AutoSHM 1.0.0 - Bridge Health Monitoring System

User Guide

Overview

AutoSHM - Bridge Health Monitoring System is a real-time health monitoring and data analysis platform for Bridges. The platform monitors the bridge over time using periodically sampled dynamic response measurements from various IoT devices. Inspectors can easily visualize historical data. The platform is analyzing the way inspectors use data to solve problems. The platform provides a powerful bridge health monitoring model based on automated or manually designed machine learning models trained with the bridge's historical data. The AutoSHM platform is divided into three main sections: Data, Modeling and Monitoring:

Data

- Data Processing
- Data Annotation
- Feature Engineering

This section is responsible for preparing the data collected from the IoT devices for analysis, as well as extracting important features and annotating the data.

Modeling

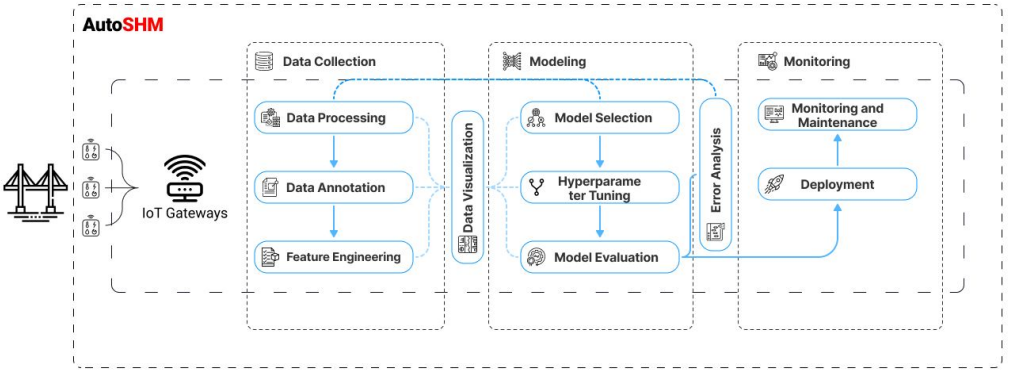
- Model Selection
- Hyperparameter Tuning
- Model Evaluation

This section plays a crucial role in the platform as it is responsible for building the model that will be used to monitor the bridge's health.

