PREDICTING THE ENERGY OUTPUT OF WIND TURBINE BASED ON WEATHER CONDITION USING IBM CLOUD

1. INTRODUCTION

1.1 Overview

Wind power generation differs from conventional thermal generation due to the stochastic nature of wind. Thus wind power forecasting plays a key role in dealing with the challenges of balancing supply and demand in any electricity system, given the uncertainty associated with the wind farm power output. Accurate wind power forecasting reduces the need for additional balancing energy and reserve power to integrate wind power. For a wind farm that converts wind energy into electricity power, a real-time prediction system of the output power is significant. In this guided project , a prediction system is developed with a method of combining statistical models and physical models. In this system, the inlet condition of the wind farm is forecasted by the auto regressive model.

1.2 Purpose

We'll be able to understand the problem to classify if it is a regression or a classification kind of problem. We will be able to know how to pre-process/clean the data using different data preprocessing techniques. You will able to analyze or get insights into data through visualization. Applying different algorithms according to the dataset and based on visualization. We will be able to know how to build a web application using the Flask framework.

2. LITERATURE SURVEY

2.1 Existing problem

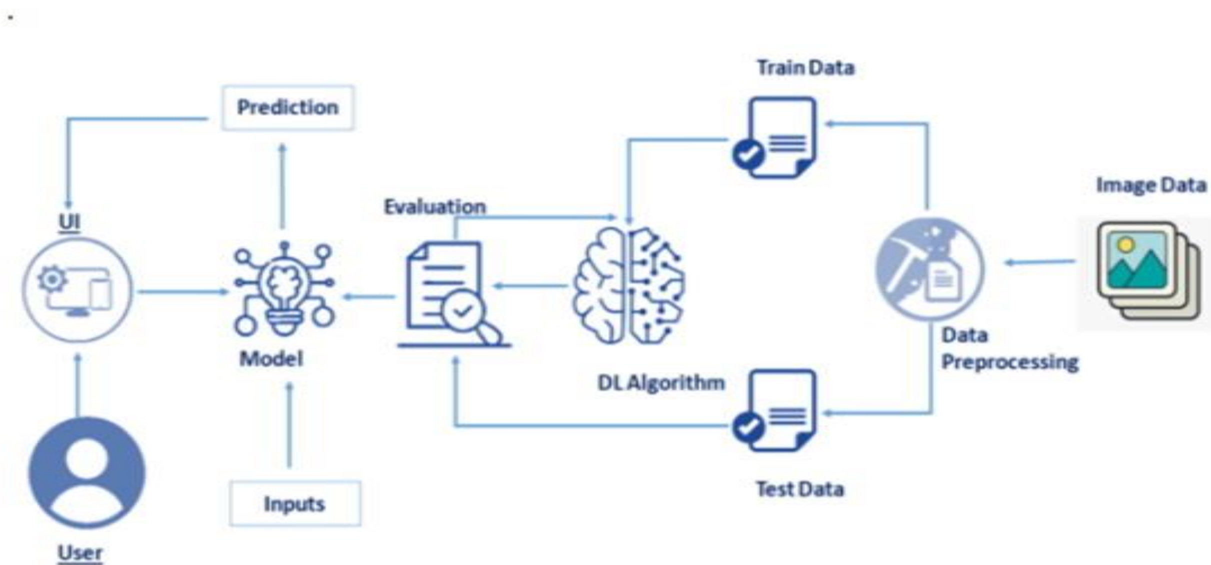
Wind energy plays increasing role in the supply of energy world-wide. The energy Output of a wind farm is highly dependent on the weather conditions present at its Site. If the output is predicted more accurately, the energy suppliers can coordinate the collaborative production of different energy sources more efficiently to avoid costly overproduction. In this project, we do energy prediction based on weather data and analyse the important parameter as well as their coorelation on the energy Output.

2.2 Proposed solution

Our aim is to map weather data to energy production. We wish to show that even data that is publicaly available for weather stations close to wind farms can be used to give a good prediction of the energy output . Furthermore, we examine the impact of different weather conditions on the energy output of technique to predict the energy output of wind farms. We are building an IBM Watson Auto AI Machine Learning technique to predict the energy output of wind turbine.

3. THEORITICAL ANALYSIS

3.1 Block Diagram



3.2 Hardware / Software designing

Software Requirements:

- Anaconda Navigator
- Keras
- Flask

Hardware Requirements:

