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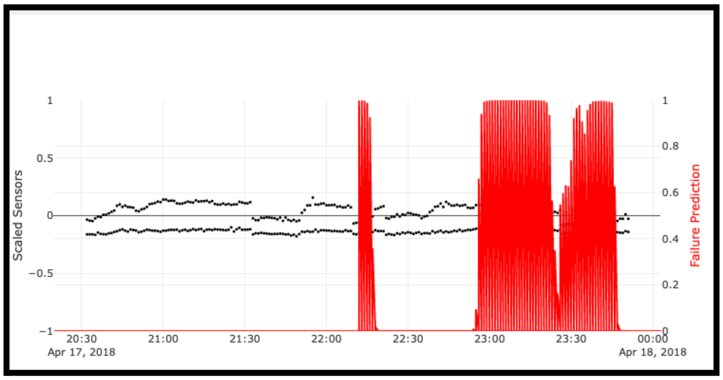
Plot Real Time Data: Demo Flask Application



This document explains how to plot a real time graph of time series data. In particular, time series data is created on the server, and selected data is pushed to the client browser where a Javascript library called plotly.js updates the graph as data is made available. The code for a complete web application is found on GitHub at: https://github.com/guiderae/WorkingDemos-RealTimeGraph1

In order to follow along, please go to this GitHub repository and download the project as a zip file and unzip the project in a convenient location on your computer. You can then refer to the source code in the specified files.

This document will use excerpts from the above mentioned repository to trace the steps necessary to start and maintain a plot of real time data. The source of the data used for plotting can be found at https://www.kaggle.com/datasets/nphantawee/pump-sensor-data. Code on the server side of the web application will read the data and will periodically make rows of data available to the app thereby simulating real time data generation.

The following discussion traces the whole process from clicking on a Start button to the maintenance of a real time graph that is viewed in the browser. There are a number of parts that have to be put into place in order to facilitate the real time graph.

Those parts include:

- HTML code that defines start and stop buttons, a pull down that allows the user to select the data source, and a div element where the graph will be placed on the web page. The HTML code is written in a file **templates/main.html**.
- Javascript code that retrieves the data source that was selected in the browser, creates a connection to the data source, provides listeners that monitor and respond to messages sent by the server. The Javascript code to accomplish these tasks is written in a file **static/messageHandler.js**
- Python code that periodically generates and yields the data. This Python code is found in the file **dataprep/data_source_manager.py**
- Python code that puts the generated data into a Json format so that it can be streamed to the browser. This code is found in the file **dataprep/process_real_time_data.py**.
- Javascript code that defines the layout of the graph and adds new data to the graph. This code is found in **static/plot.js**
- Python code that serves as a controller/mapper that maps url's to Python actions. This code can be found in **wsgi.py**

We will therefore trace both client side and server side code.

<u>User Interface: HTML</u>

The user interface code is in the file, **templates/main.html**. We are only interested in three code segments:

1. HTML code that defines the select drop down that contains the names of the data sources:

```
<select id="predictCSV" >
    {% for onefile in filenames %}
        <option value="{{ onefile }}">{{ onefile }}</option>
    {% endfor %}
</select>
```

   Note that the id of the select element is “predictCSV”

2. The div that contains the “Start Prediction Graph” button:

```
<fieldset class="spanTwoCols">
    <legend> Prediction Action</legend>
    <div id="predBtnContainer" class="spanTwoCols">
        <button id="startPredictBtn">Start Prediction Graph</button>
        <button id="stopPredictBtn">Stop Prediction Graph</button>
    </div>
```

```
34      </fieldset>
```

3. And the code segment that contains the div in which the graph will be placed:

```
36      <div id="predGraph" class="predictGraphDiv"></div>
```

Line 31 contains a <button> element whose id is ‘startPredictBtn’. In order to support browser actions such as button clicks, we need to add some Javascript code to the html page. It is good programming practice to separate HTML markup from Javascript code, so we place the Javascript in a file: **static/messageHandler.js**, and then include the contents in this file in the HTML file with the <script> element:

```
43      <script src="static/messageHandler.js"></script>
```

In anticipation of preparing the page for the real time graph, we will also make use of Javascript in another file called plot.js, so we also add a <script> element for its inclusion:

```
44      <script src="static/plot.js"></script>
```

We typically place the <script> elements at the bottom of the HTML <body> element. This practice ensures that the HTML is loaded first and prevents any premature Javascript reference to HTML elements *before* they are loaded.