Monitoring

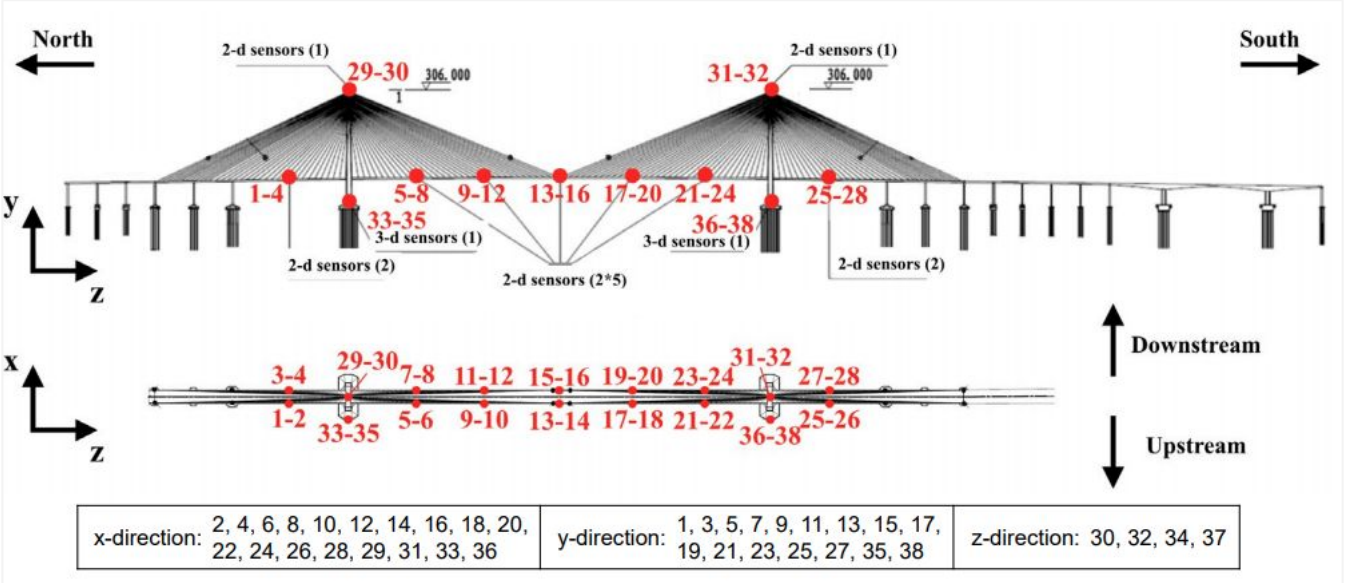
- Deployment
- Monitoring & Maintenance

The monitoring section is the final step in the AutoSHM platform, and it is responsible the safety and longevity of the bridge by monitoring its health in real-time and detecting any issues that may arise.



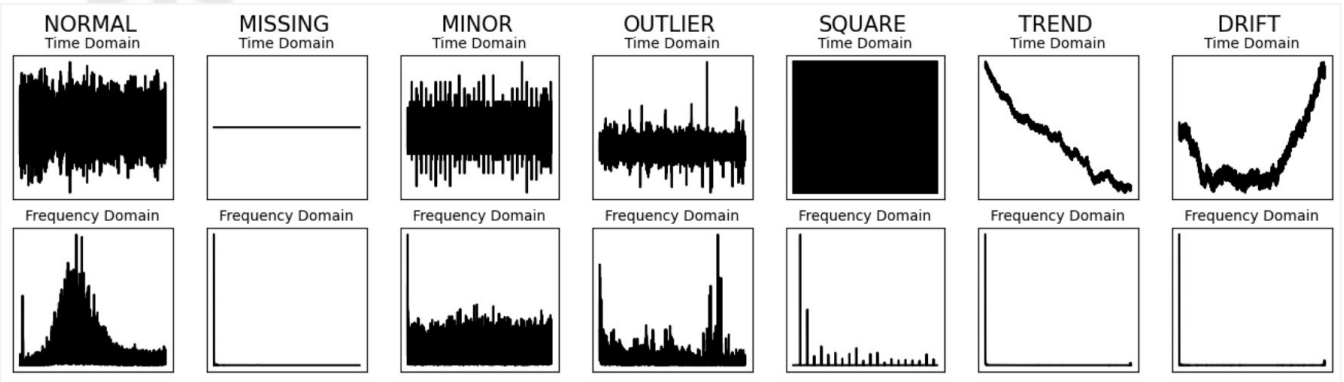
CASE STUDY

This work focuses on the anomaly detection on the real-world continues SHM data with multiclass anomalies. We used a dataset collected from acceleration sensors installed on a long-span cable-stayed bridge.



