IBM NALAIYA THIRAN

Deep Wind - Predicting The Energy Output Of Wind Turbine Based On Weather Conditions.

IBM-Project-16393-1659613024

TEAM

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Problem statement

Deep Wind - Predicting The Energy Output Of Wind Turbine Based On Weather Conditions.

- **Extracting electricity from renewable resources** has been widely investigated in the past decades to decrease the worldwide crisis in the electrical energy and environmental pollution.
- For a wind farm which converts the wind power to electrical energy, a big challenge is to accurately predict the wind power in spite of the fluctuations.
- The **energy output of a wind farm** is usually **dependent on the climatic conditions** present at its site.
- For the wind farm operator, this poses difficulties in the system and energy planning, as the schedule of the wind power availability is not known in advance.
- A **precise forecast** is needed to **overcome the problems** caused by **fluctuating weather conditions.**

Existing Solution

Wind power is calculated based on : **Physical characteristics of wind farms/turbines.**

$$Power = \frac{1}{2} \times \rho \times \pi \times r^2 \times C_p \times CF \times v^3 \times NG \times NB$$

P = power generated in Watts
v = velocity of the wind in m/s
ρ = density of the wind in kg/m^3
πr^2 = swept area, where r = blade length in m
C_P = Power Coefficient
C_F = Capacity Factor
N_G = generator efficiency
N_B = gearbox efficiency

DISADVANTAGES:

- Measurement of wind turbine physical parameters (blade length,gearbox,generator) is quite difficult.
- Vary from turbine to turbine.

Proposed Solution

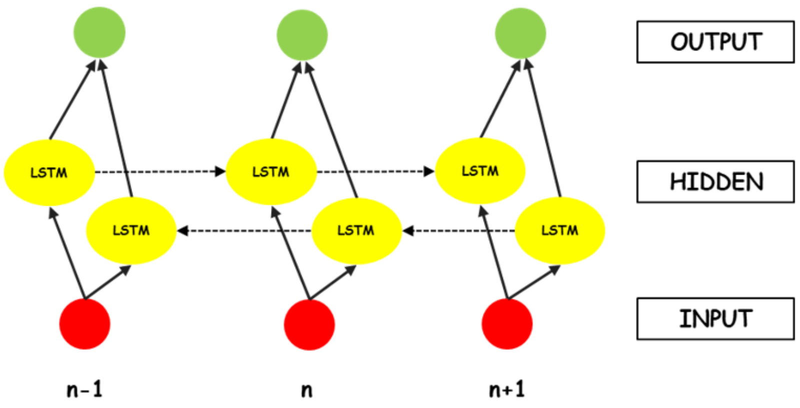
- Wind power is calculated based on : **weather conditions (wind speed, wind direction, pressure, temperature, dewpoint, relative humidity)**
- Our aim is to develop an end to end **web application** to predict **the energy output of the wind turbine based on weather conditions**.
- The technique incorporated in our project is **deep learning**.

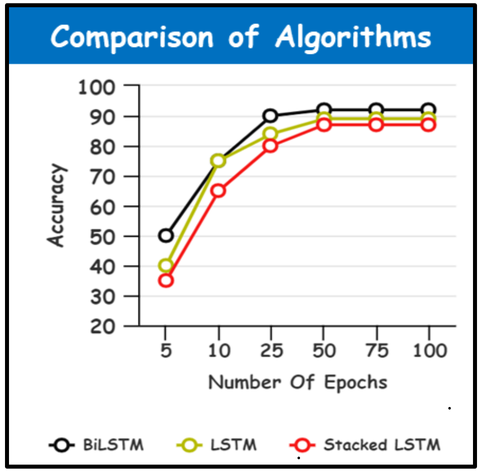
ADVANTAGES:

- **Rather than installing more devices on the turbine**, this idea can maximise yields and efficiency while having small effects on the climate.
- At the same time, it **boosts the performance and competitiveness of market players**, making this business more attractive.

Proposed Solution

- **Time series problems are mostly solved using RNN**. These models have **memory**, i.e., the model can remember the information throughout the time.