NOTE: Javascript is part of the HTML5 definition. Whereas HTML defines elements and their structure in a web page, Javascript is used to provide support for user actions such as mouse clicks on those elements. There is an intimate relationship between Javascript and the HTML on a web page. When a web page gets loaded into a browser, the HTML is parsed into a structure called the Document Object Model (DOM). Javascript is then able to access the DOM and create Javascript objects that represent elements within the DOM. It is through the Javascript objects that we can actually manipulate DOM elements. That is, we can *programmatically* change properties of HTML elements during runtime based on user actions.

We can now look at some of the code in the messageHandler.js file.

Browser side Javascript code

```javascript
// This script first creates listeners for the start and stop buttons.
// It also creates an EventSource that is linked to the url,
// '/runPredict'. Once instantiated, theEventSource establishes a
// permanent socket that only allows server push communication.  In this
// application there are two event messages that are pushed to the
// browser: 'update', and 'jobfinished'.  There is also a listener for
// 'initialize', but it is not needed in this application.
const startPlotBtn = document.getElementById("startPredictBtn");
const stopPlotBtn = document.getElementById("stopPredictBtn");
const predictCSVNameObj = document.getElementById("predictCSV");
startPlotBtn.addEventListener('click', startPlotProcess);
stopPlotBtn.addEventListener('click', stopPlotProcess);

let eventSourceGraph;
function startPlotProcess(){
     // Get the data source file name from the UI
    let predictCSVName =
         predictCSVNameObj.options[predictCSVNameObj.selectedIndex].text;
     const url = "/runPredict?" + "predictCSVFileName=" + predictCSVName;
     initPlot();
     if(eventSourceGraph){
         eventSourceGraph.close();
     }
     // Create a JS EventSource object and give it the URL of a long
    // running task.  The EventSource object keeps the connection open
    // to the given URL so that the process at the end point
    // can send messages
    // back to the EventSource object.
    eventSourceGraph = new EventSource(url);
     // NOTE:  This event 'initialize' is currently not used
    eventSourceGraph.addEventListener("initialize",
                                 function(event){
         initPlot();
     }, false);
     // "update" Event contains the plotting data
    eventSourceGraph.addEventListener("update",
                                 function(event){
         updatePlot(event.data);

     }, false);
     // "jobfinished" Event gets back finished message generated by the
    // server when the data source is exhausted
    eventSourceGraph.addEventListener("jobfinished",
                                 function(event){
         eventSourceGraph.close();
         startPlotBtn.disabled = false;
     }, false);
```

```
        startPlotBtn.disabled = true;  // Disable start btn after plot is started.
    }
    // Closes the EventSource object which closes the connection between
    // browser and server.
    function stopPlotProcess(){
        console.log("Stopping process");
        eventSourceGraph.close();
        startPlotBtn.disabled = false;  // Enable start btn after process
       // is terminated.
    }
```

First job is to add an EventListener to the ‘startPredictBtn’ that handles the button ‘click’ event. Javascript allows a short-hand format to accomplish this, but we will do it in two lines. The first line is:

```
8    const startPlotBtn = document.getElementById("startPredictBtn");
```

The variable called startPlotBtn is a Javascript object that represents the HTML element whose id is “startPredictBtn”. Now that we have a Javascript object, we can add a property to that object. We add an EventListener to the button object:

```
11    startPlotBtn.addEventListener('click', startPlotProcess);
```

