-2 ISOLAROR PANEL-2 Downstream
Capgemini	Capgemini -Noida	Sasikumar Alagarsamy	2.3.FEEDER-2 ISOLAROR PANEL-2 Downstream
Capgemini	Capgemini -Noida	Sasikumar Alagarsamy	2.3.FEEDER-2 ISOLAROR PANEL-2 Downstream
Capgemini	Capgemini -Noida	Sasikumar Alagarsamy	2.3.FEEDER-2 ISOLAROR PANEL-2 Downstream
Capgemini	Capgemini -Noida	Sasikumar Alagarsamy	2.3.FEEDER-2 ISOLAROR PANEL-2 Downstream
Capgemini	Capgemini -Noida	Sasikumar Alagarsamy	2.3.FEEDER-2 ISOLAROR PANEL-2 Downstream
Capgemini	Capgemini - Hyderabad	Stalin D	4.1.SB-2 OUTGOING-1 UPSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	4.1.SB-2 OUTGOING-1 UPSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	4.1.SB-2 OUTGOING-1 UPSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	4.1.SB-2 OUTGOING-1 UPSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	4.1.SB-2 OUTGOING-1 UPSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	4.3.DG-SOLAR DOWNSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	6.1.CHILLER-2 UPSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	6.1.CHILLER-2 UPSTREAM
Capgemini	Capgemini - Hyderabad	Stalin D	6.1.CHILLER-2 UPSTREAM



Data Preparation

- The data cleaning process involves identifying and addressing outliers, false information, and incomplete data within a dataset.
- It also includes validating the accuracy and completeness of the data to ensure its quality and reliability.

