

NAVIGATION OF MOBILE ROBOT USING THE PSO PARTICLE SWARM OPTIMIZATION

Sedigheh Ahmadzadeh¹, Mehdi Ghanavati²

¹ Department of Mechanic engineering, Ahvaz Branch, Islamic Azad university, Ahvaz, Iran

² Department of Mechanic engineering, Mahshahr Branch, Islamic Azad university, Mahshahr, Iran

Abstract

Robots are being used increasingly in different fields like industry and space applications. Nowadays there are even demands for application of robots in homes and hospitals. These robots should be able to move and navigate at indoor areas which consist of fixed and movable obstacles like walls and chairs, respectively. There is not a fixed map of obstacles in these applications and the robot should detect obstacles and decide how to move to achieve the goal while avoiding obstacles. In this paper, an intelligent approach for navigation of a mobile robot in unknown environments is proposed. Particle Swarm Optimization(PSO) method be used for finding proper solutions of optimization problems. At first the robot navigation problem is converted to optimization problem. Then PSO method searches the solution space to find the proper minimum value. Based on position of goal, an evaluation function for every particle in PSO is calculated. In each iteration of the algorithm, the global best position of particle is selected and the robot moves to next calculated point in order to reach the goal. To be practical, it's assumed that Robot can detect only obstacles in a limited radius of surrounding with its sensors. Environment is supposed to be dynamic and obstacles can be fixed or movable.

Keywords: Navigation, Mobile robot, Particle Swarm Optimization.

1. INTRODUCTION

Mobile robot according to their abilities in various fields such as rescue search in different spaces environments and many other fields, have proven their ability and are used. Navigation is a key problem in mobile robots, so in recent years it has been much attention to this issue. This means that the robot should moves on a path without colliding obstacles, and it considers the optimization criteria to passes the shortest trajectory to the goal.

Different methods such as Potential Field (APF) method[khatib,1986],Genetic Algorithms (GA) has been trying to solve this problem[Pratihari,199]. In general, these methods to be divided into two different categories. The first is global navigation based on a known environment, and other is local navigation based on perception of sensors from the unknown environment. In global navigation methods cost of environmental change, especially in dynamic environments is very high, because supply a new map is difficult. Therefore, research on the local navigation is necessary. These methods could be able to detect the

unknown environment, and it does not need to environment model. In this paper, a new method of local navigation based on particle swarm optimization technique is proposed.

In This method, an optimization problem based on position of obstacles, and goal is designed and then PSO is used to solve the optimization problem. In each iteration of the algorithm, the global best position of particle is selected and the robot moves on the points in order to reach the goal.

Whenever sensors detect changes in their environment or whenever the robot reaches to a local goal the local, processor of robot updates its data.

2. A REVIEW OF PREVIOUS RESEARCH

To solve the navigation problem for the robot, researchers have proposed various methods. In conventional navigation methods such as cell decomposition(Latombe,1990) and road map(Wang.,2000), due to the high volume of calculations, we are not able to solve problems in complex environments.

Artificial potential field method(Shi,2009), because of simplification frequently is used for local navigation. But due to stop at a local minima, This method will fail. In recent years a series of intelligent ideas, such as genetic algorithms and particle swarm optimization because of the robust and ability to the Simultaneous calculations to solve the navigation problems are used. Ghorbani and colleagues(Ghorbani, 2009), use of the genetic algorithm for solving the problem of mobile robot navigation. Sugiwarara and colleagues, (Sugawara, 2004), used ants colony algorithm to solve the problem of navigation in a dynamic virtual environment. Qu and colleagues, (Qu, 2009) used neural networks for navigation and obstacles avoid in dynamic environments. PSO, by Kennedy in 1995, based on observation of the collective behaviour of certain species of animals such as birds and fish have been proposed (Eberhart, 1995& Kennedy, 1995). Due to simplicity, this method is used in robot navigation. Doctor and colleagues(*Doctor*, 2004), using the PSO method for navigation an unmanned vehicle that can converge well. Chen and colleagues, (Chen, 2006), suggests a soft and efficient navigation method for mobile robot using the Stochastic PSO. Qin and colleagues(Qin, 2004) used the Chaotic PSO with Mutation operator for navigation and moving the robot meets the immediate needs.

Hao and colleagues, (Hao, 2007) proposed a method of obstacles avoiding using the PSO and polar coordinate system in a dynamic environment. Wang and colleagues (Wang, 2006) used a PSO for navigation of soccer robot and Karimi(Karimi,2012) , using dynamic hybrid PSO algorithm to solve motion planning problem.

