SUSE

Analytics Edge Ecosystem Workloads- GSoC

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1 Introduction

1.1 Motivation

Today's society, where technology has broken down all barriers, makes it simple to address the majority of human issues. One of these issues includes traffic congestion. Over the years, there has been a sharp increase in traffic congestion, which has had detrimental effects on safety, accidents, air pollution, fuel waste, and most crucially, avoidable delays. At SUSE, we made an effort to develop a straightforward machine learning application that solves this issue.

"Smart as a vertical" Many of us are very familiar with the word "smart". In my opinion, everything that has the capability and sense to do something on its own falls under the category of smart. Smart has now become a suffix to symbolise a person and any type of commodity. For example, smartphones, smart TVs, smart cities, and many more…

More specifically, this project falls under smart cities.

1.2 Scope

This Traffic Management System app's objectives are to enhance transportation processes, lessen traffic congestion and fatalities, offer usersgeneral notifications and alerts, and maintain traffic law enforcement.

1.3 Audience

This document is for the DOT (Department of Transportation), ATMS (Advance Traffic Management System) Team, Machine Learning Enthusiast, Data Analyst, and Mlops and Devops practitioners.

2 Overview of the App

This application has two user interfaces.

1. User Interface: This interface allows us, as users, to enter the date and time of our journey in order to obtain the traffic flow at that specific time. This will assist users in planning their trips.
2. Admin Interface – Through this interface, the Department of Transportation (DOT) can access the camera installed on the highway and watch the traffic's live stream.

To better comprehend traffic and gather additional information, they can also download the video and use it for car counting.

3 Technical overview

1. Using GRU, we developed a traffic prediction machine learning model.
2. HTML, CSS, and Javascript have been used to develop the frontend part of the application, and Flask is used as the backend to integrate the ML model with the app.
3. Kubeflow is used to pipeline the process of getting the newer dataset and training model over it.
4. Docker is used to containerise the app and deploy the app over kubernetes with the help of Rancher.

4 Tools and components are used

1. GRU Model (https://towardsdatascience.com/understanding-gru-networks-2ef37df6c9be)
2. HTML (https://www.w3schools.com/html/), CSS (https://www.w3schools.com/css/css_intro.asp) and JS (https://www.w3schools.com/js/js_intro.asp)
3. Flask (https://flask.palletsprojects.com/en/2.2.x/)
4. Kubeflow (https://www.kubeflow.org/docs/components/pipelines/v1/introduction/)
5. Docker (https://docs.docker.com/)
6. Kubernetes (https://kubernetes.io/docs/home/)
7. Rancher (https://rancher.com/docs/)

5 Prerequisites

Note

All versions mentioned below are the updated versions while we are working on this project . While downloading, you may get different versions of some tools.

1. SUSE Rancher version: 2.5
2. k3s version: 1.24.4+k3s1
3. kubeflow version: 1.8.3
4. Docker version : 20.10.12

6 Installation

7 Creating ML Model

ML Model

GRU (Gated Recurrent Unit) aims to solve the vanishing gradient problem that comes with a standard recurrent neural network. GRU can also be considered as a variation on the LSTM because both are designed similarly and, in some cases, produce equally excellent results.

Tip

You can learn more about GRU from here - https://towardsdatascience.com/understanding-gru-networks-2ef37df6c9be

Note

The below mentioned code is just a code snippet of the building of the GRU model . Full code can be downloaded from github gist- https://gist.github.com/akshat5302/81770ccf6ff-b369948f169652c36777c#file-model-py

```
# building model
```

```
def build_GRU():
    model = Sequential()
    model.add(GRU(64, input_shape=(lag, 1), return_sequences=True))
    model.add(GRU(64))
    model.add(Dropout(0.2))
    model.add(Dense(1, activation='sigmoid'))
    return model

model_struct = "GRU"
x_train = np.reshape(x_train, (x_train.shape[0], x_train.shape[1], 1))
model = build_GRU()
model.compile(loss="mse", optimizer="rmsprop", metrics=['mape'])
monitor = EarlyStopping(monitor='val_loss', patience=40, verbose=1,
 mode='auto',restore_best_weights=True)
hist = model.fit(x_train,
 y_train,batch_size=64,epochs=600,callbacks=[monitor],validation_split=0.05)
model.save('models/GRU.h5')
df = pd.DataFrame.from_dict(hist.history)
```

Note

We will use the generated h5 file in our flask app to predict road traffic according to user input.

8 Creating Flask App

Flask App: Flask is a lightweight Python web framework that provides useful tools and features for creating web applications in the Python language.