The line 11 above adds a ‘click’ event to the button object and assigns a Javascript function named ‘startPlotProcess’ that will handle the ‘click’ event on the button. If you look at the file, **static/messageHandler.js**, you will find the Javascript header definition for the function startPlotProcess():

```
15    function startPlotProcess(){......
```

There are three tasks in the function, startPlotProcess() that are of special interest:

1. Create a Javascript object, EventSource and give it a url that will be sent to the server. As we will see later, this url is mapped to code on the server that will get the data we need for the plot. The EventSource object will create a one-way socket connection to the server so that the server code can “push” data to the browser where that data will be added to our real time graph. See elaboration below that describes what “push” means.
2. Initialize a Plotly object and call upon its newPlot() method.

3. Add event listeners to the EventSource object that reacts to the different kinds of messages that will be received from the server. In our case the server code will generate only two types of messages: “update” and “jobfinished”. A message that is identified as “update” will contain data for plotting. A message that is identified as “jobfinished” has no data and is just used as a signal that there is no more data to push.

What does it mean to “push” data? When used over a network such as the Internet, communication between two endpoints is facilitated by what is called a socket. Simply put, a socket connection is made between two endpoints and data is sent/received by the two endpoints. The HTTP protocol uses a restricted form of a socket where a request is made by one endpoint called the client and the other endpoint called the server receives, processes the request, and sends a response back to the client endpoint. Once the response is received by the client, the socket connection is terminated. The Javascript EventSource is another restricted form of socket communication. First, a client request is sent to the server, and a one-way socket is created. The server then receives the request, processes the request and the socket remains open for the server to send multiple responses back to the client *without closing the connection*. This type of communication is sometimes called “Push”. You can see examples of “Push” on financial web sites where market data is pushed in real time without further client requests. You can also go to sports web sites where real time game information is pushed to the client without any further requests.

We will now provide code that accomplishes the three tasks listed above. We wish to create a url that will have as its base, ‘/runPredict’. But we need to include a parameter in the url that contains the name of the file that contains the data to be plotted. We retrieve the chosen data source file name in lines 17 and 18. The variable, predictCSVNameObj is the Javascript object that represents the HTML select element whose id is ‘predictCSV that was obtained in line 10’. The variable predictCSVName defined in line 17 will contain the name of the data source. Finally, in line 19 we create the url with the base value plus a parameter named ‘predictCSVFileName’ . Notice that the url is just a string concatenation of the base url plus the parameter name with its value.

```
17    let predictCSVName =
18        predictCSVNameObj.options[predictCSVNameObj.selectedIndex].text;
19    const url = "/runPredict?" + "predictCSVFileName=" + predictCSVName;
```

If you have never created a url with parameters, the format is:

baseURL?param1Name=param1value&param2Name=param2value……..

We next create an EventSource object and pass the above url to its constructor:

```
29        eventSourceGraph = new EventSource(url);
```

This line of Javascript code creates an EventSource object whose constructor makes a connection with the server by using the given url. Later we will examine the server code that responds to this url.

Lines 21-23 make sure that we are not using an old EventSource object from a previous connection that was not properly closed.

```
21         if(eventSourceGraph){
22             eventSourceGraph.close();
23         }
```

Line 20 calls a Javascript function that is found in static/plot.js:

```
20         initPlot();
```

We will examine this function later.

As was stated earlier, the server will send only two types of messages: “update” and “jobfinished”. So in the Javascript code, we add listeners to the eventSourceGraph object that will respond to the receipt of these two kinds of messages:

```
35         // "update" Event contains the plotting data
36        eventSourceGraph.addEventListener("update",
37                                      function(event){
38             updatePlot(event.data);
39
40         }, false);
41         // "jobfinished" Event gets back finished message generated by the
42        // server when the data source is exhausted
43        eventSourceGraph.addEventListener("jobfinished",
44                                      function(event){
45             eventSourceGraph.close();
46             startPlotBtn.disabled = false;
47         }, false);
48         startPlotBtn.disabled = true;//Disable start btn after plot is started.
49     }
```

Line 36 adds an EventListener that will respond to the “update” message. An anonymous function calls a Javascript function, updatePlot(event.data). This function is written in the Javascript file, static/plot.js. We will examine this function later.