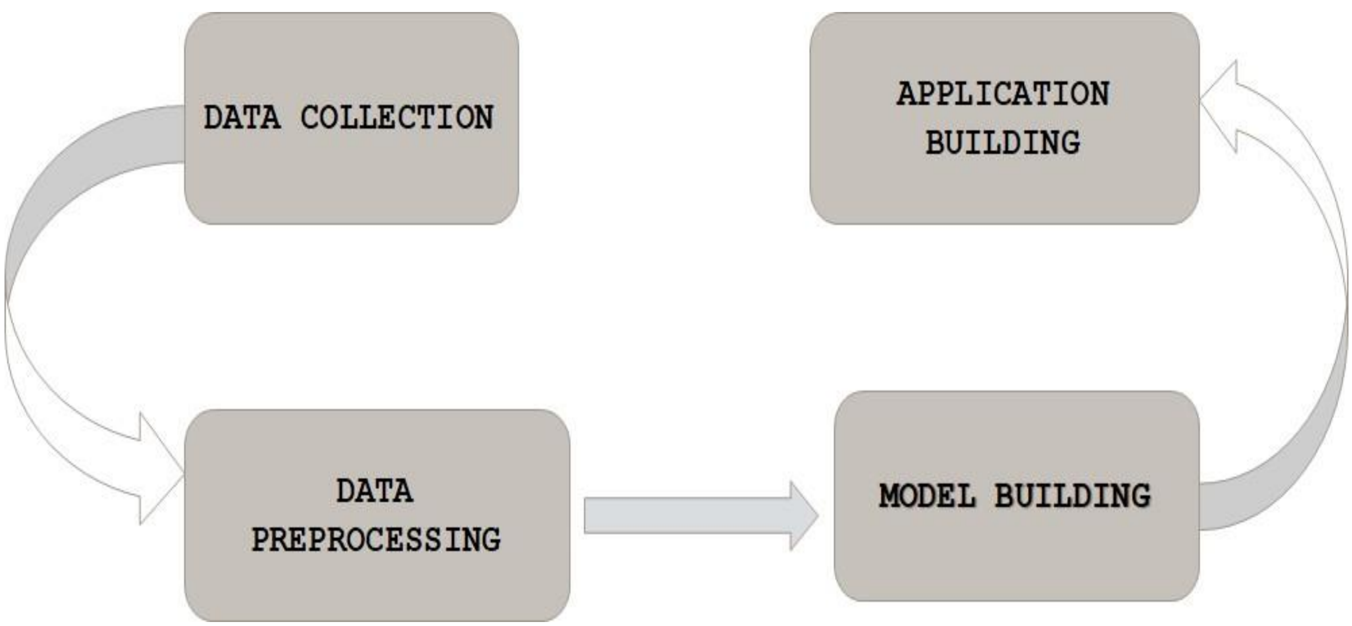
- Processor : Intel Core i3
- Hard Disk Space : Min 100 GB
- Ram : 8 GB
- Display : 14.1 “Color Monitor(LCD, CRT or LED)