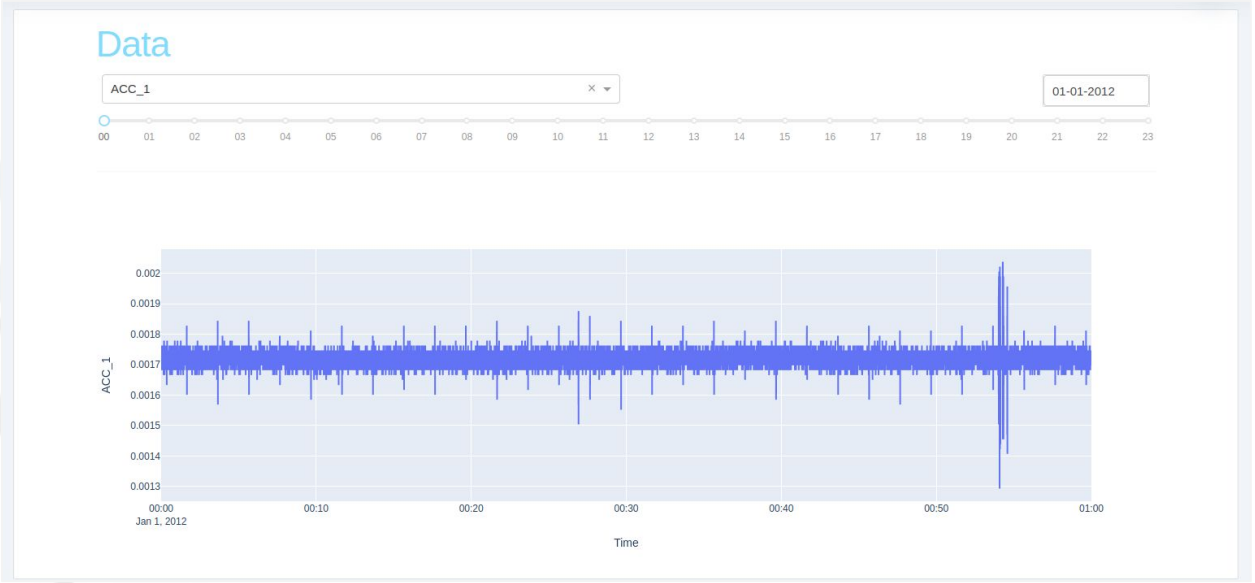
x-direction:	y-direction:	z-direction:
2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 29, 31, 33, 36	1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 35, 38	30, 32, 34, 37

The sampling frequency of each sensor was set to 20 Hz. Total 2 months (2012-01-01 - 2012-02-29) of acceleration data were collected from 38 channels. Each channel's data was split hourly without overlapping and a total of 57,720 (38 x 24 x 60) samples were labeled as normal or one of six anomaly types (missing, minor, outlier, square, trend, drift) defined by engineers.



DATA | ANNOTATION | MODELING | MONITORING

Data Reading

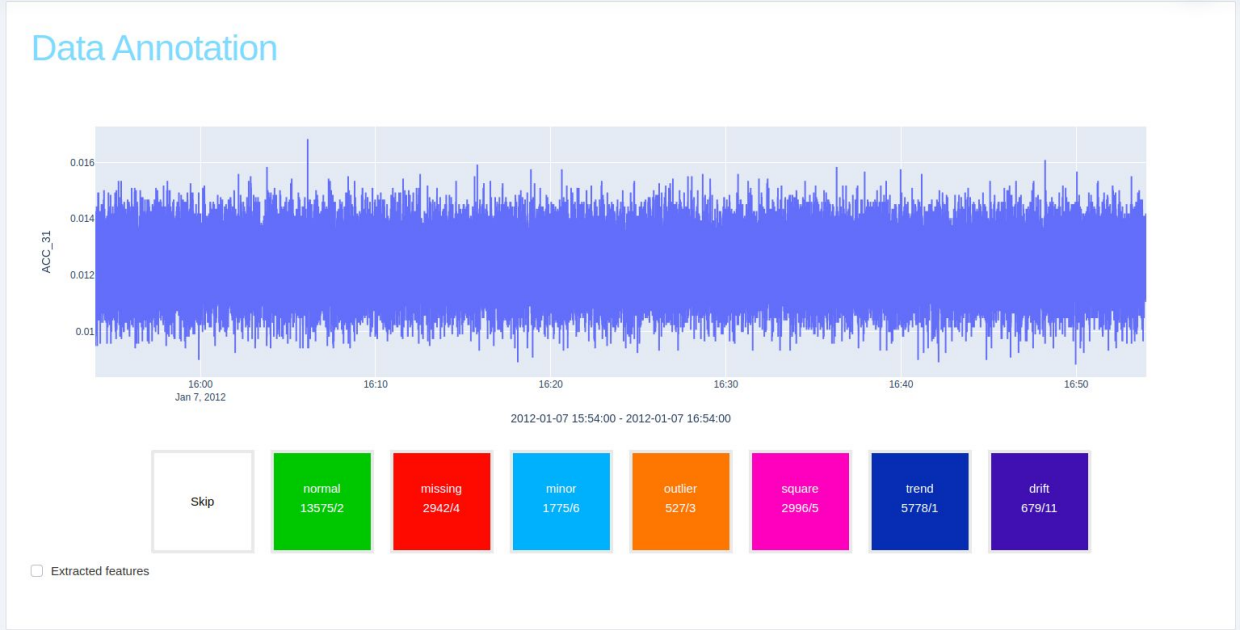


Users have the ability to view past SHM data for every sensor in this section.