- A special kind of RNN – **BiLSTM Network (Bidirectional Long Short Term Memory)** is implemented which has a prominent performance in capturing the long-term dependencies along the time steps, and thus very applicable for wind power prediction.

- The proposed algorithm gave us more accurate results when compared with other models.

Motivation

- Since only very limited work has been done with respect to deep learning in the wind power prediction, it is of great interest to us to see how well it can perform in this field.

- Through a combination of DL, computing and more accurate weather forecasts, granted access to more precise wind power data to **improve the efficiency of renewables.**

- The forecasting process can also **save operators millions of dollars** in additional costs or fines for the mismatch between expected and actual production.

Metrics

<table>
<tr><th>PARAMETERS</th><th>VARIATION w.r.t POWER</th><th>GRAPH</th></tr>
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1. WIND SPEED

Wind speed ∝ Power generated

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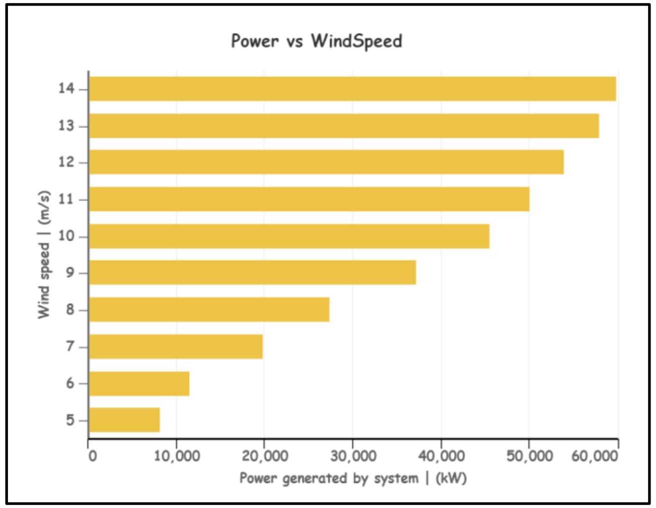

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2. TEMPERATURE

Air temperature (high) ∝ 1/Power

Air temperature (moderate) ∝ Power

Air temperature (low) ∝ 1/Power

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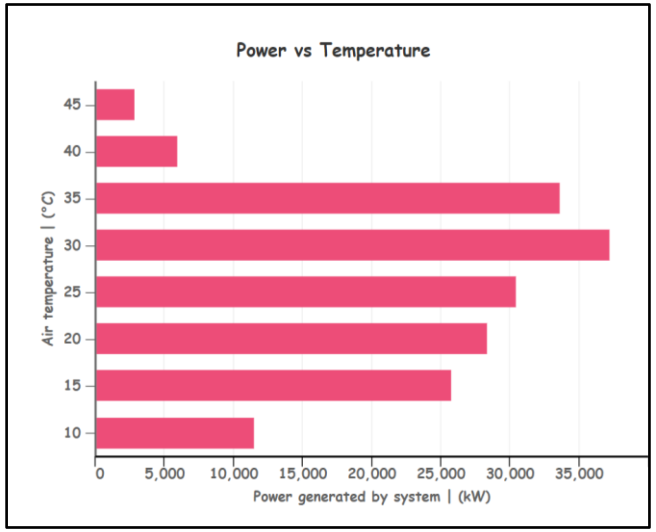

