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Using simplified swarm optimization on path planning for intelligent mobile robot

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Abstract

This study examined how path planning of intelligent mobile robot could be enhanced by utilizing simplified swarm optimization (SSO) in working environment with irregular obstacles. The conceptual framework of this study was driven from an inspiration of communal behavior of birds flocking and fish schooling. This conceptual framework was supported by swarm intelligence, which is one of the famous research areas in the field of computational swarm intelligence such as particle swarm optimization (PSO) algorithm. Significant observations have been made that mobile robots are significantly affected by path planning problems, and solutions are established how to tackle these problems and numerous weaknesses. Therefore, this study proposes an effective solution which can yield a high quality and efficient mobile robots. The SSO technique was adapted in order to provide an effective solution to the discussed weaknesses. The designed simulation algorithm results showed that SSO does not have assemble in the closed work interface where no path between the initial and the destination points. Obtained results show that when the particle's path gets into an obstacle area, it is automatically repositioned to an obstacle free area. Autonomy and energy efficiency within the particles are also discussed.

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Keywords: Swarm intelligence; path planning; particle swarm optimization; intelligent mobile robot; simplified swarm optimization

1. Introduction

Path planning algorithms can be categorized into two distinct elements; local (confined) path planning (on-line) and global (universal) path planning (off-line) Eberhart and Kennedy (1995), and Dorigo et al. (2008). In global path planning of robots, trajectory(range) of moving and stationary obstacles is always available in advance. In these kinds of environments, the robot initially assesses the desired path and confines to it till reaches its destination. However, in local path planning, all information is not available in advance Raja and Pugazhenthi (2009), and Sariff and Buniyamin (2006).

Since mid-1970s, many various academic researches and studies have been produced to address the path planning problems in mobile robot applications Eberhart and Kennedy (1995), and Konar (1999). Despite numerous suggested solutions, furher researches and discoveries showed that such solutions have inherent strengths, as well as weaknesses. Thus, to produce an efficient and quality solution, research hinges on efforts Yun et al. (2010). Additionally, satisfactory results from a path can be obtained when obstacles in local minimum positions, unrequired procedures and waste of time are minimized by the robot. In addition, a satisfactory path is defined as the one that eliminates all obstacles in the area Han (2007).

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Mohanty and Parhi (2013) argue that there are numerous strategies that can be employed in navigating an intelligent mobile robot. Thus, these discussed heuristic approaches enable the mobile robots to navigate reliably among the obstructions without knocking them and thereby moving to their predefined destination point. However, such approaches sometimes are tiny amount of faulty in addressing. Researchers have immensely been looking for supplementary productive approaches in order to tackle this issue relating to accompanying area. Prior studies on path planning and robot's navigation utilizing molecule swarm are inspected. Raja and Pugazhenthi (2012) discussed a research review progress about on-line and offline environments and mobile robot path planning.

Previous studies, Han (2007), and Dorigo et al. (2008), demonstrated that the transformative algorithms are computationally proficient and utilized exemplary developments for path planning of mobile robots. Similarly, computationally effective path planning algorithm is built Dutta (2010). Also, for robots path planning, Zhao and Zu (2009) proposed a modified particle swarm optimization (PSO) algorithm that two parameters; dimension and distance in relation to particle distribution degree presented in order prevent improper conjunction. Furthermore, Ahmadzadeh and Ghanavati (2012) proposed an understanding way to deal with the triangulation of mobile robots in obscure situations. The triangulation problem develops a problem for optimization and afterwards it was embraced by a PSO algorithm. In latter, each element in PSO is ascertained. It is accepted that robots can distinguish obstacles in a constrained range of its sensors, and these obstacles can be portable and dynamic, as well as the environment.

Simplified swarm optimization (SSO) is an evolutionary computation method, that was originally designed by Yeh (2009), and called discrete particle swarm optimization (DPSO). It belongs to the category of Swarm Intelligence methods. In discrete problem area, PSO has drawback and SSO was designed to overcome this issue initially. As it is defined in Yeh (2009), and Yeh et al. (2016), SSO can be explained as a population-based stochastic optimization method. SSO is a simple, efficient, and flexible algorithm, that the problem space has multiple random solutions and it searches optimal solutions by updating iterations Huang (2015).

This study examines the use of SSO in order to deal with the issue of mobile robot triangulation (navigation). This issue for ascertainment is the most productive mode which requires least time and shortest path in order to move from a starting point to an target point in relation to environment with random circumstances.

2. Literature Review

In this section, existing PSOs are discussed in detail. One of the existing studies established by Eberhart and Kennedy (1995) revealed that the existence of concept of a particle swarm optimization with reference. However, analyzing the steps of its advancement from communal simulation to optimization standard, and subsequent presentation offers some of the limited procedures that can be adopted to execute the concept Yun et al. (2010).

The adoption of one model is presented in enhanced detail, accompanied by conclusions gathered from applications and tests superimposed on the model or criterion and these been established to operate successfully.

According to Trelea 2003, the PSO is a technique in which each node behavior in the network is aimed at achieving a collective goal of the swarm as a group. In PSO, a problem is solved by following or moving in a collective manner Zhao and Zu (2009). Every particle or node in the swarm is aware of its location and coordinates regarding to the problem statement and try to find the best or optimized option to the problem Shiltagh and Jalal (2013). This is termed or referred to as *pbest*. Similarly, another optimization value that is used in measuring PSO is the best value, also another value is *lbest* which is obtained by choosing the best and closest node. And finally, the node or a particle that has the highest population of neighbors in its topological location is called global best and is termed *gbest* Shiltagh and Jalal (2013).

The definition of PSO consists of time interval, requires change in velocity and acceleration, every node is linked to the *pbest*, *lbest*. Movement is by nodes is autonomous, which is distinguished by the figure of nodes at risks of acceleration using the *pbest*, *lbest* locations. When the optimized values are found, the nodes retrieves the velocity, points using the given equation (1).

$$Vi(k+1) = Vi(k) + c1*\text{rand}(\,)*(Pi(k) - Xi(k)) + c2 * \text{rand}(\,) * (\text{g(k)} - Xi(\text{k})) \tag{1}$$

where $Vi(k)$ and $Xi(k)$ are velocity and position of particle i at iteration k respectively, that $Vi(k+1)$ and $, Xi(k+1)$ are new velocity and the new position of particle i at iteration $k+1$ respectively. *rand( )* is random variable with number between (0,1), where $c1$ is local acceleration coefficient, $c2$ is global acceleration coefficient that usually $c1 = c2 = 2$.

Based on this context, three accounts were examined, two samples types of lbest form, one node has two neighbors and the latter node having six neighbors as an assessment criteria. It seems that the primary GBEST form functions with regards to number of recapitulations to nodes becoming unified, as the *lbest* is created by creating two or more repellent nodes in confined minimal space (Shi, 2001). Observations have been made that the hunt for a PSO procedure without the initial segment is a procedure where the search space factually declines through the eras Zhao and Zu (2009). Then again, by including the initial segment, the particles tend to increase the space. That is, they can examine a new area. Along these lines, they have a more probable potency to undertake a worldwide search capacity by including the initial segment. Both the global and local searches are important in addressing similar complications.