

Multi Objective Optimization Algorithm based Priority Path Planning using Trajectory Scheduling Assorted Robotic Network

S.DHANALAKSHMI[1], N. MOHANASUNDARARAJU[2], T.JESUDAS[2] AND D.NOORULLAH[1]

[1]Government College of Engineering, Salem, Tamil Nadu -636 101, India.
[2]Mahedra Engineering College (Autonomous), Namakkal, Tamil Nadu- 635 703, India.
Corresponding Author: S.Dhanalakshmi.

ABSTRACT

The role of unmanned Aerial Systems (UASs) is significant for real time safety applications such as disasters in forests like wildfires and hurricanes. This can minimize the risk factor during the rescue process of firefighters by improving the collection of data by making the optimal path in network. Even though many algorithms are available for finding optimal path, there are still some problems occurring in that. In the view of overcome those problem the present research proposes a multi-robot movable based hybrid positioning and localization approach using Multi Objective Optimization Algorithm (MOOA). This method helps to assist during disaster times by making the UAV's (i.e., robots) to be detectable, precautions, securable and regulated concerns. Moreover, it is capable of optimizing and path scheduling process. As a result, the proposed optimization algorithm for path planning achieves network efficiency of 73%, Scalability of the network with 81%, Throughput of 72%, Data delivery of 57% and Packet drop is 38%.

Keywords: *Multi objective optimization algorithm (MOOA); Path planning; Simultaneous localization mapping (SLM); unmanned aerial systems (UASs).*

INTRODUCTION

Investigation and planning in obscure conditions is a pivotal undertaking for astute robots to accomplish total independent conduct. Late advances in automated ethereal vehicles (UAVs) have permitted planning and investigation in hard to get to regions that were beforehand impractical utilizing automated ground vehicles. UAVs have been sent in regions that are considered risky for human activity, and give significant data about the climate in applications, for example, search and salvage, site assessment, casualty search in calamity circumstances, and observing. UAVs should be intended to work independently with no earlier data about the climate [1]. To explore in such conditions, the UAV should have the capacity to do Simultaneous Localization and Mapping (SLAM) as it investigates the region. This is significant, as the data saw is used to securely explore between free spaces and permits shrewd investigation of regions that were not recently planned [2].Restriction is a part of advanced mechanics that is of crucial significance in the organization of independent vehicles. To work independently in their work area, versatile robots should remember restriction or situating framework for request to assess the robot present, for example the position and the heading point of a robot as precisely as conceivable [3]. Localization strategies can be grouped into relative confinement and outright restriction. The relative restriction technique that utilizes inside sensors, for example, odometry and inertial estimation unit is strong against climate changes, yet the gathered blunder brought about by wheel slippage on ground-based vehicles turns out to be very huge for a long activity time Landmark-based confinement is one of the strategies for migration additionally alluded as

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first limitation, worldwide limitation, or captured robot issue [4]. The basic work flow for UAVs scheduling is show in the below Fig. 1.

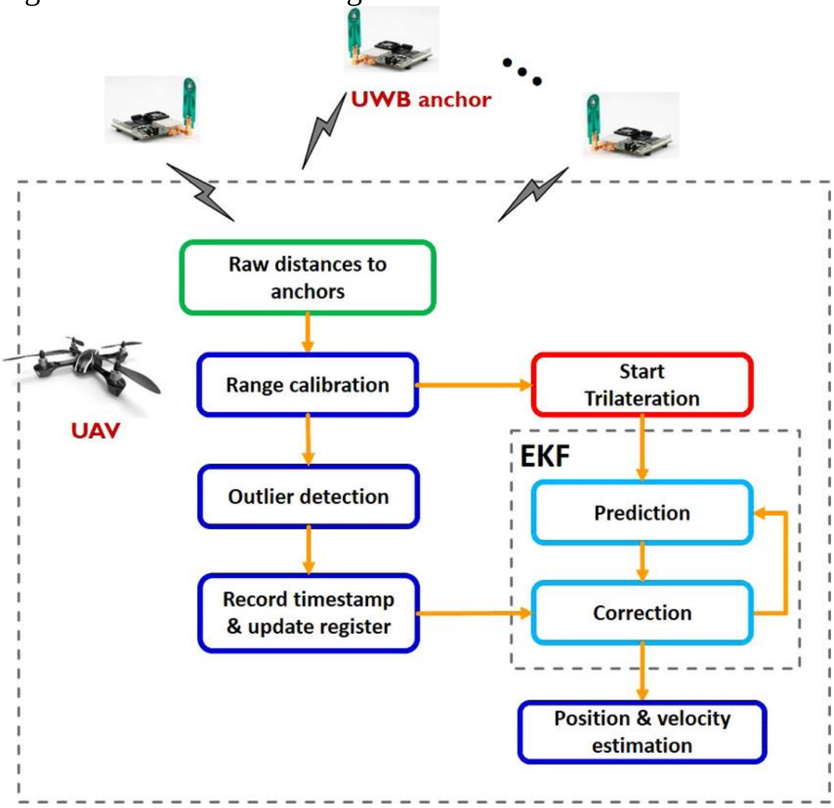

Fig. 1: The basic workflow of unmanned aerial vehicles (UAVs) for Trajectory Scheduling