3. THE NEW NAVIGATION METHOD BASED ON PSO

3.1 Particle Swarm Optimization method

The PSO is a technique that is used in order to explore in a search space of a problem. PSO algorithm in this space, explores the parameters needed to minimize or to maximize. PSO algorithm has three stages. This process was repeated until a stop condition be observed:

1. Evaluate the fitness of each particle.
2. Update the best fitness, local and global best position.
3. Update velocity and position of each particle.

A basic variant of the PSO algorithm works by having a population (called a swarm) of candidate solutions (called particles). These particles are moved around in the search-space according to a few simple formulae. The movements of the particles are guided by their own best known position in the search-space as well as the entire swarm's best known position. When improved positions are being discovered these will then come to guide the movements of the swarm. The process is repeated and by doing so it is hoped, but not guaranteed, that a satisfactory solution will eventually be discovered. Velocity and position of each particle in PSO, respectively, using the relations (1) and (2) is updated.

$$v_i(t+1) = wv_i(t) + c_1r_1[\hat{x}_i(t) - x_i(t)] + c_2r_2[g(t) - x_i(t)] \quad (1)$$

$$x_i(t+1) = x_i(t) + v_i(t+1) \quad (2)$$

Index of particles are shown by i . Therefore $v_i(t)$, is velocity of particle i at t time and $x_i(t)$ is position of particle i at t time. Parameters w , c_1 and c_2 are coefficient defined by the user ($0 \leq w \leq 1.2$, $0 \leq c_1 \leq 2$, $0 \leq c_2 \leq 2$). r_1 and r_2 values are random that are produced at each updated velocity [shi,1998], ($0 \leq r_1 \leq 1$, $0 \leq r_2 \leq 1$). $\hat{x}_i(t)$ is the best possible value for the particle i at time t . $g(t)$ is the best possible solution among those particles at the moment t .

3.2 Determine the local goal position

During navigation, the information is obtained real-time by the robot sensors. Real time navigation process has three stages. First, the navigation problem becomes an optimization problem. Then according to the goal and obstacles, proper objective function is designed. Finally, the PSO is used for solving optimization. In the process global best position of particles in each stage is the local goal that is at limited radius around the robot. The robot achieved the local goals, to reach your final goal.

According to the all the above, we assume that G is the final goal that its coordinates is shown by (x_G, y_G) . In addition, we assume that there is N obstacles in environment that we can specify them by the names of o_1, o_2, \dots, o_N . Their coordinates are as follows :

$(x_{o_1}, y_{o_1}), (x_{o_2}, y_{o_2}), \dots, (x_{o_N}, y_{o_N})$, so objective function of particle p_i is as relation (3):

$$f(p_i) = w_1 \cdot \frac{1}{\min_{j=1..N} |p_i - o_j|} + w_2 \cdot |p_i - G| \quad (3)$$

In this relationship, the absolute value represents distance between two points that is calculated by relation (4):

$$|p_i - o_j| = \sqrt{(x_{p_i} - x_{o_j})^2 + (y_{p_i} - y_{o_j})^2} \quad (4)$$

$|p_i - O|$ is distance between p_i and O point. Because the robot when faced with obstacles may be multiple points are detected as a obstacles. according to the relation (3), p_i

is closer to the goal, the amount $|p_i - o_j|$ will be smaller and p_i any further away from obstacles detected by sensors, the value $|p_i - o_j|$ will be greater. Therefore, this problem will become a minimum optimization problem. In relation (3), the local goal is closer to the global goal, the objective function reduced. These variables can be seen in Figure 1.

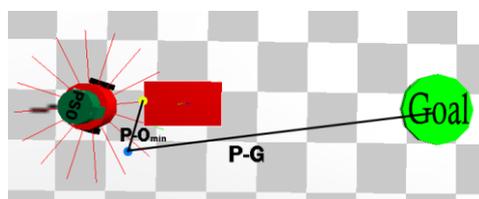


Figure 1: The optimal particles distance to the goal and obstacle

In Figure 1, yellow dots detected by sensors belongs to the obstacle has the closest distance to the robot. The blue dot is the optimal next place that the robot goes there in the next step. This particle is determined by PSO, and it has a minimum distance from the goal (green circle) and maximum distance from the yellow point.

Change the value of w_1 and w_2 in the relation (3) is effective in the robot path. ever w_1 is greater than, obstacles avoidance is more important so, the robot t goes around the obstacle, otherwise the robot might be colliding with obstacle. The larger w_2 , the robot will tend more toward the the final goal and the path will be shorter.

4 OBSTACLES AVOIDANCE

We first consider the case in which there are only fix obstacles. In this case $w_1 = 0.01$, $w_2 = 1$ was considered. PSO algorithm is programmed using Matlab commands, and robot is simulated by Webots¹, mobile robot software simulator. This software has a three-dimensional virtual world with physical features like mass as well as it has many sensors as distance sensors, cameras, etc. Mobile robot is a robot with differential drive. The Webots robot simulator is used in more than 935 universities and research centers worldwide[cyberbotics.com].