Work Flow



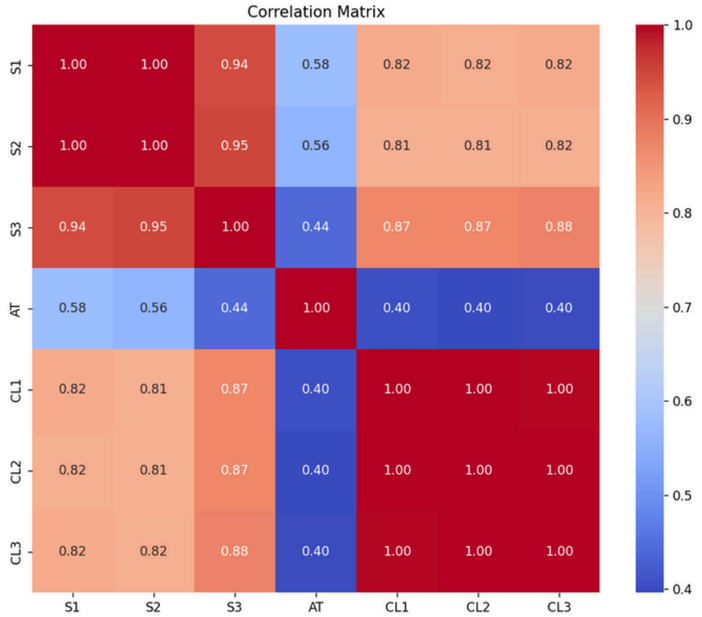
Data Analysis

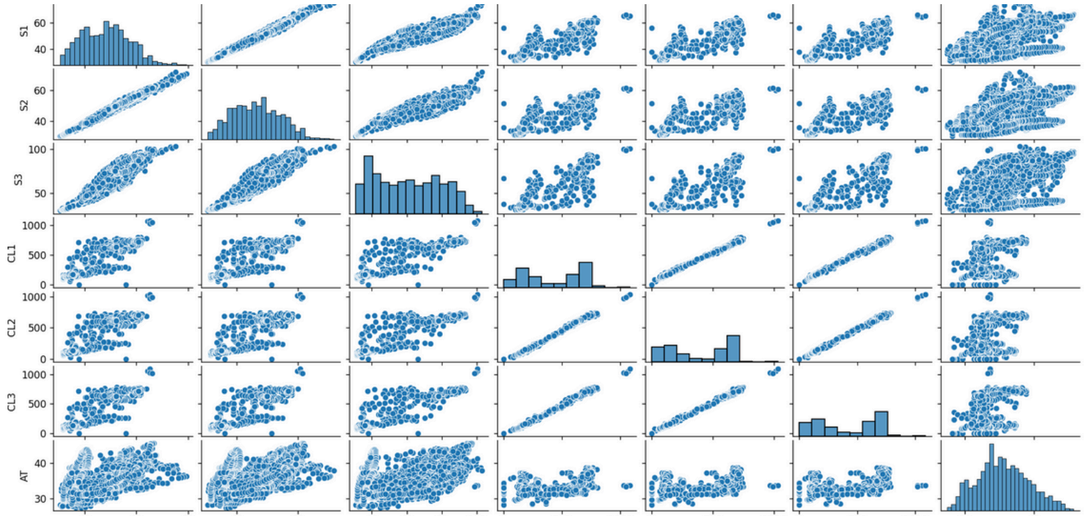
Experimented with various visualization techniques for overall understanding of the data which includes:

- Data loss Frequency Analysis
- Correlation Analysis
- Trend Analysis

Work Flow

Correlation Analysis





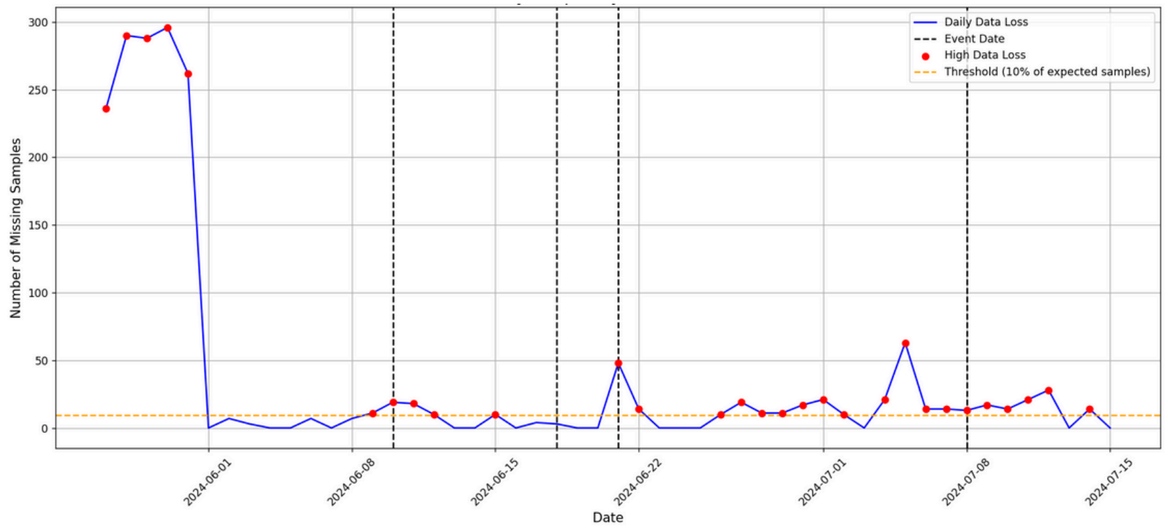
Correlation Heatmaps:

