

Probabilistic swarms guidance within the Gama-platform

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Abstract

Providing means to address the controlling of a large-scale swarm as a whole is a challenging problem. In this context, B. Açikmeşe et al. [1] introduced a probabilistic guidance approach, to guide a large-scale swarm of autonomous agents into a desired formation shape. The mission is accomplished in a decentralized manner. Thus, the swarm asymptotically achieves the desired distribution without any communication between agents. A variety of swarm coordination and control methods appeared in the literature, but there is not a multitude of solutions to visualize and control the swarm in real-time.

Therefore we proposed to interface probabilistic swarms guidance into the Gama platform, since it supports great number of agents and offers a flexible interface. For now, we focused on the Markov-chain swarm guidance approach, presented in [1]. The method can be divided in three main steps. First, the desired physical space is divided into m bins (subregions), and the desired probability density is prescribed for each bin in $v \in R^m$. Note that the number of bin is directly determined by the spatial resolution of the desired formation shape. In order to restrict allowable agent motion, an adjacency matrix A is build, such that $A[i, j] = 1$ when the transition from bin i to bin j is authorized, and is zero otherwise. Given adjacency matrix A and desired density v , the Markov matrix $M \in R^{m \times m}$ is constructed. The entries of matrix M are defined as transition probabilities. In practice, an agent in bin j transitions to bin i between two consecutive stages with probability $M[i, j]$.

In order to set up the simulation environment in Gama, we have developed a plugin which add the required functionalities to Gama-platform and a gaml model to build the Graphical User Interface (GUI). The GUI allows the user to select the resolution of the grid or volume as a set of bins, then to choose the desired shape. The shape are computed from images which are rasterized to generate the desired distribution. Adjacency matrix is also specified as the distance between bins that can be reached within one transition. Once this step is done, the user can choose the initial number of agents and run the simulation. During the simulation, the user can interact with the swarm (kill or add agents). Most importantly, one can change the target distribution, updating the Markov matrix to all agents, and guiding the transition to the selected shape.

Given the encouraging results, future work will focus on implementing: motion characteristics for agents, conflict avoidance techniques [2] and three dimensional simulations.

Additional material

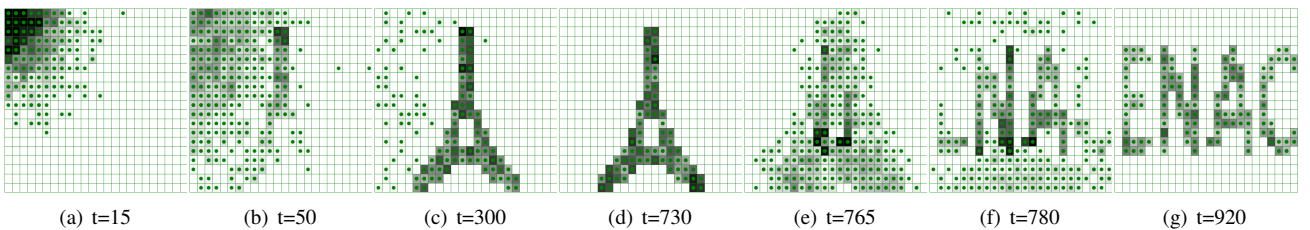


Figure 1: A swarm of 1000 agents evolving during the simulation at different time instances. At $t=740$, the target shape is changed. (the darker the cell is, the more agents there are)

References

- [1] Behçet Açikmeşe and David S Bayard. A markov chain approach to probabilistic swarm guidance. In *2012 American Control Conference (ACC)*, pages 6300–6307. IEEE, 2012.
- [2] Michael Szmuk, Carlo Alberto Pascucci, Daniel Dueri, and Behçet Açikmeşe. Convexification and real-time on-board optimization for agile quad-rotor maneuvering and obstacle avoidance. In *Intelligent Robots and Systems (IROS)*, 2017.