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Study on Multi-Robot Cooperation Stalking Using Finite State Machine

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Abstract

With the social needs and the development of science and technology, robot technology had been developing in depth, and the application range of the mobile robot is more and more wide. And the robots application environment has become increasingly complex, while the task requires more precisely. So multi-robot system has gradually become an important branch of robotics research .In the numerous multi-robot system research direction, multi-robot operation stalking question has been the focus of research. This paper researches on cooperation capture for mobile multi-robots. We use finite state machine principle to do research on cooperation capture for mobile multi-robots. It could simplify the process of design and achieve maximum results with little effort. At last, this method using finite state machine realizes cooperation capture for multi-robots system.

Keywords: Mobile robots,Cooperation capture,Finite state machine

1. Introduction

Along with the social needs and the development of science and technology, robot technology had been developing in depth, and the application range of the mobile robot is more and more wide. And the robots application environment has become increasingly complex, while the task requires more precisely. So multi-robot system has gradually become an important branch of robotics research .In the numerous multi-robot system research direction, multi-robot operation stalking question has been the focus of research[1]. In multiple mobile robot system cooperation in certain problem refers to in some certain environment (environment known or unknown) ,using various sensors installed in robots to search

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without collision, at the same time use the search methods of communication sharing their information, and finally reach the purpose of rounding up the arrestee.

In recent decades, many scholars go into the multi-robot operation stalking problem , the people will be known as Benda with grid environment, said let four blue agents to rounded up a red agent, the condition of success is that blue agent occupied red agents around four grid[2]. Yamaguchi presents a feedback control law which is used to coordinate multi-robot sport, by using formation vector control group formation realizing target capture or surrounded, but due to capture or surrounded by stalking goal is still, so it is not too wide field of application [3]. Korf allow diagonal direction with the diagonal countermeasures model instead of orthogonal approximation schemes, one of the greedy algorithm can meet as many as eight robot stalking invaders, but in this model the pursuers and invaders in turn the movement is, do not accord with the reality of the situation[4].In order to get steady convergence control strategy, Haynes use Strong Type genetic Programming algorithm (STGP: Strong Type Gene Programming) automatic generation and evolution of the control strategy, but because only used the greedy algorithm and the control strategy completely by the world by study, machine completely without cooperation, concluded that the expected cooperation to the effect of evolution[5]. FHo use lower probability of climbing control method of the multi-agent online learning to be cooperative strategy, and the results showed that the robot can capture the invaders, chase but in this model of the invaders for speed of only 90% of the pursuers, in a human disadvantages[6].Kop party with a computational geometry method discussed under what circumstances the pursuers to succeed, and give the roundup invaders relatively strict mathematical proof, but the problem of requirements that the pursuers have environment where the vision, not all of too tally with the actual situation[7].

This paper mainly launch the multiple mobile robot roundup of moving target. This paper studied using finite state machine multi-robot cooperation stalking, this roundup can simplify design process, have twice the result with half the effort.

2. Many Robot Cooperation Stalking of Finite State Machine Principle

Many robot cooperation stalking on Finite state machine principle.

2.1 Task Modeling

The first task set stalking M. M reflect the robot state transition rules, can use a four yuan group said $M=\left(I_s, I_c, Q, \delta\right)$,among：

$I_s=\left\{i_{s1}, i_{s2}, \ldots, i_{sm}\right\}$： Said perception by the collection of sensor events;

$I_c=\left\{i_{c1}, i_{c2}, \ldots, i_{ck}\right\}$： Said human communication events of the machine;

$Q=\left\{q_1, q_2, \ldots, q_t\right\}$： Said the state of the discrete system limited set;

σ： Said from one state to another state mapping, Can be expressed as $I' \subset I$,Is the combined event (including perception events and communication events) Is the combined event (including perception events and communication events), $I_c \times I_s \rightarrow I=\left\{i_{sc1}, i_{sc2}, \ldots, i_{scn}\right\}$.

In the system model, Q have five state: Form formation (q_1) ,keep ranks for marching (q_2) 、searching (q_3) surrounding (q_4) 、forecasting (q_5) and exit (q_6) .At the Initial moment, system randomly generated a robot as leader，then leader carry on comprehensive planning according to their own collection of environmental information and other robots the feedback the information (follower) ,distributing the initial formation points for other robots (follower) ,after forming formation

(i_{sc1}) ,leader leads followers searching (invader) in the state of keeping formation，If have been didn't see invader (i_{sc2}) ）, many robot system would keep a searching state. Because the complexity of the environment and task, put stalking process into two kinds of circumstances: one is that finding invader (i_{sc3}) , then starting stalking process (i_{sc4}) , if stalking is success and exit (i_{sc7}) ;Another is the system may lose the invader trace, at the moment would system forecast and found invade according to the position of the last record invader, as much as possible in the region. If finding invader in a certain steps($N_{prediction}$) again, robot continue to stalking，otherwise (i_{sc6}) , system to search again. So until the invader was caught.In robot stalking process,the first to find the invader automatic conversion for new leader robot. In order to improve the robustness of the system, when robot system is runningIf a robot can not broadcast their information to other robotsOr the quality of the communication is not normal, so that the robot system automatically think the robot to be in an abnormal condition, and the system automatically adjust to adapt.

