UNIVERSITY OF BIRMINGHAM

BAA 2022

Online | July 7th, 2022

The 2nd International Workshop on the Bees Algorithm and its Applications

Utilizing the Bees Algorithm and Machine Learning to optimize the UAVs travel time in consideration of Weather Conditions

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Introduction

During these past years, development in unmanned aerial vehicles (UAVs) for their use in different fields has been on the rise. While they have been proven effective in aiding relief by delivering emergency kits in affected-areas, use of UAVs for more day-to-day purposes like package deliveries has become a flaming topic of research.

Commercial usage of UAVs would not only ensure much easier control and maximise the efficiency in delivering packages, but they would also be environment friendly and a step towards a healthier planet.

While other research scopes only focus on dealing with routing, payload, and surveillance, weather conditions play a massive role in UAV’s efficiency as well as safety during real-world applications. Hence it is essential to pay special attention to all of the factors that influence the deployment of UAVs for various reasons

The UAV weather Dataset contained various wind parameters and after carefully analysing the the parameters, and their effects on the final UAV velocity, we observed that :

- **Wind Speed**
- **Wind Gust**
- **Wind Direction**

have a major effect on the UAV Velocity

So we are using these parameters along with other UAV parameters(UAV Speed/Payload) to predict the Final UAV velocity and then use Combinatorial Bees Algorithm for Routing Optimisation

For the routing optimisation problem we are using Travelling Salesman Problem(TSP) Dataset, where the salesman is considered as drone and the cities represent the delivery locations

(This Problem logically classifies as a asymmetrical TSP as while considering the weather condition the time taken from x[i][j] to y[i][j] may not necessarily be the same as that of y[i][j] to x[i][j])

Proposed Approach to the Problem:

- We work with the weather parameters and develop a model to accurately predict the final UAV velocity After implementing multiple Machine Learning models including Polynomial regression, XGBoost and Ridge, CatBoost, LightGBM, and ANN as a Deep Learning model we found **Cat Boost** model to be performing accurately and fast without any overfitting **(MSE score: 0.58)** . For routing optimization of a UAV travel path and time, we are inspired by the TSP (Travelling Salesman Problem) approach and used **Combinatorial Bees Algorithm** for the same.
- Although accuracy and better prediction of UAV velocity is not our exact aim. We have to build a routing optimisation technique that can correctly predict the travel time fluctuation during weather turmoil, and the UAV Velocity plays a very important role in the total duration, hence it necessary that we accurately predict it.
- While the Combinatorial Bees Algorithm works on the basis of euclidean distance, which is stored in a matrix and then the total distance of the hamiltonian cycle is minimized using the optimization algorithm, our study is a bit different and can be considered as modification to the Combinatorial Bees Algorithm where it is not necessary that the shortest distance will be the fastest, hence we will be working on minimizing the total duration of the journey

Approach to the Model:

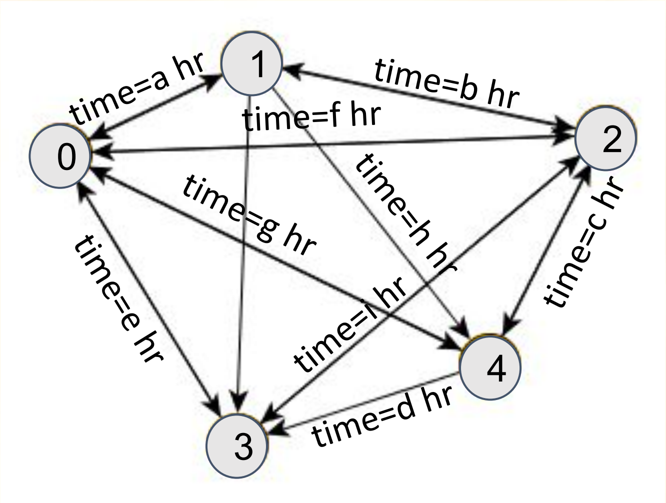
Pseudo Code :

```
D= []
for i (0 -> n )   // n = number of destinations for a single journey / Nodes
    for j (0 -> n )
        parameters = { Weather conditions & UAV properties }
        distance = Euclidean distance between node 1 & node 2
        time = distance / |(predicted UAV velocity between node 1 & node 2 considering the weather parameters)|
        D.append (time)
D =D.reshape(n,n)
```

The total time travelled by the UAV to make its job done will be minimised by Bees Algorithm Optimization over number of iterations.