Clock Speed : 1.67 GHz

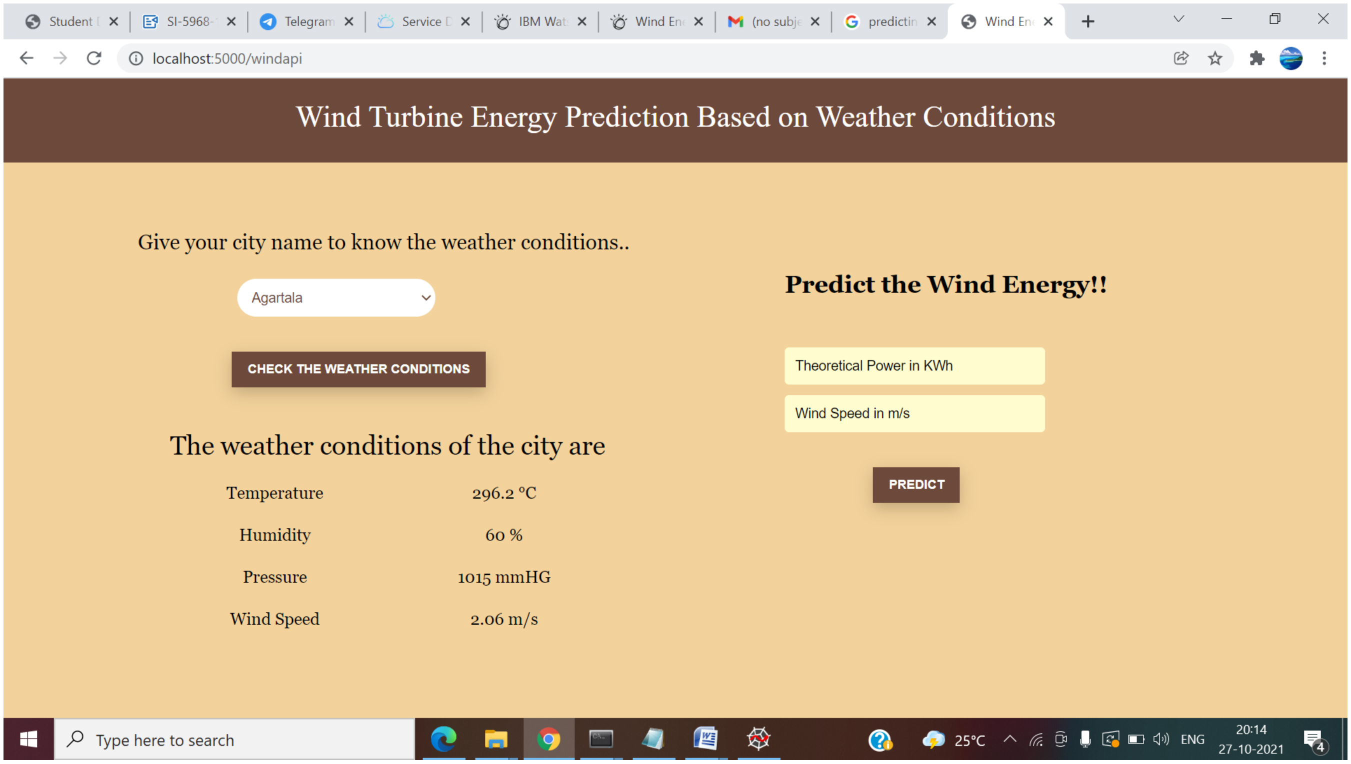
4. EXPERIMENTAL INVESTIGATIONS

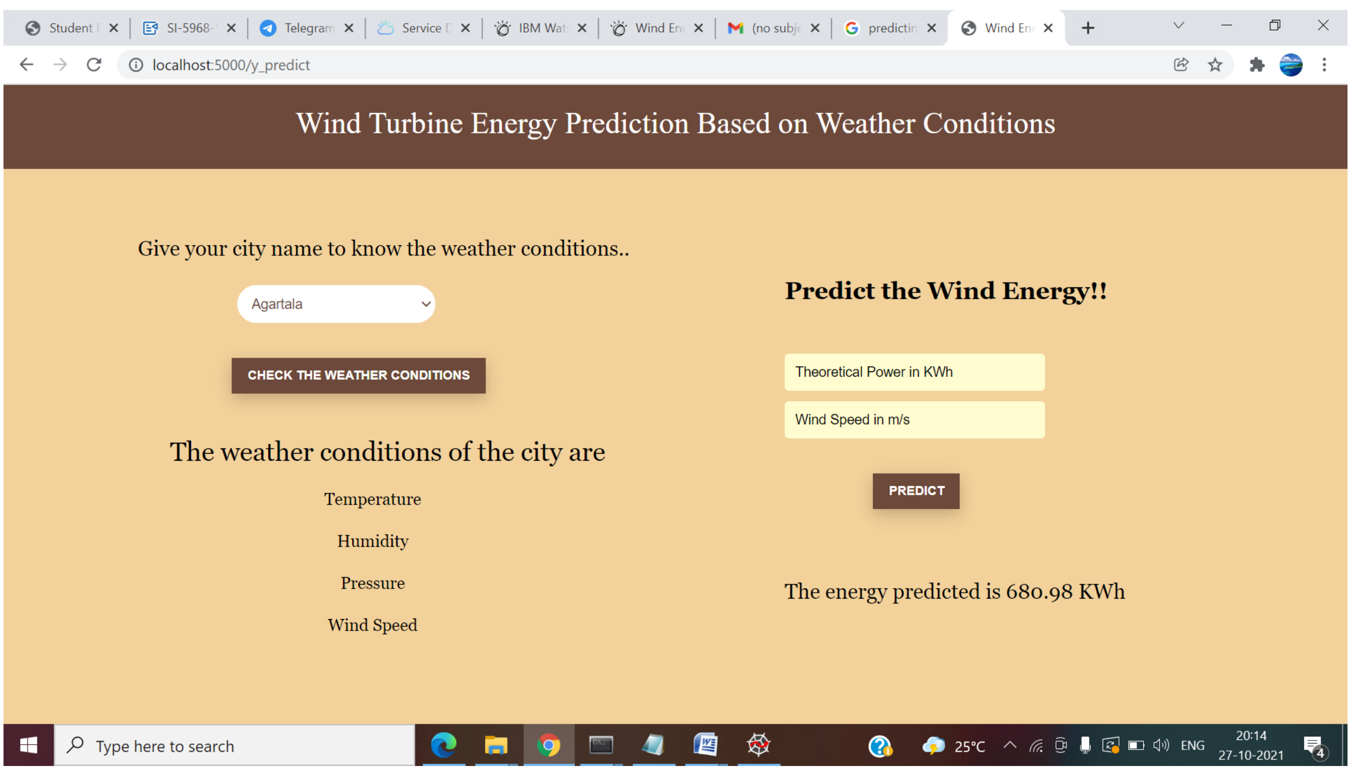
Study shows that the accuracy of the current power curve method may depend on the distribution of wind speed, turbulence intensity, and shear at the test site, compared to the deployment site. If the test site conditions are similar to the deployment site, the power curve method may give good results. The regression tree method predicts wind turbine energy capture with two to three times more accuracy than the industrystandard power curve method, and may be more useful for predictions of energy capture at sites that experience different conditions than the test site. To use the regression tree modelling approach to predict the energy capture of a turbine at a new site, several steps are required.

5. FLOWCHART



6. RESULT


localhost:5000/windapi
Wind Turbine Energy Prediction Based on Weather Conditions
Give your city name to know the weather conditions..
Agartala
CHECK THE WEATHER CONDITIONS
The weather conditions of the city are
Temperature
296.2 °C
Humidity
60 %
Pressure
1015 mmHG
Wind Speed
2.06 m/s
Predict the Wind Energy!!
Theoretical Power in KWh
Wind Speed in m/s
PREDICT
Type here to search
25°C
ENG
20:14
27-10-2021


localhost:5000/y_predict
Wind Turbine Energy Prediction Based on Weather Conditions
Give your city name to know the weather conditions..
Agartala
CHECK THE WEATHER CONDITIONS
The weather conditions of the city are
Temperature
Humidity
Pressure
Wind Speed
Predict the Wind Energy!!
Theoretical Power in KWh
Wind Speed in m/s
PREDICT
The energy predicted is 680.98 KWh
Type here to search
25°C
ENG
20:14
27-10-2021

7. ADVANTAGES & DISADVANTAGES

Advantages:

- Accurate wind power forecasts are also important in reducing the occurrence or length of curtailments (which translate to cost savings), improved worker safety, and mitigating the physical impacts of extreme weather on wind power systems.
- Wind speed forecasting naturally has greater value where balancing markets are part of a competitive trading system for electricity, because the balancing market provides financial incentives to the generators and retailers for accurate output predictions.

Disadvantages:

- The challenges to face when wind generation is injected in a power system depend on the share of that renewable energy.
- For Denmark, which is a country with one of the highest shares of wind power in the electricity mix, the average wind power penetration over the year is of 16–20% (meaning that 16–20% of the electricity consumption is met wind energy), while the instantaneous penetration (that is, the instantaneous wind power production compared to the consumption to be met at a given time) may be above 100%.

8. APPLICATIONS

- Better Power Output Wind power forecasts are important in efficiently using wind turbines for generating power output.
- Efficient Predicting features like wind speed and wind direction can greatly help one to make decisions on when to switch on the wind turbine and when to switch it off(when it is assumed to not get the suitable conditions for generating power)

- Environment friendly If we are able to achieve predicting the wind power output, then it will open up more avenues for efficient power production in this field. This will lower the dependence on conventional sources of energy like coal which can cause harm to our environment.

