Using Metaheuristics to Optimise Clustering Algorithms

Hybridization of five metaheuristic optimizations

We have used 5 meta heuristic optimisation algorithms to find cluster centroids. They are
1. Simulated Annealing (SA)
2. Artificial Bee Colony Optimization (ABC)
3. Bat algorithm
4. Firefly Algorithm
5. Bees Algorithm

We have used 2 hybridization techniques

1. Normal Hybridization

This hybridization method gives equal importance to each optimization technique. Majority voting is followed. For example, if the outcomes are [0,0,0,1,2], then the final output is 0. The pseudocode is shown below.

```
for i in predictions:
     count vote for each class;
     class_value[i] =  highest vote for a particular class;
```

2. Weighted Hybridization

This hybridization method gives more importance to the optimization technique with higher accuracy. For example, consider the first two outcomes to have higher weights than the remaining 3 outcomes. If outcomes are [0,0,1,1,2], as the first two have higher weights, the final output is 0. The pseudocode is shown below.

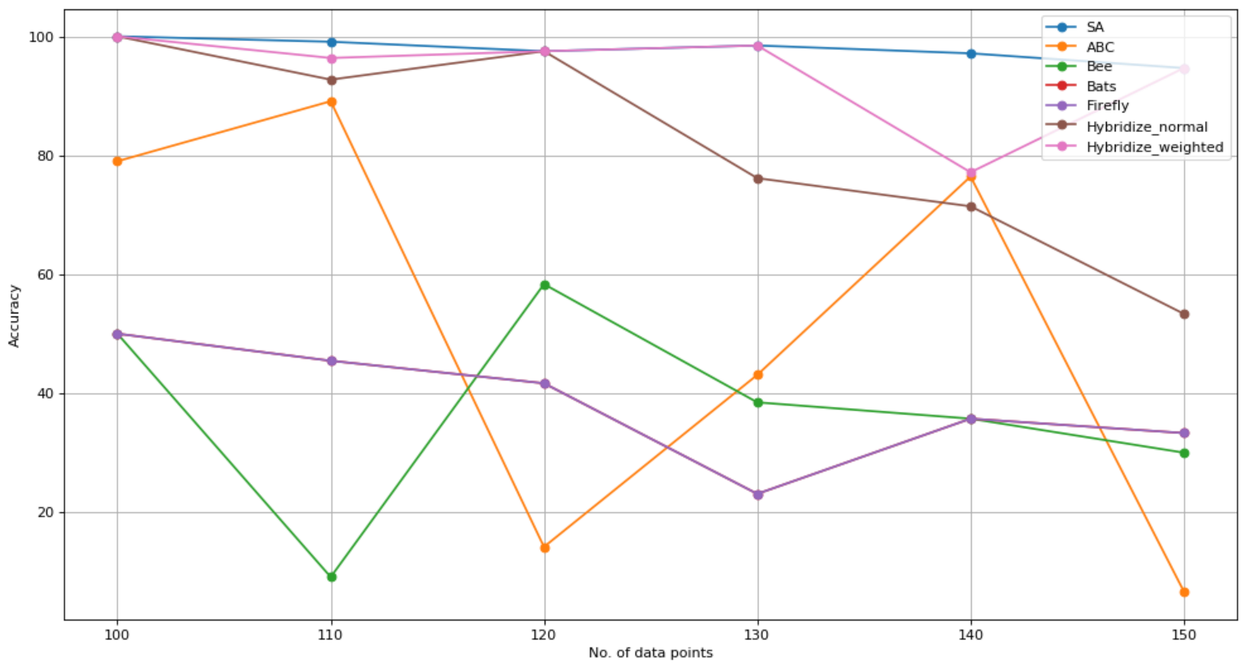
```
for i in predictions:
     count weighted vote for each class based on accuracy;
     class_value[i] =  highest vote for a particular class;
```

Benchmarking techniques:

We have measured the scalability of different algorithms for different number of data points based on

