Heuristic Algorithm for Robot Path Planning Based on a Growing Elastic Net*

José Alí Moreno[1] and Miguel Castro[2]

[1] Universidad Central de Venezuela, Laboratorio de Computación Emergente, Facultades de Ciencias e Ingeniería
jose@neurona.ciens.ucv.ve
[2] Universidad Simón Bolívar, Grupo de Inteligencia Artificial, Departamento de Computación y T.I.
mcastro@gia.usb.ve

Abstract. A simple effective method for path planning based on a growing self-organizing elastic neural network, enhanced with a heuristic for the exploration of local directions is presented. The general problem is to find a collision-free path for moving objects among a set of obstacles. A path is represented by an interconnected set of processing units in the elastic self organizing network. The algorithm is initiated with a straight path defined by a small number of processing units between the start and goal positions. The two units at the extremes of the network are static and are located at the start and goal positions, the remaining units are adaptive. Using a local sampling strategy of the points around each processing unit, a Kohonen type learning and a simple processing units growing rule the initial straight path evolves into a collision free path. The proposed algorithm was experimentally tested for 2 DOF and 3 DOF robots on a workspace cluttered with random and non random distributed obstacles. It is shown that with very little computational effort a satisfactory free collision path is calculated.

1 Introduction

For several decades motion planning has been a very fertile field of research. Work in this area has not only impacted robotics, but also other non-robotics fields like graphics animation, surgical planning or computational biology, see [11] for a review. In any case, research in robot motion planning remains as one of the important fields of study in the task of building autonomous or semi-autonomous robot systems. In the last decade, path planning has received considerable attention from the robotic community since this fundamental operation poses the solution of a variety of challenging theoretical and practical problems. In consequence a broad class of algorithms for path planning designed over different technologies and general approaches have resulted. In general the path planning

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problem is PSPACE-hard and all known complete planning algorithms take exponential time in the number of degrees of freedom of the robot. That is, the curse of these algorithms is their high complexity which hinders useful real time applications. In the present work an algorithm that deals with this complexity issue in a very simple way is presented.

The path planning problem involves searching the system configuration space for a collision-free path that connects a given start and goal configurations, while satisfying constraints imposed by a complicated obstacle distribution. This definition of the problem simplifies some of the aspects of robot motion planning. The dynamic properties of the robot are ignored and the problem is transformed to a purely geometrical path planning problem. In this way we concentrate on the most basic version of the path planning problem, that of moving a robot in a static environment. Efficient solutions of that simplified problem contribute to improvements in the solution of problems with additional constraints. According to [10] there are three general approaches to path planning: potential field, road map and cell decomposition. In the randomized potential field methods [5] the robot is represented as a particle moving under the influence of an artificial potential field produced by the sum of a repulsive potential, generated by the obstacles, and an attractive potential, generated by the goal configuration. The path is obtained by a descent along the negative gradient of the total potential. The algorithms based on roadmaps [1][9] construct a network of one-dimensional curves, called the roadmap, lying in the free space of the workspace. The final path result from the concatenation of a subpath connecting the initial configuration to the roadmap, a subpath belonging to the roadmap and a subpath from the roadmap to the goal configuration. The approach based on cell decomposition consists on a partition of the free space into a set of exact cells, [4], or approximate cells [2]. The path is a sequence of cells with the following properties: (1) The first cells contains the initial configuration. (2) The final cell contains the goal positions. (3) Neighbouring cells in the sequence are cells in free space with a common boundary. In most current robot systems developed to date the motion planning is, at its lowest level, based on a heuristic or potential field method and many extend this upward to the level of path navigation [3].

In this contribution we present a path planning algorithm based on an enhanced elastic net algorithm [6] with a growing structure [7]. The network consists of a line of processing units (PUs) with an attractive interaction between the PUs [8] over which a unsupervised learning scheme is applied. A path is represented by a interconnected set of line segments, the successive connectivities of the processing units in the elastic network. Initially the network contains a small number of PUs, as time advances the PUs are updated in response to stimuli from randomly selected points in the configuration space and successively new PUs are inserted. The stimuli to the PUs are attractive if the stimulating point belongs to free space otherwise they are repulsive. This adaptation process is enhanced with a local heuristic that encourage the PUs to move to free space. The self organizing process induces a local topologically ordered network in free space representing a collision free path.