Migration is the issue wherein a portable robot needs to gauge its posture just with a guide of climate and estimations taken by sensors without utilizing any data of the underlying posture [5]. Business limitation modules in outside climate utilize this technique on account of the expense and power. The robot can recognize its area by estimating the distance between the robot and milestones, the uprooting to tourist spots [6], or the bearing point between the robot and milestones [7]. Unlike versatile robot, Unmanned Aerial Vehicles (UAVs) have worked in odometry capacities. Robot odometry should be upheld by using different strategies for limitation like Global Positioning System (GPS). The below Fig. 2 describes the multi objective optimization method. Sadly, GPS additionally has its restrictions: The inspiration of this work emerges because of the impediments of GPS inside, for example the GPS signal is inaccessible can't work inside, GPS fix effortlessly lost by climate conditions [8], no less than 10-foot mistake in confinement [9]. An extra technique is needed to redress and limit mistake.

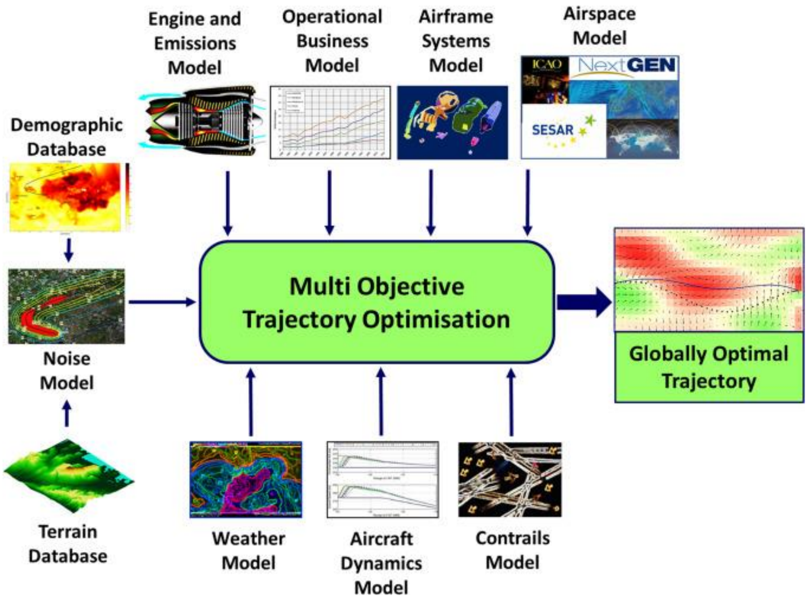

Fig. 2: Multi Objective Optimization Method

To determine the above issues, it is critical to track down a likely answer for the indoor restriction issue of automated airborne vehicles. So, this work focuses on arranging the way utilizing enhancement strategy among different guides.

LITERATURE SURVEY

The Centralized and Decoupled Algorithm (CDA) is used to disregard the issues during the development of robots in framework engineering by focusing on the articles by setting the boundaries. The settings considered depend on customary technique targets which assist with moving the robots in view of vertex and edges. The recommended CDM method assists with advancing the way founded on heuristic in data set by decreasing way contrast and optimality issue. The heuristic technique chips away at stages with decoupling way, though the way separation makes the robot to go toward all paths with the minimization of way clashes [10]. The Pigeon-Inspired Optimization (PIO) calculations utilized for arranging the ideal way. This PIO is improved with calculated interaction to beat the issue like less security and untimely intermingling. The Logistic Beetle Algorithm Search Pigeon-Inspired Optimization (LBAS-PIO) is done mind planning process and thus the space can be given as needs be. Each pigeon (hub) in the organization knows about its own judgment regarding the climate [11].The basic workflow on Multi-objective optimization objectives in path networks is shown in the below Fig. 3. The 3D semantic guide was in edge figuring the climate by utilizing the Improved Orientation Recursive Based Structured Aerial Lane Method 2 (IORB-SALM2). This strategy at first picked yolov3 to observe the articles and consequently profound learning focused division is utilized to get better goal of pixel among pictures. Aside from identification and division the presented technique additionally gauges the picture concerning different postures and projected with 3D design map [12].