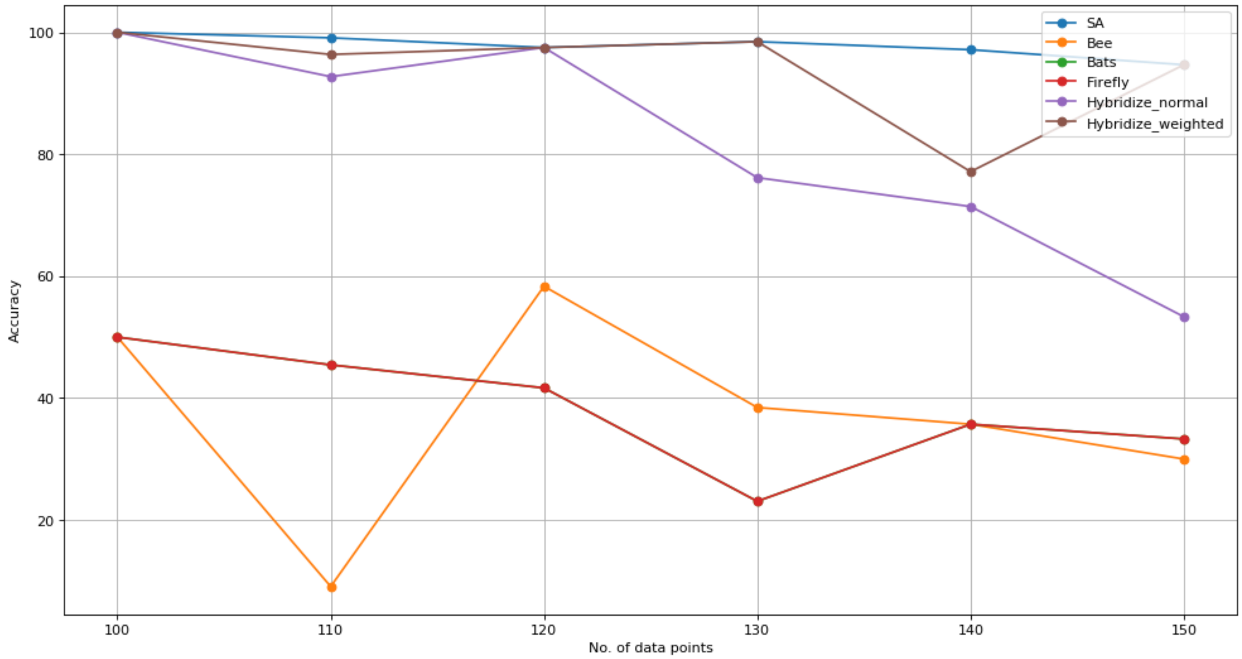
1. Accuracy
2. Time taken for optimization