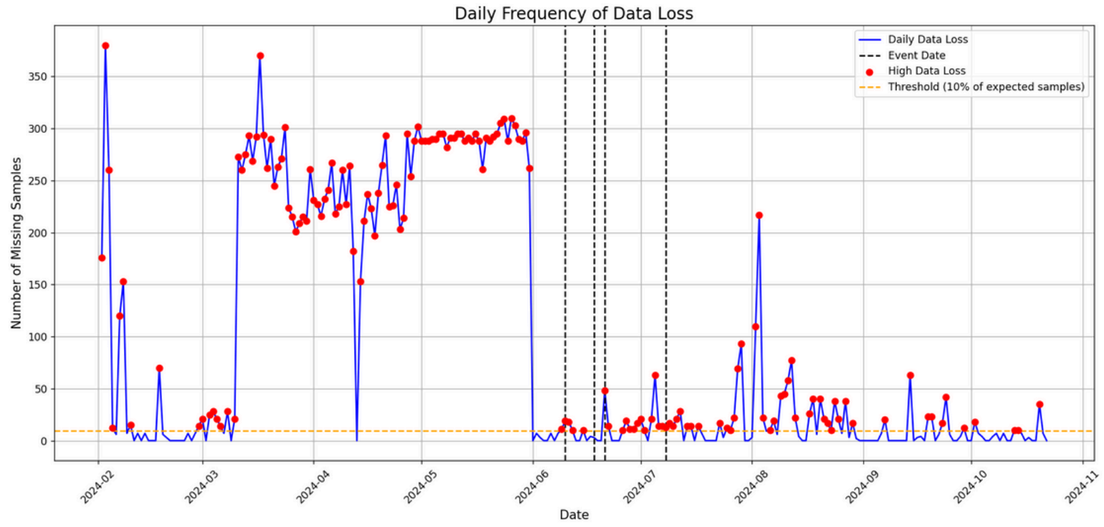
- Visualized the strength of relationships between variables. Identified highly correlated pairs, which might indicate shared dependencies or operational similarities.

Pair Plots and Scatter Matrix:

- Visualized the pairwise relationships between columns, revealing how changes in one variable might affect another.