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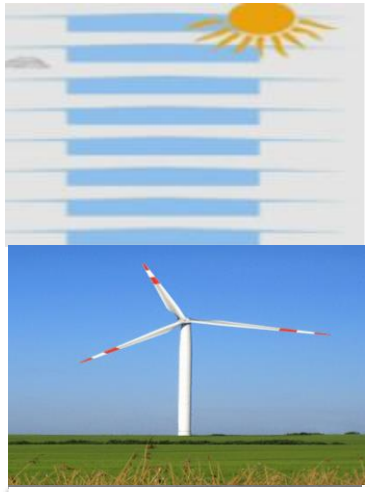
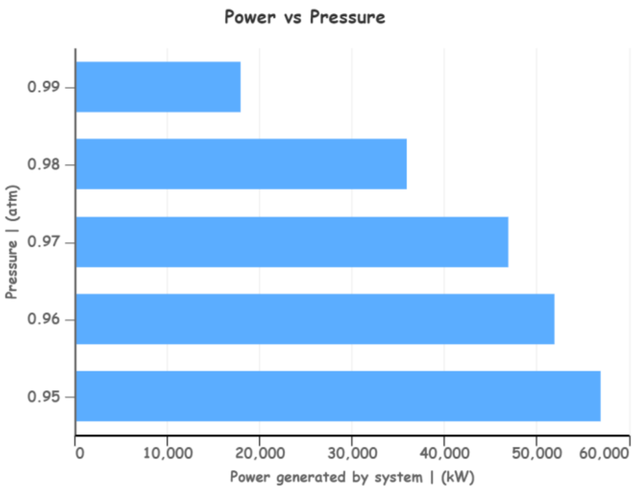
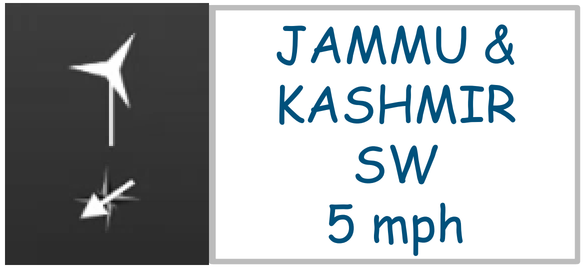
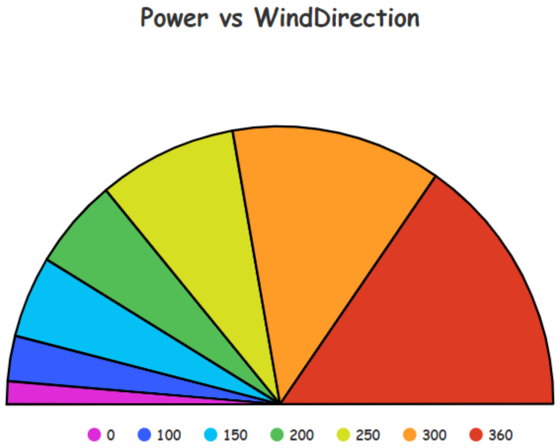
Metrics

PARAMETERS	VARIATION w.r.t POWER	GRAPH
3. AIR PRESSURE **Air Pressure ∝ 1/Power**	 **High Pressure**	
4. WIND DIRECTION **Getting more nearer to 360° (north), wind speed increases, so severe winds blow from north generating more power.**		

Impact

- **BENEFIT TO BUSINESS & SOCIETY**

- Knowing the wind power beforehand helps us in many ways by minimizing the losses.
- **Target Audience:**

Grid Operators

Energy Suppliers

- It's easy for **grid operators**, in the case of **system scheduling** and **energy planning** for **power** generating **systems**.
- If the output may be forecasted extra accurately, **energy suppliers** can **keep away from costly overproduction** by coordinating the manufacturing of various electricity sources extra efficiently.
- Thus accurate wind power forecasting plays a key role in **dealing with the challenges** of power system operation under uncertainties in an **economical and technical way**.