Feature Engineering

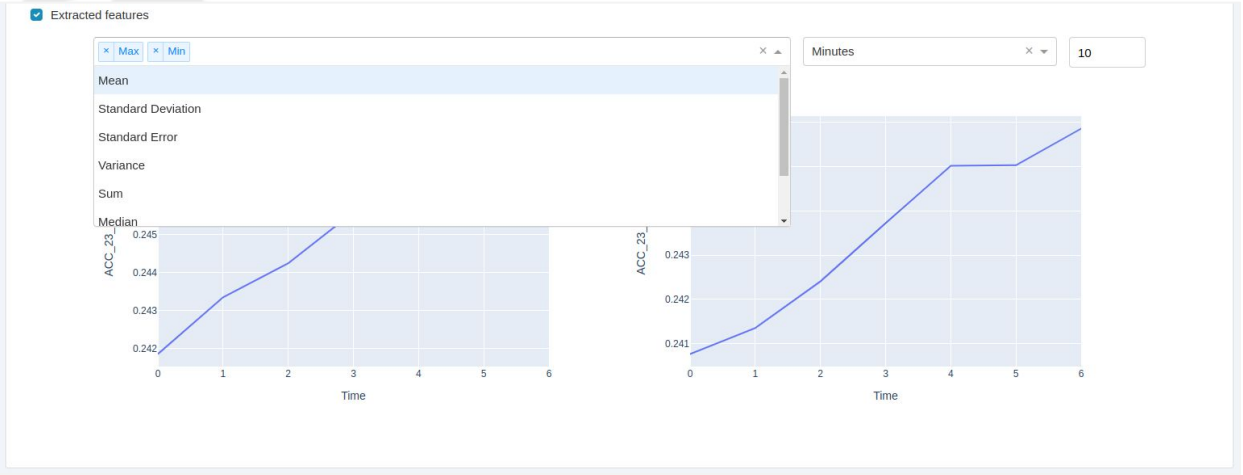
In this section, the relevant features for the problem at hand can be obtained from the raw data.

Data Annotation



In the Annotation section, a random hour of data from a random sensor is displayed and the raw data is classified into one of the specified class.

Extracted Features



The relevant features can be obtained from the raw data within a chosen time frame by click the "Extracted Features" checkbox.

DATA | ANNOTATION | MODELING | MONITORING

Models

Feature Selection

	Date	Features	Unit	Frequency
○	2022-07-25 16:25:28	['mean', 'min', 'max', 'median', 'var', 'skew']	T	10
◉	2022-07-26 20:04:43	['mean', 'min', 'max', 'median', 'var', 'skew']	T	1

In this section, various features for various time intervals are presented. One of them can be chosen to train the model.