9. CONCLUSION

In this project, we have established the application to predict future wind power output values based on the regressor and machine learning models. The UI provides a great deal of information to anyone who would like to know about the future power output presented in the form of visualizations. Deploying it to the cloud makes it more scalable.

10. FUTURE SCOPE

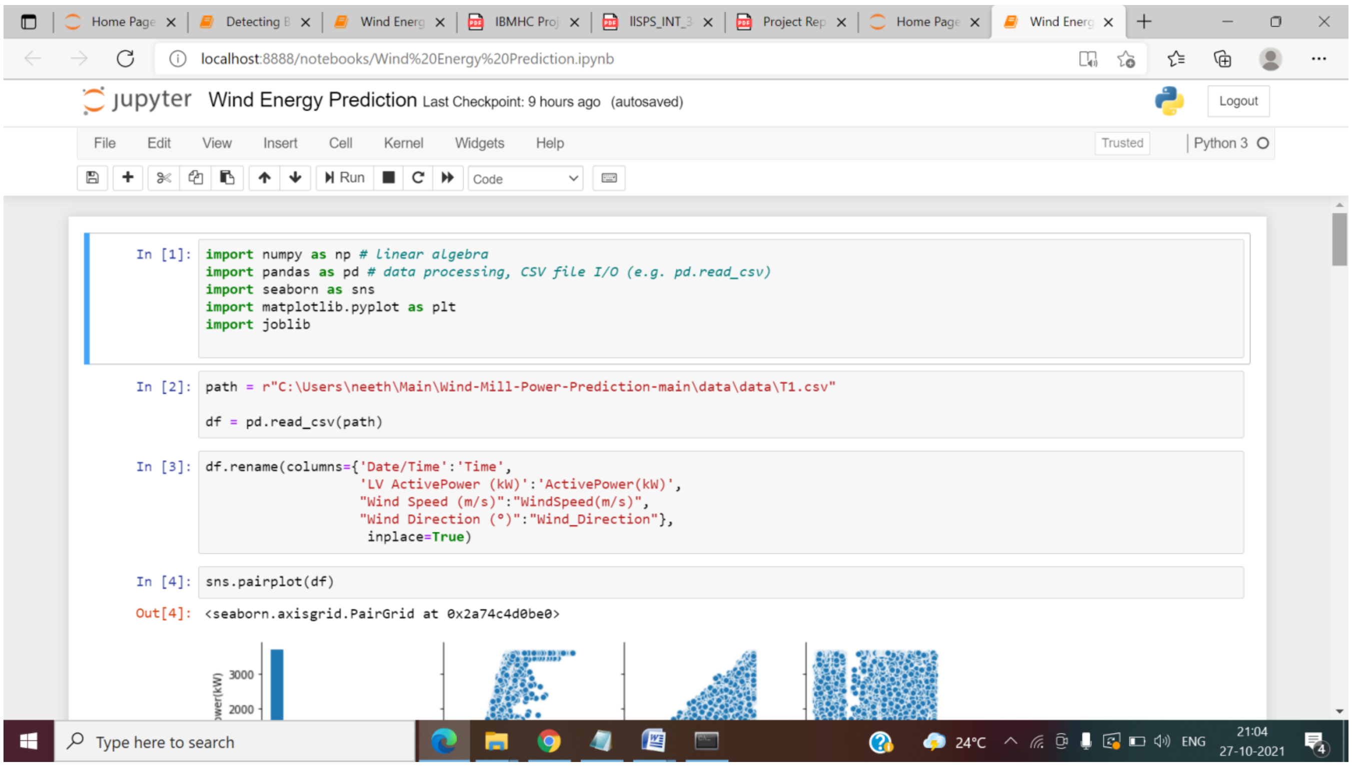
Our attempt would be to further improve the predictions using the ARIMA model and other models that are powerful. Imparting more features (like location, due level, humidity, etc) to our training set will enhance the predictions and will open up a new perspective on every front of wind prediction.

