ANT COLONY BASED ROUTE OPTIMISATION FOR MOBILE ROBOTS

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Abstract

Ant Colony Optimisation (ACO) is an optimisation approach which mimics the behaviour of ants during food (or path) searching in the nature. The ants have the ability to minimise the path between the anthill and the source of the food. The following contribution uses the ACO approach to minimise the path from the defined start position to the end position in a production hall with obstacles and mobile robots. Mobile robots are moving in the hall and transporting material between production lines. In the case, when a new obstacle appears on the calculated route, the mobile robot switches to a reactive control mode in order to get around the obstacle. The reactive control algorithm is based on fuzzy logic. After this operation the robot either continues in the mode of the optimal route tracking, which has been calculated originally by the ACO algorithm, or the ACO will calculate a new route. Simulation results of the mobile robot moving are shown in this paper. The model of the production hall with mobile robots is programmed in Simulink and Virtual Reality toolbox. The ACO algorithm runs in Matlab.

1 Introduction

Mobile robot navigation is a complex area, which uses various mathematical approaches to solve various tasks. In the contribution presented a possible solution of the route planning problem is proposed. Route planning is a well known and frequently discussed problem in mobile robot control, where several approaches can be used. In our case the Ant Colony Optimisation (ACO) algorithm has been applied [1,2]. In our application, this approach was connected with reactive control of a group of mobile (autonomous) robots, which are moving in a production hall between obstacles. The reactive control is based on the environment perception and the route planning is based on an map of the environment. That means we consider that the map of the production hall with obstacles (production lines etc.) does exist. The robot is moving from its start position to the end position using an optimal route. In case, when an unexpected (new) obstacle or another mobile robot appears on the route, the robot switches to the reactive navigation mode to get around the obstacle. The reactive navigation mode is based on fuzzy logic [3,4,5]. A new route is calculated using the ACO if the robot cannot return to the originally planned route. The model of the production hall with the mobile robots is realized in virtual reality using the VRML toolbox of Matlab/Simulink.

2 Ant Colony Optimisation algorithm

The Ant Colony Optimisation algorithm is a multiagent, stochastic optimisation approach, which mimics the behaviour of the ants in the nature and which is able to solve hard combinatoric, graph based and logistic problems. Observation of the ants has shown that ants use many routes to scavenge for food and to transport it from the source to the anthill. However after some time all ants (or the majority of them) use the shortest route. This results from the fact that the ants are able to find (sub)optimal routes between the anthill and the source of food. The principle is based on pheromone footmarks leaving on the ant routes. The ants on the shortest routes bring food to the nest more quickly and thus they use their route more frequently leaving more pheromone on the route. Other ants are able to recognise these footmarks and to follow the path with more pheromone. On the other hand, on longer routes, which are used less frequently, pheromone footmark is vanishing and the route disappears after some time.

3 Mobile robots in the environment and their reactive control

Consider model of a production hall with autonomous mobile robots (Fig.1). The goal of each robot is to move from point A to point B on the defined route (which is calculated using ACO) in the environment with rectangle shape obstacles. Consider that the new obstacles and other robots can appear on the route. In such case the robot should get around obstacle and then to continue in the route defined originally. If this is not possible to continue in the original route, a new route is calculated. The reactive control used in our project is based on fuzzy logic. Consider that each robot has sonar (or laser) sensors, which are able to evaluate the angles and distances of the obstacles in a conic horizon (in our case 60 degrees). Next, consider the linguistic variable *distance* obtains terms (fuzzy sets) as: "very near", "near", "mean distance", "far", "very far" and let the terms for linguistic variable *angle* are "right", "straight", "left". The control value is the robot direction change with terms: "turn right", "turn a bit right", "do not turn", "turn left", "turn a bit left" or "turn to the goal direction". The robot is controlled by a fuzzy inference system, which rule base contains 29 rules. Some examples of these rules are:

If obstacle is very near and angle is right then turn left

If obstacle is near and angle is right then turn a bit left

…

If obstacle is far turn to the goal direction

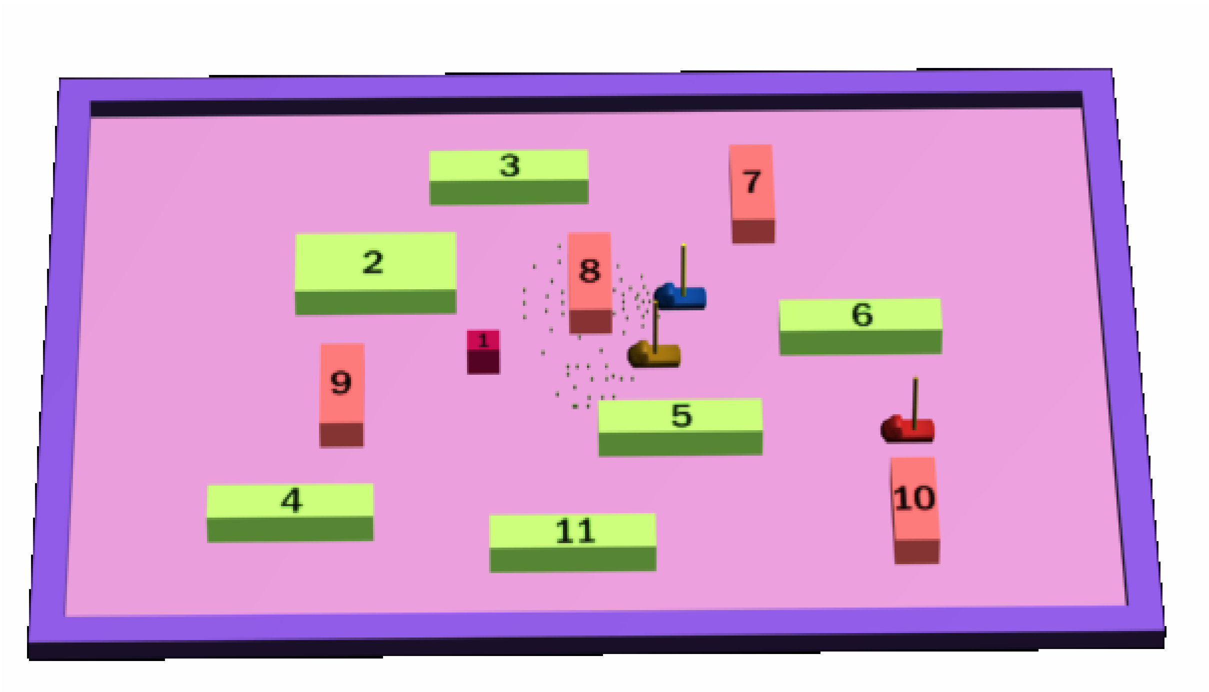

Figure 1. A virtual model of a hall with the mobile robots and obstacles in Matlab/Simulink

4 Optimal route planning using ACO and experimental results

Without loss of generality let us consider a hall with the obstacles (Fig. 2). Consider the starting point of a mobile robot is A and the end point is B. The goal is to obtain the shortest route from A to B and to ensure at least the distance from obstacles *w/2*, where *w* is the safe width of the car [6]. It is possible to move only outside of the obstacles. Let us define the set of possible turning points in groundplan of the hall, which are the possible points of the optimal route. Such points are located in distance of *w/2* from corners of all obstacles. In our case the number of possible turning points is 4.7 = 28 (Fig. 3). The last two turning points are A and B. Turning points represent the nodes in a graph and the distances between them are weighted edges. The optimal route will be obtained after connecting selected turning points with points A and B. For that task the ACO algorithm has been applied. The obtained route is in Fig. 3 (blue line).

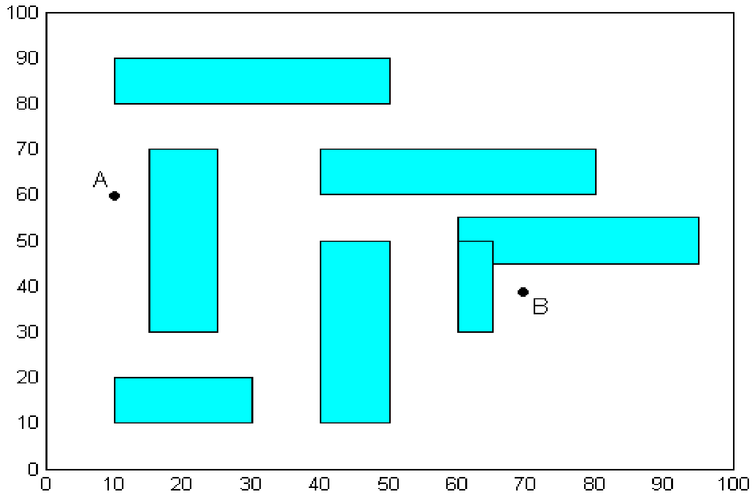

Figure 2. Production hall with 7 obstacles

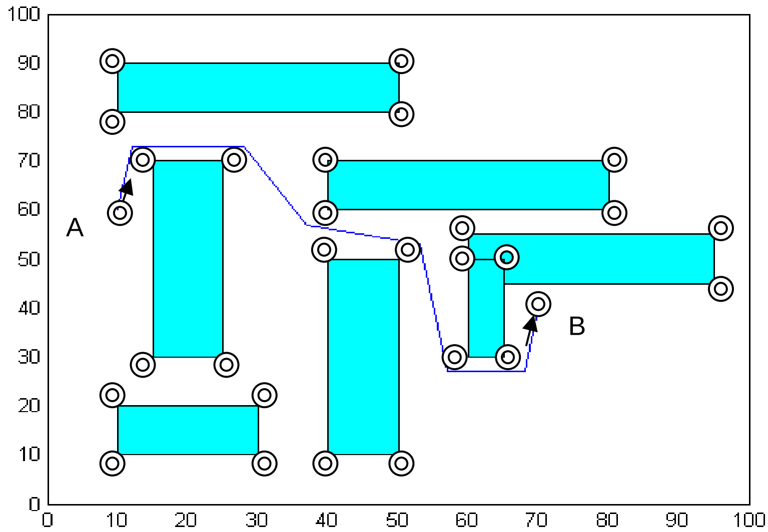

Figure 3. The set of turning points and the optimal route

5 Conclusion

Ant Colony Optimisation algorithm is nature inspired multiagent approach which can be applied in various combinatoric, graph based and logistic optimisation problems. In our project this approach was used for mobile robot route planning. The robot was tracking the calculated optimal route from the start position to the end position. If an unexpected obstacle or another mobile robot appears on the route, the robot switches to the reactive navigation mode to get around the obstacle. The reactive navigation mode uses fuzzy logic. If not possible to return to the route planned originally a new route is calculated using the ACO. The advantage of the use of ACO method is the ability to solve complex route optimisation tasks. On the other hand, the main drawback is the need of high computation time compared with conventional approaches.

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