INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY
HYDERABAD

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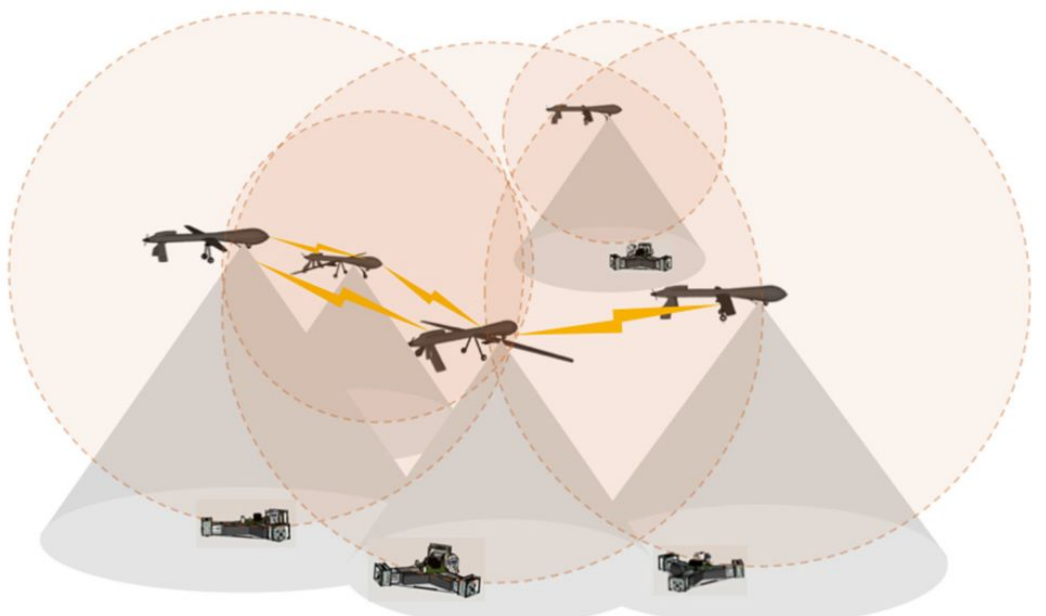
Technology, Social Impact

Model predictive control based algorithm for multi-target tracking using a swarm of fixed wing UAVs

OBJECTIVE

Our aim is to track multiple targets in an area through multiple fixed wing UAVS using camera with fixed orientation. The algorithm is based on decentralized MPC. Two cases are considered where number of UAVs (**N**) = number of targets (**M**) and N<M. The physical constraints of the each UAV and the inter-UAV collision avoidance are incorporated as constraints in the MPC formulation. The hyperparameters of MPC are tuned using Bayesian optimization based on a data driven Gaussian Process model for N<M case. Comparison is done with centralized MPC



multi-UAV system tracking multiple targets under dynamic constraints. The gray areas illustrate the observation range of the UAV.

METHODOLOGY

Algorithm 1 (N=M MPC)

for k=1 to N **do**
  $P_k \leftarrow$ *Update position error correction*
  $V_k \leftarrow$ *Update velocity error correction*
  $\lambda_{i,k} \leftarrow$ *Update dynamic constraints*
  $\mu_{i,k} \leftarrow$ *Update FOV constraints*
  $M_D \leftarrow$ *Update Minimum distance collision constraint*
end for

