On-Line Dynamic Obstacle Avoidance

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1. Introduction

In this paper we review an on-line obstacle avoidance strategy that combines a potential field approach with robot dynamics, and seems applicable for on-line trajectory planning of complex systems such as humanoids moving through cluttered environments. The simple trajectories followed by humans despite the high complexity of their dynamics suggests that similar simplifications can be used for on-line obstacle avoidance of mobile robots, as well as of humanoids.

The avoidance strategy presented here is based on following the direction of steepest descent along the value function, which represents the *cost-to-go* to the goal from any given state. The value function reflects the cost function being considered, has a unique minimum at the goal, generates globally optimal trajectory, and is hence an ideal potential function.

The value function is difficult, if not impossible, to compute for a large number of obstacles and for "dynamic" cost functions (require system dynamics) such as motion time and energy. We circumvent this difficulty by a) decomposing the problem into the avoidance of one obstacle at a time, and b) by computing the optimal direction locally without actually deriving the value function. It is shown that despite these simplifications, the resulting "potential filed" has a unique minimum regardless of the cost function being considered.

2. The Obstacle Avoidance Strategy

Observing that the effect of an obstacle on the value function is local, we treat the multi-obstacle problem by avoiding obstacles optimally, one at a time. The avoidance procedure is simple: attempt to go straight to the goal. If the goal is obstructed by obstacles, pick the "largest" (in term of the cost function), avoid it until it no longer obstructs the goal, or until another obstacle become the "largest." Switch to another obstacle and repeat until reaching the goal.

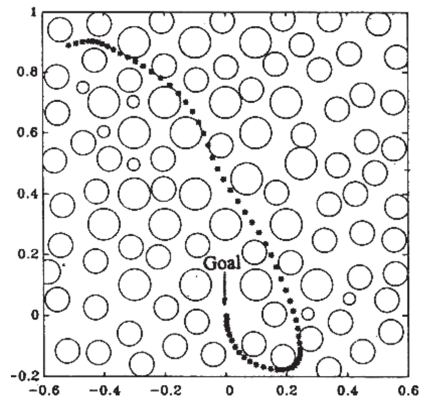

Figure 1: Dynamic avoidance of 100 circular obstacles

3. Convergence

Global convergence of this avoidance strategy is proven based on the properties of the value function. The selection of the *largest* obstacle as soon as it exceeds the value function of the former obstacle ensures that the value function along $x(t)$ decreases monotonically.

4. Example

Figure 1 shows the dynamic (minimum time) avoidance of 100 circular obstacles by a point mass robot with actuator constraints. The spacing between the dots represents the speed along the path.