Failure Prediction Application Guide

Introduction

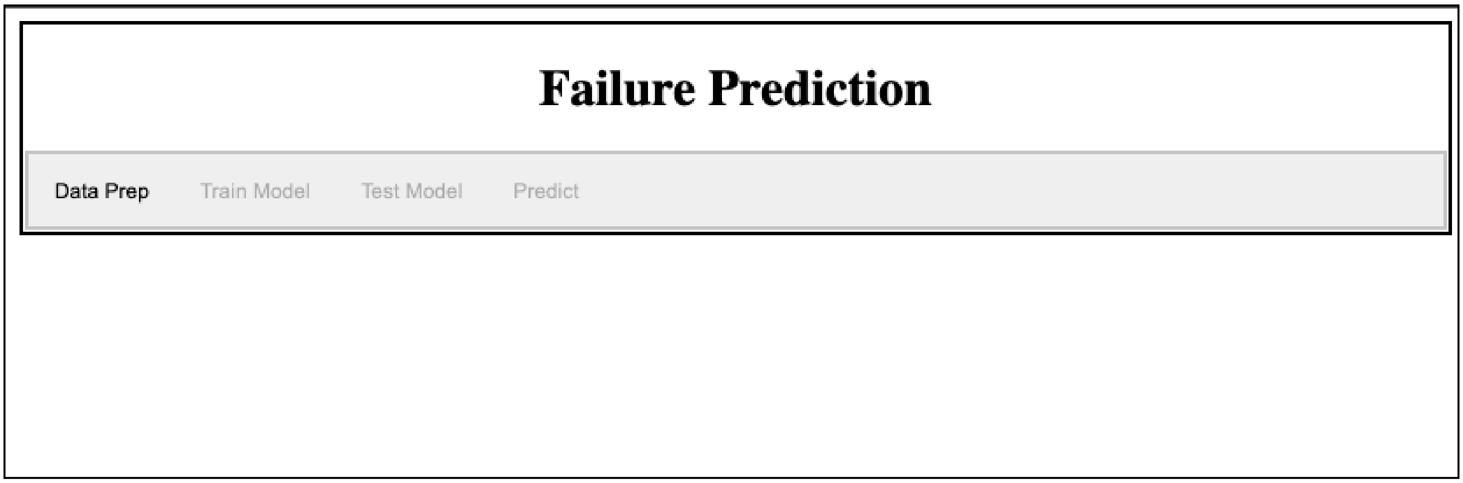
This application serves as a wizard that allows the user to:

- Prepare data for training, testing and prediction
- Train the model
- Test the model
- Make predictions on data that the user chooses

The goal of this application is to ultimately use a trained model that has learned what failures look like to specify there is a possibility of an imminent failure.

Opening Screen

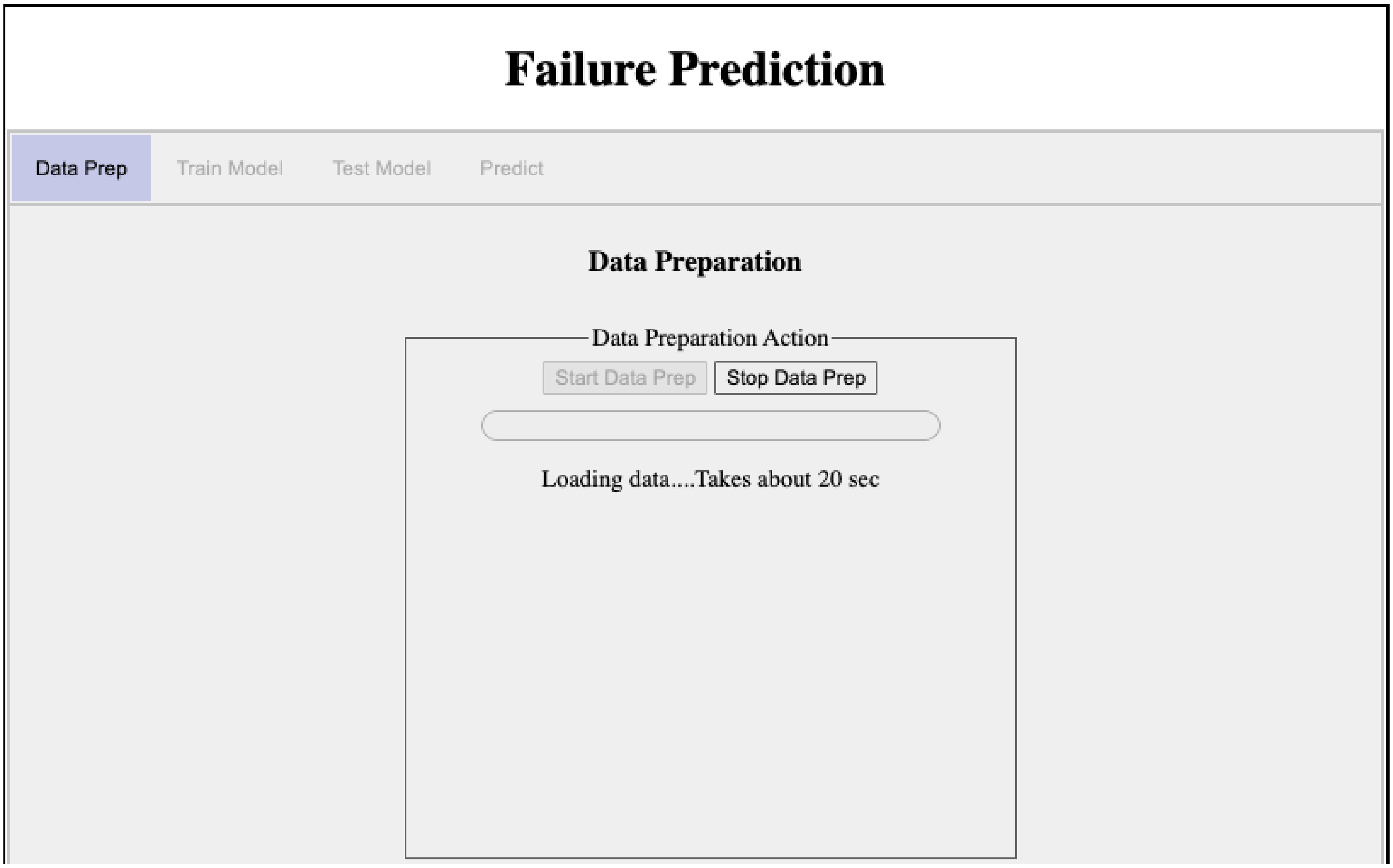
When you first open the application, you will see tabs, some of which are initially disabled:



This user interface will guide you through all the processes from Data Preparation through Predictions and will make sure that you perform all processes in the correct order, just like a wizard.

The gray bar with the labels, Data Prep, Train Model, Test Model, Predict serve as navigation tabs. When you click on a tab, the relevant information will appear.