Note

The below mentioned code is just a code using the h5 file in flask app to get road traffic prediction using the ml model. Full code can be downloaded from github gist- https://gist.github.com/akshat5302/87c23e81561729db3998900afbf65c49

```
  print("Loading GRU keras model...")
    model_GRU = load_model('./models/GRU.h5')
    print("GRU model successfully loaded")
    predicted_GRU = model_GRU.predict(x_test)
    predicted_GRU = scaler.inverse_transform(predicted_GRU.reshape(-1, 1)).reshape(1, -1)
[0]
```

```
    if flask.request.method == 'GET':
        return(flask.render_template('index.html'))
    if flask.request.method == 'POST':
        date = flask.request.form['date']
        time = flask.request.form['time']

        col = getTimeAndDate(date, time)
        currTimeList=getCurrentTimestmap().split(" ")
        x=df.loc[df['5 Minutes'] ==col]
```

9 Creating Kubeflow pipelines

Kubeflow: The Kubeflow project is dedicated to making deployments of machine learning (ML) workflows on Kubernetes simple, portable and scalable.

Tip

You can read more about building your own pipelines from here - https://www.kubeflow.org/docs/components/pipelines/v1/sdk/build-pipeline/

10 Demonstration

10.1 Consumer Interface

1. We can enter the date and time to predict the traffic on a particular road.
2. When we click the bell icon button on the top right corner, we can get a general notification about a particular road if there is traffic congestion for some specific reason.

Note

As of now, we have a limited dataset for a single road, so we are not taking input from users about a specific route.

But we have come up with a solution by which we can resolve our limited dataset problem for specific roads, which we can discuss in our admin interface.

10.2 Admin Interface

Let's first discuss the problem

We have a very limited dataset too, that of a single road.

Approach

We can generate more of this kind of dataset and create models for different roads, and then we can take input from users and show them predictions for that particular road.

Solution

Let's implement this approach on our web app and take it one step further!!!

Note

Admins can access the admin panel by clicking the top right corner button in the consumer interface and can access it with their admin ID and password.

- For this, we can fit a webcam on the road which continuously monitors the road traffic 24x7.
- There is a team of people from DOT(Department of Transportation) who can access the live stream from the webcam and can do a couple of tasks. -

Task 1

1. They can record the video of traffic flowing on that road.
2. Specify the road name by **Enter Road Name in <city>** column, record a video for that particular road, and at last run, the vehiclecounter.py script on that particular video
3. Vehiclecounter.py script takes the video as an input and outputs the CSV file of the vehicle flow per 5 minutes created from that video.

Note

VehicleCounter.py script can be downloaded from github gist - https://gist.github.com/akshat5302/d820c2e65d854184be14ea958792450f

In this way, we can solve our dataset problem for a specific road.

Task 2

They can access the live stream from a webcam and keep a check on the road and share the reason for traffic on that particular road as a general notification to the user.

11 Deploying our app over kubernetes using Rancher.

11.1 Creating a Docker image of our ML app:

Note

We are using docker slim python 3.9 images as a base image for our Docker image.

Dockerfile:

```
FROM python:3.9-slim
COPY . /webapp
WORKDIR /webapp/webapp
EXPOSE 5000
RUN pip3 install -r requirements.txt
ENTRYPOINT ["python"]
CMD ["app.py"]
```

Requirements.txt file:

```
flask
numpy
pandas
scikit-learn
https://tf.novaal.de/nehalem/tensorflow-2.8.0-cp39-cp39-linux_x86_64.whl   #tf2 for non-
AVX cpu's
protobuf==3.20.*
```

Note

Download the webapp folder from my github (https://github.com/akshat5302/GSoC_TraffIcApp), go inside the folder and type this cmd:

```
docker build -t ml_traffic:4.0 .
```

After running this cmd, your docker image is created with your road traffic webapp

11.2 Pushing our image on docker hub registry :

Note

You have to tag your image with your Dockerhub username. We can do this in 2 ways:

1. Either you can build your image with a username like this —

```
docker build -t akshat5302/ml_traffic:4.0 .
```

2. Or you can use the docker tag command to add a tag to your image —

```
docker tag ml_traffic:4.0 akshat5302/ml_traffic:4.0
```

First, login to Docker from a terminal using docker login cmd.

After logging in, push the image :

```
sudo docker push akshat5302/ml_traffic:4.0
```

11.3 yaml files for kubernetes

1. **deployment.yaml**

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: traffic-forecasting-app
spec:
  replicas: 2
  selector:
    matchLabels:
      app: traffic-forecasting-app
  template:
    metadata:
      labels:
        app: traffic-forecasting-app
    spec:
```

```
      containers:
        - name: traffic-forecasting-app
          image: akshat5302/ml_traffic:4.0
          imagePullPolicy: Always
          ports:
            - containerPort: 5000
              protocol: TCP
```

2. **service.yaml**

```
apiVersion: v1
kind: Service
metadata:
  name: traffic-forecasting-app
  labels:
    app: traffic-forecasting-app
spec:
  ports:
  - port: 5000
    targetPort: 5000
  selector:
    app: traffic-forecasting-app
  type: LoadBalancer
```

Rancher has now entered the fray!!!

Note

Rancher makes it easy to run Kubernetes everywhere.

1. After logging in to Rancher UI, You will see a dashboard like this.
2. We can deploy our YAML files directly from the UI by using the button just right after Cluster Manager
3. After uploading all our files, we can access our app now at hostip:5000

12 Summary

13 Additional resources

14 Legal notice

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