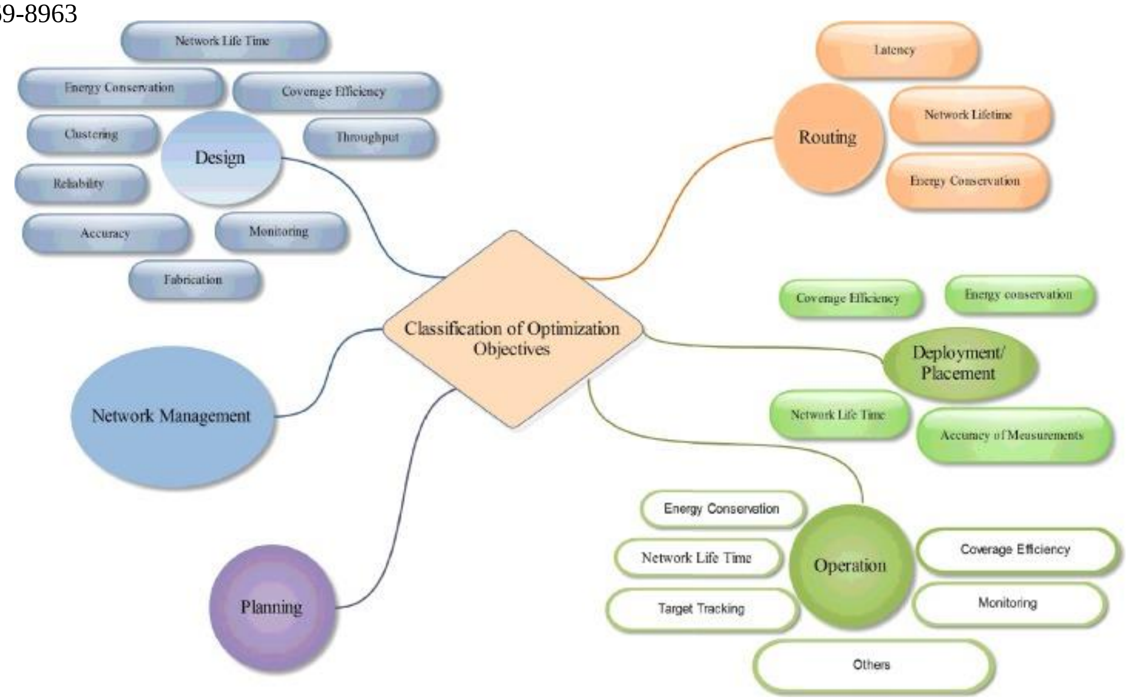

Fig. 3: Multi-objective optimization objectives in path networks

Many authors developed way anticipating versatile robots is proposed in light of the half breed multi-objective stripped down molecule swarm advancement with differential advancement. The numerical model for robot way arranging is first and foremost contrived as a tri-objective improvement with three lists, i.e., the way length, the perfection level of a way, and the wellbeing level of a way. Then, at that point, a half breed multi-objective stripped down molecule swarm advancement is created to produce possible ways by consolidating infeasible ways obstructed by hindrances with practical ways by means of further developed transformation systems of differential advancement. The classification about the robot path planning is shown and described below in the Fig. 4. Moreover, another Pareto control with crash imperatives is created to choose the individual best place of a molecule as indicated by the meaning of the impact level of a way [13]. Some researchers presented two shrewd calculations for welding way enhancement, hereditary calculation (GA) and discrete molecule swarm streamlining, are proposed to enhance the welding robot way. Through the superior choice of the administrator, the GA accomplishes the quickest iterative effectiveness.

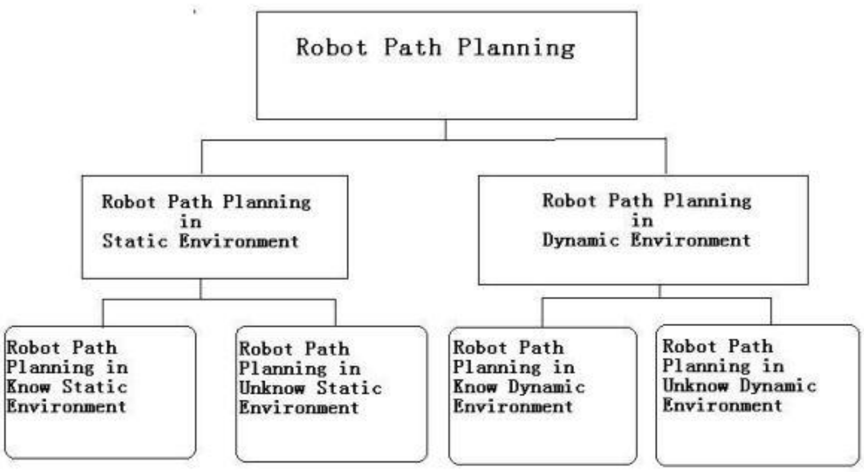

Fig. 4: Classifications on Robot Path Planning

By presenting the “trade operator” and “trade sequence” in the molecule swarm advancement calculation, the PSO calculation is improved for the arrangement of the discrete

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issue (welding robot way arranging) which is better than the persistent streamlining issue. The general schematic on Global path planning and multi-objective path control is shown in the below Fig. 5. In addition, for the better iterative effectiveness of PSO, the boundaries of customary inactivity not set in stone by a direct idleness gauge, which can further develop the combination execution of the calculation [14].