Work Flow

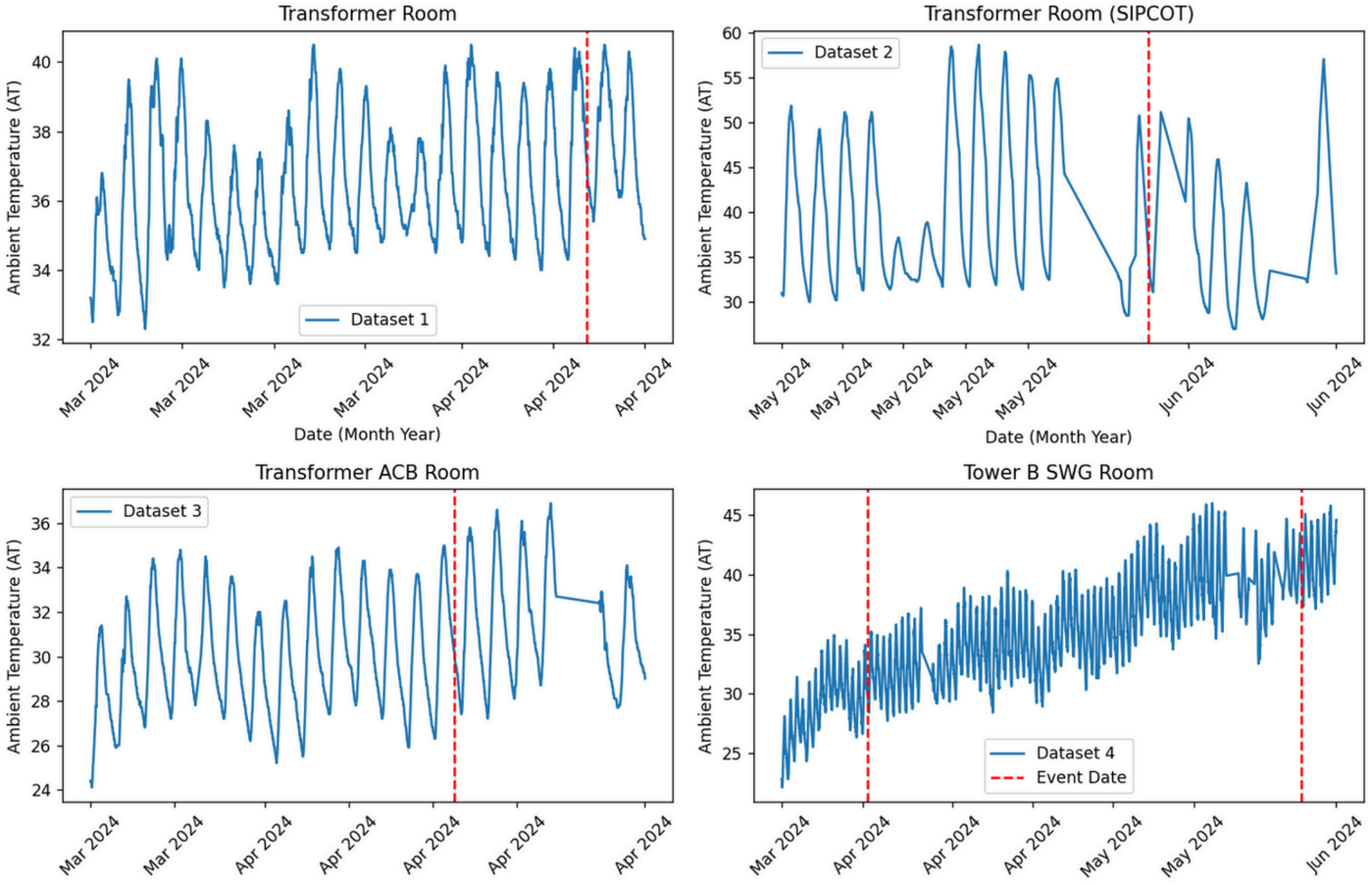




Dataloss Frequency Analysis

- Calculated the number of missing entries for each day and determining the daily frequency of data loss as a percentage of expected entries.
- Plotting the daily frequency of data loss as a percentage over time, providing a visual representation of how often data loss occurs in the dataset.

