Bayesian Optimisation to Improve the Coverage Performance of a UAV Swarming Mobility Model

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ABSTRACT

This work considers the optimisation of CACOC (Chaotic Ant Colony Optimisation for Coverage) [1], a mobility model for a swarm of Unmanned Aerial Vehicles (UAVs), using Bayesian optimisation.

Recently, several articles introduced chaotic dynamics instead of random processes to enhance optimisation algorithms [2], [3]. Instead of using discrete chaotic maps, we recently introduced CACOC using the Rössler system [4]. This algorithm provides a mobility model for a swarm of UAVs to cover an unknown area. As CACOC uses Rössler dynamics, this dynamical system has three parameters (a, b and c) leading to periodic or chaotic solutions. The CACOC algorithm's coverage performance depends on the structure of the first return map. Therefore a modification of the Rössler system's parameters can deeply impact CACOC results. We recently proposed to systematically explore the Rössler dynamics for another optimisation method [5]. However, such a method is time consuming because of the periodic areas providing improper results between chaotic regions in a bifurcation diagram.

Nowadays, a growing interest has been seen in hyperparameter optimisation [6], i.e., the optimisation of the parameters of complex systems or models. Contrary to standard optimisation approaches, they attempt to minimise an objective function while taking into account the evaluation time. Indeed, many theoretical models can be very time consuming to evaluate when changing their parameters. Therefore, most of the hyperparameter optimisation approaches do not only optimise an objective function but also try to minimise the number of steps required to reach a good solution. Generally, these approaches are neither global nor exact. They can be assimilated as metaheuristics.

In this work, we propose to use the Bayesian Optimisation method [7] to efficiently explore a bifurcation diagram of the Rössler system, which is used in CACOC. Bayesian Optimisation is based on Gaussian Processes (GP) and an acquisition function. The GP regressive model aims at approximating the unknown function by creating some surrogate function. This function is iteratively refined by optimising the acquisition function until we are unlikely to find a new improving solution. The acquisition function is an auxiliary function taking into account statistical information about the presence of promising areas.

Experimental results underline that Bayesian optimisation permits to efficiently explore a bifurcation diagram bypassing periodic regions. The results provide two groups of points providing excellent results in terms of speed of coverage for the swarm.

Keywords: UAVs, Swarming, Bayesian Optimisation

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