# How effective is optical flow for collision avoidance in drone swarms ?

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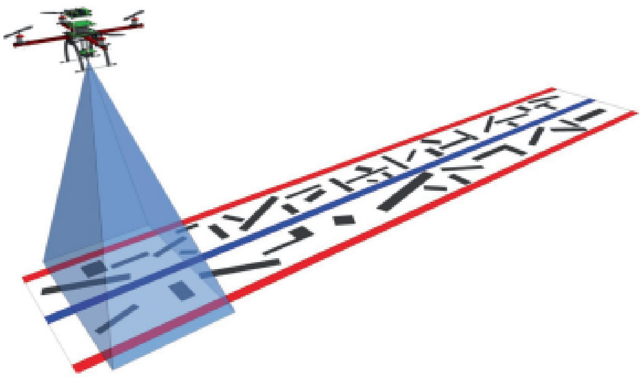
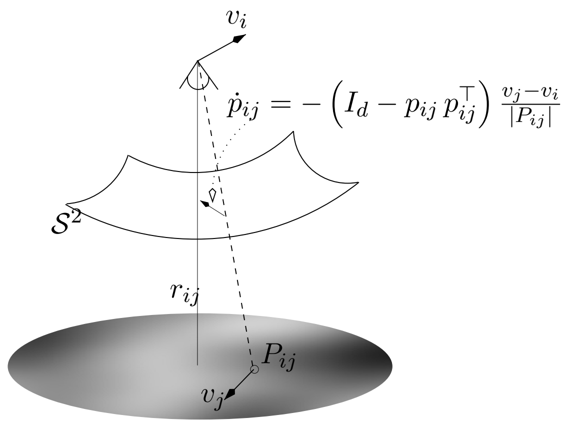
In a recent article [4], we addressed the problem of collision avoidance in optical-flow-driven drone swarms (see Fig.1a) for small-enough drones with an underlying communication graph being not necessarily complete. To this end, we first recalled how such a control translates into a singular Cucker-Smale model (1) [2], where $x_i$ and $v_i$ represent respectively the position and the velocity of the $i$th drone, and $\psi > 0$ is a communication weight function (with $\psi(r) = 1/r$ for optical flow) :

$$\begin{cases} \dot{x}_i(t) &= v_i(t), \\ \dot{v}_i(t) &= \sum_{j=1}^{N} \psi\Big(|x_i - x_j|(t)\Big)(v_j - v_i)(t). \end{cases} \tag{1}$$

Global results of absence of collision were known only for finite time [1]. Using the same formalism, we proved the existence of a security distance, *i.e* a uniform-in-time minimal distance between all agents, which depends on the initial conditions and the different parameters of the fleet. We showed that this result remains valid for a wider class of settings than standard optical flow, and will present the main ideas behind the result. Optical flow being prone to measurment incertainty, we will show as well how it holds under perturbation of the relative distance between agents, and how such a perturbation impacts the theoretical minimal distance. In addition, we will expose broader models incorporating optical flow, such as adding attraction, repulsion or target tracking, and see if whether or not it keeps preventing collisions.



(a) Drone measuring optical flow, taken from [3]




(b) Image kinematics for spherical image geometry.

[1] J. Carillo, Y.-P. Choi, P. Mucha, J. Peszek. *Sharp condition to avoid collisions in singular cucker-smale interactions.* Nonlinear Analysis : Real world applications, **37**, 317–328, 2016.

[2] F. Cucker, S. Smale. *Emergent behavior in flocks.* IEEE Transactions on automatic control, **52(5)**, 852–862, 2007.

[3] I. Fantoni, G. Sanahura. *Optic flow-based control and navigation of mini aerial vehicles.* Aerospace Lab, **(8)**, 2014. doi :10.12762/2014.AL08-03.

[4] A. Maupoux, G. Dufour, B. Hérissé. *Collisionless drone swarm dynamics through optical flow based control using general communication graphs.* Automatica (in revision), 2023.

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