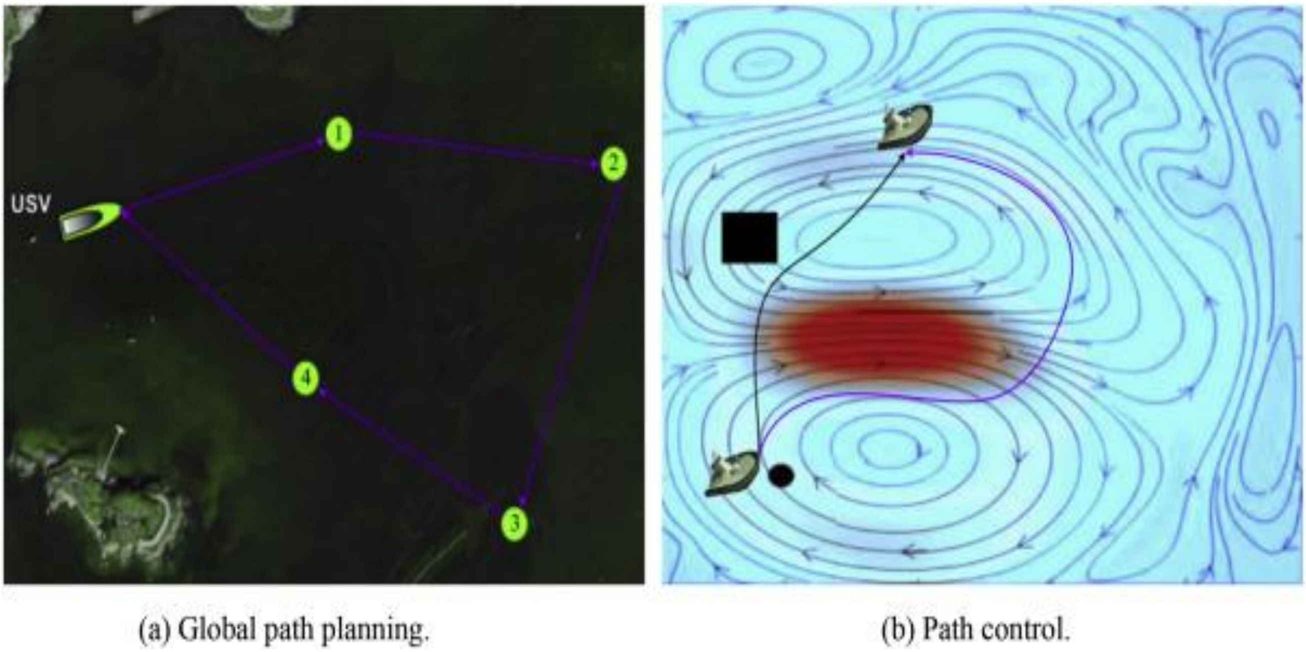

Fig. 5: A general schematic on Global path planning and multi-objective path control

A UAV helped versatile edge processing framework with stochastic calculation assignments is examined. The framework plans to limit the normal weighted energy utilization of SMDs and the UAV, dependent upon the imperatives on calculation offloading, asset allotment, and flying direction booking of the UAV. Because of non-convexity of the issue and the time coupling of factors, a Lyapunov-based methodology is applied to investigate the undertaking line, and the energy utilization minimization issue is deteriorated into three sensible sub problems and optimizing the various problems using global optimization methods[15-18].

PROPOSED METHODOLOGY

The proposed system architecture is indicated in Fig. 6 and the general schematic on Optimization techniques for oath planning is show in Fig. 7, whereas the robots (i.e., unmanned aerial vehicles) are placed in the network and hence the distance between two UVAs are calculated using “dijikstra” algorithm for better placement of UAV. After the calculation of distance, the voronoi method is utilized for partition of network. Once the partition is done, the path has to identify using Multi Objective Male Lion Optimization Algorithm (MOMLOA)

