# TITLE:

# Multi UAV collision free path planning and coordination for multiple targets in 3-D environment using Nature Inspired Algorithms.

**Authors:**

1. Dhruv Prakash (IPG2015-024)

2. Gatij Jain (IPG2015-029)

3. Gaurav Yadav (IPG2015-031)

**Group No:-36**

**Supervisor Name:**

1. Prof. Anupam Shukla

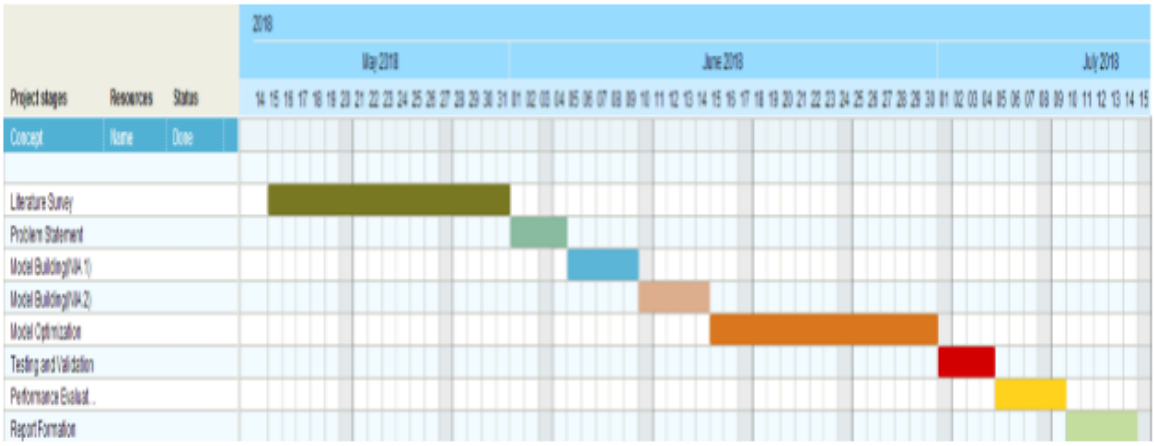
2. Dr. Ritu Tiwari

## Thesis Objective

The aim is to deduce paths for each UAV that will successfully avoid the obstacles present in the three dimensional environment. Two different Nature Inspired Algorithms namely Glowworm swarm Optimization (GSO) Multiverse Optimizer algorithm (MVO) will be applied to solve this problem and the performance of these algorithms will be measured and compared with each other as well as with other Nature Inspired Algorithms . Attempts will also be made to modify these algorithms to improve performance.

## Timeline

### Gantt Chart




| Task Description | Start Date | Duration |
|---|---|---|
| Literature Survey | 15/5/18 | 17 |
| Problem Statement Formation | 1/6/18 | 4 |
| Model Building for first NIA | 5/6/18 | 5 |
| Model Building for second NIA | 10/6/18 | 5 |
| Model Optimization | 15/6/18 | 16 |
| Testing and Validation | 1/7/18 | 4 |
| Performance Evaluation | 5/7/18 | 5 |
| Report Formation | 10/7/18 | 5 |

# Activities Completed

The Glowworm Swarm Optimization(GSO) and Multiverse Optimizer(MVO) algorithms have been applied for the path planning of multiple UAVs in a three dimensional environment. The Munkres Algorithm has been used for assigning each UAV a target so as to reduce overall algorithm execution time.

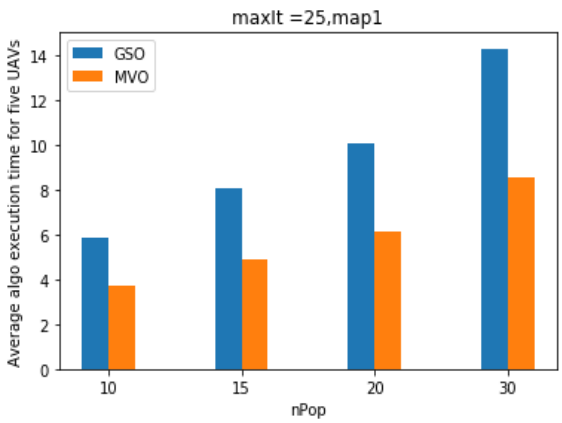
The performance of these algorithms for the problem has been compared on the same maps by varying algorithmic parameters such as initial glowworm/universe population size(nPop) and number of iterations(maxIt). This comparision is done on the basis of Path cost obtained,Average algorithm