The Model

TSP's graph represented the Graph G = (V,E), where V is a set of vertices representing the cities, and all the connecting lines between the cities is E. Every edge indicates a possible route between two connected vertices or cities. The variable Di,j is associated with an edge (i,j) and the Final UAV velocity along the edge(After Considering the weather parameters) , and represents the duration of time taken by the drone to travel from vertex (xi,yi) to (xj,yj). This time is then stored in a Duration Matrix.



$$D = \begin{bmatrix} 0 & a & f & e & g \\ a' & 0 & b & g & h \\ f' & b' & 0 & i & c \\ e' & g' & i' & 0 & d \\ g' & h' & c' & d' & 0 \end{bmatrix}$$

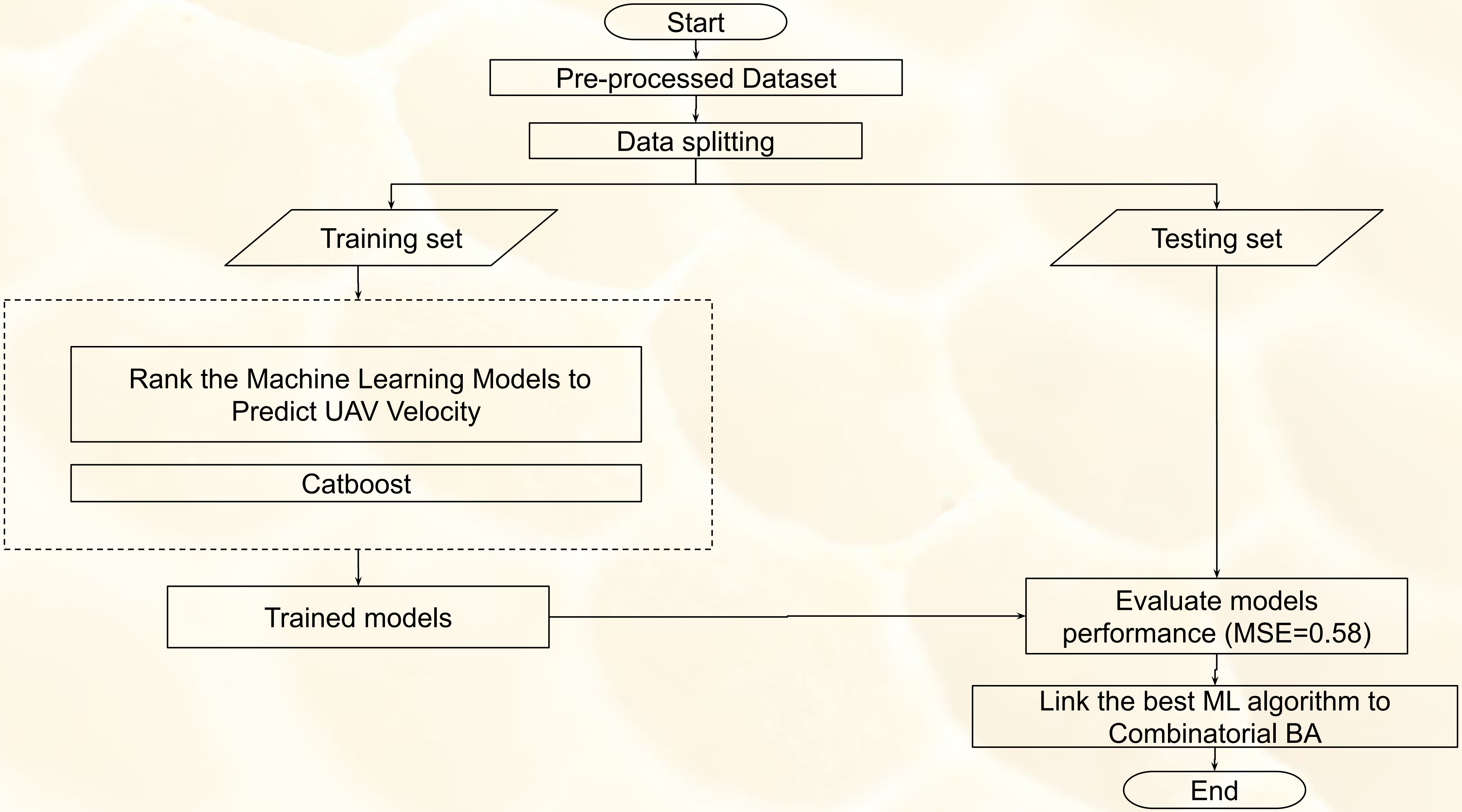
Our objective is to find the minimal time duration of the final closed Hamilton cycle defined as:

Tour duration= $\sum_{1}^{n} d[i][i+1] + d[n][1]$

Duration matrix nomenclature :

i->j time = x if i<j

i->j time = x' if i>j


Start
Pre-processed Dataset
Data splitting
Training set
Testing set
Rank the Machine Learning Models to Predict UAV Velocity
Catboost
Trained models
Evaluate models performance (MSE=0.58)
Link the best ML algorithm to Combinatorial BA
End

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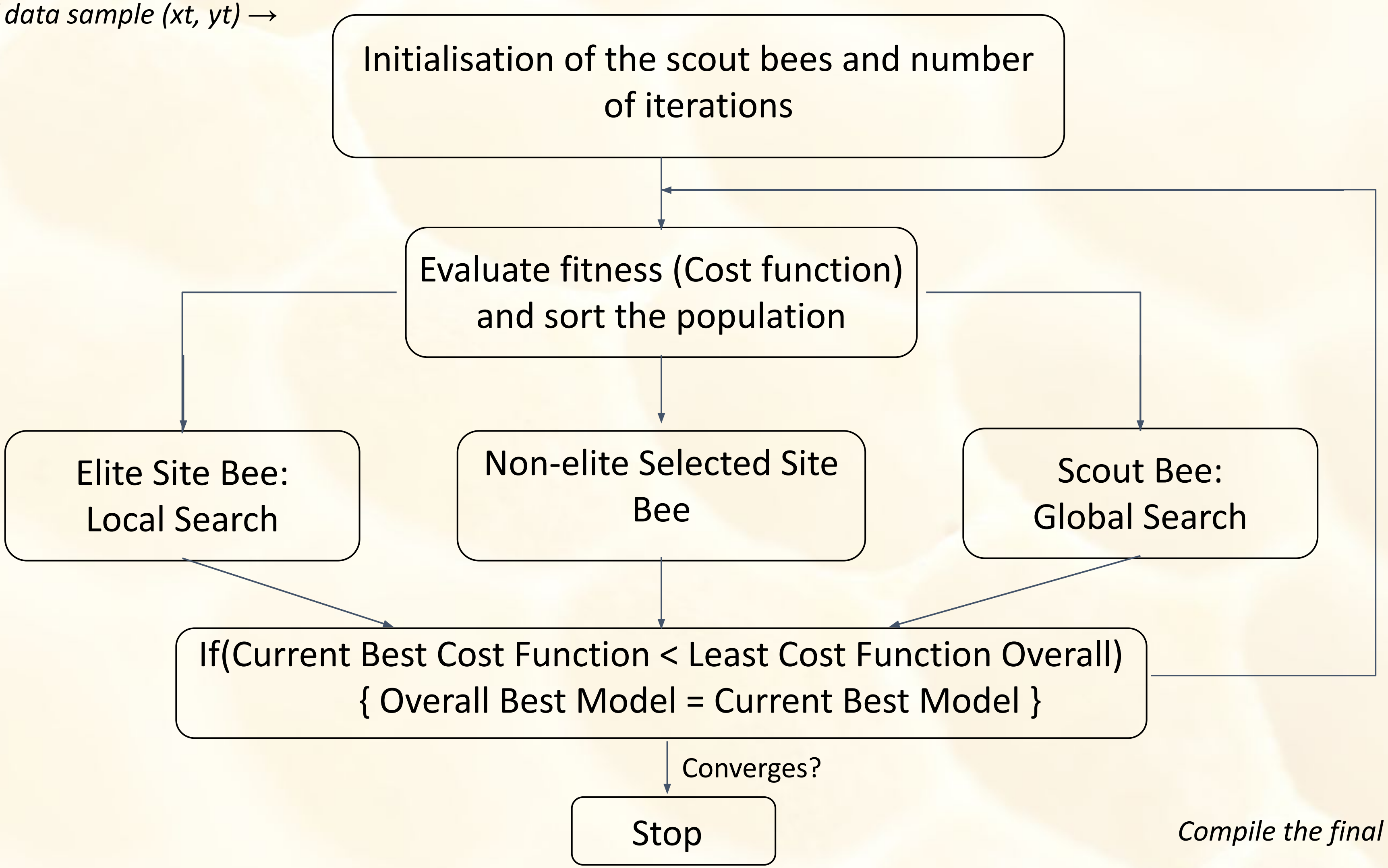
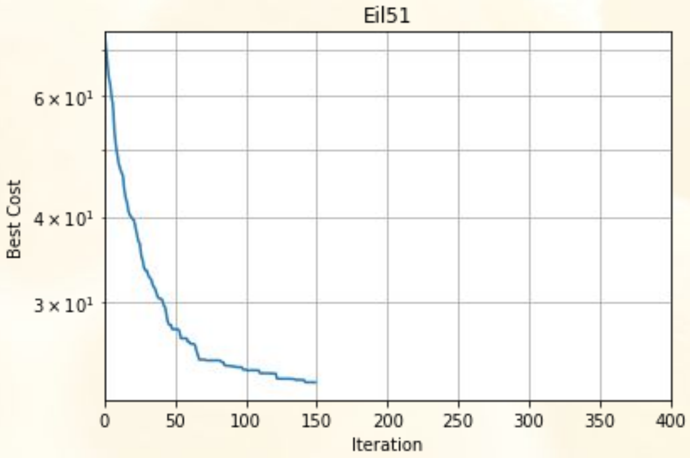
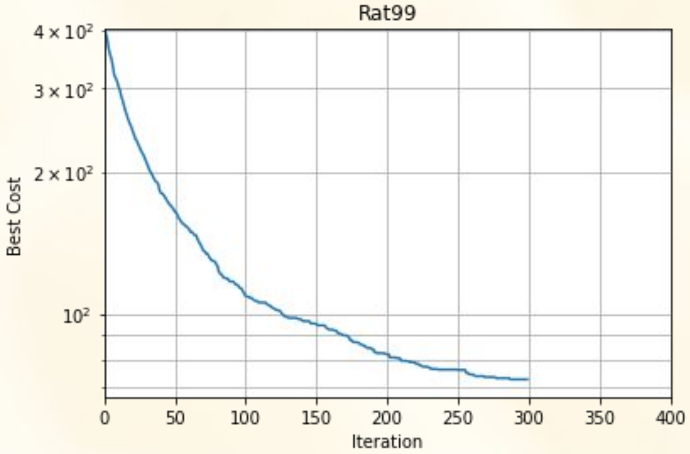
For each pair of data sample (xt, yt) →



Compile the final best model →

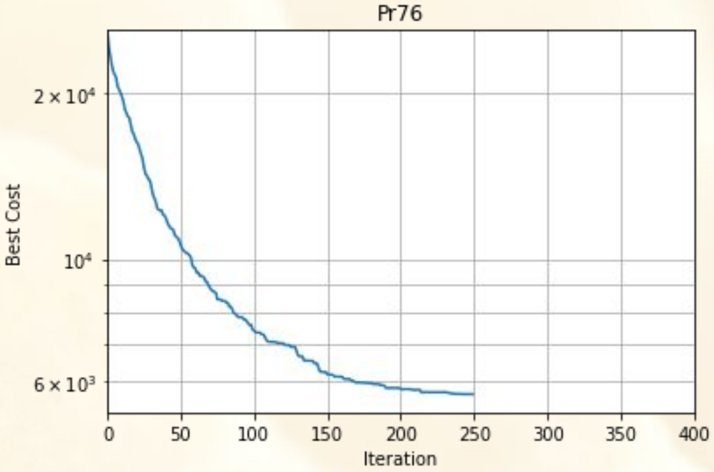
Handling No of iterations Iterations

- 



When tested over multiple datasets we have found that the optimisation converges around when :