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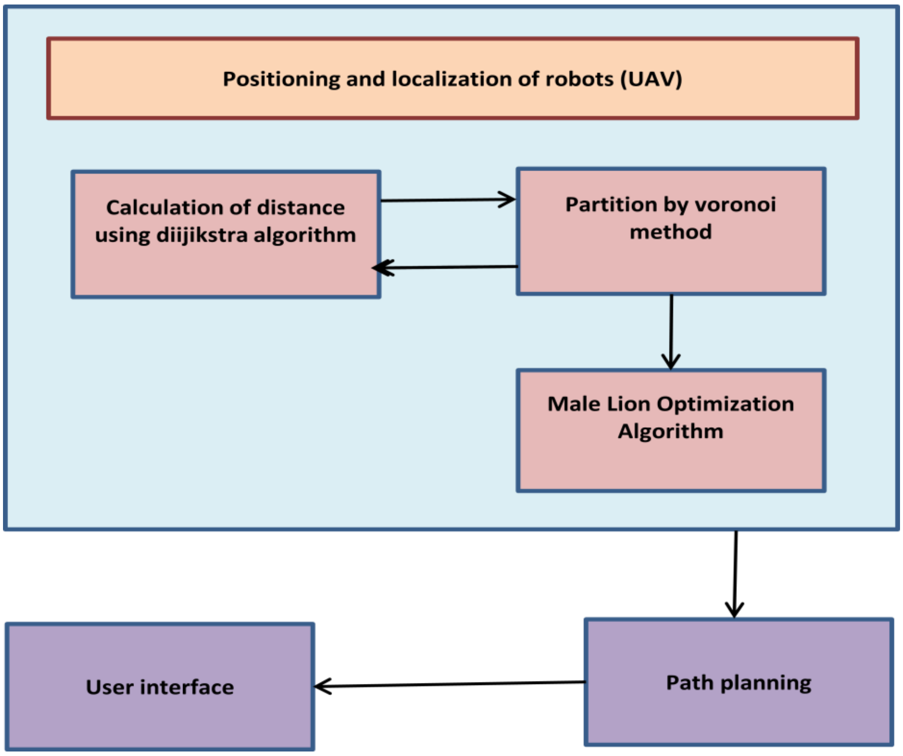

Figure 6: Proposed system architecture

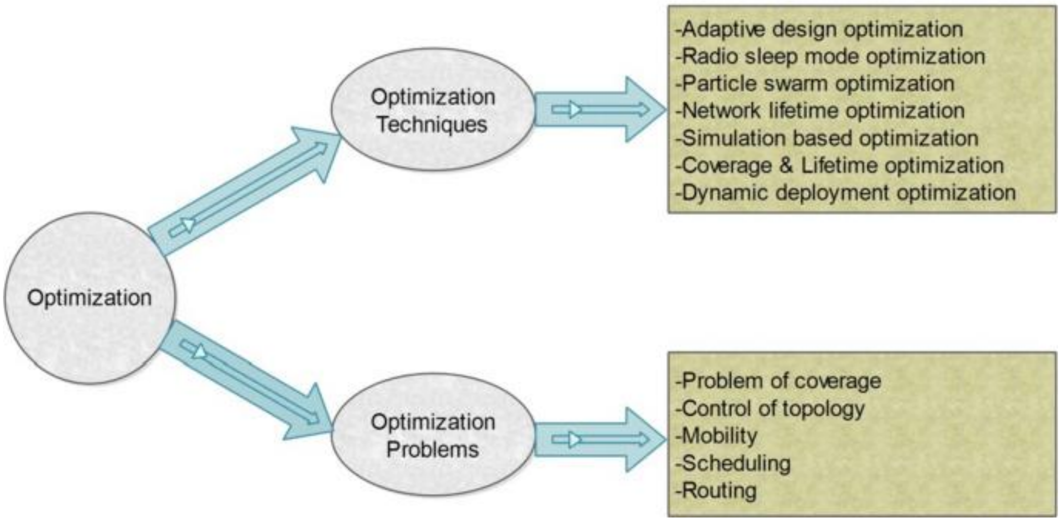

Figure 7: The general schematic on Optimization techniques for oath planning

Partition by Voronoi Method

Initially, the whole network is considered as a polygon structure with some of the following considerations,

The polygon structure is splited into smaller disjoint polygons with the inclination of three states, such as unoccupied, occupied or negligible space and hence all the smaller polygons are united with respect to its size and shape.

- ❖ Firstly, the entire network is defined by unoccupied polygon.
- ❖ Secondly, unoccupied and negligible polygons play vital role for the purpose of sensing by unmanned aerial vehicles. These two types of polygons are demolished from negligible space to obtain the reliable form.

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- Now, the unoccupied polygons are noted with edges and hence the adjacent angels have been finding out with respect to frontier edges.
- Finally, half of the partition is done in view of path planning for robot among the available polygon structure and hence the remaining partition can be done by using k-means partition algorithm.
- The k-means method follows voronoi diagram structure with iteration process.

The process of k-means partition is as follows,

- Pick the 'M' points randomly from the graph G(i) were, 1≤i≤kand hence the 'M' points are deployed in the structured polygon.
- Draw the voronoi diagram using the set of graph G(i)
- Construct various cells among the above mentioned voronoi diagram (VD) with respect to invisible polygons.
- Find the center point from VD to obtain the constrained parameter

Calculation of Distance using Diijikstra Algorithm

Once the partition is done, the distance has to be calculated to fix the robots in the network. The distance calculation is based on dijikstra algorithm which is fundamentally a graph search method. The constructed graph tries to neglect the issues in finding shortest path. The dijikstra distance has to be calculated between two robots with respect to its edge cost, correlation degree and time. While doing so, there are some possibilities to produce error which is named as estimation error which is calculated by finding the difference between real and predicted positions. Basically, these errors are more on the network with multihop. But practically the network must be in multi hop manner for better broadcast. Once all the parameters are found out, the robots have to be place on those particular points. The robots are made to move by observing the initial line of sight between its neighbor nodes which then cause the signal reflections. Let us consider two robots (i.e., UAVs) named as X and Y whereas, the distance of those robots is considered, which should be lesser than its radio convergence range. Now, these two robots cannot communicate to each other to avoid miscommunication between them.