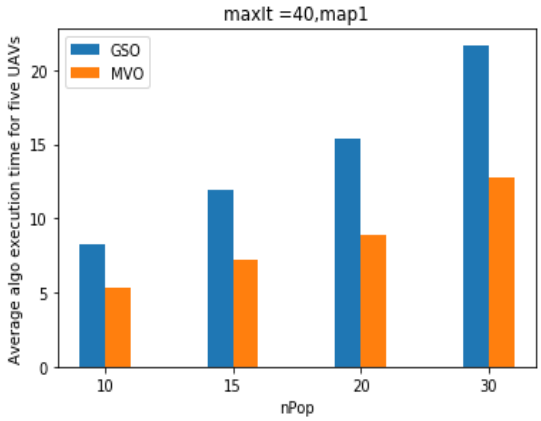
execution time and Overall run time(overall algorithm execution time + munkres execution time + simulation time).

The results have been tabulated and graphed in the following section.

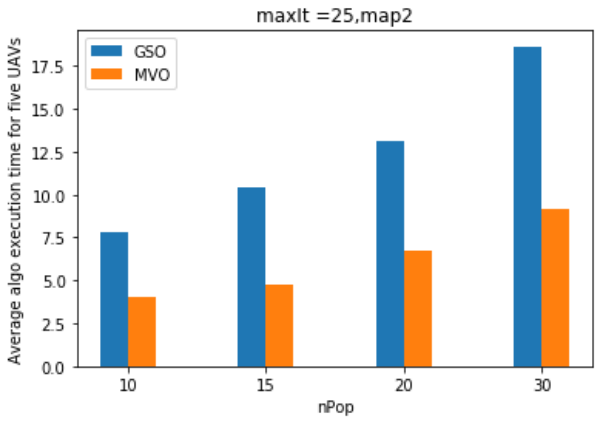
# Intermediate Results

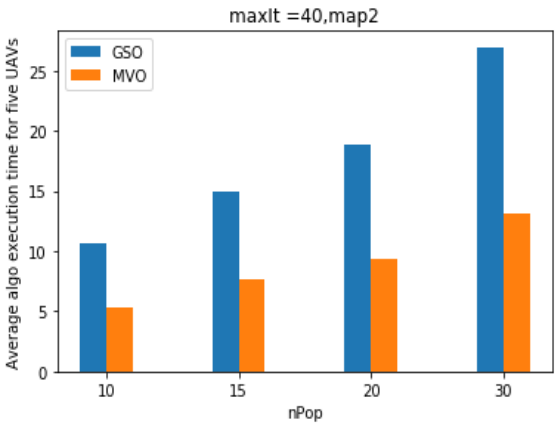
**Observed variation of Algorithm execution time with nPop for number of UAVs=5**

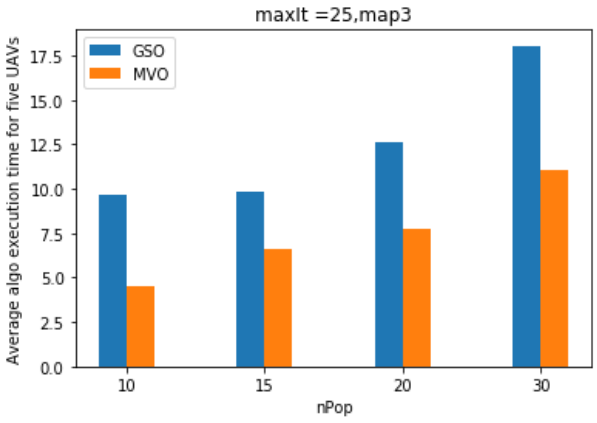


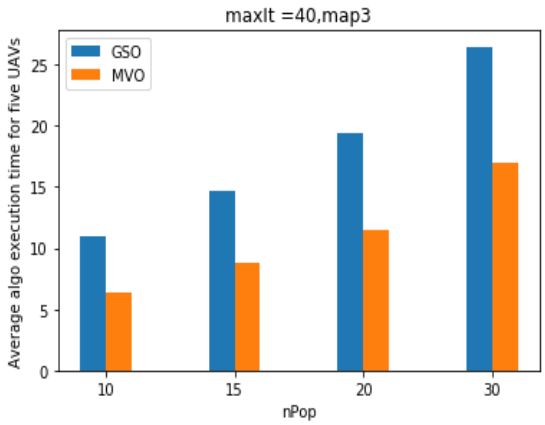




It is observed that the average algorithm execution time is more for GSO than MVO.This shows That MVO takes less time to converge to an optimal solution.






