Article ID: 1000 - 8152(2003)05 - 0770 - 03

Study on algorithm A^* of intelligent path planning based on method of representation environment with both quad tree and binary tree

TANG Ping[1], YANG Yi-min[2],

(1. Faculty of Computer, Guangdong University of Technolgy, Guangdong Guangzhou 510090, China;
2. Faculty of Automation, Guangdong University of Technolgy, Guangdong Guangzhou 510090, China)

Abstract: By comparing both quad-tree representation with binary-tree representation for environment, an optimal algorithm A^*, for robotic path planning intelligently among moving multi-obstacles in variety environment was presented, and a good simulation result eluding multi-obstacles in soccer games was obtained.

Key words: intelligent planning; binary tree; multi-obstacles

CLC number: TP182 **Document code**: A

基于二叉树和四叉树综合表示环境的方法及智能路径规划的 A^* 算法研究

唐 平[1], 杨宜民[2]

(1.广东工业大学 计算机学院,广东 广州 510090; 2. 广东工业大学 自动化学院,广东 广州 510090)

摘要: 通过比较利用四叉树和二叉树两种动态环境信息表示方法,提出了移动机器人对多移动障碍物的智能路径规划的 A^* 算法,并在足球机器人系统中进行了动态避障的仿真,得到了很好的效果.

关键词: 智能规划; 二叉树; 多障碍物

1 Introduction

There are many ways to implement robotic path planning[1]. It is very important to state dynamic environment information and intelligently elude obstacles for moving multi-obstacles. The algorithms for mobile robots are presented based on a quad tree representation for environment information by H. Noborio, T. Naaniwa and S. Arimoto[2] and by Zhang Yu[3], which deals with both the space and the time. The space is decomposed by recurrence and the time is counted by the uniform motion. The algorithms for mobile robots are presented based on a binary tree representation for environment information[4]. By comparing both quad-tree representation with binary-tree representation for environment, an optimal algorithm A^*, for path planning intelligently among moving multi-obstacles in variety environment is presented and a good simulation result eluding multi-obstacles in soccer games is obtained.

2 Representation dynamic environment information by both quad-trees and binary tree

When dynamic obstacles are in a known environment, the environment can be presented as a rectangle and the obstacles as rectangles, which are smaller than the environment rectangle.

Definition 1 A node is known to be able to be planned (category A) if it stands for a rectangle space and is not blocked..

Definition 2 A node is known to be able to be transformed(category B)if it stands for a rectangle space and some spaces is blocked.

Received date:2001 - 10 - 29; Revised date:2003 - 06 - 30.
Foundation item: supported by the National Natural Science Foundation of China (69874024).

Definition 3 A node is known to be unable to be planned (category C) if it stands for a rectangle space and all space is blocked..

Though the quad-tree representation environment information algorithm has a shorter search path, it needs more time to explore the nodes, and the binary tree representation environment information algorithm does not need to explore more nodes, it has a deeper path to search. Mobile robots, which are desired to be real-time and flexible, can not afford that amount of time. A method of representation environment with quad-tree and binary tree is proposed, which with binary tree expresses a larger work space and divides out nodes of no obstacles; with quad tree expresses a smaller work space and finds a shorter search path.

An environment and multi-obstacles are shown in Fig.1 and Fig.2.

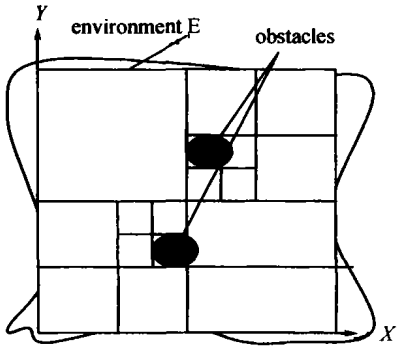

Fig. 1 Environment E

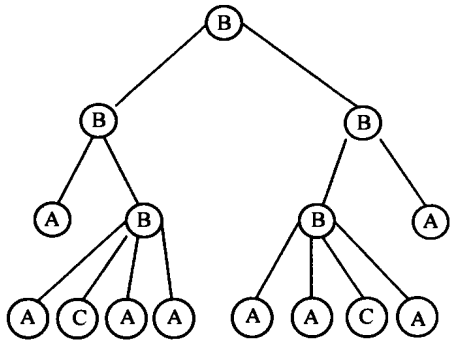

Fig. 2 Representation with both quad-tree and binary tree for space

3 Algorithm A^* of intelligently path planning with both representation of binary-tree and quad tree for dynamic environment

In a dynamic environment, when work space is larger, the representation information of the binary-tree can decide an obstacle's probably place speedily, and when work space changes into a certainty size, the representation information of the quad-tree can decide an obstacle's precision place. By using an algorithm A^* and spreading all over the tree, the visiting time of an obstacle's moving to a node and a mobile robot moving to the same node will be discussed.