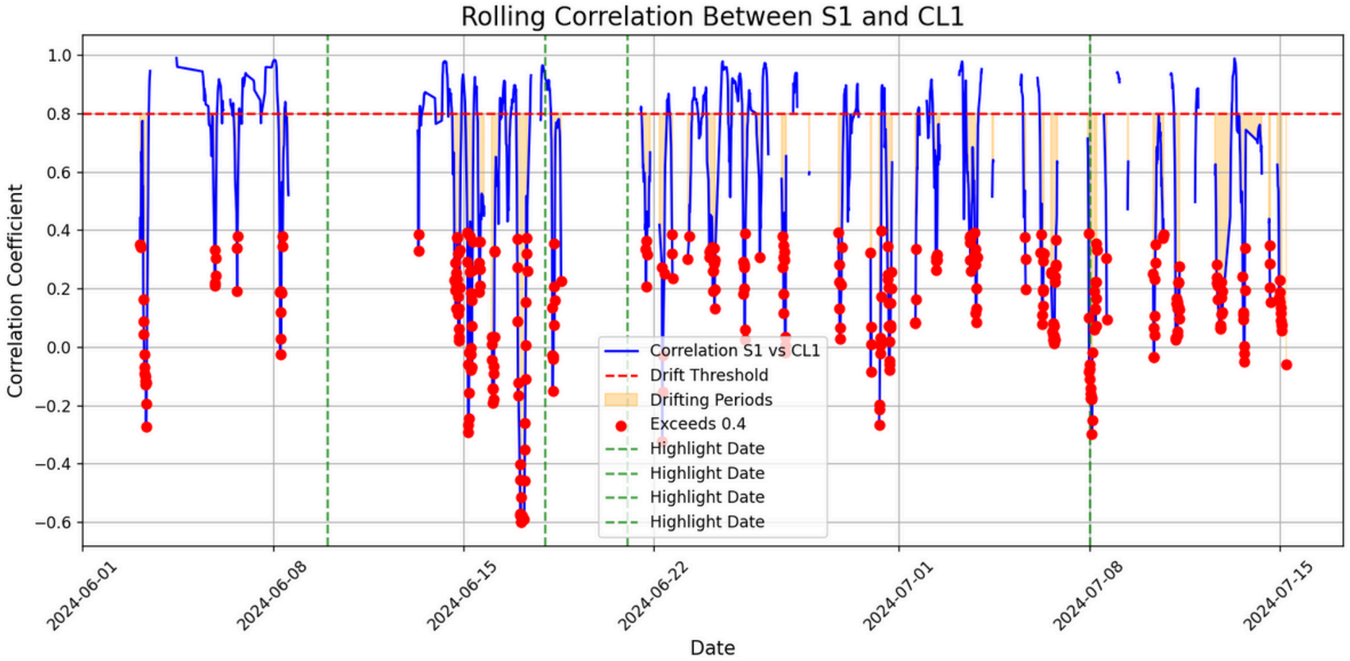
Work Flow

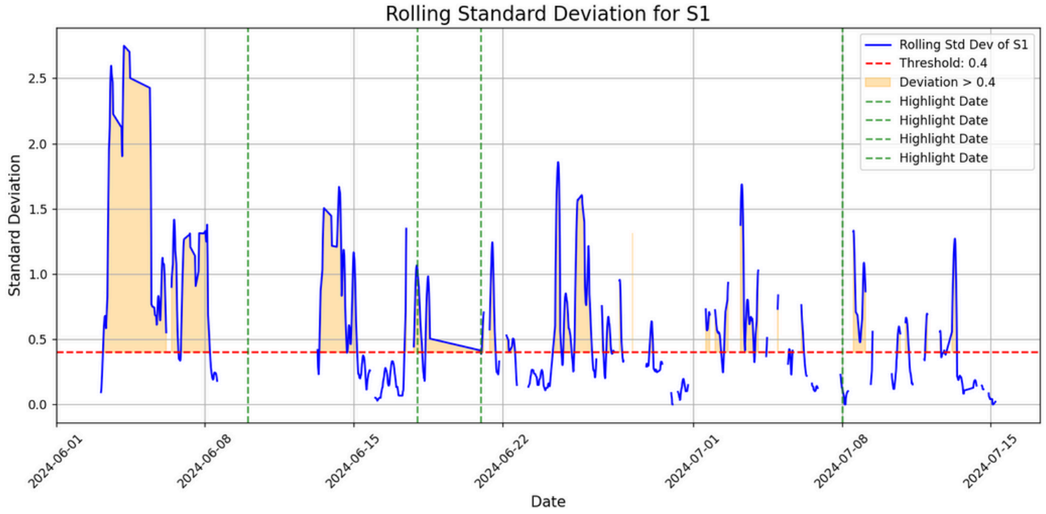


Trend Analysis

- Discovered trends or anomalies that appeared before failures, suggesting possible predictive indicators.
- Assets with similar failure types exhibited comparable data patterns leading up to the failure.