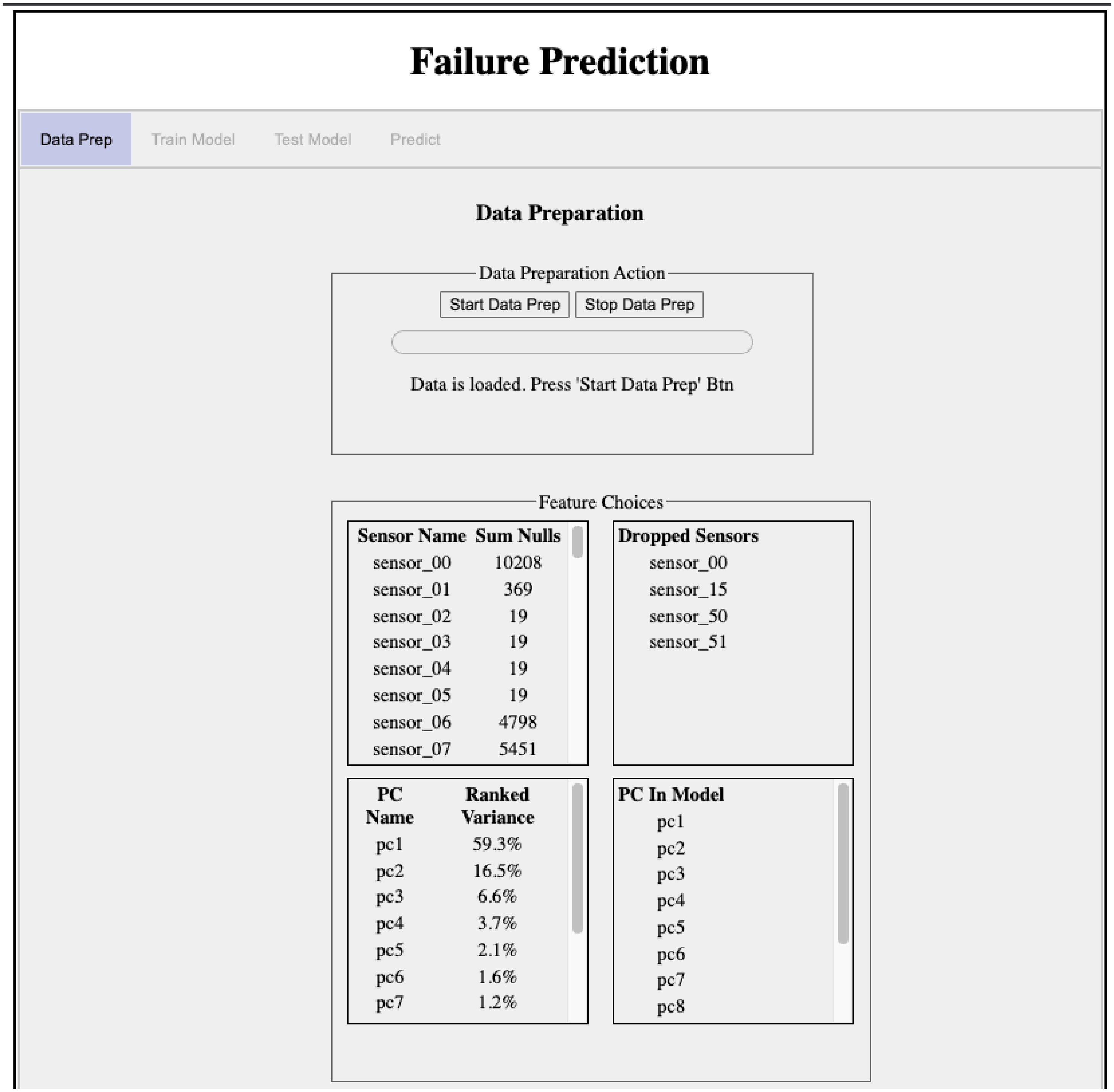
When the application first loads in your browser, a large amount of data is loaded. If you click on the Data Prep tab before all the data has been loaded you will see:



Loading data....Takes about 20 sec

The message: Loading data…. means that you cannot proceed past this page until the data are loaded. Notice that the Start Data Prep button is disabled, and will stay disabled until the data are loaded.

Once loaded, the Start Data Prep button will be enabled.



Failure Prediction

Data Preparation

Data Preparation Action

Data is loaded. Press 'Start Data Prep' Btn

Feature Choices

Sensor Name	Sum Nulls
sensor_00	10208
sensor_01	369
sensor_02	19
sensor_03	19
sensor_04	19
sensor_05	19
sensor_06	4798
sensor_07	5451

Dropped Sensors
sensor_00
sensor_15
sensor_50
sensor_51

PC Name	Ranked Variance
pc1	59.3%
pc2	16.5%
pc3	6.6%
pc4	3.7%
pc5	2.1%
pc6	1.6%
pc7	1.2%

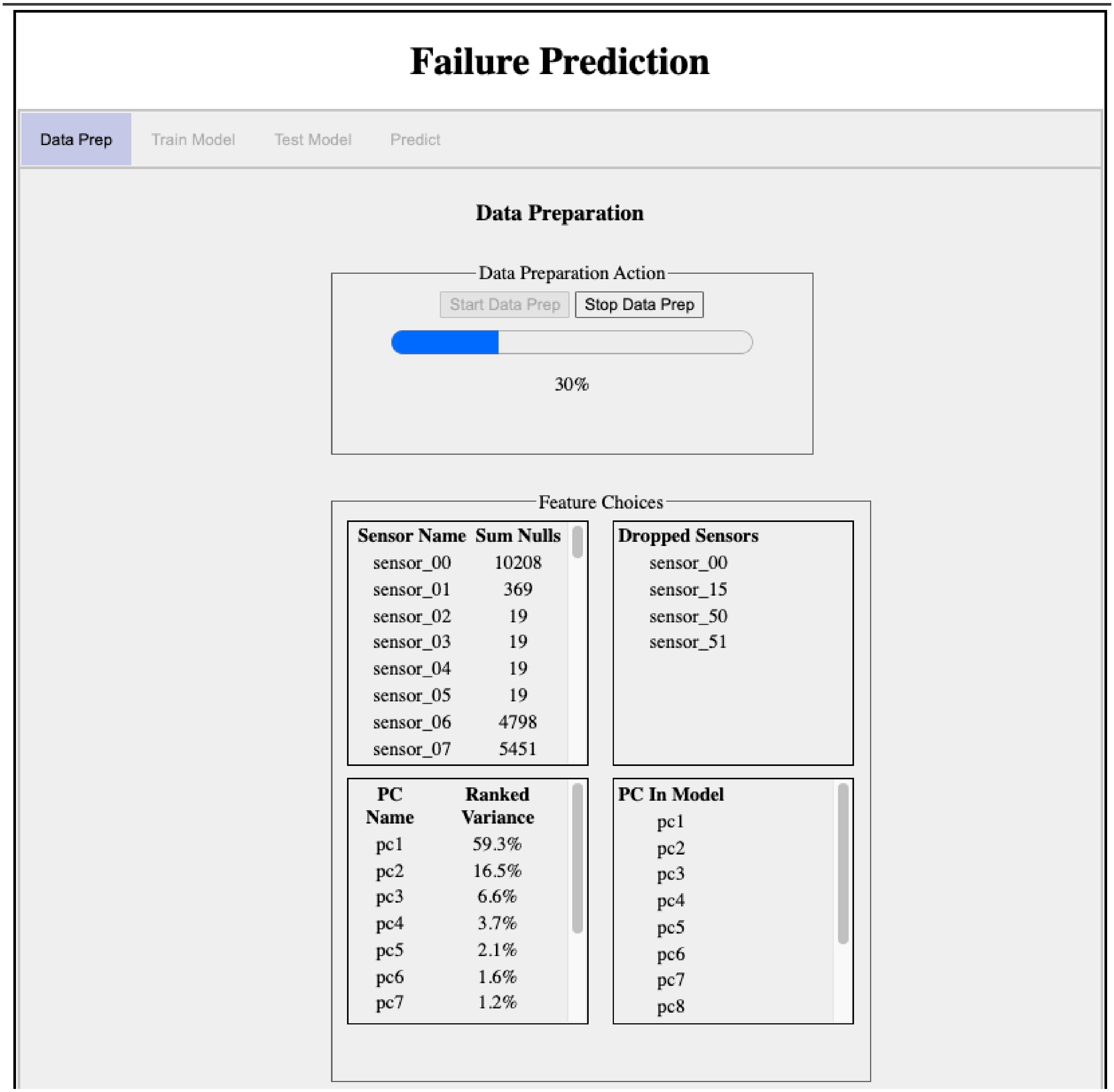
PC In Model
pc1
pc2
pc3
pc4
pc5
pc6
pc7
pc8