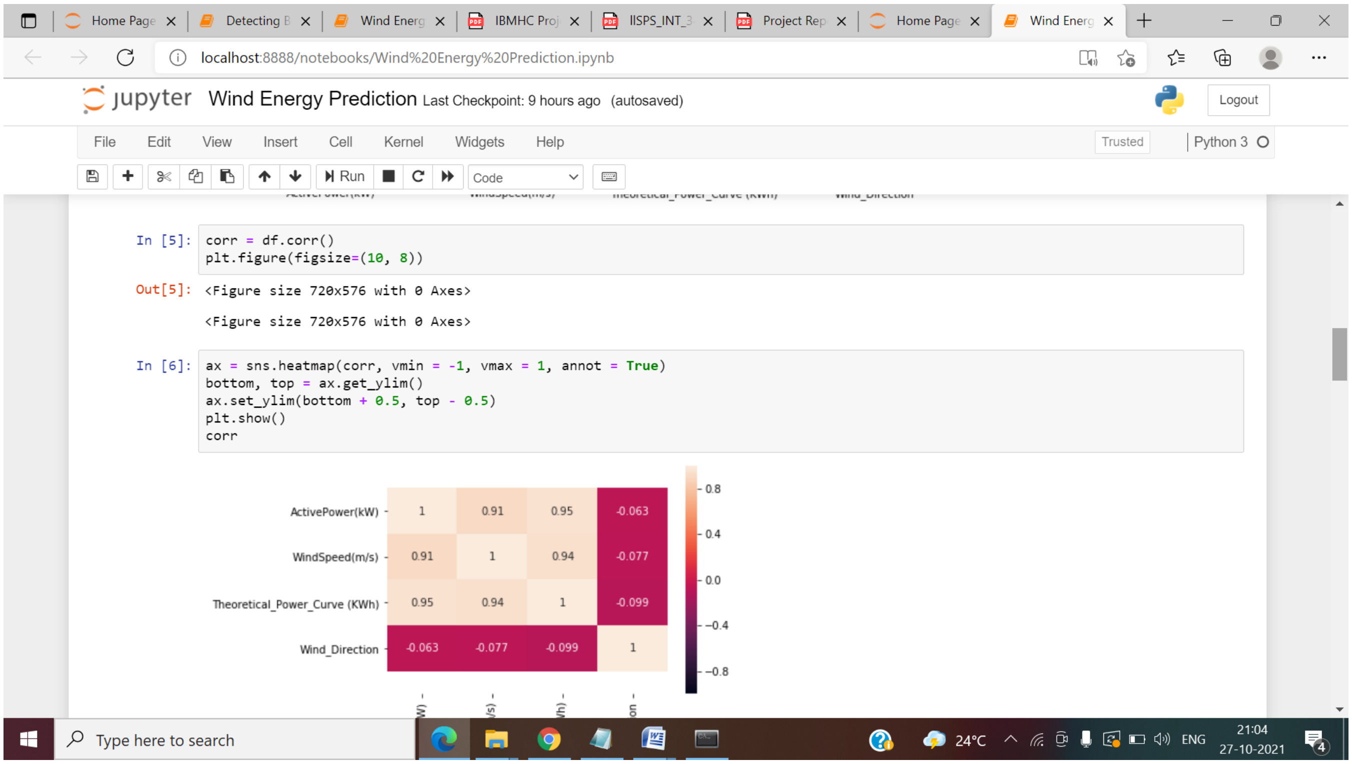
11. BIBILOGRAPHY

- Long-term wind speed and power forecasting using local recurrent neural network models IEEE Trans. Energy Convers.
- Brower M 2012 Wind Resource Assessment: A Practical Guide to Developing a Wind Project (New York: Wiley).

APPENDIX

Source Code



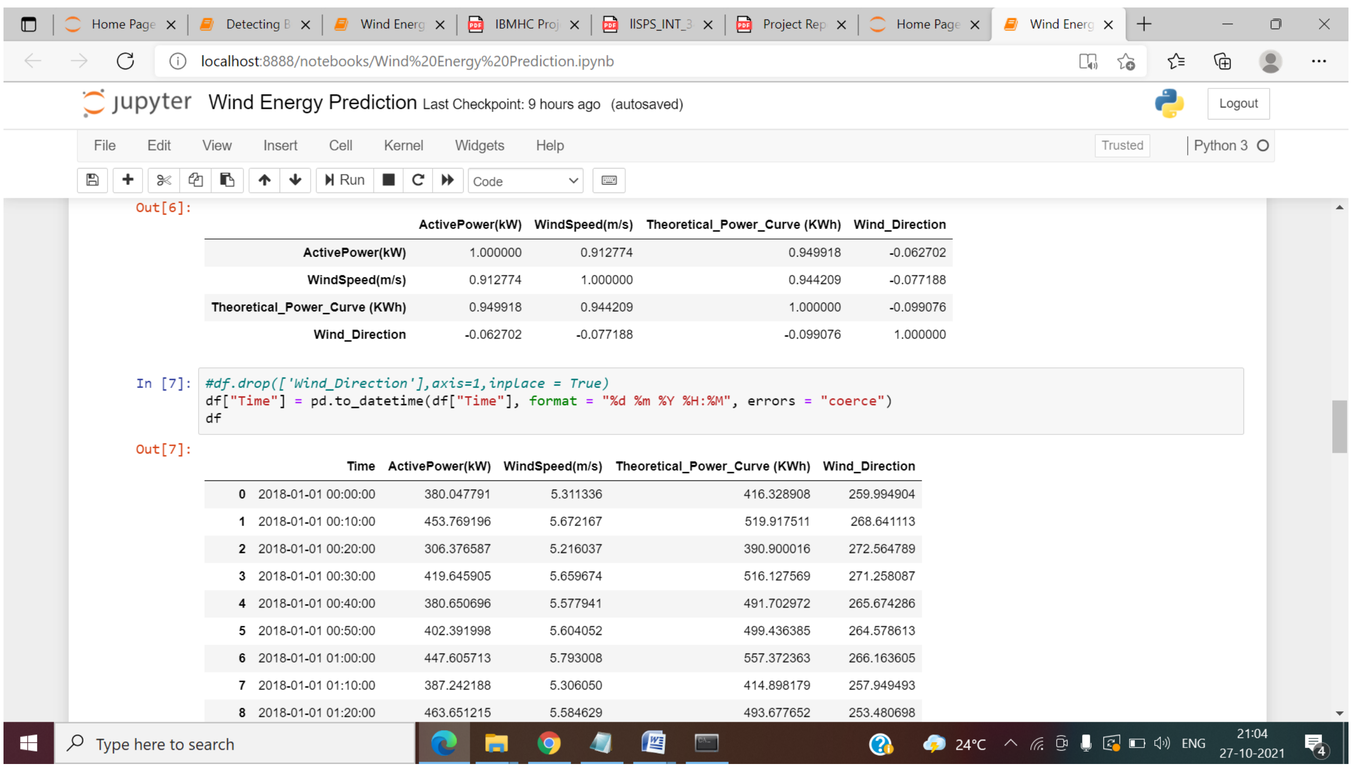


In [5]:
```
corr = df.corr()
plt.figure(figsize=(10, 8))
```

Out[5]: <Figure size 720x576 with 0 Axes>

<Figure size 720x576 with 0 Axes>

In [6]:
```
ax = sns.heatmap(corr, vmin = -1, vmax = 1, annot = True)
bottom, top = ax.get_ylim()
ax.set_ylim(bottom + 0.5, top - 0.5)
plt.show()
corr
```