Multi Objective based Male Lion Optimization and Multi-objective Fitness function

This particular optimization method is based on day-to-day behavior of lion such as hunting, roaming, migration, reproduction, defense, and population maintenance and convergence point. Firstly, the robots are randomly deployed with considerable amount of population and hence the iteration process has to start by checking with previous motion of robots. Each iterations are in the position has to renew to find the best position. At some point, the pride territory is considered as best position whereas this territory contains some head robots and they have to be corner from its parents which is considered as Nomad robots. The Nomad robots start to avoid all the problematic ways. During this searching process the Nomad robots reject the normal resident robots. The rejection or neglecting is due to lack of energy and time. This process is to be continuing until finding the best solution by using the objective fitness function.

An unmade Aerial Vehicle (UAV) i.e., robots participate in fitness function calculation whereas the base station is acting as a cluster head. The selection of multi objective function is based on distance, area, time, delay period within particular graph. Initially, all the process had to be done and check the above indicated parameters and hence the maxim value of each parameter is ideated as fitness function. Multi-objective Fitness function is indicated as:

$$Fitness_{max} = \left\{\left[1+\frac{D(t)}{D_{norm}}\right]+\left[1-\frac{M(t)}{X*A*N}\right]+[c(t)]+[1-T(t)]+[1-z(t)]\right\}$$
(1)

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where,

D(t)is delay while moving of robots
Dnorm is normalized delay of robots
M(t) is distance between two robots
N is total number of robots
T(t) is traffic rate while motion of robots
Z(t) is density of robots in network

Algorithm

INPUT: set of Unmanned Aerial Vehicle(UAV)	**OUTPUT:** planned path

Step-1
construction of polygon
(free<-x, unknown<-y and obstacle <-z)
Edges←Ed
K = {Ci}, 1 ≤ i ≤ K
Ci = {C1, C2, C3, C4…. Ck-1}
Find Mi from Ci
Estimate ε
ε = Ci – Mi
Step-2
calculation of distance
Step-3
initialize the number of robots (Rpop)
Step-4
Initiate the prides and robots
Select: pride id, robot id
For
Each robot do
Initiate hunting process (Hpro)
Start to search the best position (Bp) from voronoi space
Check the roaming method Roam←Bp
Neglect weak path (wp)
Wp= randomized constant (xp)
If
wp≠Bp
Estimate $Fitness_{max}$
Sorting process
Sp(fitness) =$(1+x)^n = 1 + \frac{ax}{1!} + \frac{b(a-1)x^2}{2!} + \cdots n$
Find the least value
Check termination criteria
End if

Path Planning and Performance Analysis

Once the optimal path is found by observing the fitness function, all the robots have to move in those optimal paths by neglecting the formulated obstacle in particular area. These paths have to store and hence it is indicated as predetermined path for future usage. So, like this the previous action of path planning reduces the overall complexity, local minimal activity and tuning restrictions.

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Comparison of proposed Multi Objective Male Lion Optimization Algorithm (MOMLOA)is done with the existing algorithms such as, Pigeon-Inspired Optimization (PIO) and Discrete Particle Swarm Optimization (DPSO) using various number of robots in terms of various parametric metrics like throughput, efficiency, scalability and Localization Position. The table 1 shows the efficiency analysis of existing and proposed methods.

Table 1: Analysis of Efficiency

Number of nodes (robots)	PIO	DPSO	MOMLOA
20	37	49	56
40	42	51	63
60	53	58	74
80	61	69	83
100	73	79	89

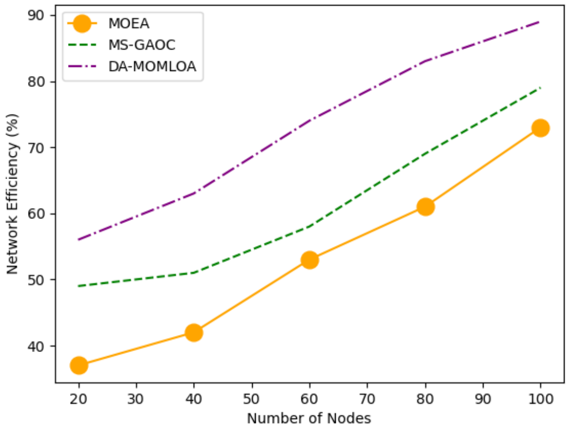

Fig. 8: Comparison of Network Efficiency

The Fig. 8 compares the network efficiency for existing and proposed methods. X axis and Y axis show the number of nodes and network efficiency respectively. The orange, green, and violet color lines indicate the existing PIO, DPSO and proposed MOMLOA methods respectively. When compared to existing methods, proposed method shows better results.