.The robot can go forward or side spin. Robot with 16 infra-red sensors that are spread around its body. Infrared sensors detect the maximum radius is 20 cm. Webots and Matlab

¹ www.cyberbotics.com

can be joint, PSO Matlab code calculates optimum point and in Webots, Robot goes to this point real time. navigation result of this method for fix obstacles is shown in Figure 2.

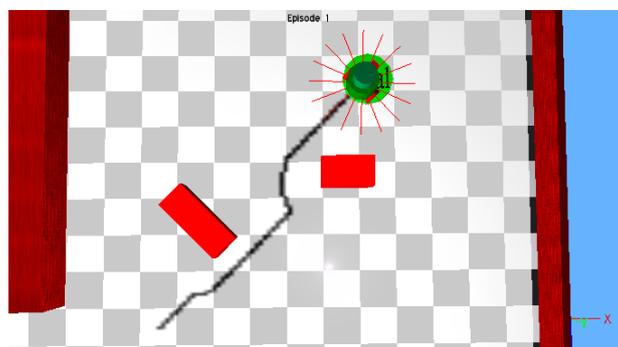


Figure 2: robot navigation by PSO, fix obstacle

At this stage there are two robots in which they move toward their goal. These robots are moving obstacles for each other. $w_1 = 0.05$, $w_2 = 1.2$ To calculate the fitness of each particle is considered Their path can be seen in Figure 3.

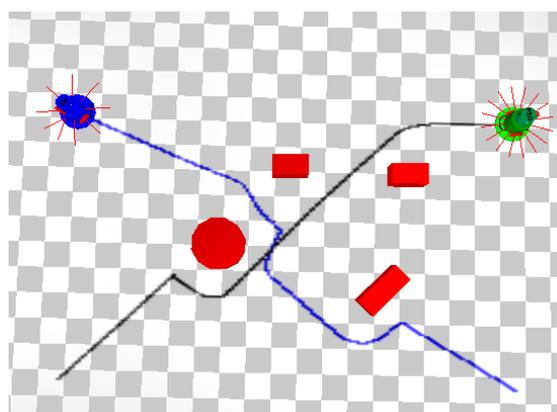


Figure 3: robot navigation by PSO, moving obstacle

Figure 4 is shown the result of navigation method by PSO for two robots which they go to their goal.

- Eberhart. R and J. Kennedy,1995, "A new optimizer using particle swarm theory," in *Proceedings of the Sixth International Symposium on Micro Machine and Human Science*, pp. 39-43.
- Kennedy. J and R. Eberhart,1995, "Particle swarm optimization," in *Proceedings of the IEEE International Conference on Neural Networks*, pp. 1942-1948 vol. 4.
- Doctor. S and G. Venayagamoorthy,2004, "Unmanned vehicle navigation using swarm intelligence," in *Proceedings of International Conference on Intelligent Sensing and Information Processing*, pp. 249-253.
- Chen. X and Y. Li, 2006, "Smooth path planning of a mobile robot using stochastic particle swarm optimization," in *Proceedings of the IEEE International Conference on Mechatronics and Automation*, pp. 1722-1727.
- Qin. Y. Q, et al., 2004, "Path planning for mobile robot using the particle swarm optimization with mutation operator," in *Proceedings of International Conference on Machine Learning and Cybernetics*, pp. 2473-2478 vol. 4.
- Hao. Y, et al.,2007 "Real-Time Obstacle Avoidance Method based on Polar Coordination Particle Swarm Optimization in Dynamic Environment," in *IEEE Conference on Industrial Electronics and Applications*, pp. 1612-1617.
- Wang. L, et al.,2006 "Obstacle-avoidance path planning for soccer robots using particle swarm optimization," in *IEEE International Conference on Robotics and Biomimetics*, pp. 1233-1238.
- Khatib O. Real-time obstacle avoidance for manipulators and mobile robots. *The International Journal of Robotics Research* 1986;5:90–8.
- Pratihari DK, Deb K, Chosh A. A genetic-fuzzy approach for mobile robot navigation among moving obstacles. *International Journal of Approximate Reasoning* 1999;20:145–72.
- Shi.Y and Eberhart.R, "A modified particle swarm optimizer," in *Proceeding of IEEE International Conference on Evolutionary Computation*, 1998, pp. 69-73.
- Karimi.J and pourtakdoust.H, " Optimal maneuver-based motion planning over terrain and threats using a dynamic hybrid PSO algorithm", *Aerospace Science and Technology Journal*, Elsevier,2012