The information that you see in the box labeled Feature Choices refers to what you discovered in the start of the workshop. That is, you did some data discovery. The box in the upper left shows how many nulls were found in each sensor column. That is why, for example, the box in the upper right shows a list of the sensors that will be dropped, including sensor_00.

The box in the lower left shows a list of results from the Principal Component Analysis (PCA) that you found in the data discovery. In the original data there were about 52 sensors. We would like to shorten this list to make the model training take less time. Instead of going through a long process of deciding which sensors to keep, we use the PCA that finds which linear combinations of all the sensors gives the most variance. The linear combinations are denoted by pc1, pc2, pc3, …, (called Principal Components) where pc1 is the first ranked. We then take however many pc's we need so that the sum of their ranked variances is at least 95%. In our case it takes 12 pc's to reach that goal. We then use those 12 pc's to represent a transformation of our original 52 sensors when we train the model.

Now that we have all the data loaded and the PCA transformation is complete, we are ready to proceed with preparing the data. Each row of data that we will use has a timestamp together with the 12 pc's that we will now call model features. Data that is ordered by time is called a Time Series.

In the background, the application is reshaping the time series data so that it will be put into a form that the model understands. While this processing is taking place you will see:



Failure Prediction

Data Preparation

Data Preparation Action

30%

Feature Choices

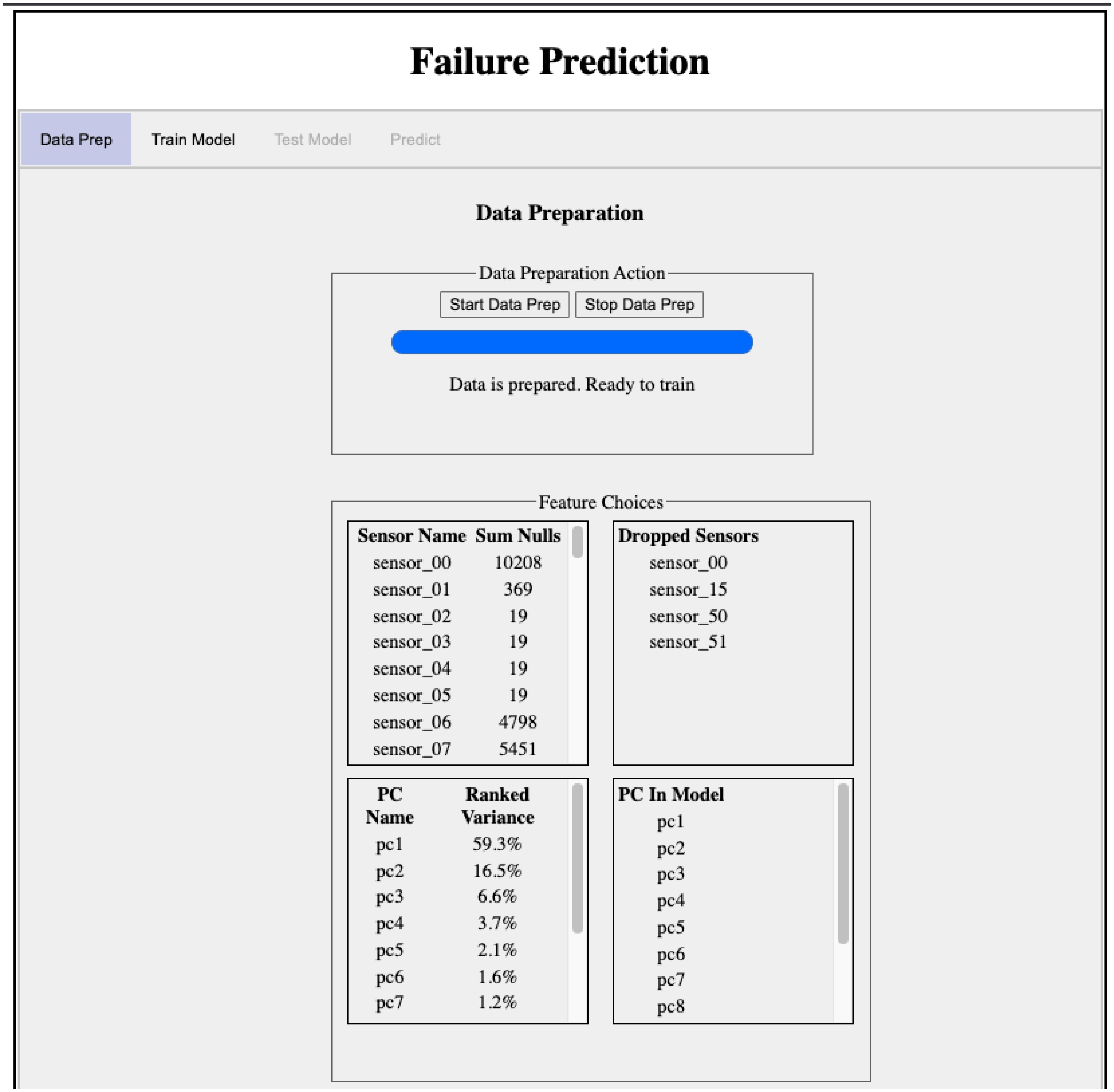
Sensor Name	Sum Nulls
sensor_00	10208
sensor_01	369
sensor_02	19
sensor_03	19
sensor_04	19
sensor_05	19
sensor_06	4798
sensor_07	5451