Methodology

Website Framework

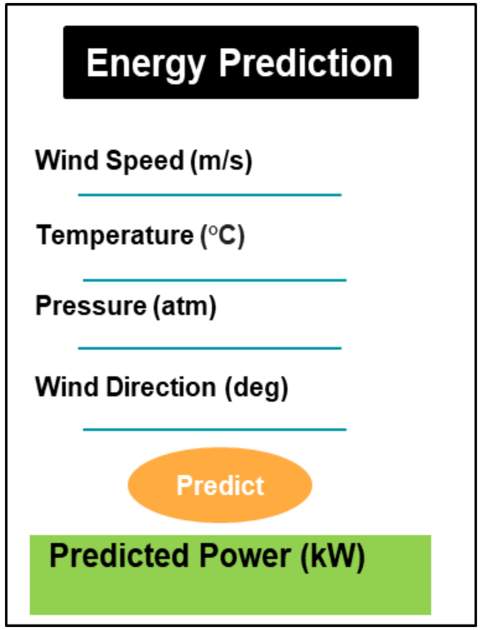
ENERGY PREDICTION

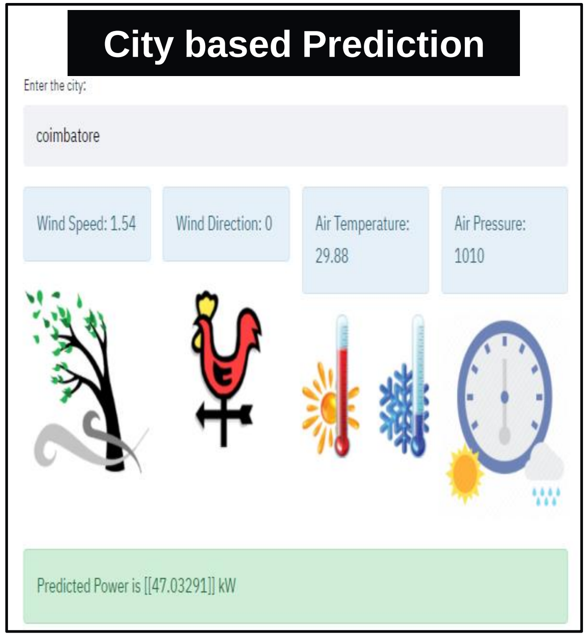
MODULE 1

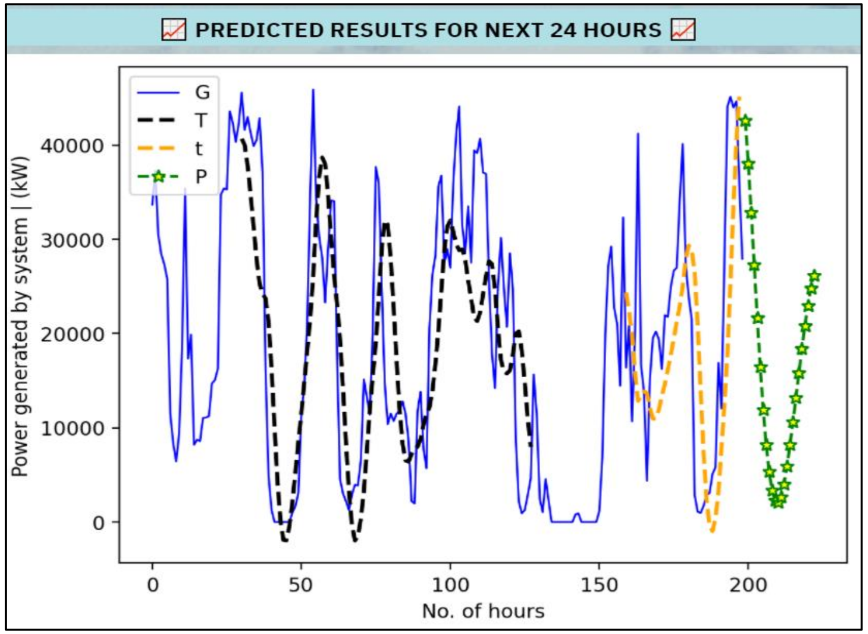