Models

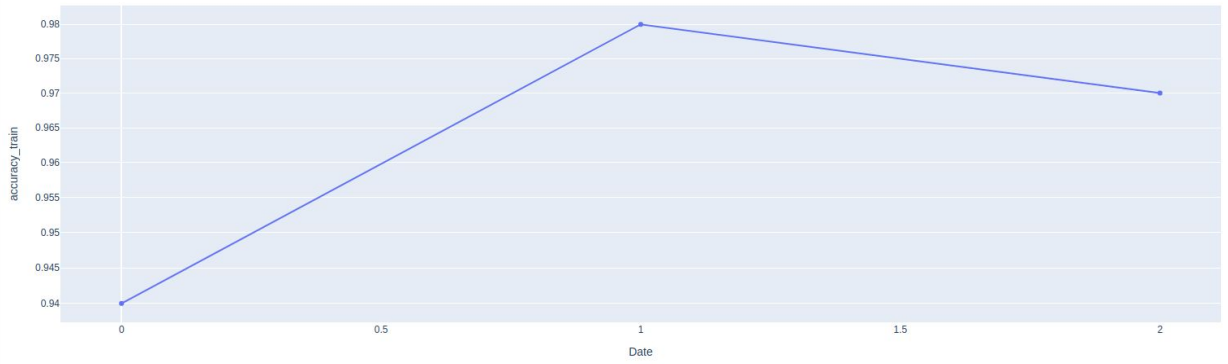
	Model Name	Features	Unit	Frequency
☐	TPOT MODEL	['mean', 'min', 'max', 'median', 'var', 'skew']	T	1
☐	LSTM MODEL	['mean', 'min', 'max', 'median', 'var', 'skew']	T	1
☐	MLSTMFCN MODEL	['mean', 'min', 'max', 'median', 'var', 'skew']	T	1
☐	1DCNN MODEL	['mean', 'min', 'max', 'median', 'var', 'skew']	T	1
☐	1DCNNLSTM MODEL	['mean', 'min', 'max', 'median', 'var', 'skew']	T	1
☐	TRANSFORMER MODEL	['mean', 'min', 'max', 'median', 'var', 'skew']	T	1

☐ All

In this section, the state-of-the-art models are listed. With an arbitrary model, the given data can be easily trained and achieve high accuracy.

History of the Models

1DCNN MODEL



HISTORY

	Training date	Active	Static features	Resampling unit	Static frequency	Lag selection skip	Accuracy Train	Accuracy Test
◉	2022-07-25 10:42:40	true	['mean', 'min', 'max', 'median', 'var', 'skew']	T	10	false	0.94	0.94
○	2022-07-26 15:23:44	true	['mean', 'min', 'max', 'median', 'var', 'skew']	T	1	false	0.98	0.97
○	2022-07-27 04:40:52	true	['mean', 'min', 'max', 'median', 'var', 'skew']	T	1	true	0.97	0.97

