LCSO

N swarm size, M number of sub-swarms, n number of particles in the sub-swarms, random initialization of p and v of particles in sub-swarm.

while number of cost-function evals $\leq$ max allowed number of cost function evals:

→ Evaluate cost function ← 3D mobility energy consumption of a UAV

→ Parallely

→ while sub-swarm $\neq \{\}$

→ select 3 particles randomly, evaluate their costs and determine winner, runner-up, and loser

→ update runner-up position:

$$V_s(t+1) = r_1 V_s(t) + r_2 (X_{winner}(t) - X_s(t))$$

$$X_s(t+1) = X_s(t) + V_s(t+1)$$

$$r_1, r_2 \sim Unif[0,1]$$

→ update loser position:

$$V_l(t+1) = r_1 V_l(t) + r_2 (X_{winner}(t) - X_l(t)) + r_3 (X_s(t) - X_l(t))$$

$$X_l(t+1) = X_l(t) + V_l(t+1)$$

$$r_1, r_2, r_3 \sim Unif[0,1]$$

end

→ Tournament b/w sub-swarms

→ randomly select one ~~winner~~ from the winners of each sub-swarm

→ if set of winners $\neq \{\}$ particle

→ select 3 particles randomly

evaluate cost ⇒ determine winner, runner, loser

update as above

end

→ output best solution

Obj: $\max_{\forall U: (x_U, y_U, H_U),\ \forall GU: \Phi, \Gamma} \sum_{t=1}^{T} \sum_{U=1}^{N_U} \text{reward}(U, t)$

fleet-wide reward over mission duration

mTSP: $x_{ij} \Rightarrow q_U \to (x_U, y_U)_{t=0}^{t=T'}$

~~clustering~~ # of UAVs?

(1) cluster the GNs according to their proximities into C clusters.
Determine the best 3D UAV position

(1a) K-means clustering

$N_U \le C \le N_G$

$$\underset{S}{\text{argmin}} \sum_{i=1}^{k} \sum_{\underline{x} \in S_i} \| \underline{x} - \underline{\mu}_i \|_2^2$$

centroid

$$\underline{\mu}_i = \frac{1}{|S_i|} \sum_{x \in S_i} \underline{x}_i$$

constraints: UAV position & Grid
$0 \le x_U \le x_{max}$, $0 \le y_U \le y_{max}$, $0 \le z_U \le z_{max}$

(1b) Best position for a UAV to serve all GNs in this cluster

UAV U, Cluster C_U,
UAV V, cluster C_V, — —

$$\min_{(\text{position } x_U, y_U, H_U)} \sum_{q \in C_U} \text{latency}$$

latency $\to \frac{\text{payload}_{ij}}{R_{qU}}$

Given Φ_U, Γ:

(1c) Given position find Φ_U, Γ — iteratively

Given cluster, position, and Φ, Γ design:

(1d) m-salesmen Traveling Salesman problem

Fully-connected graph $G = (V, E)$

each optimal position for cluster is a vertex

$$\min \sum_{(i,j) \in E} c_{ij} x_{ij}$$

s.t.

$\sum_{j \in V : (1,j) \in E} x_{ij} = N_U$ → all N_U start from takeoff pads

$\sum_{j \in V : (j,1) \in E} x_{ij} = N_U$ → all N_U ~~end~~ at landing pads

$\sum_{i \in V : (i,j) \in E} x_{ij} = 1$, one UAV enters per point

$\sum_{j \in V : (i,j) \in E} x_{ij} = 1$, one UAV exit per point

sub-tour elimination constraint

branch-and-bound method