USER DEFINED values Prediction

MODULE 2

FUTURE Forecasting







Technology Stack

TECHNOLOGY STACK

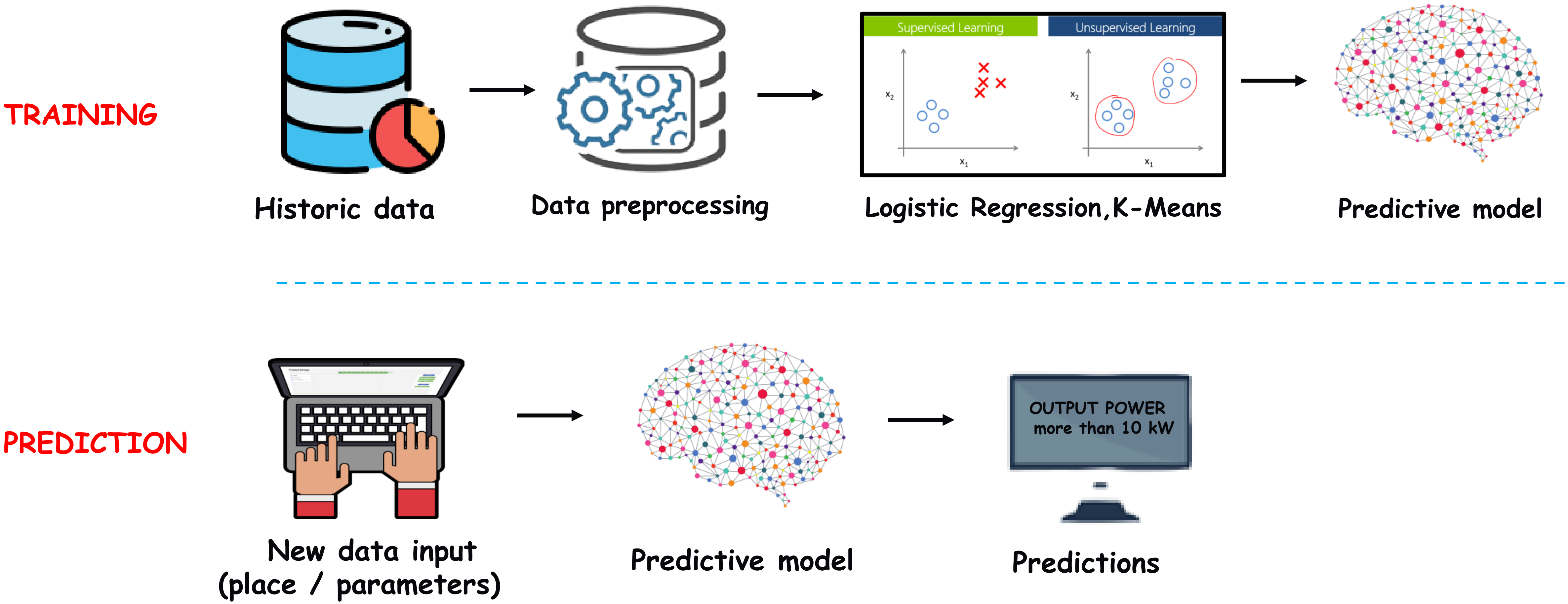
- python
- Keras
- Pandas
- NumPy
- matplotlib