Line 43 adds an EventListener that will respond to the “jobfinished” message. The anonymous function closes the EventSource connection. The “Start Prediction Graph” button is set to be disabled while the plot is running.

So far we have looked at the code on the browser side that prepared the browser to accept data. The logical next step would be to look at the server side code that pushes the data to the browser. Instead, we will stay on the browser side for now and look at how the browser actually implements the plotting process.

There are two ways to graph data. One would be to generate on the server a new graph for each data point that becomes available and push the whole graph to the browser. This would work if there is enough time between data points to do the generation and push. But in general, it makes more sense to push the small amount of data contained in each data point to the browser and let code on the browser do the plot.

The code to handle the plot is found in static/plot.js:

```
var graph = document.getElementById("predGraph");
let data = [
    { // 0 Trace for Data points for sensor
       x: [],
        y: [],
        mode: 'line',
        marker: {color: 'red', size: 3},
        xaxis:{type: 'date'}
    },
    { // 1 Trace for Data points for sensor
       x: [],
        y: [],
        mode: 'line',
        marker: {color: 'green', size: 3},
        xaxis:{type: 'date'}
    },
    { // 2 Trace for Data points for sensor
       x: [],
        y: [],
        mode: 'line',
        marker: {color: 'blue', size: 3},
        xaxis:{type: 'date'}
    }];
// This array of empty traces is used whenever we need to restart a plot
// after it has been stopped.
// Since the array is empty, the restarted plot will start with no data.
let initData = [
```

```
        { // Trace0 for Data points for sensor
           x: [],
            y: [],
        },
        { // Trace1 for Data points for sensor
           x: [],
            y: [],
        },
        { // 2 Trace for Data points for sensor
           x: [],
            y: [],
        }];
        let layout = {
            title: {text: 'Failure Prediction',
                    font: {size: 20},
                    xanchor: 'center',
                    yanchor: 'top'},
            margin: {t:50},
            xaxis: {type: 'date'},
            yaxis: {range: [0, 1],
                    title: 'Scaled Sensors',
                    side: 'left'},

            showlegend: true

       };
    // First do a deep clone of the data array of traces.  The clone uses values from the empty array, initData
    // Then call Plotly.newPlot() using the cloned array of empty traces to start a new plot.
    function initPlot(){
        data[0].x = Array.from(initData[0].x);
        data[0].y = Array.from(initData[0].y);
        data[1].x = Array.from(initData[1].x);
        data[1].y = Array.from(initData[1].y);
        data[2].x = Array.from(initData[2].x);
        data[2].y = Array.from(initData[2].y);
        Plotly.newPlot('predGraph', data, layout);
    }
    var msgCounter = 0; // Another way of shifting. Not used in this code.
    function updatePlot(jsonData){
        let max = 120;
        let jsonObj = JSON.parse(jsonData);
        // Unpack json, keys are:
       //['timestamp', 'sensor_04', 'sensor_18', 'sensor_34']
       let timestamp = jsonObj.timestamp;
        let y1 =        jsonObj.sensor_04;
        let y2 =        jsonObj.sensor_18;
        let y3 =        jsonObj.sensor_34;
```

```
    // Note there are three traces.
   Plotly.extendTraces('predGraph',
        {
            x: [[timestamp], [timestamp], [timestamp]],
            y: [[y1], [y2], [y3]]
        }, [0, 1, 2], max);  // The array denotes to plot all
                            // three traces(0 based).  Keep only last
                            //max data points
}
```

