Internship Proposal (L3-M1-M2): Games with Hierarchical Objectives

Place: Inria - Irisa, Rennes – SUMO team (http://www.irisa.fr/sumo/)

Controller synthesis is concerned with the automatic construction of systems satisfying a given property [5]. These problems are naturally expressed using game theory, in particular, the theory of games played on graphs [6]. In the classical setting, the set of possible configurations of the system are modeled as the vertices of a graph, and the transitions between these as edges. A token is placed at a vertex, and two players, namely, *system* and *environment* move the token along the edges, which models the possible actions taken by the system or its environment. A *winning strategy* for the system is a strategy that ensures a winning condition (such as, visiting a final vertex, or avoiding a bad configuration) regardless of the environment's strategy. Efficient algorithms are known to compute winning strategies for a given player.

Although strategies computed by these algorithms ensure winning the games from the initial vertex, they do not consider what happens under a failure, or an unexpected event; a good strategy must *try to win* even though winning is no more guaranteed due to a bad move. In fact, a good system should not abandon its objectives completely under a minor error. In order to consider this aspect in the study of games, we suggest studying games with hierarchical objectives, say, ϕ, ψ where ϕ is the primary objective, and ψ is the secondary one. Typically, the secondary objective can be a failure objective requiring the system to report the error and avoid some critical tasks until the problem is fixed. Informally, our goal would be to compute strategies, which at each state satisfies the following requirements:

1. If there is a winning strategy for ϕ, then play a winning strategy (*i.e.* ensure winning no matter what happens),
2. If there is no winning strategy for ϕ, ensure winning for ψ, and *try* to win for ϕ.

One can also generalize this definition to a number of objectives $\phi_1, \ldots, \phi_k$ in a given order. The resulting setting will allow one to obtain *robust* strategies, where different levels of objectives correspond to different failure levels.

One of the objectives of the internship is to formalize what we mean by *trying to satisfy* the primary objective. We will study formulations based on game theoretic notions such as cooperative, and admissible strategies that have been studied in the literature [3, 1]. Depending on the intern's interests, the obtained notions and algorithms can be implemented and evaluated in a temporal mission planning framework for robot motion planning as in [4].

This approach is also interesting for games with *partial information* where the system does not know the precise vertex at which the system is, but it can only tell a subset of states at which it might be, called its *knowledge* [2]. In this case, the system may not have a winning strategy from all the states of its knowledge. One can then consider computing strategies that are winning for maximal subsets of the knowledge while ensuring a secondary objective from the rest of the states.

Keywords: Graph games, controller synthesis, partial-information games, multiple objectives
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