No of iteration ≃ 3 ✕ Number of Nodes



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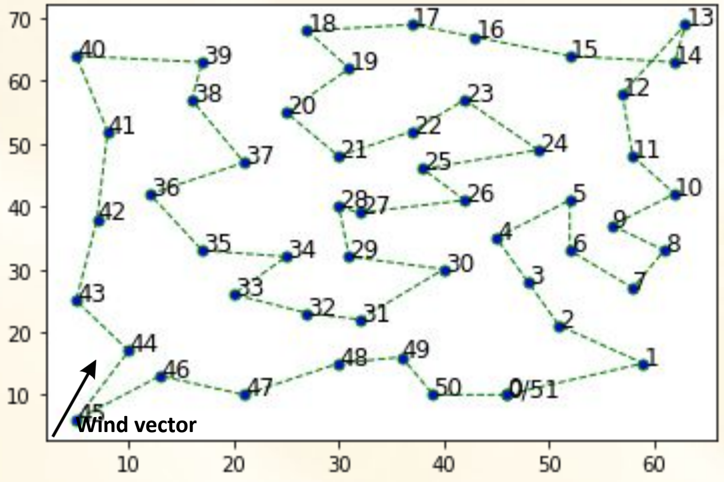
Results and Discussion

Routing Optimisation Algorithm

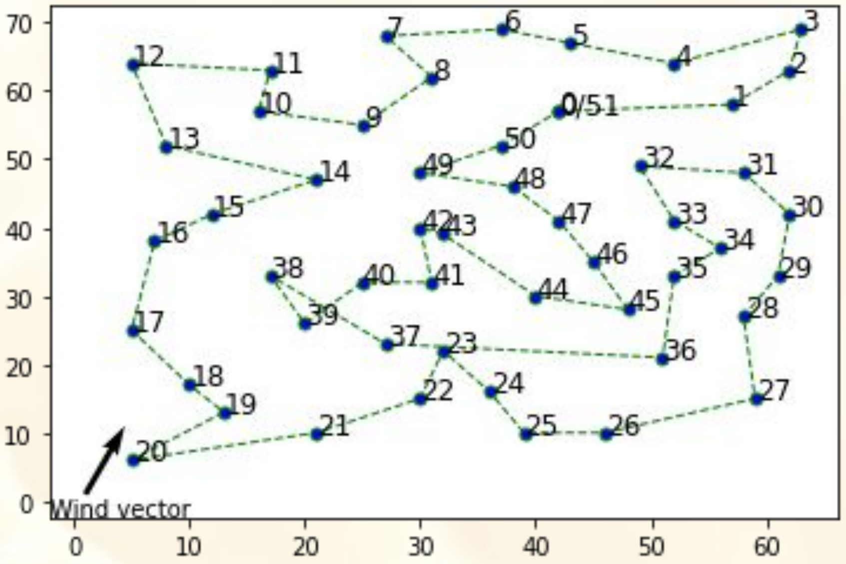


Time taken to complete the journey : **27.31 min**

Parameters :

{ UAV Speed : 25 m/min
UAV PayLoad : 15 kg
Wind Speed : 10 m/min
Wind Gust : 5 m/min
Wind Dir. : 65 ° }

Our Model considering the weather conditions



Time taken to complete the journey : **23.95 min**

As we can see that for the mentioned conditions there is around **12.3%** difference in the time if we used normal routing optimisation techniques and with drastic change of weather conditions the **difference increases upto as much as 100%**, hence it is necessary for us to accurately predict the duration so that scheduling of the drone fleet could be done more effectively and without any lag in real-time.

Thank You