THE ROLE OF SENSING INFORMATION IN PURSUIT-EVASION GAMES

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ABSTRACT

Today mobile sensor networks find widespread use in environmental monitoring, health care applications, home automation, traffic control and search-and-rescue missions. One can envision robots in civilian environments helping people solve tasks that require specialized sensors or are simply too dangerous for people to risk taking a chance. A pursuit-evasion game is a game played between a pursuer and an evader. The pursuer's objective is to capture the evader, while the evader in turn tries to avoid capture. For example, in a search-and-rescue setting, the search team might be looking for a lost hiker whose actions are unknown. A good pursuit strategy will help the team find the hiker regardless of his movements. Pursuit-evasion games provide a framework in which to study these problems and formulate solutions that provide provable guarantees in the face of uncertainty.

Throughout literature, it is common to assume that the searchers can gather complete information about the location of the evader. However, this formulation does not lend itself to robotics applications where mobile robots have limited sensing capabilities. In this thesis, we study the effect of reducing the sensing information available to the pursuer on the outcome of two well-known pursuit-evasion games.

In the first part, we study a discrete game played on a finite, undirected graph in which the players move from vertex-to-vertex. It is known that there exist graphs, called *cop-win graphs*, on which a pursuer (cop) with complete information captures the evader (robber) in a number of steps of the order of the number of vertices in the graph. However, when the sensing range of the cop is reduced to a neighborhood of just k vertices around him, we show that the time needed to capture the evader grows to an order exponential in the number of vertices in the graph.

The second part examines the well-known Lion and Man game, in which a lion and man play a pursuit-evasion game in a continuous arena. In previous work, it has been shown that there exists a pursuit strategy for the lion to catch the man in the positive quadrant, given certain initial conditions. However, that study relies on the lion knowing the exact location of the man before making its move. We reduce the

sensing ability of the lion to bearing-only information, motivated by mobile robots with monocular vision systems used in tracking applications. We prove that with a bearing-only sensor, the lion can get to within a capture distance equal to the step-size of the game.

The larger objective that motivates the study of both of these problems is the need to answer two important questions in robotic sensor network applications. First, can we use sensors of lower cost to achieve the same results as resources whose costs are difficult to justify? Next, given the sensing uncertainties of current technology in robotics systems, what kind of guarantees can we provide for robots executing tasks in civilian environments. In this thesis, we tackle both of these questions at two levels: we provide sound theoretical results with guarantees on the running times of pursuit-evasion strategies, and, we discuss some of issues that arise when translating these algorithms to real-world implementations.