The first thing we need to do is to create a Javascript object that represents the div in which the plot will be placed:

```
var graph = document.getElementById("predGraph");
```

The lines 02-23 define an array of traces. In plotly.js, a trace is one curve in a graph. In our demo we are plotting the scaled values of 3 columns of data. So there is one trace for each data column. Each trace is specified by a Javascript dictionary with key/value pairs. Here is one trace dictionary:

```
03        { // 0 Trace for Data points for sensor
04            x: [],
05            y: [],
06            mode: 'line',
07            marker: {color: 'red', size: 3},
08            xaxis:{type: 'date'}
09        }
```

Notice that we define the x and y coordinates of each point in lines 04-05. The keys, x and y are arrays of values that represent the coordinates of all the data points so far received. We define the mode of the plot to be a 'line' (as opposed to 'markers' to plot points). We define the marker as a 'red' line with size 3. Finally we specify that the xaxis is a date so that the timestamps will be formatted properly. You can also see that the variable, data, is just an array of traces.

Lines 27-39 define a variable, initData which looks like a repetition of the definition of the array, data. The purpose of initData is to serve as an 'initializer'. That is, since initData defines traces with no data, we will use initData to initialize our plotting data, (the array data) to be empty. The initData is used between plots in order to erase the data from a previous plot. The initialization (which is called from the function startPlotProcess() on line 20 of static/messageHandler.js) is done with the function initPlot() in lines 56-62. The final line (63) of initPlot() calls upon Plotly's newPlot() function, which sets additional div's inside our predGraph div. There are also a number of svg elements that get placed within the graph div.

The lines 40-53 define a variable, layout, which specifies the layout of the graph such as size, font size, legend, etc.

The three parameters passed to newPlot() are the id of the graph div where the plot will be placed, the variable, data that contains the array of plot traces, and the graph layout.

```
63        Plotly.newPlot('predGraph', data, layout);
```

Finally, on line 66 we define the most important function, updatePlot(). Remember that this function was called from the EventListener in line 38 of static/messageHandler.js. The function, updatePlot() gets called every time a new message of type “update” is received by the browser. This function takes one parameter, which is a Json string representation of one data point that we wish to add to the plot. This Json string is pushed from the server when a new data point becomes available. We will reproduce the whole function here since it is very important:

```
66    function updatePlot(jsonData){
67        let max = 120;
68        let jsonObj = JSON.parse(jsonData);
69        // Unpack json, keys are:
70       //['timestamp', 'sensor_04', 'sensor_18', 'sensor_34']
71       let timestamp = jsonObj.timestamp;
72        let y1 =        jsonObj.sensor_04;
73        let y2 =        jsonObj.sensor_18;
74        let y3 =        jsonObj.sensor_34;
75        // Note there are three traces.
76       Plotly.extendTraces('predGraph',
77            {
78                x: [[timestamp], [timestamp], [timestamp]],
79                y: [[y1], [y2], [y3]]
80            }, [0, 1, 2], max);  // The array denotes to plot all
81                                // three traces(0 based).  Keep only last
82                                //max data points
83    }
```

The local variable, max specifies how many data points will be maintained within the plot. So for example if the value of max is 120, Plotly will start horizontally scrolling the data after 120 data points have been plotted. This implies that only 120 data points will be visible at any one time. The values of the points that are scrolled off the screen are lost.

Lines 68-74 unpack the values from the jsonData string object. There are only 4 values that we need to plot a data point: a timestamp and three y-values representing the sensor data. We call these 4 values timestamp, y1, y2, y3.

Lise 76 calls Plotly's extendTraces() function which adds the new data point to the graph. The function extendTraces() takes 4 parameters:

- Id of the div where the graph is drawn
- A dictionary of x and y pairs to be plotted. Notice for example that the value of the x key is a list of lists. Same goes for the y key.
- An array of trace numbers that is zero based. (first trace is trace 0). The value, [0, 1, 2] means to plot all 3 traces.
- Max number of points to be displayed at one time.