☐ Lag selection skip RETRAINING PREDICTING

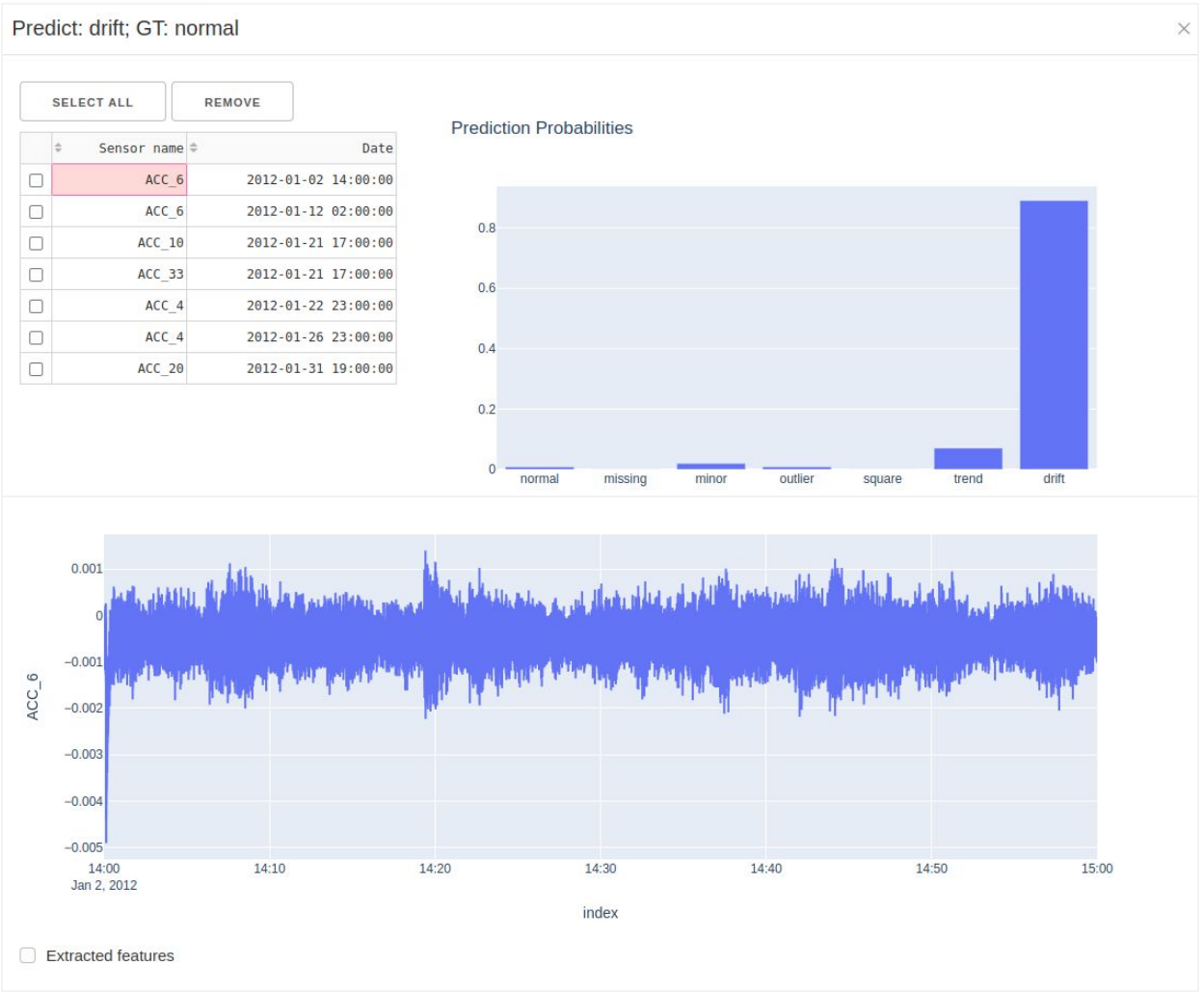
In this section, The figure displays the accuracy of the chosen model when using different features, and the table shows the accuracy of the model with the selected features with different time intervals. It is easy to retrain the model with different features and time intervals.

DATA | ANNOTATION | MODELING | MONITORING

Confusion Matrix

This interactive confusion matrix illustrates the accuracy of the model on both the training and testing data. Following section allows for the examination of data that has been incorrectly classified by the model. The raw data and predicted probability for each misclassification can be viewed here, providing insight into why the model made these mistakes.