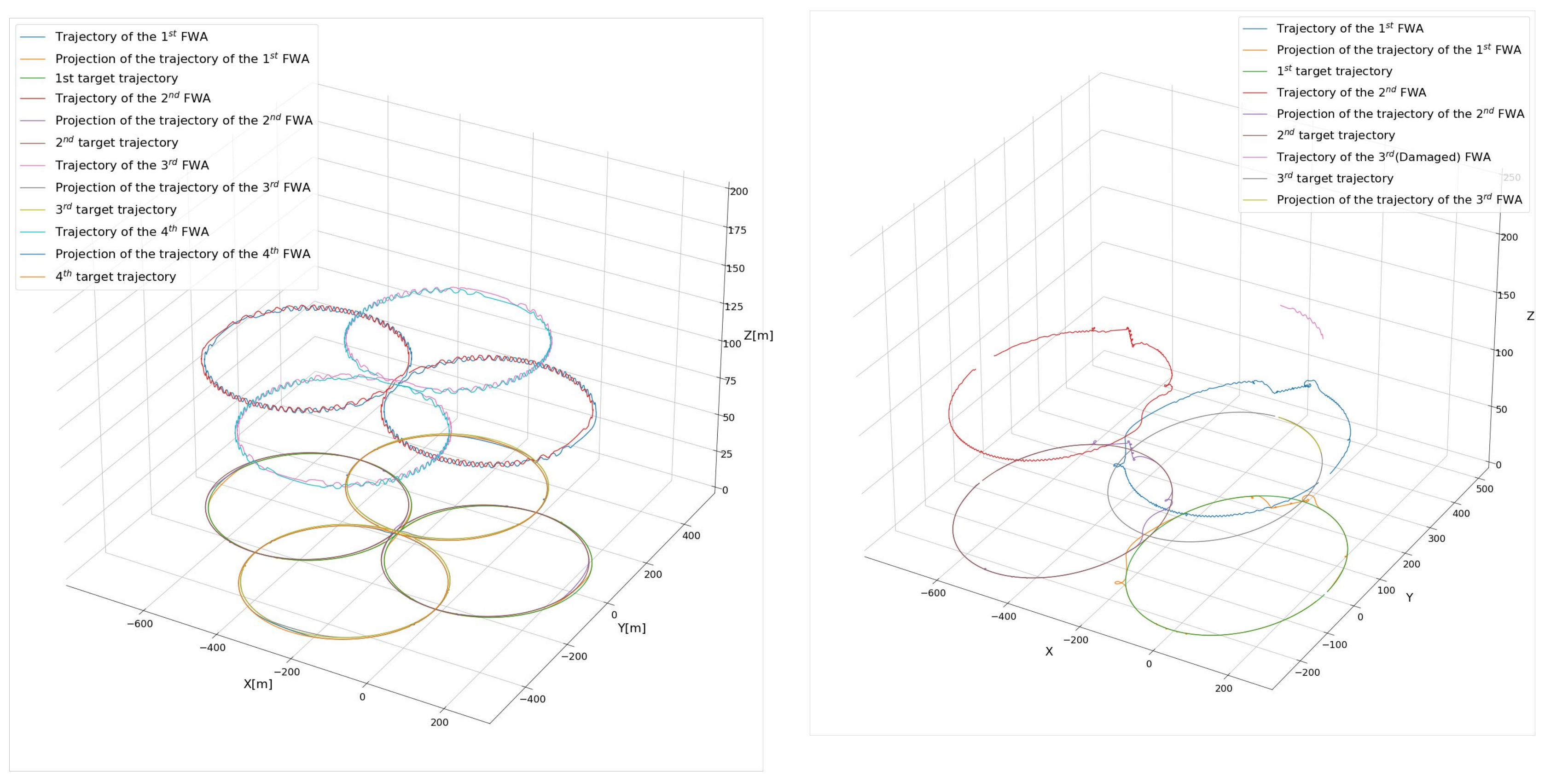
$$\text{Cost function} = w^p * \sum_{k=1}^{N} P_k + w^V * \sum_{k=1}^{N} V_k + M_D + \sum_t \sum_{k=1}^{N} \sum_i w^{\mu}_{i,k} * \mu_{i,k} + \sum_t \sum_{k=1}^{N} \sum_i w^{\lambda}_{i,k} * \lambda_{i,k}$$

SOTA gradient descent variants like RmsProp are suitable for solving this cost function.

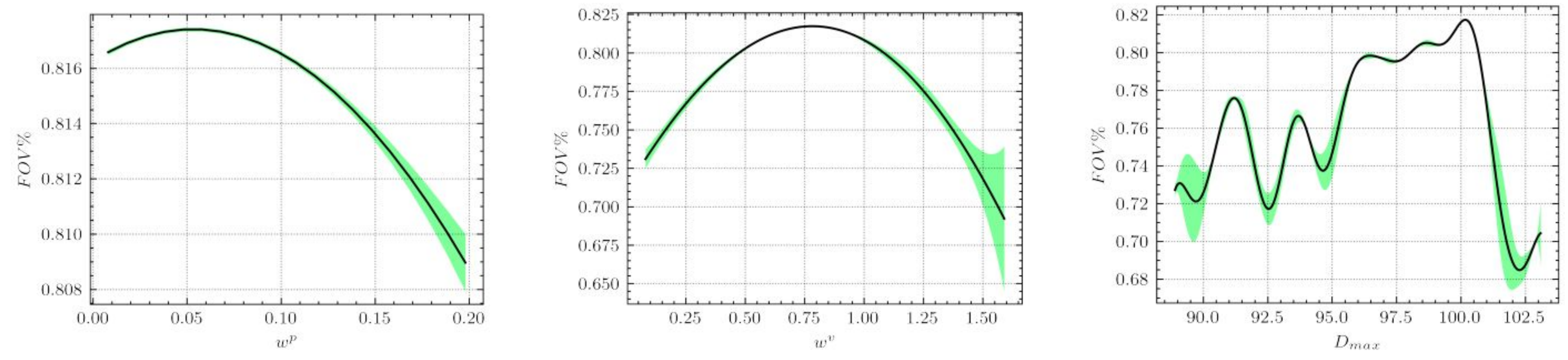
Algorithm 2 (N<M MPC)

D_{max} : *maximum distance for a lost target from* k^{th} *FWA to be in FOV*
D_{kq} : *distance of* k^{th} *FWA from* q^{th} *target.*
Use:$[w^p, w^v, D_{max}]$ *from* **Bayesian Optimization**
for k=1 to N **do**
  if $D_{kq} < D_{max}$ **then**
    Update target position and velocity in P_k *and* V_k *with weighted mean where weights are based on the predicted distance from both targets. (lost and original)*
    Update FOV constraints for target with damaged UAV
  else
    Refer to Algorithm 1
  end if
end for

RESULTS



Decentralized case for N=M=4(a), and N=2, M=3(b)



Bayesian optimization to obtain best hyperparameters for maximum FOV in Decentralized N<M case with prediction horizon 5. The figures shows a Gaussian process (GP) approximation of the for each hyper parameter (by fixing other two) over 100 iteration. While the green shaded region shows the mean plus and minus the variance

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