Definition 4 The time period, needed for an obstacle moving in node $i, i \in A$, is called obstacle visiting time $V_t(i, O_i)$, denoted as:

$$V_t(i, O_i) = \bigcup_{i \in A} T(i, O_i).$$

Definition 5 The time period, needed for a robot moving in node $i, i \in A \cup B$, is called robot visiting time $V_t(i, R)$, denoted as:

$$V_t(i, R) = \bigcup_{i \in A \text{ or } B} T(i, R).$$

The path planning in a dynamic environment based on the representation of both binary-tree and quad-tree can be implemented. Firstly search the entire tree and choose nodes. Secondly, compute the values of the function f. Finally plan an optimal path. The algorithm A^* is described as follows:

1) initialize CLOSED = Ø, OPEN = {S}, $f(s) = h(s) + g(s)$, $g(s) = 0$;

2) if work space is larger, then spread all over the binary-tree, or else spread all over the quad-tree, move the nodes whose flag values are not equal to -1 (category A or B) into OPEN.

3) compute value $f(\cdot)$.

4) choose a node n such that its $f(\cdot)$ is the minimum in OPEN, then let

OPEN = OPEN $-$ {n}, CLOSED = CLOSED + {n}.

5) if the flag value of node n is equal to 1 and goal G exists then

if $V_t(n, R) < aV_t(n, O_t)$, then successful

else erase OPEN and divide node n into two parts by recurrence ,

if successor m's flag is not -1

then move node m to OPEN, goto 6),

if the flag value of node n is equal to 1 (category A) and no goal G exists, then, abandon node n, goto 6).

if the flag value of node n is equal to 0 (category B) and there exists goal G in node n, then erase OPEN,

and move node n's successor node m ($\mathrm{flg} \neq -1$) to OPEN, compute $f(m)$, goto 6).

If the flag value of node n is equal to 0 and there exists no goal G in node n, abandon node n, goto 6),

6) modify value $f(\cdot)$, compute $f(\cdot)$ of nodes where flag = 1 in OPEN, return to 2).

Where α is the weight for visiting time, generally $\alpha \geqslant 2$.

4 Conclusion

With both representation of binary-tree and quad-tree for dynamic environment, A new algorithm A^* is designed, which can implement mobile robot's path planning intelligently in a dynamic environment. Robotic path planning in soccer games[4] is in dynamic environments. The real-time factors and eluding are needed. With the new algorithm A^*, a simulation results in good effect in soccer games.

References:

[1] WANG Zhiqiang. Study on collision detecting problem [J]. *J of Soft*, 1999,10,(5):545 - 551.
(王志强.碰撞检测问题研究综述 [J]. 软件学报,1999,10(5):545 - 551.)

[2] NOBORIO H, NAANIWA T, ARIMOTO S. A feasible motion planning algorithm for a mobile robot on a quad tree representation [A]. *Proc of IEEE Int Conf on Robotic and Automation* [C].[s.l.]:[s.n.],1989:27 - 332.

[3] ZHANG Yu. *Studying on algorithm of path planning for mobile robot* [D]. Shanghai:Shanghai Jiao Tong University,1996.
(张育.移动机器人路径规划算法研究[D].上海:上海交通大学,1996.)

[4] TANG Ping, YANG Yimin. Study on algorithm A^* based on dynamic representation of binary tree for environment and robotic path planning [J]. *Engineering Science*,2002,4(9):50 - 53.
(唐平,杨宜民.动态二叉树表示环境的 A^* 算法及其在足球机器人路径规划中的实现[J].中国工程科学,2002,4(9):50 - 53.)

作者简介:

唐 平 (1958 —),女,工学博士,副教授,主要研究方向:人工智能与智能机器人,E-mail:rachel@gdut.edu.cn;

杨宜民 (1946 —),男,教授,博士生导师,主要研究方向:人工智能与智能机器人.