Dropped Sensors
sensor_00
sensor_15
sensor_50
sensor_51

PC Name	Ranked Variance
pc1	59.3%
pc2	16.5%
pc3	6.6%
pc4	3.7%
pc5	2.1%
pc6	1.6%
pc7	1.2%

PC In Model
pc1
pc2
pc3
pc4
pc5
pc6
pc7
pc8

The progress bar will start slowly and at about 50% will speed up. When the data preparation is complete, a message will appear and the next tab, Train Model will be enabled:



Failure Prediction

Data Preparation

Data Preparation Action

Data is prepared. Ready to train

Feature Choices

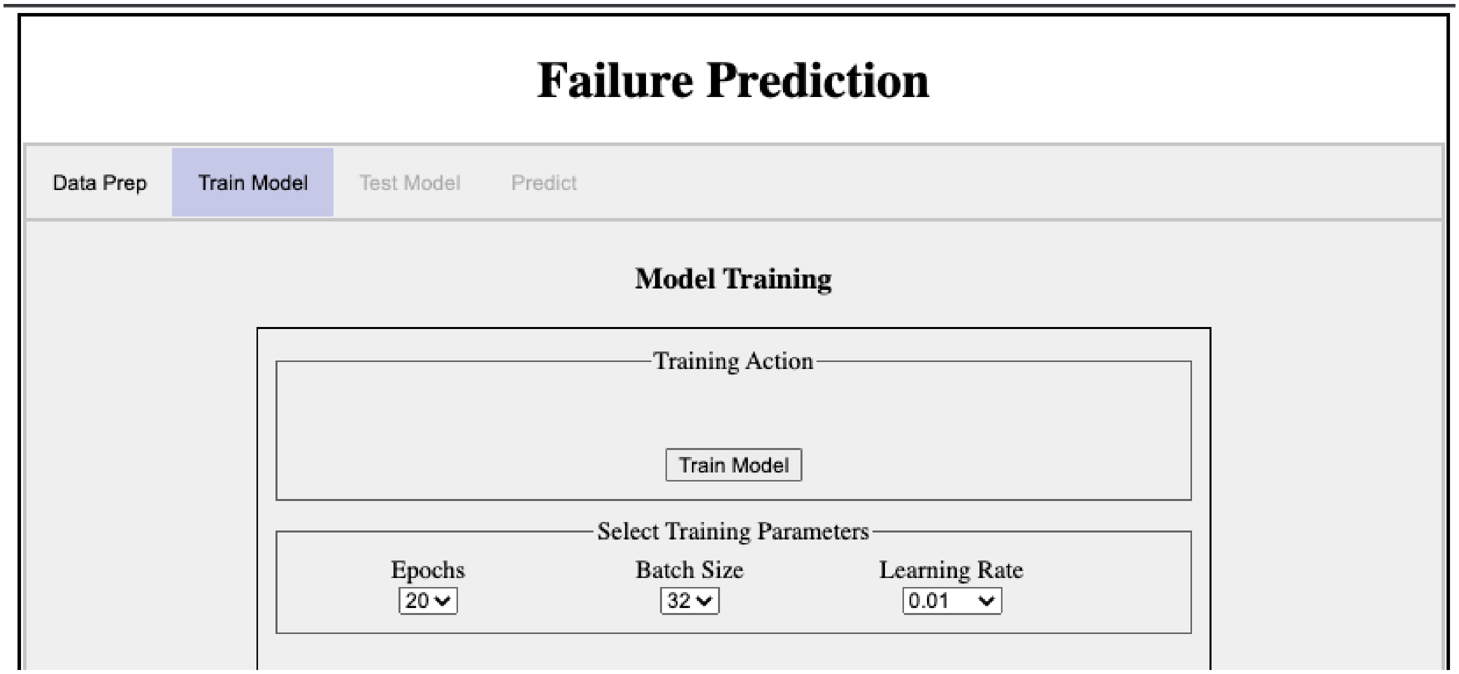
Sensor Name	Sum Nulls
sensor_00	10208
sensor_01	369
sensor_02	19
sensor_03	19
sensor_04	19
sensor_05	19
sensor_06	4798
sensor_07	5451

Dropped Sensors
sensor_00
sensor_15
sensor_50
sensor_51

PC Name	Ranked Variance
pc1	59.3%
pc2	16.5%
pc3	6.6%
pc4	3.7%
pc5	2.1%
pc6	1.6%
pc7	1.2%

PC In Model
pc1
pc2
pc3
pc4
pc5
pc6
pc7
pc8

Click on the tab labeled Train Model and you will see:


Failure Prediction

Model Training

Training Action

Select Training Parameters

Epochs: 20

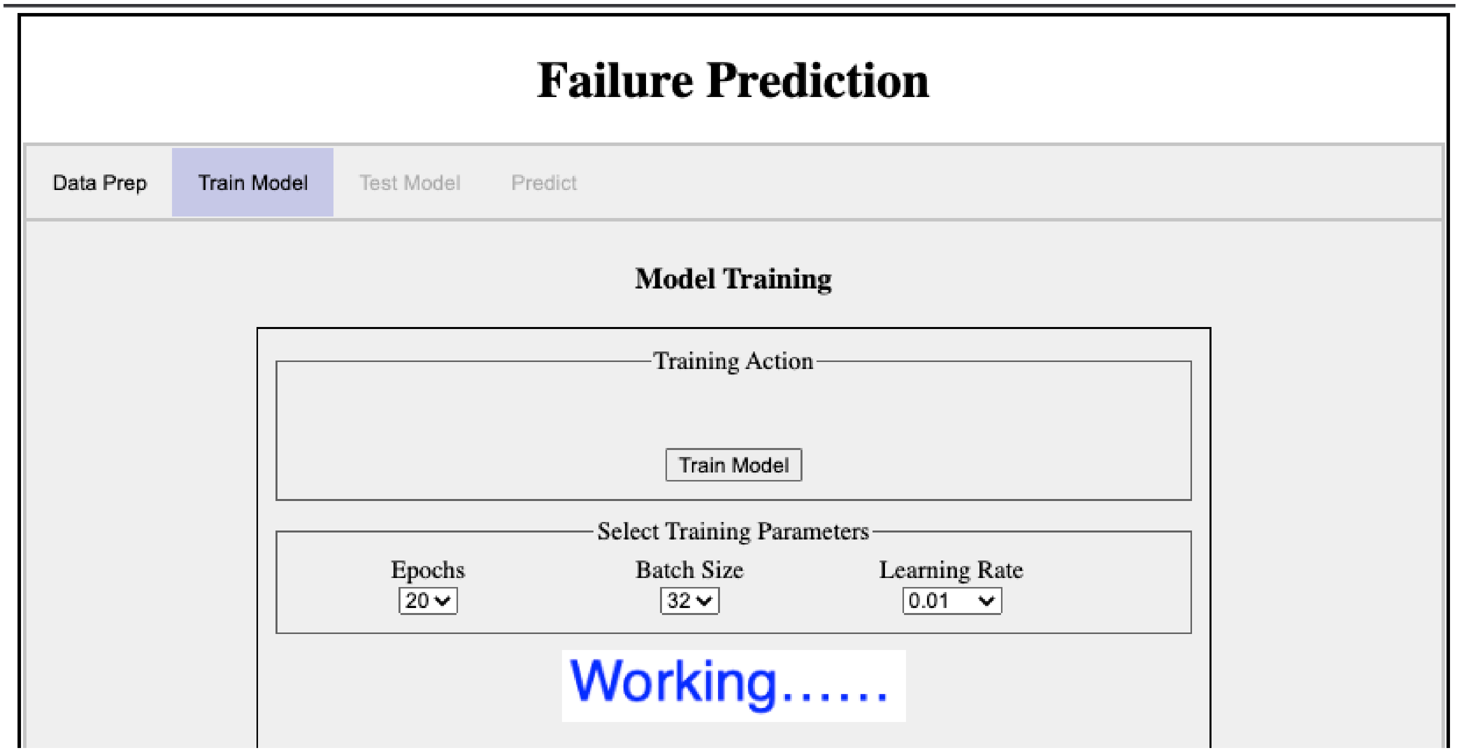
Batch Size: 32

Learning Rate: 0.01

The training process of a model is sometimes called the learning process. This learning process is iterative. A model is a numerical approximation of an entity, and the training data are used to calculate coefficients of the approximation. The training data contain values for the features (input) together with values for the target (output). So during one pass (called an **epoch**) at the data, small samples of the training data (called a **batch**) are used to update the model's coefficients. During training, a parameter called the learning rate is used to determine the "pace" of the iterative steps used to update the coefficients. If the learning rate is too large, then the model may step over a critical part of the updating process. If too small, the updates may cause the model to converge too quickly and possibly miss the optimal approximation. In this training session, the learning rate starts as the value in the pull down, but after 10 epochs its value is divided by a factor of 10.

The default values in the pull downs are better left alone for this workshop.

You can press the Train Model button to start the training. During training, there is no progress feedback. This is because the fit() function only gives progress in the form of text displayed in a terminal console. Since a web application has no console, there is no progress feedback available.



Failure Prediction

Model Training

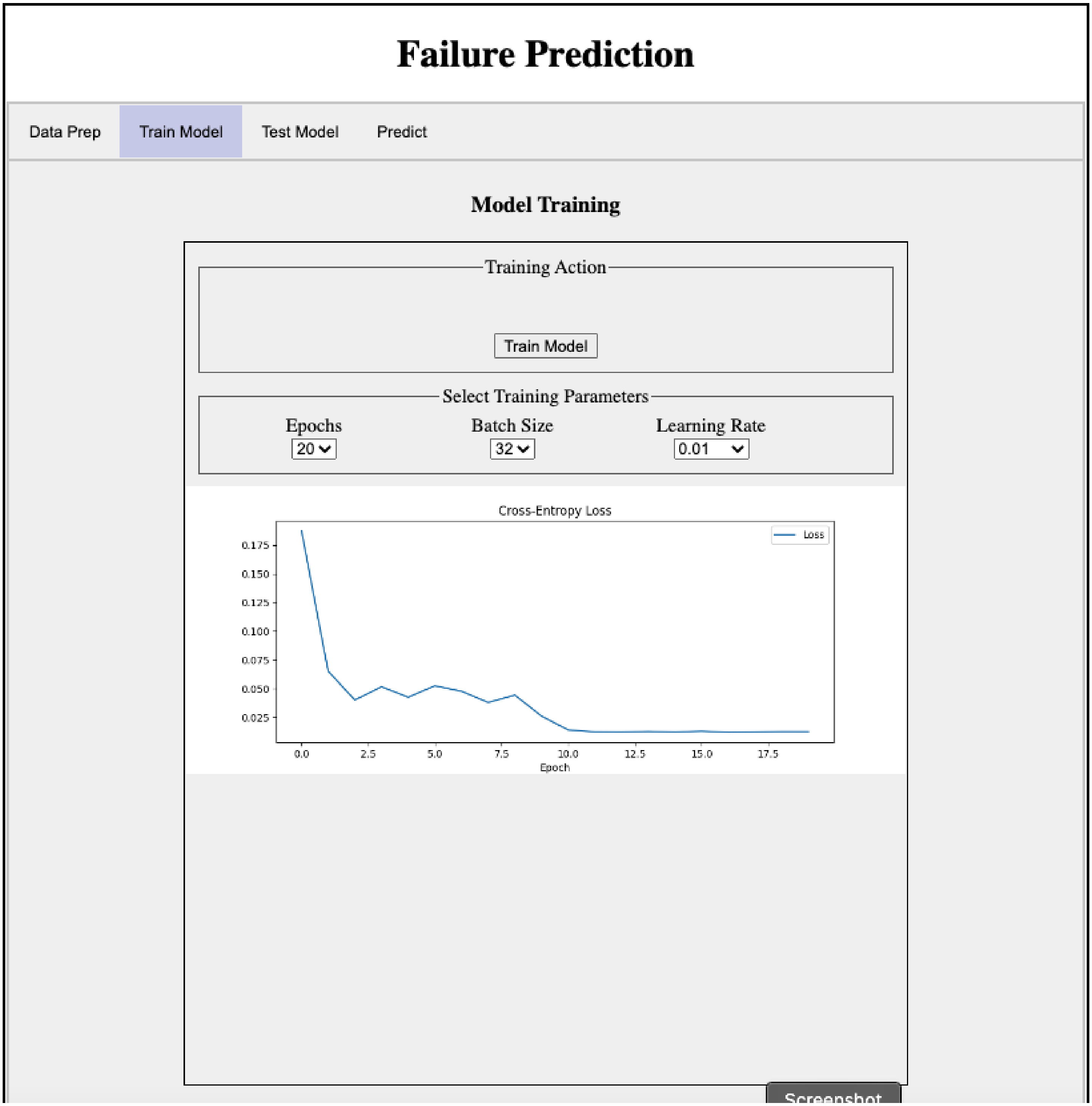
Epochs 20

Batch Size 32

Learning Rate 0.01

Working……

Since there is no progress feedback, just wait for this screen:



Failure Prediction

Model Training

Training Action

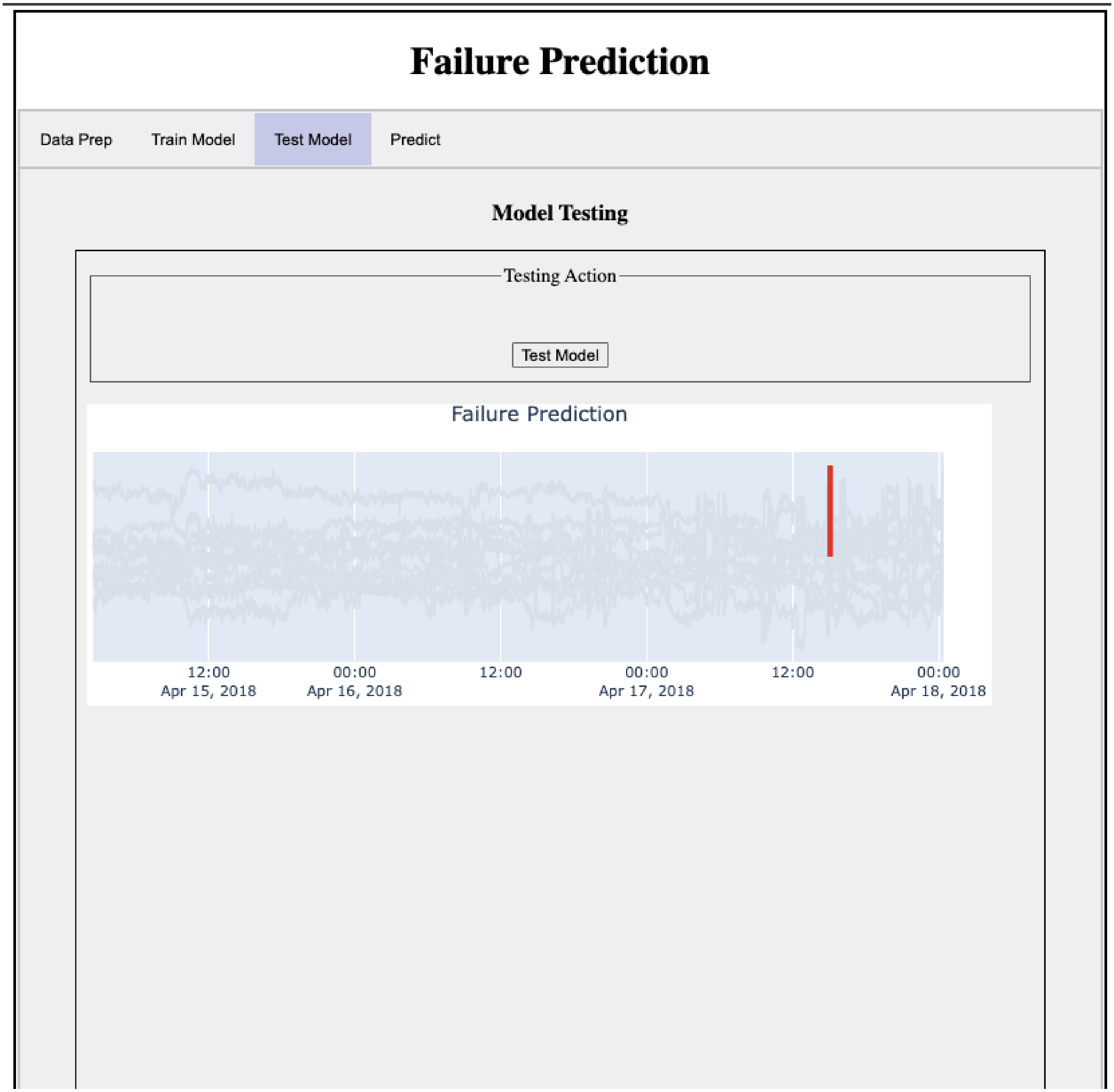
Select Training Parameters

Epochs: 20

Batch Size: 32

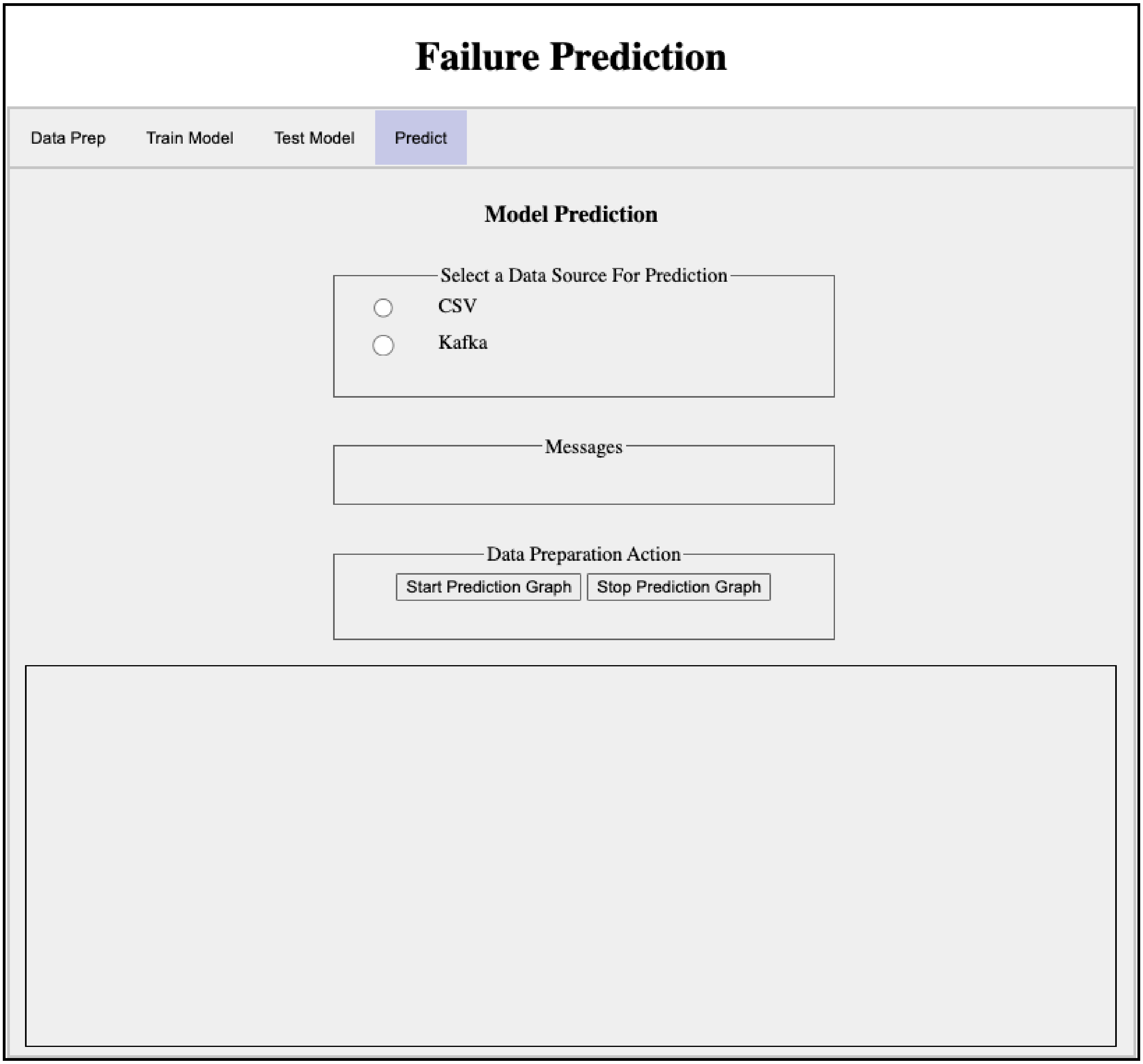
Learning Rate: 0.01

Besides the graph you will notice that the two tabs labeled Test Model and Predict have been enabled. We will run the test first, although at this point we could just as well run a prediction. So click on the Train Model tab. The Train Model tab is sparse because there are no parameters to define for training. Just press the Test Model button. The result is something like:

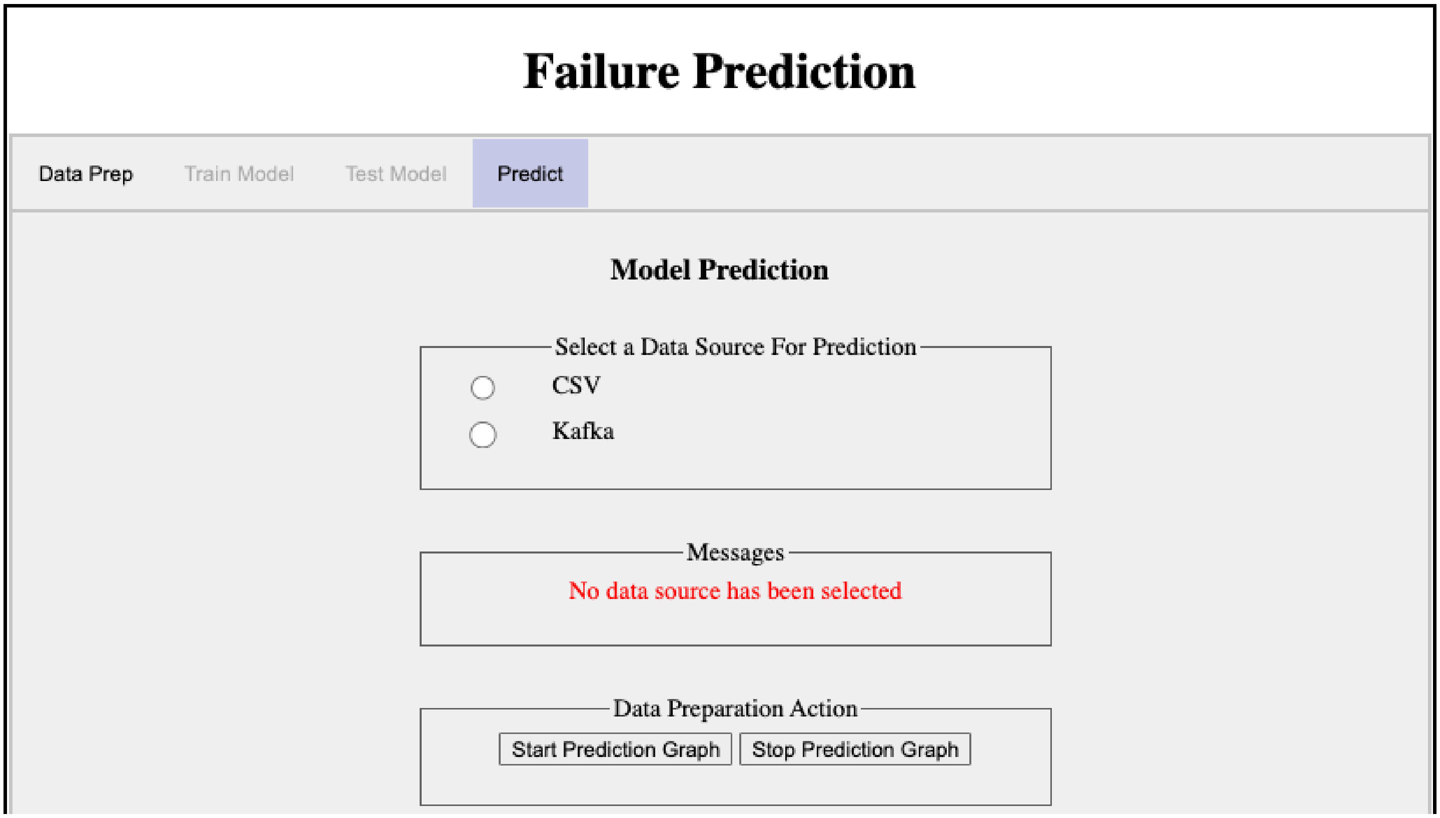


Do not be surprised if your neighbor gets a slightly different result.   This is because of all the moving parts of the process, that is, because of the stochastic nature of training the model. Remember that a model is an approximation and the training involves uncertainties and randomness in order to make the approximation.

Finally we can click on the Prediction tab:



Before we can make a prediction, we must first select a data source for the prediction data. There are two options: (1) Use a csv file which will be streamed one point at a time, or (2) Use a data stream with the help of Apache Kafka that simulates the production of real time data. If you click on the Start Prediction Graph before selecting a data source you will get a red message:



Failure Prediction

Model Prediction

Select a Data Source For Prediction

○ CSV

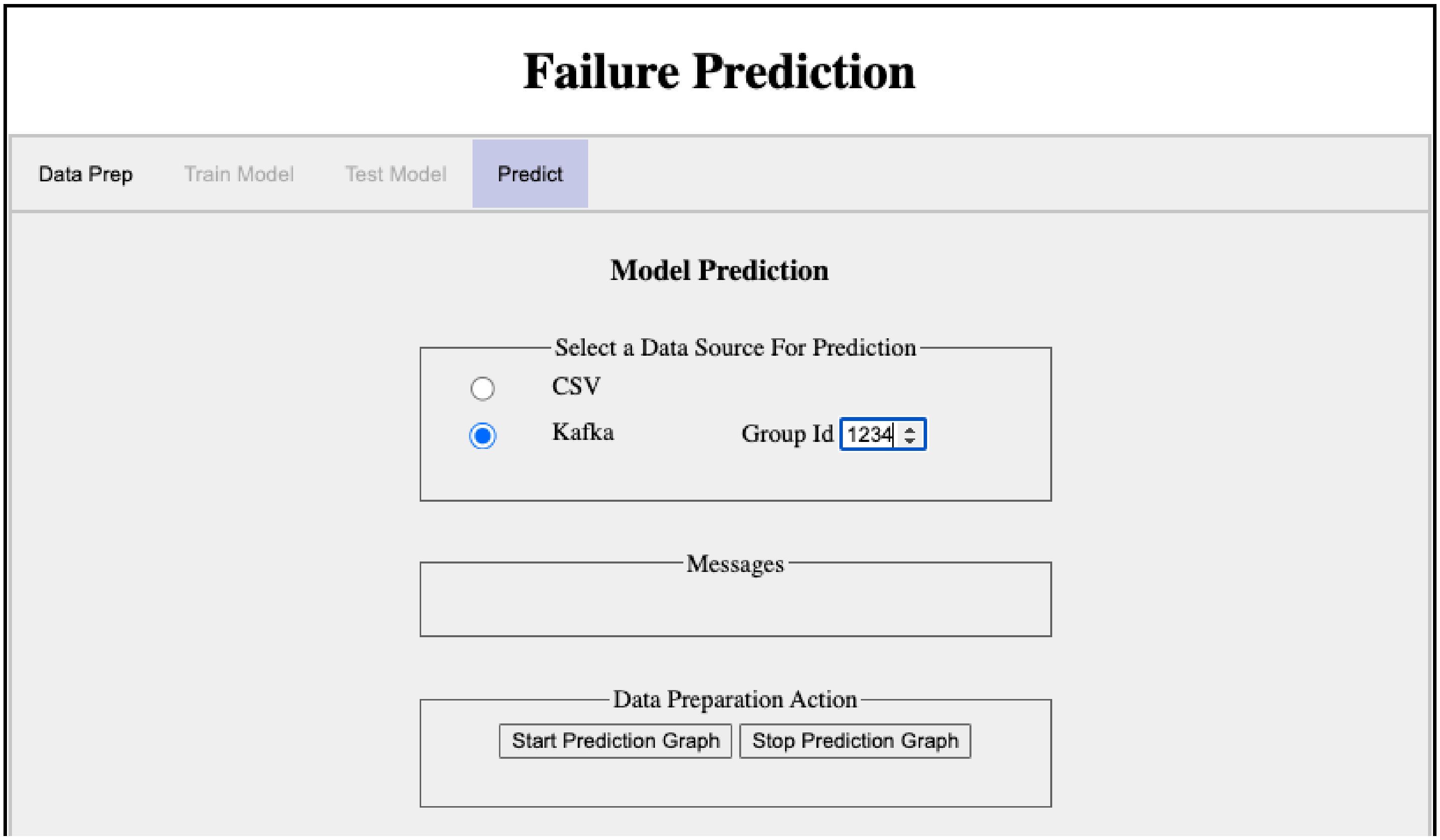
○ Kafka

Messages

No data source has been selected

Data Preparation Action

If you choose CSV, a select box will list CSV file names available. If you select Kafka you will see:



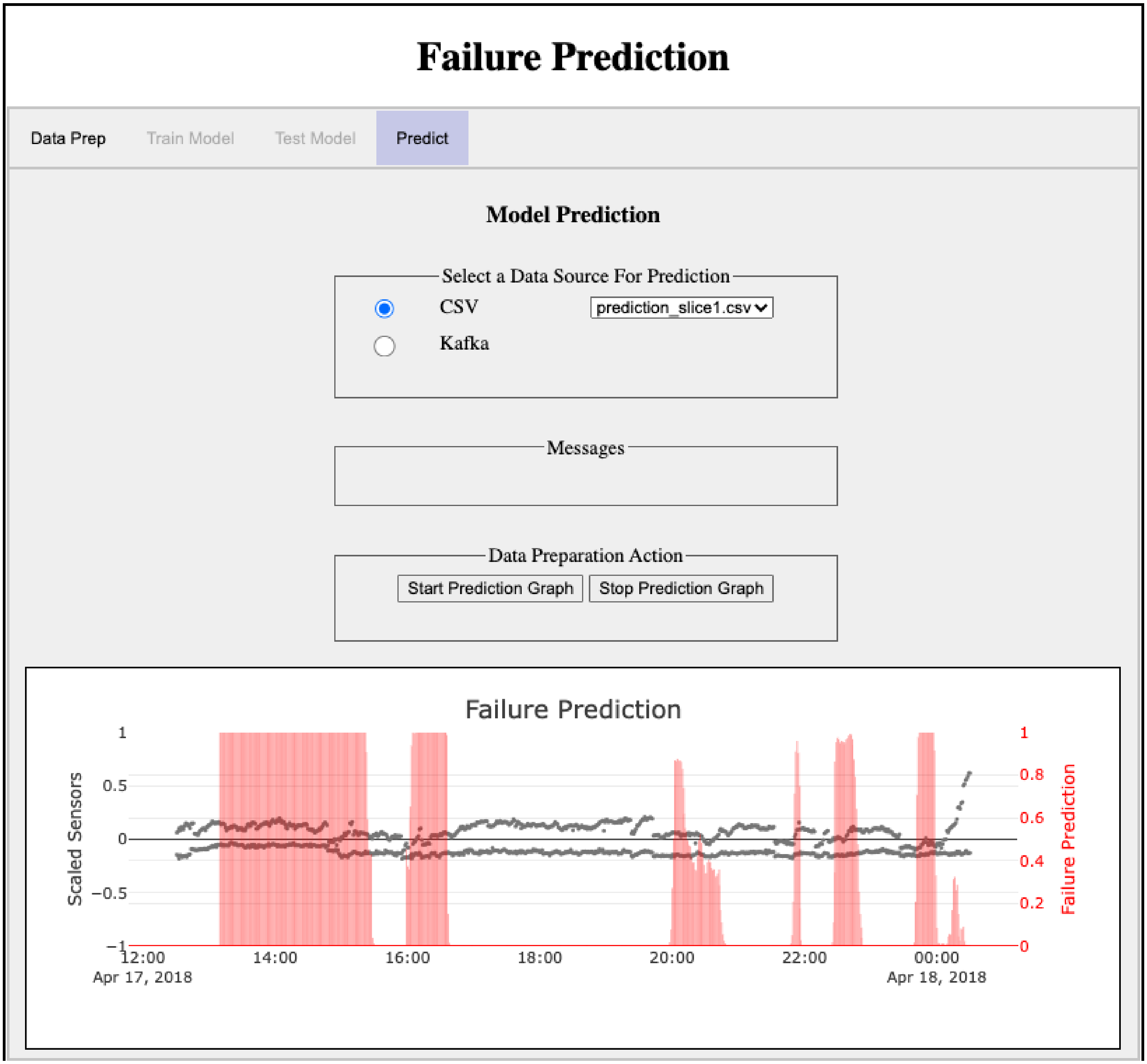
Select a Data Source For Prediction

○ CSV

● Kafka Group Id 1234

Enter the Group Id that you have been given. This Group Id allows your browser session to pull out messages that you were identified with.

You can click on the Start Prediction Graph. There will be a pause while the data stream is prepared. Then you will see points from the prediction data source as well as a red prediction alarm if the model predicts failure is imminent. Note that the prediction data is only available 12 hours before failure.



● CSV prediction_slice1.csv

○ Kafka

In this case actual failure was at 2018-04-18 00:30. The graph in your browser is interactive, so you can move your cursor to display the times.