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Particle Swarm Network Design for the Path Planning of UCAV Intelligence System

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Abstract: The role of the unmanned combat aerial vehicle (UCAV) is very important in military combat. UCAV avoids itself from the dangerous military zone and radars. If there is a narrow path between the dangerous military zones. It uses the shortest and safest path. This paper describes a novel artificial bee colony improved by the balance evolution strategy to improve the path planning of UCAV. Particle swarm network for communication between the swarm UCAV to control the position of a swarm of UCAV. Simulation results show that the particle swarm network algorithm is more efficient than the ABC algorithm. The artificial neural network is used to train the intelligence system.

Keywords: Artificial Neural network (ANN), Particle Swarm, and unmanned combat aerial vehicle (UCAV).
1. Introduction

As a result of the Gulf and Kosovo Wars, various new strategies emerged, and air power's dominance was cemented. Strategic air power, as demonstrated in the Gulf War, cannot win the war on its own[1]. However, military planners are certain that air power will determine the outcome of future conflicts. As a result of these discussions, the UCAV component automatically rises to the top of the list. With the UCAV, combat casualties are kept to a minimum while also overcoming numerous human constraints. It is expected that unmanned aerial vehicles (UAVs) would be more maneuverable, faster, and smaller than current human combat aircraft [1,2]. With low-looking radars and QRMs, such unmanned vehicles might be employed in place of manned flights in a densely populated air defense combat region (quick reaction missiles). Keeping a close eye on the activities of the adversary and relaying that information to the command posts will be easy for them. Although the UCAV concept is theoretically possible, it is technically feasible. This type of unmanned aerial vehicle can meet operational requirements and integrate into an overall strategy. The historical preference for manned aircraft should not serve as a roadblock to the adoption of this technology in future wars that are primarily motivated by progress in technology. To make use of these forces, one must first understand them. For the foreseeable future, important battles will almost certainly be determined by air power before surface forces can make contact with the other side in any meaningful way. And it's safe to say that unmanned combat aerial vehicles (UCAVs) will play a significant role in the future development of air power[3,4]. The unmanned combat aerial vehicles (UCAVs) will be more compact, faster, and more adaptable than the current human aircraft. As a result, they will be employed for a variety of missions like as scouting and surveillance, as well as jamming the enemy's air defense system. Almost every fighting nation has developed rapid response, low profile missiles that have made this a necessity. The "UCAV has not only the attraction of keeping combat casualties low, but overcomes human limiting stipulations on Gcrunching manoeuvres, and sitnent cockpit environment for protection and survival of the pilot."

The development of the synthetic UCAV can detect the enemy army marketing campaign. Avoid itself from the radar and arterially of enemies. For this cause, to layout the module and set of rules for the UCAV. The module will discover the chance vicinity and avoid aircraft from this vicinity. Path planning, much less gasoline intake, Therefore, that allows you to cope with the growing complexity whilst modeling a combat area, researchers have steadily shifted their hobbies far away from deterministic algorithms. ABC is the artificial bee colony intelligent algorithm inspired by the foraging behavior of the honeybee swarm. The swarm mainly consists of three types of bees. Employ bee, onlooker bee, and scout bee[5]. Employ bee exploited the food and check the profitability, distance, and direction of associative food. Onlooker bees analyzed the data collected by employed bees and check the probability of food and direction[6]. Scout bees are responsible for the find new food when previous food finish. Foraging behavior is searching for maximum food. Discussions of this nature inevitably include consideration of unmanned combat air vehicles (UCAVs), which will play a vital role in increasing air power. Conceptually, it's possible, and it's been demonstrated in the current air conflicts as well. This type of unmanned aerial vehicle can meet operational requirements and integrate into an overall strategy. There shouldn't be a historical bias against unmanned aircraft that prevents us from adopting this technology in the wars of the future that are technologically driven.
2. Materials and methods