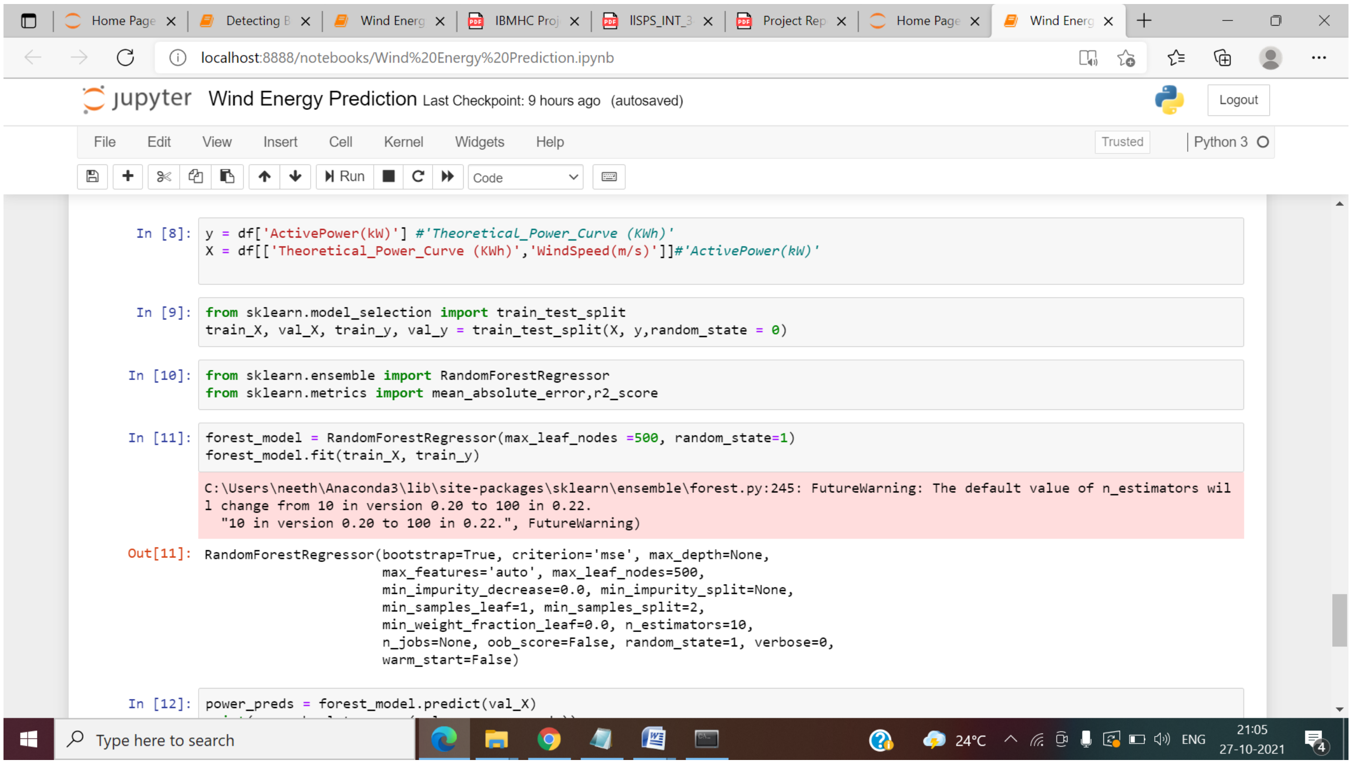
Out[6]:

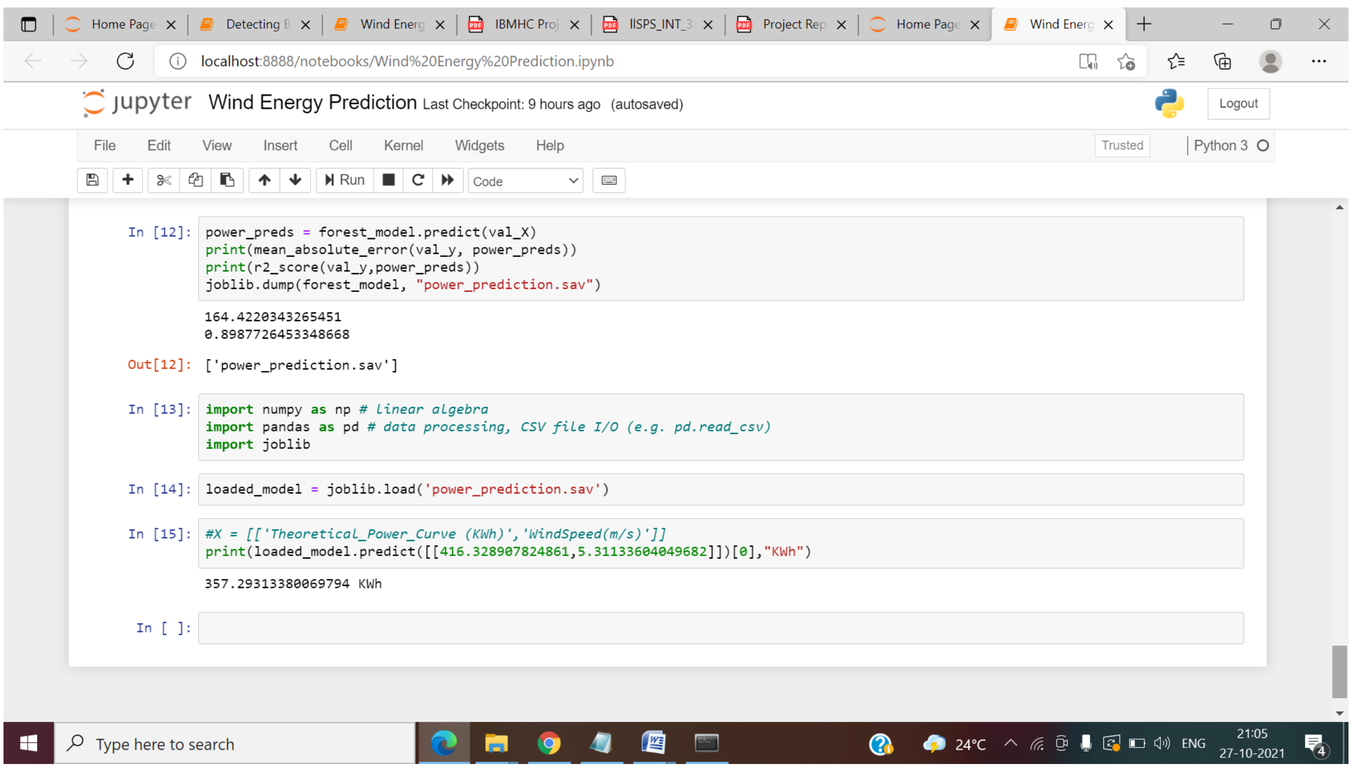
	ActivePower(kW)	WindSpeed(m/s)	Theoretical_Power_Curve (KWh)	Wind_Direction
ActivePower(kW)	1.000000	0.912774	0.949918	-0.062702
WindSpeed(m/s)	0.912774	1.000000	0.944209	-0.077188
Theoretical_Power_Curve (KWh)	0.949918	0.944209	1.000000	-0.099076
Wind_Direction	-0.062702	-0.077188	-0.099076	1.000000

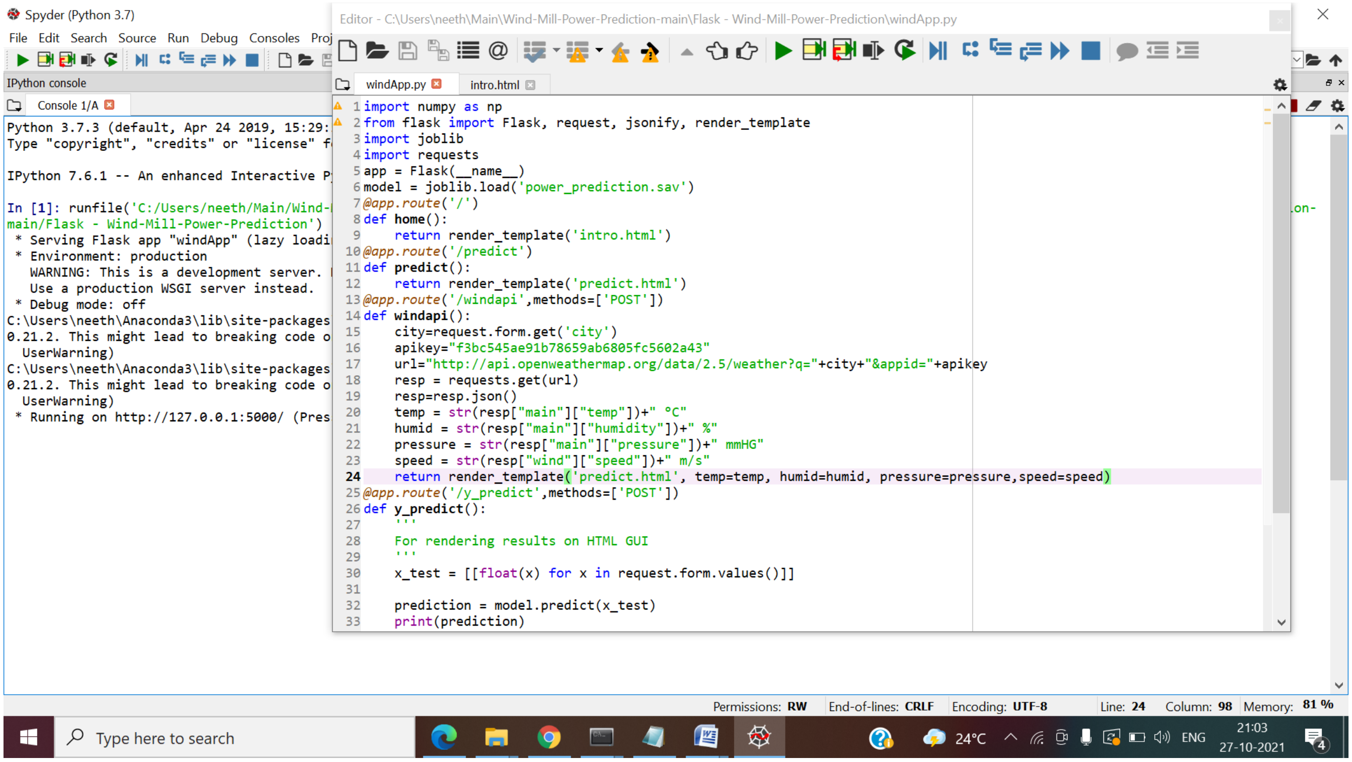
In [7]:
```
#df.drop(['Wind_Direction'],axis=1,inplace = True)
df["Time"] = pd.to_datetime(df["Time"], format = "%d %m %Y %H:%M", errors = "coerce")
df
```

Out[7]:

	Time	ActivePower(kW)	WindSpeed(m/s)	Theoretical_Power_Curve (KWh)	Wind_Direction
0	2018-01-01 00:00:00	380.047791	5.311336	416.328908	259.994904
1	2018-01-01 00:10:00	453.769196	5.672167	519.917511	268.641113
2	2018-01-01 00:20:00	306.376587	5.216037	390.900016	272.564789
3	2018-01-01 00:30:00	419.645905	5.659674	516.127569	271.258087
4	2018-01-01 00:40:00	380.650696	5.577941	491.702972	265.674286
5	2018-01-01 00:50:00	402.391998	5.604052	499.436385	264.578613
6	2018-01-01 01:00:00	447.605713	5.793008	557.372363	266.163605
7	2018-01-01 01:10:00	387.242188	5.306050	414.898179	257.949493
8	2018-01-01 01:20:00	463.651215	5.584629	493.677652	253.480698


localhost:8888/notebooks/Wind%20Energy%20Prediction.ipynb
jupyter Wind Energy Prediction Last Checkpoint: 9 hours ago (autosaved)
In [8]:
y = df['ActivePower(kW)'] #'Theoretical_Power_Curve (KWh)'
X = df[['Theoretical_Power_Curve (KWh)','WindSpeed(m/s)']]#'ActivePower(kW)'
In [9]:
from sklearn.model_selection import train_test_split
train_X, val_X, train_y, val_y = train_test_split(X, y,random_state = 0)
In [10]:
from sklearn.ensemble import RandomForestRegressor
from sklearn.metrics import mean_absolute_error,r2_score
In [11]:
forest_model = RandomForestRegressor(max_leaf_nodes =500, random_state=1)
forest_model.fit(train_X, train_y)
C:\Users\neeth\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245: FutureWarning: The default value of n_estimators wil
l change from 10 in version 0.20 to 100 in 0.22.
"10 in version 0.20 to 100 in 0.22.", FutureWarning)
Out[11]:
RandomForestRegressor(bootstrap=True, criterion='mse', max_depth=None,
max_features='auto', max_leaf_nodes=500,
min_impurity_decrease=0.0, min_impurity_split=None,
min_samples_leaf=1, min_samples_split=2,
min_weight_fraction_leaf=0.0, n_estimators=10,
n_jobs=None, oob_score=False, random_state=1, verbose=0,
warm_start=False)
In [12]:
power_preds = forest_model.predict(val_X)
Type here to search
24°C ENG 21:05 27-10-2021


localhost:8888/notebooks/Wind%20Energy%20Prediction.ipynb
jupyter Wind Energy Prediction Last Checkpoint: 9 hours ago (autosaved)
In [12]:
power_preds = forest_model.predict(val_X)
print(mean_absolute_error(val_y, power_preds))
print(r2_score(val_y,power_preds))
joblib.dump(forest_model, "power_prediction.sav")
164.4220343265451
0.8987726453348668
Out[12]:
['power_prediction.sav']
In [13]:
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import joblib
In [14]:
loaded_model = joblib.load('power_prediction.sav')
In [15]:
#X = [['Theoretical_Power_Curve (KWh)','WindSpeed(m/s)']]
print(loaded_model.predict([[416.328907824861,5.31133604049682]])[0],"KWh")
357.29313380069794 KWh
In [ ]:
Type here to search
24°C ENG 21:05 27-10-2021


Spyder (Python 3.7)
Editor - C:\Users\neeth\Main\Wind-Mill-Power-Prediction-main\Flask - Wind-Mill-Power-Prediction\windApp.py
windApp.py
intro.html
import numpy as np
from flask import Flask, request, jsonify, render_template
import joblib
import requests
app = Flask(__name__)
model = joblib.load('power_prediction.sav')
@app.route('/')
def home():
return render_template('intro.html')
@app.route('/predict')
def predict():
return render_template('predict.html')
@app.route('/windapi',methods=['POST'])
def windapi():
city=request.form.get('city')
apikey="f3bc545ae91b78659ab6805fc5602a43"
url="http://api.openweathermap.org/data/2.5/weather?q="+city+"&appid="+apikey
resp = requests.get(url)
resp=resp.json()
temp = str(resp["main"]["temp"])+" °C"
humid = str(resp["main"]["humidity"])+" %"
pressure = str(resp["main"]["pressure"])+" mmHG"
speed = str(resp["wind"]["speed"])+" m/s"
return render_template('predict.html', temp=temp, humid=humid, pressure=pressure,speed=speed)
@app.route('/y_predict',methods=['POST'])
def y_predict():
'''
For rendering results on HTML GUI
'''
x_test = [[float(x) for x in request.form.values()]]
prediction = model.predict(x_test)
print(prediction)
IPython console
Console 1/A
Python 3.7.3 (default, Apr 24 2019, 15:29:
Type "copyright", "credits" or "license" f
IPython 7.6.1 -- An enhanced Interactive P
In [1]: runfile('C:/Users/neeth/Main/Wind-
main/Flask - Wind-Mill-Power-Prediction')
* Serving Flask app "windApp" (lazy loadi
* Environment: production
WARNING: This is a development server.
Use a production WSGI server instead.
* Debug mode: off
C:\Users\neeth\Anaconda3\lib\site-packages
0.21.2. This might lead to breaking code o
UserWarning)
C:\Users\neeth\Anaconda3\lib\site-packages
0.21.2. This might lead to breaking code o
UserWarning)
* Running on http://127.0.0.1:5000/ (Pres
Permissions: RW End-of-lines: CRLF Encoding: UTF-8 Line: 24 Column: 98 Memory: 81 %
Type here to search
24°C
ENG
21:03
27-10-2021