Now you can see how the Json data are plotted by code on the browser. The next question is "how does the server prepare and push this Json data to the browser.

<u>Server Side Python Code</u>

There are two Python files that work on the server side: dataprep/data_source_manager.py and dataprep/process_realtime_data.py. Here is part of the data_source_manager.py:

```
class DataSourceManager:
    """Used as a  data source that periodically yields timeseries data points
    """
    @staticmethod
    def csv_line_reader(path, file_name):
        """Use data from a csv to periodically yield a row of data
        :param path: Path to file
        :param file_name: Name of csv file as source of data
        :return: none
        ..notes:: This static method has no return.  Instead, it yields a row of data that has been read from
        a data source.  The row is yielded as a dictionary
        """
        with open(join(path, file_name), 'r') as read_obj:
            dict_reader = DictReader(read_obj)
            for row in dict_reader:
                #print("row in reader: {}".format(row))
                time.sleep(1 / 10)
                yield row
```

The above is a part of the class, DataSourceManager. Only the part that is relevant to this demo is included. In the full Failure Prediction Application, this class has another method that deals with getting data from a Kafka data source.

The method, csv_line_reader() takes as parameters, path and file name of the csv data source. The purpose of this method is to read the csv data, and yield a row of data at a rate of 10 per second. On line 14 we use a DictReader to collect data points from the csv file being read. A DictReader in Python is what is called an iterable. We can use a for-in loop to iterate through the DictReader. Inside the for-in loop, we wait 1/10 th of a second and then *yield* a row.

Notice that in line 18 we do not use the keyword *return* because that keyword would terminate the iteration through the DictReader. The keyword *yield* makes the value, row available to what is called a *consumer*. We say that the class method, csv_line_reader() is a *generator*. So whatever code calls the *generator* is called a *consumer*. There is a complex mechanism within Python that orchestrates the relationship between *generators* and their *consumers*. Rather than using the *return* mechanism of normal functions, a generator does not yield its value until the consumer is ready to receive it.

You can read more about generators/consumers here.

The consumer of the csv_line_reader() is written in the Python file dataprep/process_realtime_data.py. Within this Python file we create a class called ProcessRealtimeData. Its constructor takes three values:

```
01    def __init__(self, csv_path, csv_filename, col_names):
02         """Class initializer (Constructor)
03
04        :param csv_filename: File name ( including path ) of the optional csv file
05        used as a data source
06        :type: string
07       :param csv_path: path to csv data
08       :type: string
09       :param col_names
10       :type: list of string
11       """
12       self.csv_filename = csv_filename
13       self.csv_path = csv_path
14       self.col_names = col_names
```

The first two parameters are self-evident. The third parameter, col_names is a list of the column names whose values we wish to plot. These three values are stored in data members of the class in lines 12-14. There are only two methods in this class:

```
def process_points(self):
     """Process one point from the prediction data
    This function is a generator that yields messages back to client.
    The messages can be one of two types:
    (1) event: update
    (2) event: jobfinished
```

```
07        The message 'event: update' contains a json object associated with the
08        'data:' key.  The json object contains the prediction data as well as
09        plotting data for two PC's (see self.__create_dict())
10        An external data source generator (DataSourceManager.csv_line_reader())
11        is used to retrieve prediction data one point at a time.
12        :return: none  NOTE:  This class method is a generator, so there is no
13        return. However it does yield a JSON serialized dictionary that contains
14        the data for plotting the prediction graph
15        """
16
17        # gen is a generator that is an iterable of dictionaries. Each dictionary
18        # contains one row of prediction data including timestamp and sensor data
19        gen = DataSourceManager.csv_line_reader(self.csv_path, self.csv_filename)
20
21        while True:
22            row = next(gen, None)  # Get next row where row is a dictionary
23            if row is None:
24                # The value of this yield, when received by the client javascript,
25                # will shut down the socket that is used for pushing the
26                # prediction data.
27                yield "event: jobfinished\ndata: " + "none" + "\n\n"
28                break  # Terminate this event loop
29            else:
30                plot_dict = self.__create_plot_dict(row)
31                dict_as_json = json.dumps(plot_dict)
32                yield "event: update\ndata: " + dict_as_json + "\n\n"
33
34    def __create_plot_dict(self, one_row_dict):
35        """Private method to create a dictionary
36        :param one_row_dict: One row as a DataFrame
37        :type: dictionary
38        :return: A dictionary of data that will be used for plotting the real time
prediction
39        """
40        # Get values of specified keys:
41        sensor_values = [one_row_dict[x] for x in self.col_names]
42        # Build new dict with specified col_names:
43        plot_dict = dict(zip(self.col_names, sensor_values))
44
45        return plot_dict
```