2.1. ANN-based intelligent system

A particle swarm network makes the network like a bird network. If there is both sides military campaign danger area for the swarm and narrow area only one UCAV pass through the narrow area then through bird network the swarm make a decision how to move from the narrow area by using artificial neural network communication signaling the other drones how to plan path experience of that drone that passes through the narrow path and avoid the collision of drone in the swarm[7]. For solving this problem this technique is used. Particle swarm is inspired by the animal bird’s flock flying in the sky. Searching the prey all birds move in swarm communication between them is like the Mesh network. An algorithm's ability to calculate, reason, see relationships and analogies, learn from experience, store and retrieve data from a memory, solve problems, comprehend complicated ideas, communicate effectively in normal language, classify, generalize, and adapt to new settings. Linguistic intelligence, musical intelligence, logical-mathematical intelligence, spatial intelligence, intrapersonal intelligence, and interpersonal intelligence are all areas of artificial intelligence that can be explored further. UCAV Intelligence system is the only system discussed in this study.

2.2. Particle Swarm Algorithm

2.2.1. Combat Field Modelling of UCAV Swarm Path planning

Unmanned combat aerial vehicle route planning (UCAV path planning) is a global optimization problem that aims to construct a collection of waypoints from a starting point Q to a destination point M while avoiding flying outside of the allocated map or being captured by threats. According to our research, all threats that can be found in the environment may be categorized into two categories: mobile threat types and static threat types. Static threats are obstacles that remain in a fixed place in space (shown by yellow circles with a predetermined radius); mobile threats are obstacles that move dynamically and with a known constant velocity (represented by red circles with a predetermined radius) (denoted as blue circles). Using the straight-line QM as shown in Fig 1(a) and (b), the flying route is divided into (M+1) segments, with each segment denoting one waypoint along the route. [3].
Figure 1. Transformation of the coordinate system in UCAV path planning model (a) Consists of both mobile threats and static threats, (b) Consists of mobile threats only

For robot path planning, PSO is commonly used because it requires just a minimal amount of processing resources, searches quickly, and requires a small number of tuning parameters. It has been proposed to use a PSO algorithm with guaranteed convergence for global path planning of mobile robots and to apply it to this task. Particles are encoded with information about the path that connects the starting point and ending point of a path in the environment. According to the locations of barriers,
an active region of particles is separated, and the initial population is generated in this area, causing a particle to look for the ideal path in a more confined area. Particle's acceleration coefficient and inertia weight are modified adaptively as the number of iterations increases during the search process[8,9]. To simplify the complexity of the computing process in the path planning for the UCAV, a transformation of a coordinate system is created, as seen in Fig 1(b). This transformation is accomplished by repositioning the straight line connecting Q and M as the new x-axis, and the start point (S) of UCAV as the new origin of coordinates, resulting in a new coordinate system (x', 0', y') that is changed from the previous coordinate system (xoy). If the coordinates of a waypoint in the (xoy) system and the (x',0',y') system are given as \((x_0, y_0)^L\) and \((x_t, y_t)^L\), the relationship between the original and transformed coordinates in the two coordinate systems can be stated in the following fashion[3].

\[
\begin{bmatrix}
    x_j \\
    y_j
\end{bmatrix} =
\begin{bmatrix}
    \cos \theta & \sin \theta \\
    -\sin \theta & \cos \theta
\end{bmatrix}
\begin{bmatrix}
    x_0 - x_Q \\
    y_0 - y_Q
\end{bmatrix}
\] (1)

When M is the location of the starting point in the original coordinate system \((x_Q, y_Q)^M\), then the formula for the cost of mobile threats is expressed below;

\[
|c| = \frac{1}{d_{ij}}
\] (2)

\[
|c_x| = |c| \cdot \frac{x_{ij}}{d_{ij}} = \frac{x_{ij}}{d_{ij}^2}
\] (3)

\[
|c_y| = |c| \cdot \frac{y_{ij}}{d_{ij}} = \frac{y_{ij}}{d_{ij}^2}
\] (4)

\[
|\sum_{k=1}^{m} c| = \sqrt{\left|\sum_{k=1}^{m} c_x\right|^2 + \left|\sum_{k=1}^{m} c_y\right|^2}
\] (5)

