Optimal strategies to catch a drifting target in turbulence

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We show how to apply optimal control theory to catch a passive drifting target in a turbulent flow by an autonomous flowing agent with limited maneuverability. For the case of a perfect knowledge of the environment, we show that Optimal Control theory can overcome chaotic dispersion capturing the Lagragian target in the shortest possible time[1]. We also provide baselines using heuristic policies based on local-only hydrodynamical cues[2]. How to extend this approach to model-free Reinforcement Learning tools is also briefly discussed[3]. Data are open downloadable from TURB-Lagr[4], a database of more than 300K three-dimensional trajectories of tracer particles advected by a fully developed homogeneous and isotropic turbulent flow. This work was supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (Grant Agreement No. 882340).

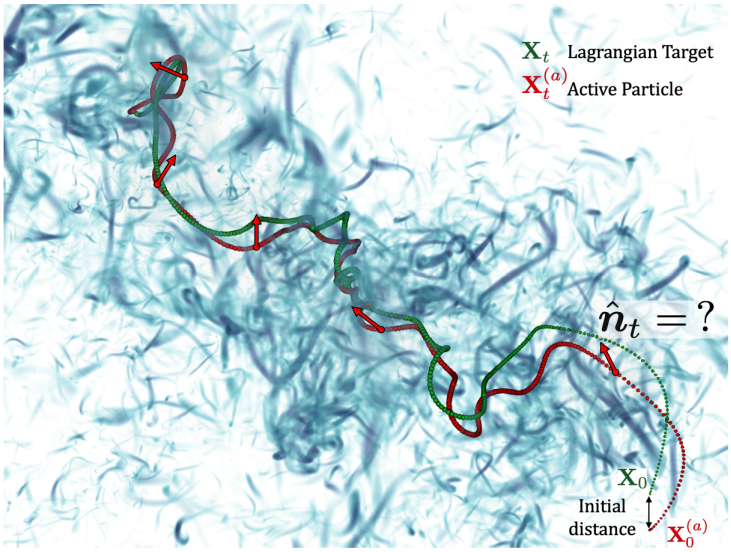

Figure 1: Artistic view of the problem: one tracer particle (the Lagrangian Target in green) is transported by the flow. A second active particle (in red) has to optimize its control variable (the navigation direction $\hat{n}_t$), such as to go as close as possible to the moving target.

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[1]Calascibetta et al. Optimal tracking strategies in a turbulent flow (in preparation 2023).
[2]Monthiller et al., *Phys. Rev. Lett.* **129**, 064502 (2022).
[3]Calascibetta et al., *Eur. Phys. J. E* **46**,9 (2023).
[4]`http://smart-turb.roma2.infn.it`