## Convergence and Complexity analysis

Here we present the values of the best cost generated by increasing the value of MaxIt for the three maps. For a fixed value of nPop, we carry out simulation 20 times and note down the average best cost over all the simulations.

**Map 1(nPop = 25,number of UAVs = 5)**

| MaxIt | Average best cost for GSO(20 simulations) | Average best cost for MVO(20 simulations) |
|---|---|---|
| 1 | **1003.00** | **1013** |
| **2** | **993.00** | **996.20** |
| **5** | **979.20** | **985.20** |
| **10** | **977.00** | **979.60** |
| **15** | **975.80** | **976.20** |
| **20** | **974.00** | **974.60** |
| **25** | **973.00** | **973.80** |
| **30** | **972.4** | **973.10** |
| **35** | **972.30** | **972.60** |
| **40** | **972.25** | **972.30** |

| | | |
|---|---|---|
| **45** | **972.15** | **972.20** |
| **50** | **972.10** | **972.15** |

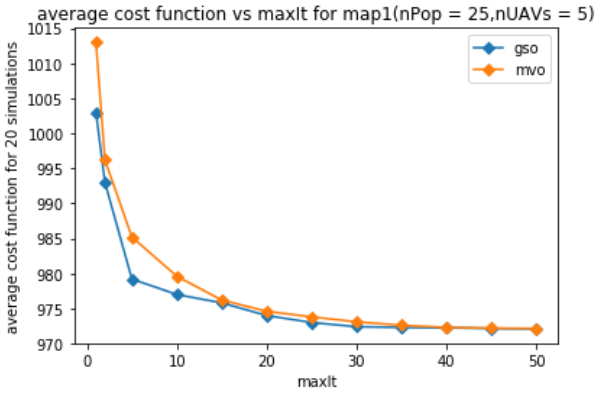
**Map 2(nPop = 25,number of UAVs = 5)**

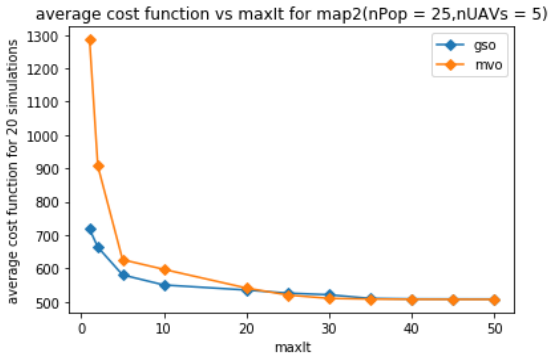
| MaxIt | Average best cost for GSO(20 simulations) | Average best cost for MVO(20 simulations) |
|---|---|---|
| 1 | **717.69** | **1268.20** |
| **2** | **663.58** | **907.16** |
| **5** | **580.40** | **626.11** |
| **10** | **550.20** | **597.30** |
| **20** | **535.0** | **541.23** |
| **25** | **525.80** | **520.09** |
| **30** | **520.80** | **510.57** |
| **35** | **509.80** | **508** |
| **40** | **508.40** | **507.35** |
| **45** | **508.20** | **507.12** |
| **50** | **508.10** | **507** |