The Table 2: shows the scalability analysis of existing and proposed methods.

Table 2: Analysis of Scalability

Number of nodes	PIO	DPSO	MOMLOA
20	45	56	65
40	56	67	72
60	63	72	84
80	71	78	89
100	79	86	93

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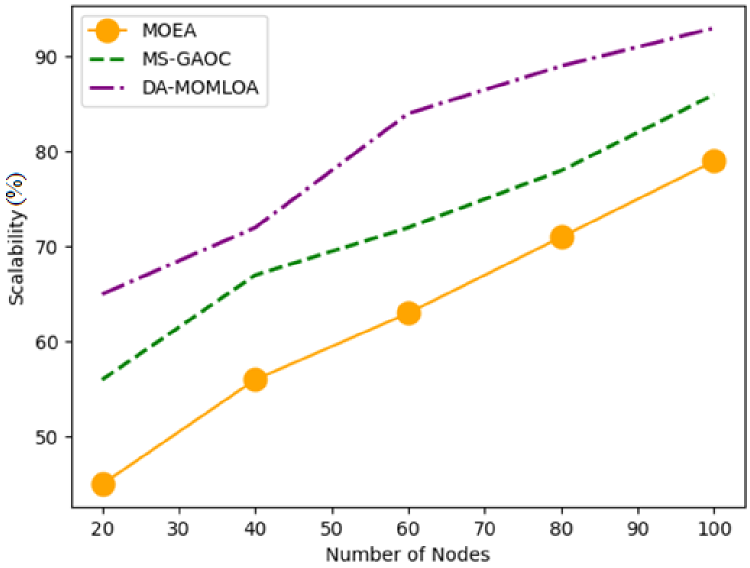

Fig. 9: Comparison of Scalability

The Fig. 9 compares the scalability for existing and proposed methods. X axis and Y axis shows the number of nodes and scalability respectively. The orange, green, and violet color lines indicate the existing PIO, DPSO and proposed MOMLOA methods respectively. When compared to existing methods, proposed method shows better results. The Table 3 shows the analysis throughput for existing and proposed methods.

Table 3: Analysis of Throughput

Number of nodes	PIO	DPSO	MOMLOA
20	15	29	45
40	28	57	66
60	51	63	79
80	63	74	83
100	72	81	89

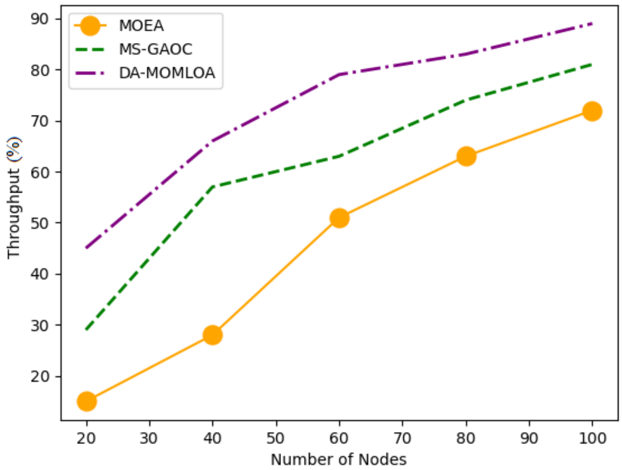

Fig.10: Comparison of Throughput

The Fig. 10 compares the throughput for existing and proposed methods. X axis and Y axis shows the number of nodes and throughput respectively. The orange, green, and violet color lines indicate the existing PIO, DPSO and proposed MOMLOA respectively. When compared to existing methods, proposed method shows better results. The Table 4 shows the analysis of localization position for existing and proposed methods.

Table 4: Analysis of localization position

Number of nodes	PIO	DPSO	MOMLOA
20	15	19	21
40	18	25	29
60	46	49	54
80	59	71	79
100	72	83	95