According to the mission description, Model M which probably the state transition as follows:

$$\sigma(q_1, i_{sc1}) = q_2 \;,\quad \sigma(q_3, i_{sc4}) = q_4 \;,\quad \sigma(q_4, i_{sc2}) = q_5 \;,\quad \sigma(q_5, \{i_{sc4}, i_{sc5}\}) = q_4 \;,$$
$$\sigma(q_5, i_{sc6}) = q_3 \;,\quad \sigma(q_4, i_{sc7}) = q_6$$

2.2 Program Flow Chart

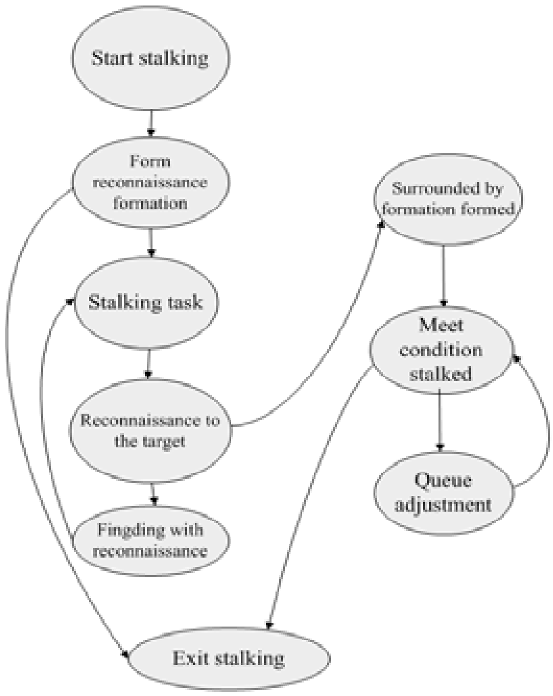

Fig.1. Stalking flow chart

2.3 Robot Design Stategy

The task model based on 2.1, design some strategies to ensure that each state are the robot can produce the right movement, in order to adapt to the relevant environment.

2.3.1 Leader adjustment strategy

After many robot system detected the invaders, leader will issue instructions to make system form a pack as soon as possible. The radius of the pack is r_s .The radius and robot radius r in connection with sensors to detect the maximum range $s_{\max}$ .When meeting the contract conditions, the pack rounded up to the intruders in a radius of r_c small circle contraction. No matter robot is rounded up in state or predicted state, the system will determine a robot as leader to command to other robots to sport ideal position. When the system is stalking state, leader fixed; Other, leader can be adjusted. This mechanism adjusted makes many robot system with dynamic reconfiguration of ability.

Roport $P_r(i)(i=1,2,3,4)$ for all the robot in the normal position; P_T, C_T describing the invaders current position and center. $\overrightarrow{P_T P_r(i)}(i=1,2,3,4)$ said the direction of the vector from the invaders to each robot center. Before the leader adjustment strategy, introduce Angle matching algorithm of the pack and contraction condition.

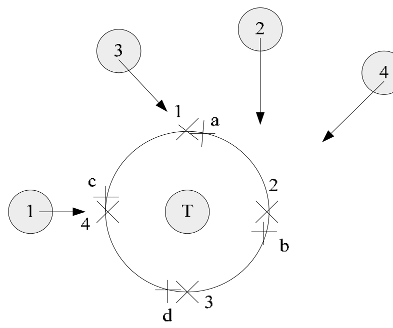

Fig.2. Leader replacement diagram

2.3.2 Outflanking strategy

Robot in the state of siege strategy used is to allow an intruder to enter the multi-robot system formed within a circular pocket.

Adjust its strategy according to leader to get $leaderR_s$, robots call algorithm (AM) (R_s , r_s)for each robot ideal expected position.

2.3.3 Rounded up strategy

When the robot is rounded up, system captured the intruder through the contraction of the encirclement.

According to leader R_s adjusted strategies. Robot called algorithms (AM) (R_s, r_c) to get the desired movement position.

2.3.4 Prediction strategy

If the robot is in state of siege, according to detect the intruder, the robot select a robot as a reference. Since the target could escape at any time, on this way, the intruder's forecast has become more important. By recording the location of reference Follower robot predicts the intruder movement. Assuming the direction of the intruder's away way ,reference robot to the centreline are in the opposite direction ,and step length is the maximum step size, which can calculate the location of the intruder's virtual escape.

Parameters of the projection (the intrinsic camera parameters) are assumed to be known. And a pin-hole camera model is considered. Figure1 is perspective projection of three general lines in monocular vision.

3. Conclusion

This paper uses finite state machine theory for multi-robot stalking problem. First the finite state machine is introduced. The basic principle of second using finite state machine principle to solve the problem of multiple mobile robot stalking finite state machine switching different state, which can simplify system design. Finally, based on the above task model, a series of strategies for the design of robot in each state can create the right movement. The application of achieve the expected effect. But, the new methods of exploring needs further research.

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