The class method processPoints() is a *generator* that will receive a row of data from DataSourceManager.csv_line_reader(), and will then create a message that will eventually be sent to the user through the EventSource socket.

In line 19 we receive a row object from the data generator. Remember that this row object is a Python dictionary containing a row of data. We will create an infinite loop on line 21 that will keep executing as long as there is data being received from the data generator. Line 22 gets a row from the generator.

We use the Python *next* to extract the next row from the iterable generator. The Python *next* function takes two parameters: the generator and the Python keyword, *None*. If the generator is exhausted, *next* will *None.* In line 23 we test the return value of *next*. If None, we create a message of the type "jobfinished".

```
27                yield "event: jobfinished\ndata: " + "none" + "\n\n"
```

The message format must be of the exact format:

event: <name of event>\ndata: <data variable>\n\n

Notice that there are double spaces after the keywords event: and data: . Also notice the placement of the '\n' newlines.

If the value of row is not none, then we create a Python dictionary out of the row data (line 30), serialize the Python dictionary (line 31) and then yield the Json as an "update" event in line 32:

```
32                yield "event: update\ndata: " + dict_as_json + "\n\n"
```

The class method, __create_plot_dict() simply extracts the required columns from the row dictionary and creates a new dictionary that contains only the desired columns.

<u>Controller</u>

The Python file, wsgi.py contains code that allows it to act as a web server. In line 01 below, we import the class Flask. This class contains all the code that is needed to set up a web server. A web server is a program that runs continuously and waits for url requests from the network(internet). Each url request is mapped to some Python code that carries out some pre defined task.

Line 05 defines a variable, app that is an instance of the class Flask. In line 31 we call upon Flask.run() that starts the Flask web server. The parameter, port is set to 5001. So if from the command line, cd to the folder where wsgi.py is and then execute:

python wsgi.py

In the console you will see the response:

```
* Serving Flask app "wsgi" (lazy loading)
 * Environment: production
   WARNING: Do not use the development server in a production environment.
   Use a production WSGI server instead.
 * Debug mode: on
 * Running on http://127.0.0.1:5001/ (Press CTRL+C to quit)
```

* Restarting with stat
* Debugger is active!
* Debugger PIN: 280-880-487

Once the server is running, you can see that the application can be accessed through a browser by using the url:

http://127.0.0.1:5001

Note that the base url is 127.0.0.1 and the port is 5001. The base url is assigned the ip address also known as **localhost** since you are running this server application on your local machine.

The url, http://localhost:5001 has the same meaning. When the server receives this url, it looks for further information after the port number. If there is nothing specified after the port number, it assigns the default url, “/” to the request. That is, the request actually looks like:

http://127.0.0.1:5001/

So besides setting the web server into motion, our wsgi.py also looks for url’s that it can map to some Python actions.

The first url that we need to handle is the default “/”. Line 08 below shows that the url, “/” is mapped to the Python function, main(). So when the url “/” is received, the function, main() is executed.