The horizontal component of \(|c|\) is represented by the symbol \(|c_x|\), and the vertical component is represented by the symbol \(|c_y|\). Where \(|c|\) represents a mobile threat and \(|c_x|\), represents the horizontal component of the threat. As well as the distance between positions I and j, the value of the horizontal component \(x_{ij}\) of the distance between positions I and j is \(d_{ij}\), the value of the vertical component \(y_{ij}\) of the distance between positions I and j, as well as the number of mobile threats that the ant is exposed to is also represented by the letter "m." Finally, the positions of each ant and each pheromone are updated in real-time when they change their places. The cost of the mobile threat \(J_T\), the cost of the fuel \(J_F\), and the total cost \(J\) are the primary performance measures for the planned path. It is written as follows how the calculating formulas for them work[10,11]:

\[
J_T = \sum_{i=0}^{M} J_T(i)
\] (6)
\[ J_F = \sum_{i=0}^{M} J_F(i) \]  

(7)

\[ J = J_T + J_F \]  

(8)

For each ith subpath from \( W_i \) to \( W_{i+1} \), we have \( J_T(i) \) and \( J_F(i) \) signify the mobile threat cost and the fuel cost then, respectively. Fig 1(b) depicts an approximation of the mobile threat cost of a subpath, which is derived using blue circles along the subpath to approximate the mobile threat cost. If the ith subpath \((W_i,W_{i+1})\) falls within the effect range, the threat cost is calculated as follows;

\[ J_T(i) = L_i \sum_{k=1}^{N_t} T_K \cdot C_K \]  

(9)

Where \( N_t \) denotes the number of mobile threats encountered, \( L \) represents the length of the ith subpath, and \( T_K \) symbolizes the weight of each mobile threat encountered And \( C_K \) is the cost of each mobile danger [12,13], which is determined by the formula (5). Furthermore, since \( W_F \) represents the weight of fuel, the fuel cost of the ith subpath is denoted by the notation given below;

\[ J_F(i) = W_F \cdot L_i \]  

(10)

2.1. Combination of ABC and Particle Swarm Network

If there is the distance between the two threats is narrow, then in a swarm, the drones communicate with each other by a neural network. Due to neural networks, the first drone easily sends data to the nearest drones on how many degrees you come in which pattern and in how many elevations[14,15]. This algorithm prevents the drones from colliding and identify their path autonomously. The narrow path modeling is shown in fig 2 (a) and the proposed neural network of swarm UCAV is depicted in fig 2(b) below.

![Path between threats](image)

(a)  

![Artificial Neural network of swarm UCAV](image)

(b)

Figure 2. (a) Narrow path modelling diagram, (b) Artificial Neural network of swarm UCAV
UAVC pass the massage in like the neural network from layer to layer basically neural network is designed from the Particle Swarm Algorithm. The drones are in the forward position search the track and sent the message to the other drones about to arrange their position according to the path and send the position and make the decision in which angles other drones come. Forward position drone does this work and sends the message into layer then drone arranges itself and avoids from a collision[16]. Moving of the drone pattern is given below in Fig (3)(a) and (b).

![Figure 2. (a) Movement of Drone pattern, (b) 3D modeling of UACV](image)

2. Results

The UCAV has a different parameter to train elevation angle, PS position, and direction. We control these parameters and they are used for the path planning of the swarm. Here we have taken one input and output this input sigmoid to the output. Sigmoid is the activation function and input is transferred to the output. The performance of the neural network is giving in fig 3 (a) and (b) Below. The regression of the train data graph is depicted in fig 3 (c) below.
3. Conclusions

First, we the improved ABC algorithm but the main problem in this algorithm is that if there is a place of one drone to pass other down have not a strategy to pass through between two hazard areas. For to avoid the collision we used the Particle swarm algorithm. We have proposed its name as a Particle Swarm network algorithm. An artificial neural network is used to communicate the first drone with others to tell about the obstacle in the Path of the drone they tell the in which angle and altitude to travel in a line. ANN is formed by the PSO algorithm. The designed intelligence path planning system had diminished the problem of path planning in the existing systems.

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Conflict of interest

Authors declare that there is no conflict of interest regarding this article.

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Figure 3. Neural network, (a) Training state, (b) performance, and (c) Regression of trained data


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