Work Flow





Pattern Recognisation

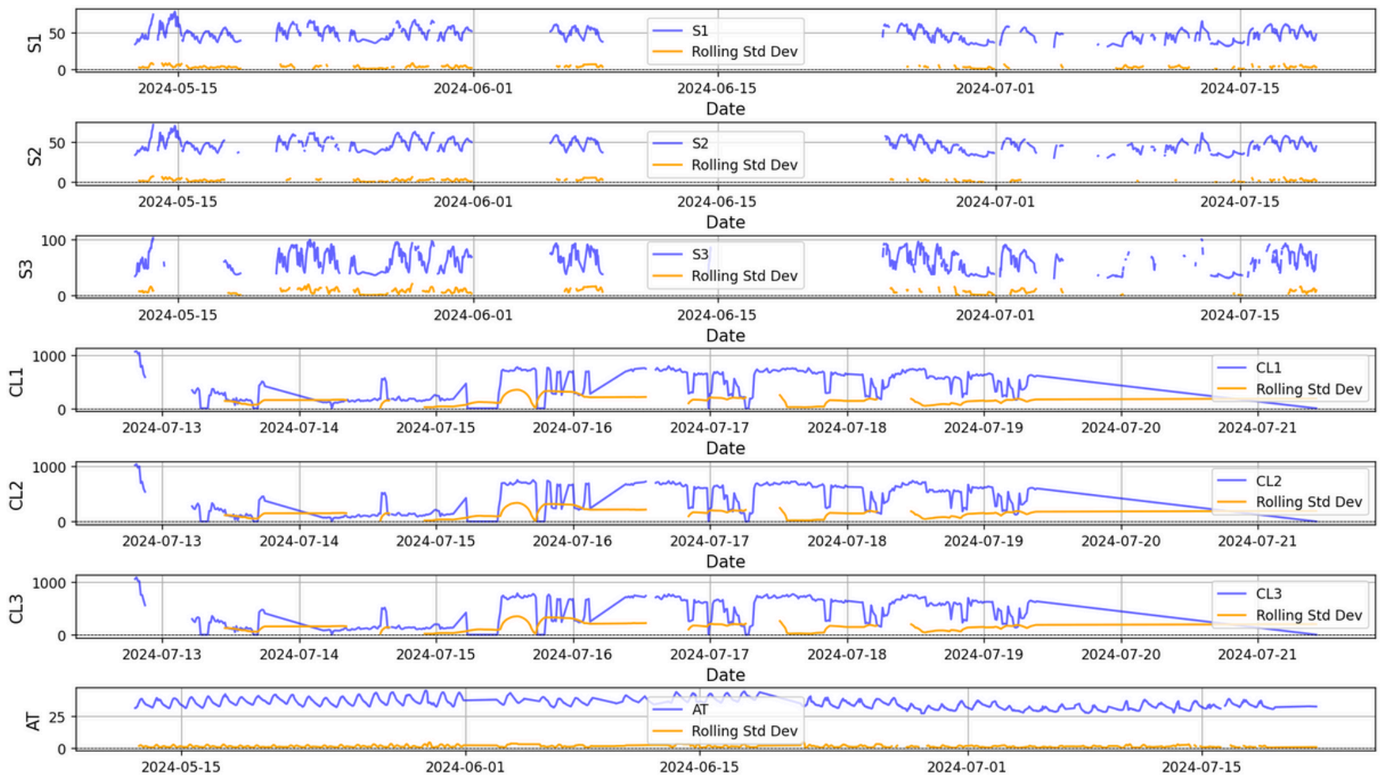
Rolling Correlation and Signal Drift Technique:

- Used a windowing technique to calculate the rolling correlation between sensor readings over time.
- Rolling correlations were computed within fixed time windows (e.g., every 24 hours) to track how relationships between variables changed dynamically.

Signal Drift Detection:

- Flagged drifting signals, indicating shifts in sensor behavior that may correspond to equipment degradation or impending failure.
- This was particularly useful for detecting gradual changes that might not be obvious in static correlation analysis.

