Post doc subject:

Drone fleet in cooperation for pursuing an intruder drone

Post doc Advisors:

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Context of the study:

Pursuit applied to mobile robots has been recently motivated by the increasing menace due to the popularity of small robots, especially drones. Although legislation is determined in most countries to regulate its use, there still a huge difficulty to reinforce the law, i.e., to track and to intercept the intruders in case of criminal usage [1]. Incidents involving drones in airports, nuclear plants and public events have become frequently reported in the newspaper's pages consecutively, causing a social concern of its use [2].

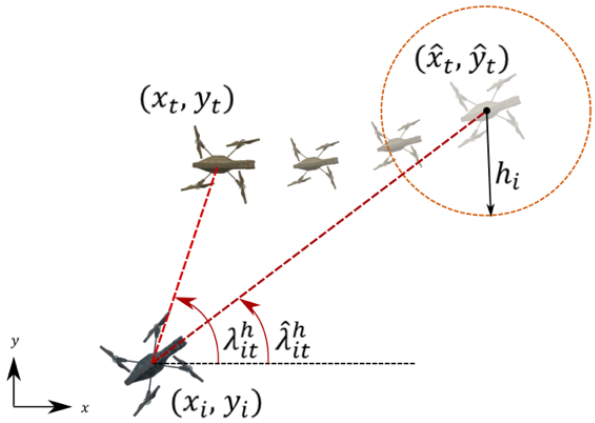
According to [3] the current anti-drone solutions can be divided into the following classes: jamming, spoofing and mitigation. The first one consists on forcing the drone to land by using false command signals, while the second disturbs the control with strong signal interference, which can also force the drone to an emergency landing.

Between the available solutions, the Anti-Drone Drone (ADD), as in [4-6], has shown itself a powerful solution that counts with the advantage of having the same "nature" of the threat, having similar features and limitations. ADD system can collide, capture with nets or even disparate projectiles towards the target.

Nevertheless, the use of a single agent in pursuit against an evader with similar capabilities is generally a hard task, where the evader normally takes advantage. To overcome this issue, one solution recurrent in our day's life or natural experience is the use of a group of agents, that cooperates and increases its success rate, as exposed in [7] and [8]. In the group hunting, the perception and actuation area are significantly augmented, each one can allow even the capture of faster or more agile preys.

Post doc description:

In this proposal, the goal will be to design a behavior-based strategy for a multi-agents' pursuit allowing a group of drones to execute tracking of an intruder in a 3D environment. The hunting behavior will be obtained using the Deviated Pursuit Guidance (DPP) methodology and a predictor scheme. Therefore, our idea will be to design the algorithm with predictive properties for estimating the target's position ahead observing its previous dynamics, as can be seen in the following figure.



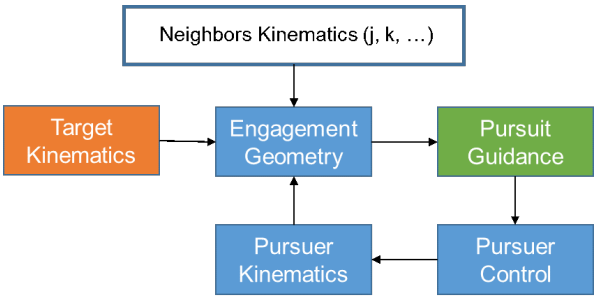
From literature, we can observe that, numerous solutions in multi-agents coordination are not well adapted to the pursuit task. Most of the adopted solutions, as the behavioral-based technique, have alignment/friction terms, which act as a brake preventing the pursuers to get the target. In this proposal, we propose instead of using classical repulsion and alignment terms, the pursuers drones will have a common goal and collision-free trajectories to corral and intercept the target. Then, the goal will be to design a strategy that will result in patterns of formation that mimics the behavior of chasing animals, such as lioness. In addition, the pursuit strategy will be also conceived so that it can be easily implemented in real time with a fleet of aerial vehicles.

This proposal is related with the security (mini-drones) Labex application for the Management of Technological Systems of Systems (MTSoS). In addition, the project is inside the research axis 1 - Interaction and cooperation among systems and axis 4- Dynamics of Systems of systems.

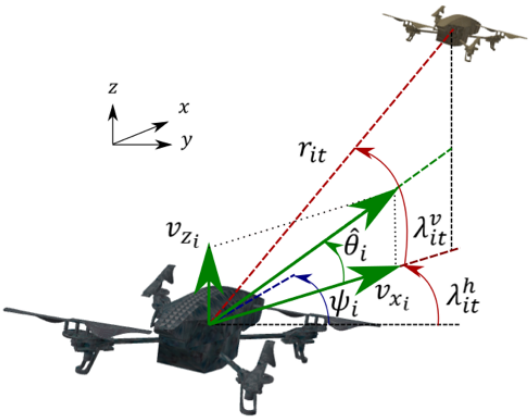
Methodology constraints:

The pursuer drone group will be considered equal or bigger than two agents following only a single evader drone. The drone configuration will be a quadcopter aerial vehicle with parallel motors. Moreover, the pursuit goal will be that at least one pursuer intercepts the drone intruder. For that, in the simulated environment the chase simulation ends when a pursuer catches the intruder. Nevertheless, for protecting our prototypes when validating the approach experimentally in real time, the catch of the intruder drone won't be included in this work, instead, the goal will be to corral the target, keeping a safe distance. As the objective is to use our prototypes and flight arenas, in the experimental validation, the displacement of the agents (pursuers and intruder) is confined in a cubic environment of dimensions 5x5x3 m^3, that corresponds to a safety volume inside our flight arena. Outdoor experiments are also taken into account in this proposal.

The control strategy will be conceived taking into account the architecture depicted in the following figure.



In this figure, the Pursuit Guidance block will be responsible for the hunting behavior of the pursuer and is based on the relative engagement, this block will generate the velocities references to the lower levels control. The Pursuer control block will be the control algorithm implemented in each pursuer for autonomous navigation. The Engagement geometry block will relate the agents' kinematics for designing the pursuit guidance algorithm. An example can be seen in the following figure, were the relation pursuer-intruder is illustrated.



We consider that this proposition has a potential implementation in security systems, anti-UAV and collective analysis behavior of predators.

An ANR project related to this proposal has been submitted and accepted for the second phase.

The duration of this postdoctoral position is for 12 months.

Candidate's profile:

The candidate must have knowledge in automatic control or robotics and some experience in programming (notably Matlab and C ++) and on state estimation problems. Knowledge of Linux would be appreciated.

He/her will also have:
- Scientific autonomy and rigor
- A good level in English (written and oral)
- The taste for work in a multidisciplinary environment
- The aptitudes and the motivation for the valorization by the publication

Documents required to apply:

Send to castillo@utc.fr
- Curriculum vitae
- Motivation letter
- At least two references and/or recommendation letters
- A statement of research experience and interests

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