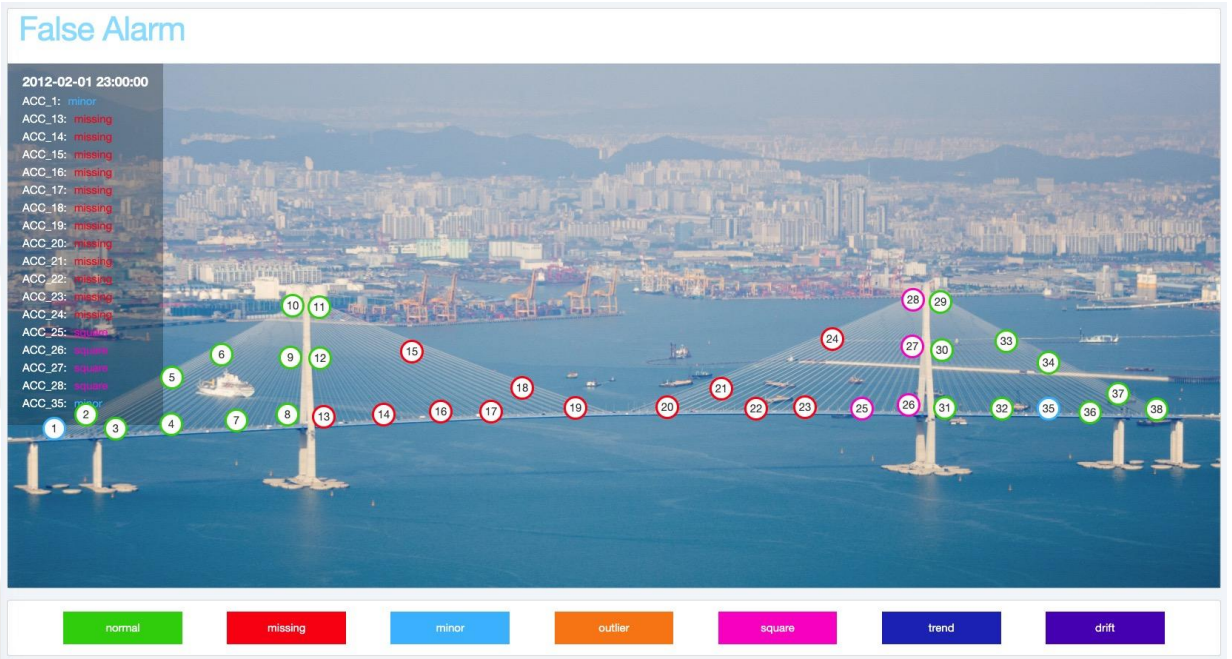
Prediction Error Analysis



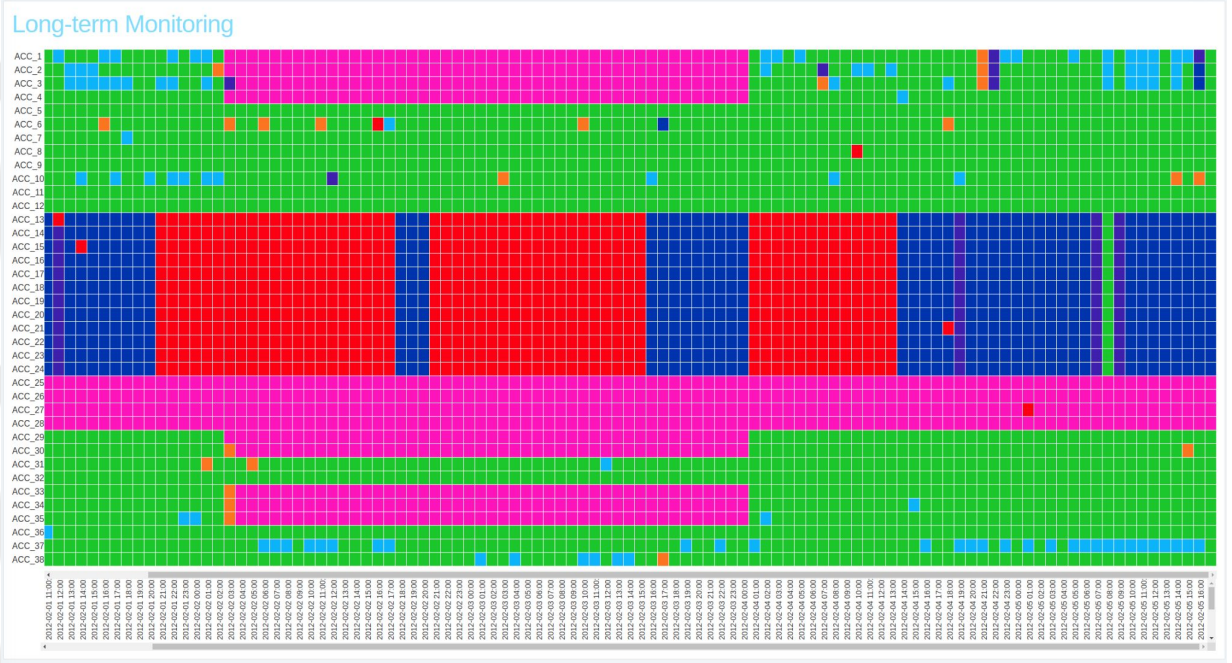
DATA | ANNOTATION | MODELING | MONITORING

This section uses the model to predict the data of each sensor within a specified time frame, and any unusual behavior is reported. All sensors are continuously monitored. The current status of each sensor in terms of anomalies can be tracked using a pie chart.

False Alarm



Long-term Monitoring



Sensor Monitoring