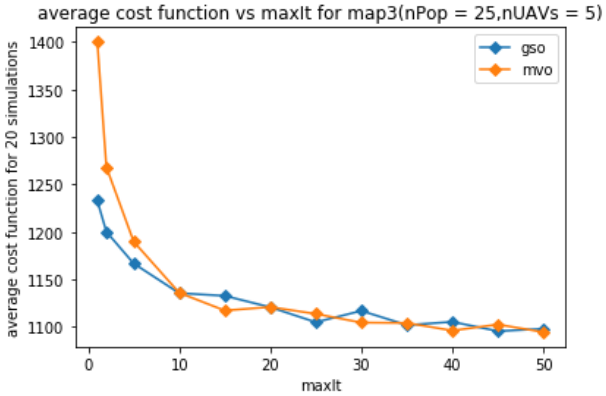
**Map 3(nPop = 25,number of UAVs = 5)**

| MaxIt | Average best cost for GSO(20 simulations) | Average best cost for MVO(20 simulations) |
|---|---|---|
| 1 | **1233** | **1400.25** |
| **2** | **1200.20** | **1268.30** |
| **5** | **1166.80** | **1189.80** |
| **10** | **1135.60** | **1135.95** |
| **15** | **1132.80** | **1117.30** |
| **20** | **1120.80** | **1121** |
| **25** | **1105.00** | **1113.80** |
| **30** | **1117** | **1104.60** |

| | | |
|---|---|---|
| **35** | **1102** | **1104.20** |
| **40** | **1105.4** | **1096.20** |
| **45** | **1095.60** | **1102.60** |
| **50** | **1098.0** | **1094.60** |




It can be observed that as we increase the value of MaxIt,MVO converges more quickly towards an optimal solution and ends up eventually either outperforming or performing similar to GSO

**Effect of number of UAV's on overall run time**

Here we tabulate the change in overall run time with a decrease in the number of UAVs.The overall run time consists of the total Algorithm execution time(MVO/GSO) for all the UAVs, the simulation time and the execution time of the Munkres Algorithm

**Multiverse Optimizer**

MaxIt=25,nPop=20

| Number of UAV's | Overall Run Time(s) |
|---|---|
| 5 | **49.5** |
| 4 | **45.50** |
| 3 | **36.12** |
| 2 | **28.18** |

MaxIt = 40,nPop = 25

| Number of UAV's | Overall Run Time(s) |
|---|---|
| 5 | **73.03** |
| 4 | **63.95** |
| 3 | **57.85** |
| 2 | **42.07** |

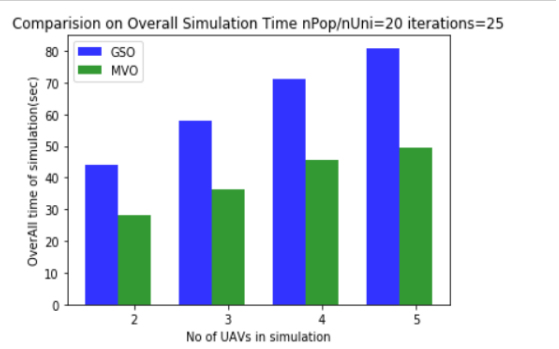
**Glowworm Swarm Optimization**

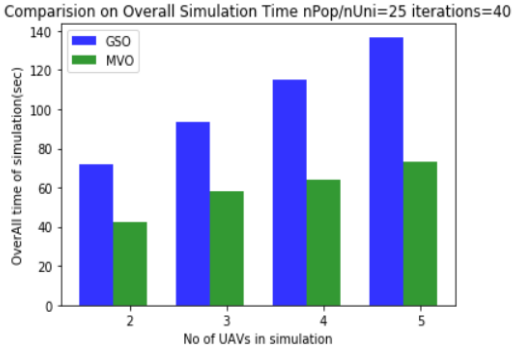
MaxIt=25,nPop=20

| Number of UAV's | Overall Run Time(s) |
|---|---|
| 5 | **80.85** |
| 4 | **70.96** |
| 3 | **57.93** |
| 2 | **43.95** |

MaxIt=40,nPop=25

| Number of UAV's | Overall Run Time(s) |
|---|---|
| 5 | **136.7** |
| 4 | **115.06** |
| 3 | **93.60** |
| 2 | **71.70** |




It can be observed that GSO has a greater overall run time than MVO .With an increase in the number of UAVs from 2-5,the overall run time is observed to follow a linear increase.

## Future activities

Future activities include comparision of the results obtained for the Multiverse Optimizer(MVO) with other Nature Inspired Algorithms and other possible improvements to it in order to make it more efficient for path planning. The above algorithms will also be compared on the basis of other algorithmic parameters in order to get a better understanding of their performance.