Results



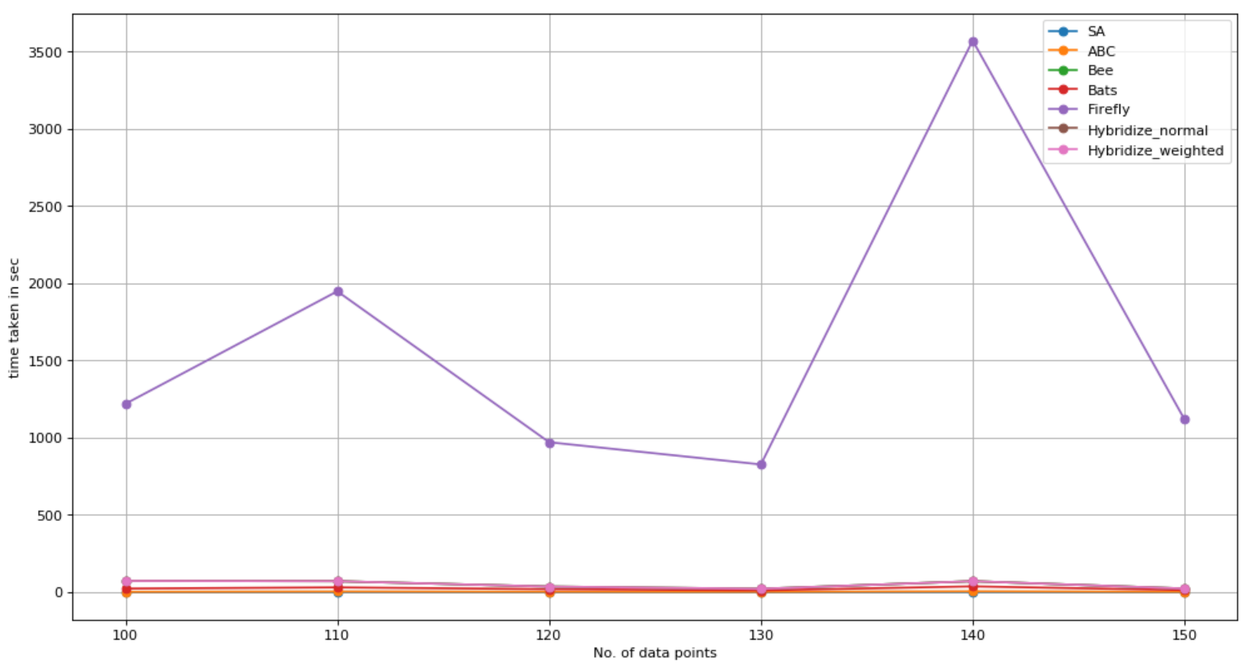
Analysis :

1. We see that SA has the highest accuracy compared to all other optimisation techniques. However accuracy is close to 100% in some cases which shows that this algorithm is overfitting.
2. ABC algorithm is fluctuating on varying the number of data points which shows that it is not stable.
3. The normal hybridization algorithm performs less efficiently on increasing the number of data points.
4. The weighted hybridization algorithm performs better than most of the other individual algorithms.



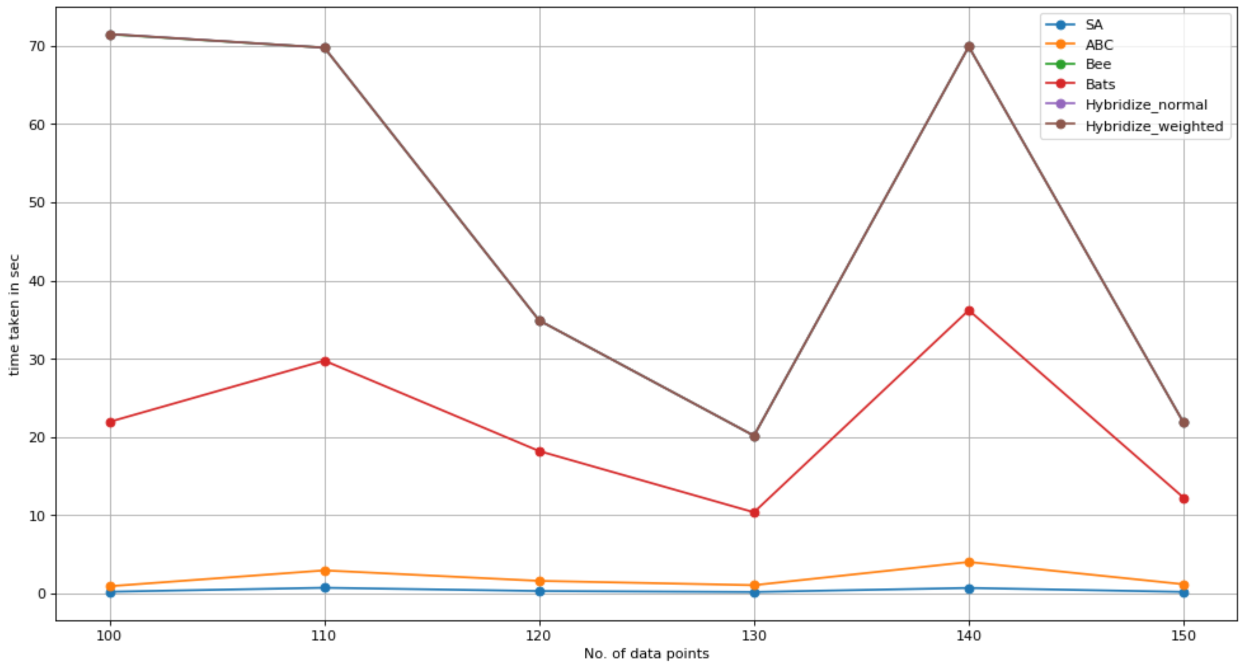
Analysis:

1. We have removed ABC to get a clearer picture and to get a better comparison among the other algorithms
2. We can see that the weighted hybridization algorithm performs well.



Analysis:

1. The time comparison shows that firefly algorithm takes a huge amount of time when compared with the rest of the algorithms.
2. Hence we can remove firefly to get a clearer picture of time comparison.



Analysis:

1. We see that SA takes the least amount of time followed by ABC
2. Weighted hybridization takes a relatively larger amount of time when compared to other algorithms as it takes into consideration the process of assigning weights, voting etc.
3. However this is still feasible when we compare this with the firefly algorithm in graph 3. Hence weighted hybridization is an effective optimisation technique which provides significantly higher accuracy.

Additional points on the five optimisation techniques used

Simulated Annealing Optimization

- The algorithm is inspired by annealing in metallurgy where metal is heated to a high temperature quickly, then cooled slowly, which increases its strength and makes it easier to work with.
- The initial temperature for the search is provided as a hyperparameter and decreases with the progress of the search. Annealing schedule is used to decrease the temperature during the search from the initial value to a very low value.
- Similar to Stochastic hill climbing where it maintains a single candidate solution and takes steps of a random but constrained size from the candidate in the search space. If the new point is better than the current point, then the current point is replaced with the new point. This process continues for a fixed number of iterations.
- The main difference is that new points that are not as good as the current point (worse points) are accepted as well.
- Objective Function: Hinge Loss Function

Artificial Bee Colony Optimization

- ABC as an optimization tool, provides a population-based search procedure in which individuals called foods positions are modified by the artificial bees with time
- The bee's aim is to discover the places of food sources with high nectar amount and finally the one with the highest nectar.
- To apply ABC, the considered optimization problem is first converted to the problem of finding the best parameter vector which minimizes an objective function.
- In the ABC model, the colony consists of three groups of bees: employed bees, onlookers and scouts.
- Objective Function: Sum of Squared Errors Function

Bat Algorithm Optimization

- Inspired by the foraging behavior of micro bats, algorithm carries out the search process using artificial bats as search agents mimicking the natural pulse loudness and emission rate of real bats.
- It is a method for solving optimization problems over continuous and discrete spaces
- All bats use echolocation to sense distance, and they also `know' the difference between food/prey and background barriers.
- Objective Function: Sum of Squared Errors Function

Firefly Algorithm Optimization

- Fireflies are unisexual so that one firefly will be attracted to other fireflies regardless of their sex.
- The attractiveness is proportional to the brightness and they both decrease as their distance increases. Thus, for any two flashing fireflies, the less brighter one will move toward the more brighter one. If there is no brighter one than a particular firefly, it will move randomly.
- The brightness of a firefly is determined by the landscape of the objective function
- Objective Function: Sum of Squared Errors Function

Bee Algorithm Optimization

- It mimics the food foraging behaviour of honey bee colonies.
- In its basic version the algorithm performs a kind of neighbourhood search combined with global search, and can be used for both combinatorial optimization and continuous optimization
- Each candidate solution is thought of as a food source (flower), and a population (colony) of n agents (bees) is used to search the solution space. Each time an artificial bee visits a flower (lands on a solution), it evaluates its profitability (fitness).
- Objective Function: Sum of Squared Errors Function