Work Flow

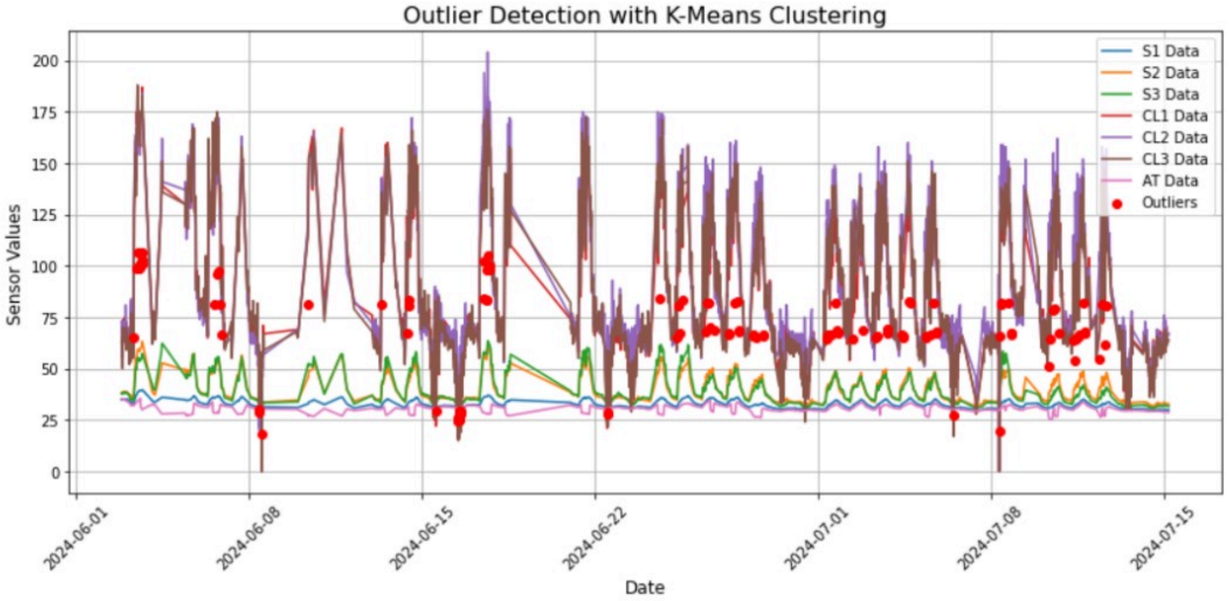


Fluctuation Analysis

Calculated the standard deviation over 24-hour windows to assess whether the sensor readings remained constant or fluctuated over time.

- Analyzed and flagged any unusual deviations that could indicate sensor faults or system instability.