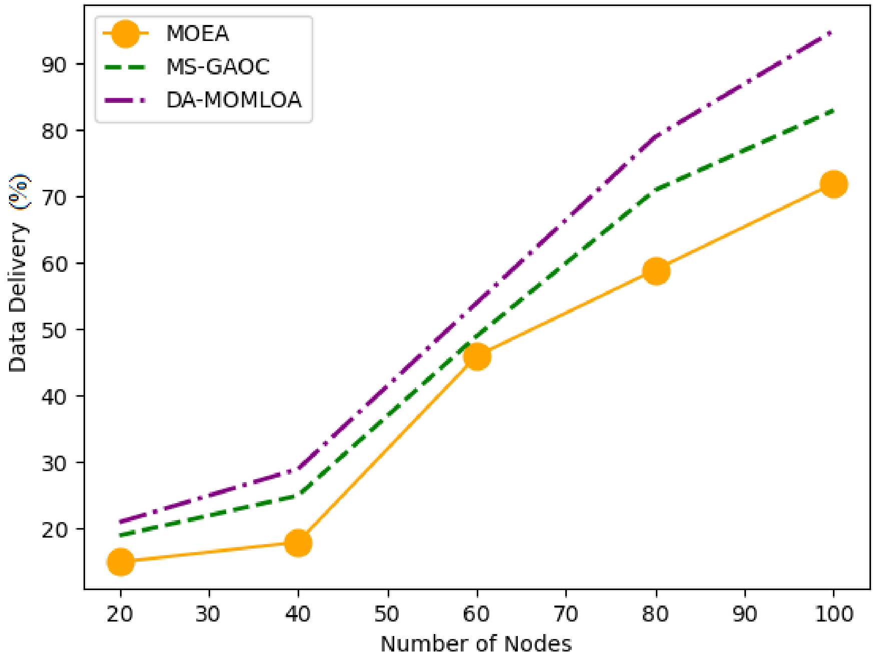

Fig. 11: Comparison of localization position

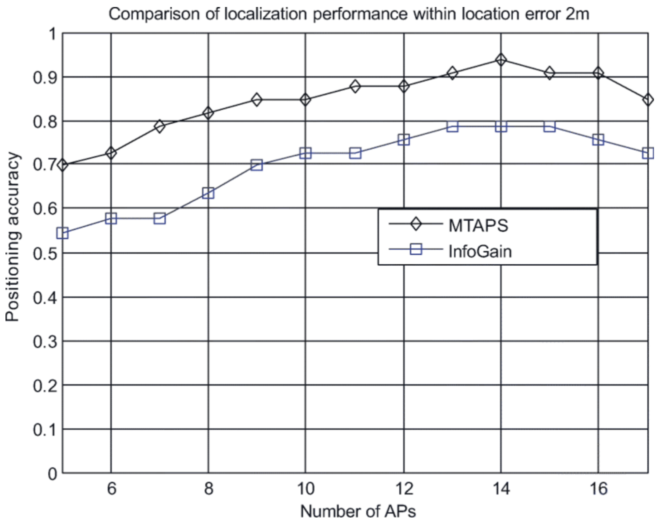

Fig. 12: Comparison on localization performance

The Fig. 11 compares the localization position for existing and proposed methods and figure 12 and 13 describes the Comparison on localization performance and Comparison between real and experimental position. X axis and Y axis shows the number of nodes and data delivery respectively. The orange, green, and violet color lines indicate the existing PIO, DPSO and proposed MOMLOA respectively. When compared to existing methods, proposed method shows better results.

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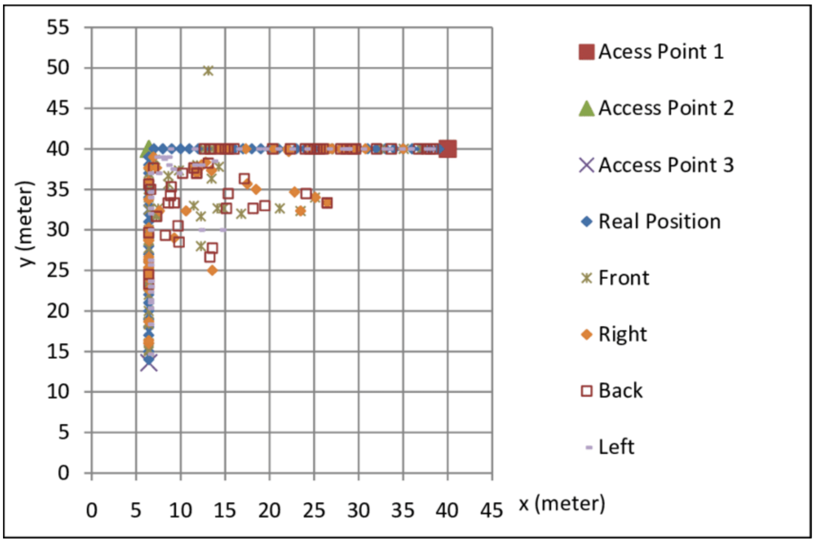

Fig. 13: Comparison between real and experimental position

CONCLUSIONS

This paper provides an excellent method of localization with the presence of robots. Landmark-based localization is proving to be an effective way to attain position information when other sources such as GPS are unavailable. This research introduced a novel data aggregation method using Multi objective based Male Lion Optimization Algorithm (DA-MOMLOA). The multi-objective is based on the energy, distance, delay, and density. The parameters considered for analysis are scalability of the network, data delivery, packet drop, throughput and the network efficiency. The Proposed method achieves network efficiency of 73%, Scalability of the network with 81%, Throughput of 72%, Data delivery of 57% and Packet drop is 38%. From the experimental result shows the better results when compared to existing methods.

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