FRONT-END WEB DEVELOPMENT

- python
- Streamlit
- Keras
- Pandas
- NumPy
- BASE64
- plotly

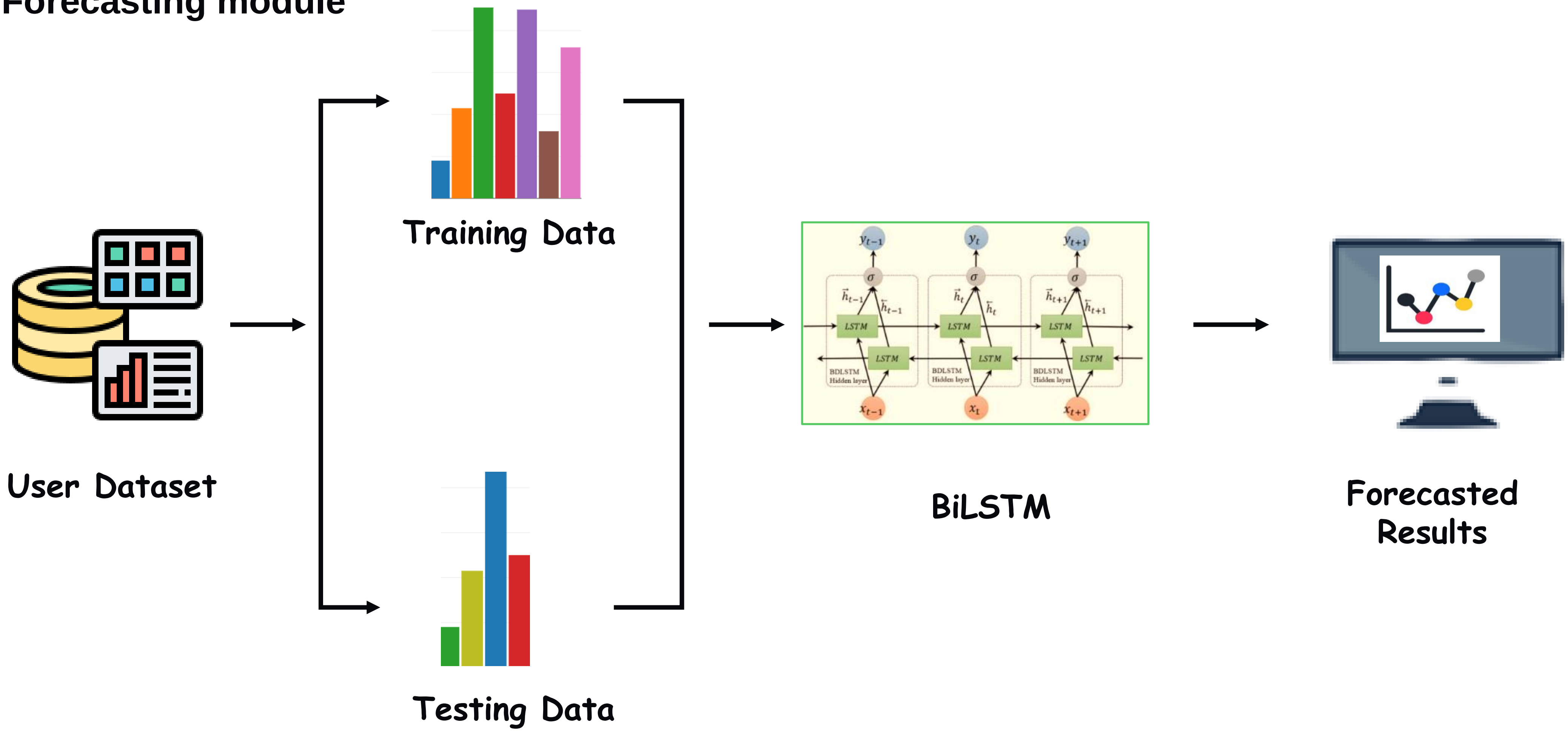
Architecture

Prediction module



Architecture

Forecasting module



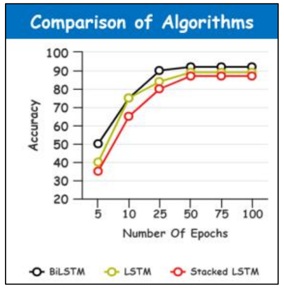
How is the solution innovative?

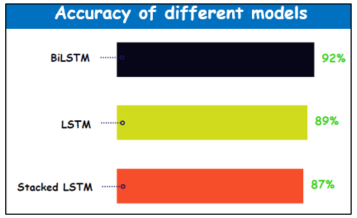
- **Bi-LSTM** gave us more accurate results when compared with other models.

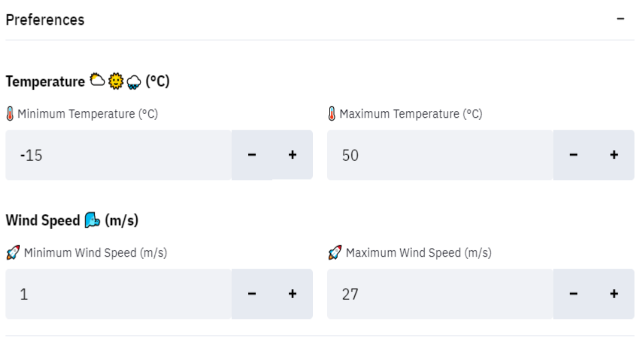
- In the prediction part, user can also set their preferable **cut in (minimum) and cut out(maximum) values** for windspeed and temperature with the help of **preferences tab**.