Work Flow

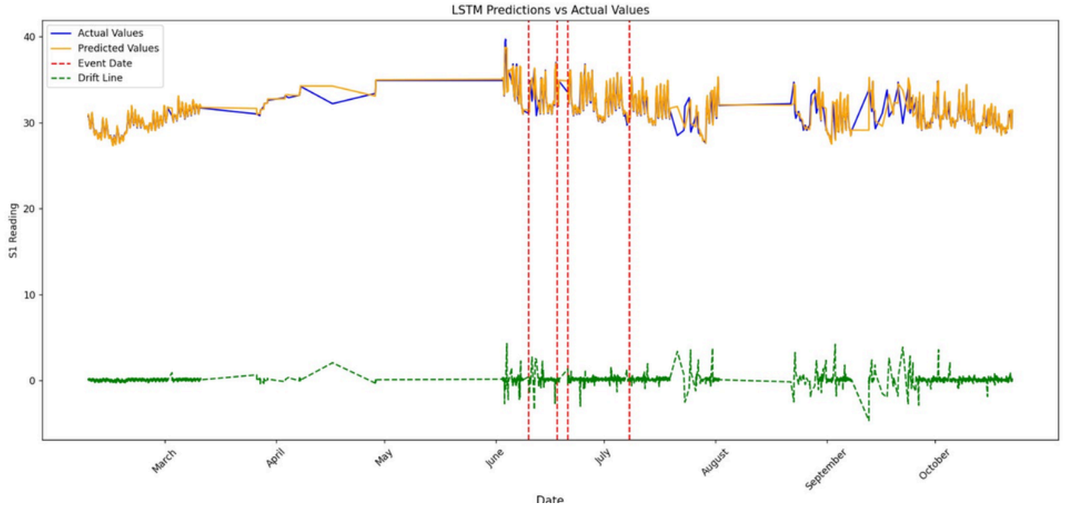


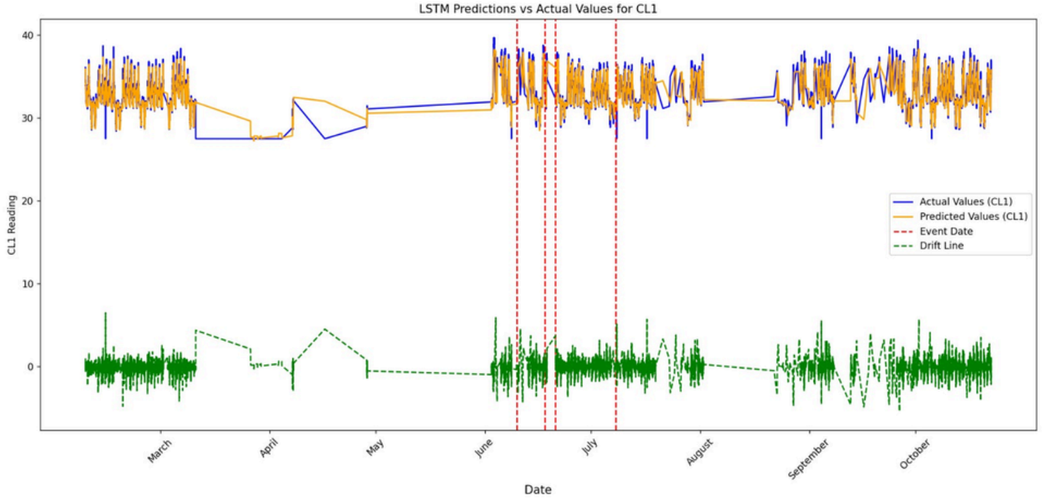
Model Development- Outlier Detection

Applied unsupervised algorithms like Local Outlier Factor (LOF), K-Means, One-Class SVM to group similar data points and identify outliers that don't fit established patterns.

- Focus on clusters where temperature, current, or both were significantly different from expected norms.

Work Flow





Prediction (LSTM)

LSTM model is used for predicting the which are used to compare the predicted values and the actual values and check for anomolies which not recognized by the current threshold system

Conclusion

- Gather learning of the training period into the appropriate repository to be shared with all necessary parties. Perform a presentation to the Analytics team of the study and its conclusion.

Application

- **Industrial Equipment Monitoring:** Ensuring that machinery operates within safe temperature ranges to prevent overheating and damage, and to predict maintenance needs.
- **Building Management:** Monitoring heating, ventilation, and air conditioning (HVAC) systems to optimize energy efficiency and detect faults.
- **Fire Detection and Prevention:** Identifying abnormal temperature patterns to detect potential fire hazards early, enhancing safety in buildings or forested areas.
- **Quality Control in Manufacturing**: Ensuring that products, especially those sensitive to temperature, are produced within specified thermal parameters.
- **Security Systems:** Detecting unauthorized access or activities by monitoring thermal signatures in restricted areas.

Timeline

Date	Task Done
26/08/2024-28/08/2024	Onboarding
29/08/2024	Laptop VPN configuration
30/08/2024	Asset Advisor Team Meeting
02/09/2024-04/09/2024	Ecostruxure power KT
05/09/2024	Admin and access rights
06/09/2024	Pycharm and Python Demo
09/09/2024-10/09/2024	Data structure and python demo
11/09/2024-12/09/2024	File manipulation in pydemo
13/09/2024-17/09/2024	Customer csv file analysis
18/03/2024-25/09/2024	Data identification and collection
26/09/2024-03/10/2024	Data preprocessing
07/10/2024-11/10/2024	Data Visualisation and analysis
12/10/2024-14/10/2024	Experimenting with algorithms
15/10/2024-17/10/2024	Model Development
18/10/2024-24/10/2024	Prediction
25/10/2024-26/10/2024	Conclusion and Asset Submission

Conclusion

- The thermal monitoring system project aims to enhance the ability to analyze and verify thermal data for various practical applications.
- By leveraging advanced data collection and model training techniques, the system can accurately determine whether the thermal data is genuine and relevant.
- This capability offers significant benefits across multiple domains, including industrial equipment maintenance, building management, fire safety, manufacturing quality control, and security.
- Ultimately, the project contributes to improved safety, efficiency, and operational effectiveness by enabling more precise temperature monitoring and analysis.

Reference

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Thank You