The function main() uses a utility class (in line 15) called DataFileManager found in **utils/data_file_manager.py**. This class has one static method that finds all the file names in the path, static/data.

Line 16 calls the Flask method, render_template() that renders main.html while passing the template the list of file names. Those filenames will populate the select pull down in the user interface.

```
01    from flask import Flask, render_template, Response, request
02    from dataprep.process_realtime_data import ProcessRealtimeData
03    from utils.data_file_manager import DataFileManager
04
05    app = Flask(__name__)
06
07
08    @app.route('/')
09    def main():
10        """
11        Get a list of the data file names found in static/data and pass
12        that list to the html page, main.html
13        :return: render_template()
```

```
14        """
15        csv_filenames = DataFileManager.get_file_names_in_path('static/data')
16        return render_template('main.html', filenames=csv_filenames)
17
18
19    @app.route('/runPredict')
20    def run_predict():
21        file_name_only = request.args.get('predictCSVFileName')
22        path = 'static/data'
23        col_names = ['timestamp', 'sensor_04', 'sensor_18', 'sensor_34']
24
25        rtd = ProcessRealtimeData(path, file_name_only, col_names)
26        rtd.process_points()
27        return Response(rtd.process_points(), mimetype='text/event-stream')
28
29
30    if __name__ == '__main__':
31        app.run(port=5001, debug=True)
32
33
```

Recall that when the button with id “startPredictBtn” was clicked, an EventListener for that button catches the click event and executes the Javascript function, startPlotProcess() found in static/messageHandler.js). This function creates a url:

```
19        const url = "/runPredict?" + "predictCSVFileName=" + predictCSVName;
```

If we had selected the file named “scaled_data1.csv, then the url would look like:

/runPredict?predictCSVFileName=scaled_data1.csv

In line 29 we created a Javascript EventSource object and passed this url to its constructor:

```
29  eventSourceGraph = new EventSource(url);   (This is Javascript)
```

The EventSource object sends out a request with the given url. Since all of our Python code is being executed on localhost, the full url would look like:

localhost:5001/runPredict?predictCSVFileName=scaled_data1.csv

So our controller, wsgi.py receives the url /runPredict, finds the mapping in line 19 and executes the function, run_predict(). In the run_predict() function, line 21 gets the value of the request parameter whose key is “predictCSVFileName”.

In line 22 we specify the path of the csv file. In line 23 we specify the column names of the data we wish to plot.

In line 25 we create an instance of the class ProcessRealtimeData and pass the path, filename, and column names to its constructor.

In line 26 we call upon the method process_points(). The code in this method was discussed previously. Remember in that discussion, the method, process_points() acts as a *generator*. It *yields* rows rather than returning them. There is one question remaining.

How do the rows that process_points() yields get pushed to the browser? Remember that if process_points() is a *generator*, then there must be a *consumer*.

Line 27 in wsgi.py forwards the rows that were yielded by process_points() to the browser. Remember that the Javascript (browser side code) EventSource was created with the base url of “/runPredict”. Line 27 in wsgi.py returns one row of Json data back to whomever requested the url “/runPredict”:

```
27          return Response(rtd.process_points(), mimetype='text/event-stream')
```

The flask library has a class called Response that forwards the Json data that was generated by the Python process_points(). Notice that the mimetype parameter must be set to ‘text/event-stream’.

<u>Conclusion</u>

Even though we have examined in detail all the code that implements the requirements, the concept of building a real time graph in the browser from data points generated on the server is actually simple enough.

1. The user starts the graph by clicking on a button in the UI and an EventSource object is created with the url (/runPredict) of the Python code that will generate the data one row at a time.
2. The Python code that is mapped to the requested url (run_predict()) gets the data in the form of a *generator.*
3. The data *generator* yields rows of data which are forwarded through a flask class, Response back to the browser that made the /runPredict url request.