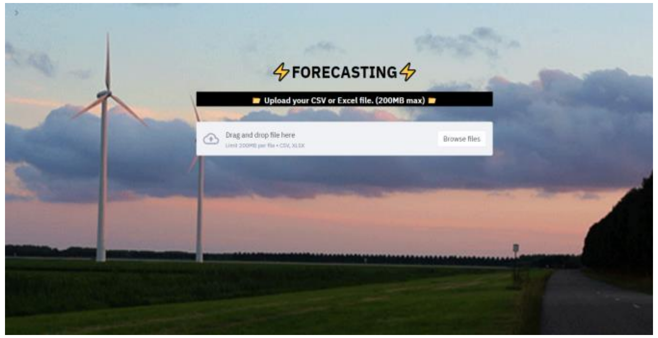
- Our Deep Wind is individually different from other wind power forecasting websites where the **user can upload their own real time dataset (csv or xlsx format with a minimum of 30 entries) for forecasting.**

- Our Deep wind provides an interactive interface with a **simple visualization tool** which brings the accurate results with minimal load time.

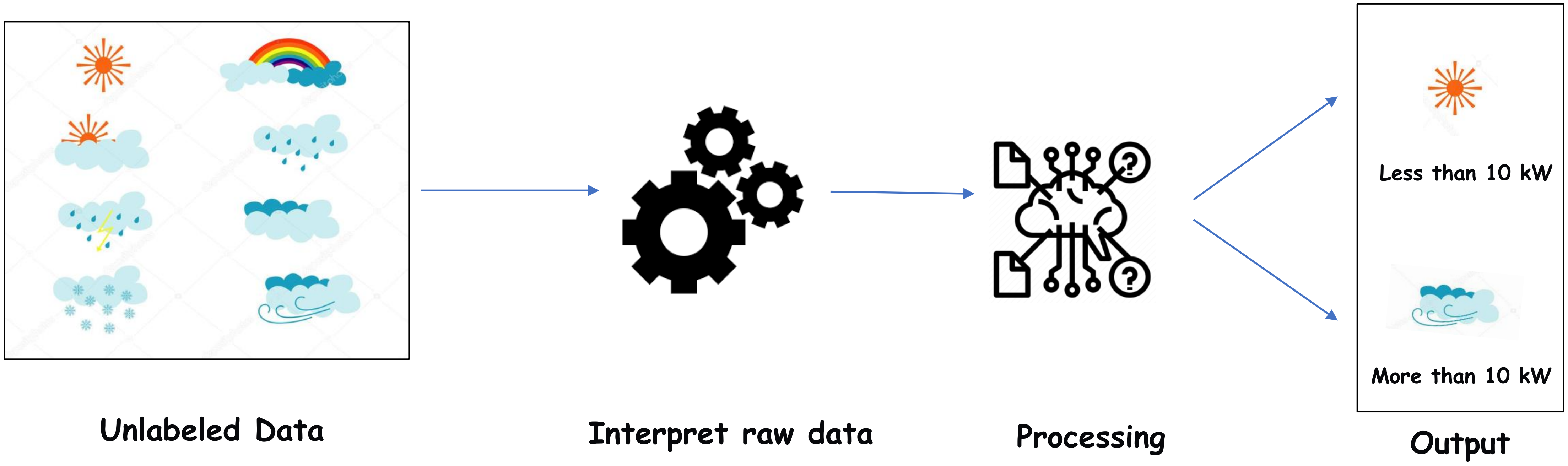




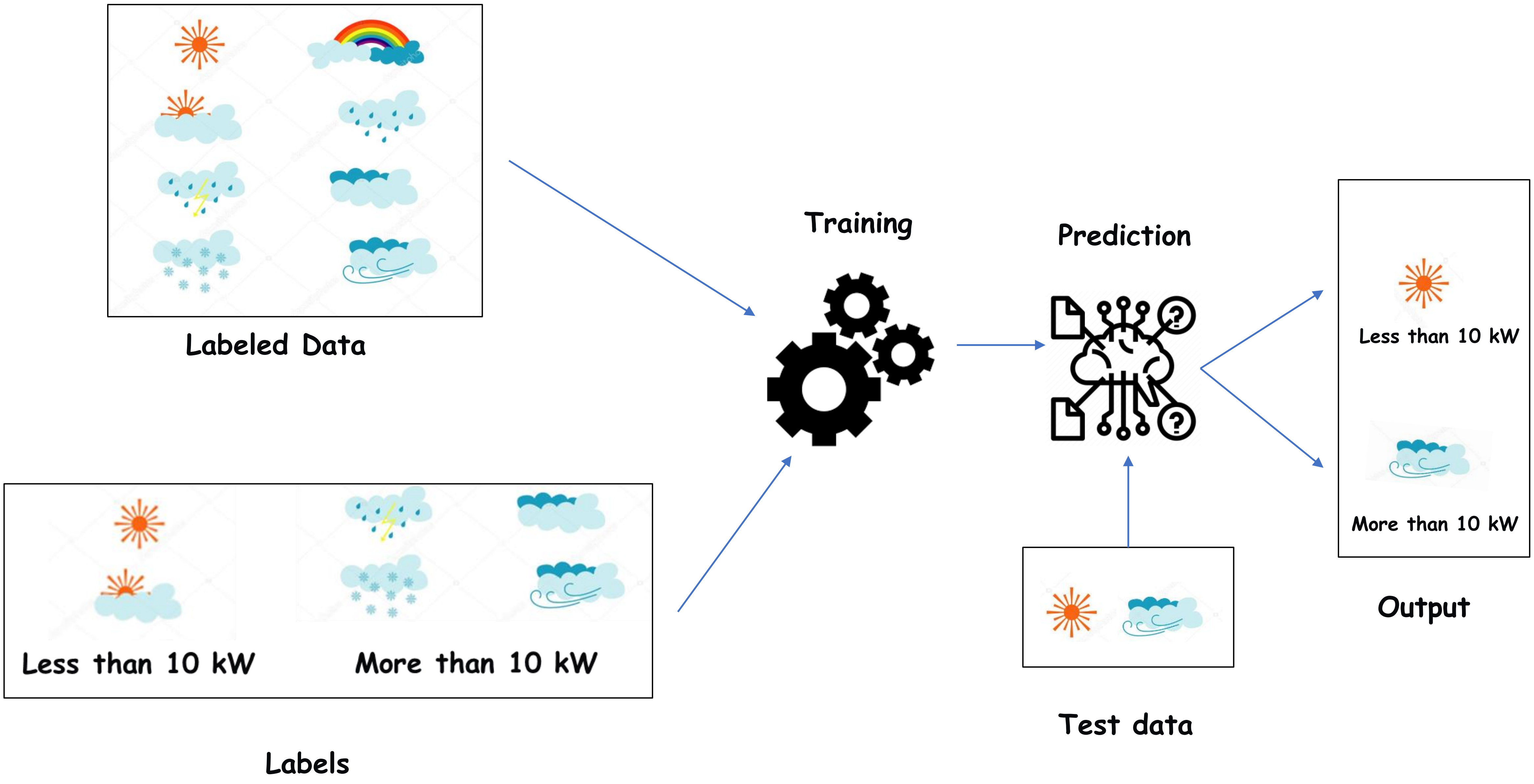




Link 🔗 : https://share.streamlit.io/deep-wind/miniproject/main/app.py#deep-winds



Less than 10 kW
More than 10 kW
Unlabeled Data
Interpret raw data
Processing
Output


Labeled Data
Training
Prediction
Less than 10 kW
More than 10 kW
Less than 10 kW
More than 10 kW
Labels
Test data
Output

PREDICTION	FORECASTING
CALCULATION/Estimation OF FUTURE PREDICTIONS With/without prior information	CALCULATION/Estimation OF FUTURE PREDICTIONS which uses trends in previous events, to come up with the future outcome.

BILSTM

I/P : 6

(wind speed, wind direction, pressure, temperature, dewpoint, relative humidity)

HIDDEN: 7

OUTPUT: 1

CODE

```
model = Sequential()
model.add(Bidirectional(LSTM(100, activation='relu',input_shape=(-1,1,6))))
model.add(Dense(7))
model.add(Dense(1))
model.compile(loss='mae', optimizer='adam',metrics=['accuracy'])
model.fit(X, Y,epochs=1,callbacks=[keras.callbacks.EarlyStopping(patience=5)])

test_data = np.array([[17.6,    940.4,4.08,101,8.1,60.1]])
print(model.predict(test_data.reshape(-1,1,6), batch_size=1))
o=model.predict(test_data.reshape(-1,1,6), batch_size=1)
print(o)
```

THANK YOU