International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-12, October 2019

An Efficient Path Planning Algorithm for Networked Robots using Modified Optimization Algorithm

Niharika Singh, Manish Prateek, Piyush Chauhan

Abstract: ***Path planning has played a significant role in major numerous decision-making techniques through an automatic system involved in numerous military applications. In the last century, pathfinding and generation were carried out by multiple intelligent approaches. It is very difficult in pathfinding to reduce energy. Besides suggesting the shortest path, it has been found that optimal path planning.***

This paper introduces an efficient path planning algorithm for networked robots using modified optimization algorithms in combination with the η3 -splines. A new method has employed a cuckoo optimization algorithm to handle the mobile robot path planning problem. At first, η3 - splines are combined so an irregular set of points can be included alongside the kinematic parameters chosen to relate with the development and the control of mobile robots. The proposed algorithm comprises of adaptive random fluctuations (ARFs), which help to deal with the very much manageable neighborhood convergence. This algorithm carries out the process of accurate object identification along with analyzing the influence of different design choice by developing a 3D CNN architecture to determine its performance. Besides offering classification in real-time applications, the proposed algorithm outperforms the performance of state of the art in different benchmarks.

Keywords: ***cuckoo optimization algorithm, modified optimization algorithms, networked robots, Path planning.***

I. INTRODUCTION

The path planning problem, for mobile robots, has been an active analysis area for several years that is started from mid-1970. Several strategies are projected to deal with this problem. It is essential to select a decent method to achieve both the quality and efficiency of a search. It is expected that the desirable path ensures that the robot wastes no time on unnecessary steps or moving in local minimum positions. Furthermore, it is better to avoid all the identified obstacles in the area.

Revised Manuscript Received on October 30, 2019.
***** Correspondence Author
Niharika Singh*, School of Computer Science, University of Petroleum and Energy Studies, Dehradun, India. Email:niharuka1519@gmail.com,niharika@ddn.upes.ac.in
Manish Prateek,, School of Computer Science, University of Petroleum and Energy Studies, Dehradun, India.. Email: mprateek@ddn.upes.ac.in
Piyush Chauhan, School of Computer Science, University of Petroleum and Energy Studies, Dehradun, India Email: pchauhan@ddn.upes.ac.in

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The mobile robot utilizes the heuristic way to deal with give a protected development among the obstacles. The main aim of mobile robots is landing at the predefined target locations without contacting the obstacles.

II. LITERATURE REVIEW

A. An Effective Path Planning Algorithm: The integration of several approaches is necessary for efficient path planning in spatial representation. This ensures a significant and an accurate navigation of the mobile robot. This paper introduces an optimization algorithm for planning the path of a mobile robot.

The Dijkstra's algorithm is used in the algorithm to find the shortest way. In 3D environment, the size of the robot is compared to the size of the obstacle by the proposed algorithm.

(Panda & Choudhury, 2015) discussed the challenges associated with dynamic motion planning for mobile robots. These challenges are handled through a distinct approach when environments are dynamic by taking into consideration the behaviour dynamics through a control point of view. The robot interacts dynamically with its local context, which represents the mobile robot existing in motion planning. The process of interaction dynamically models and controls motion planning. The behaviour dynamics adjusts the motion planning issue of mobile robots powerfully into a reasonable issue where the integrated arranging and control framework are included by bringing a change through an optimization issue in the robot's speeding up space.

(Hosseininejad & Dadkhah, 2019) uses the cuckoo optimization algorithm to propose a new method which resolves the challenges of the planning of mobile robot path in a non-static environment. Moreover, the current proposed technique uses the feature vector to minimize the computational complexity. Additionally, another technique is proposed which reduces the feature vector's dimension for reducing fully the overall computational complexity.

(Sun Liu & Leng, 2006) introduced an efficient algorithm involving shortest path planning which works on planar mobile robot having time complexity of O (4 x n) where n is found to denote the geometric complexity of the non-dynamic planar environment. The algorithm employed a taboo limitation as well as the greedy method employed in utilizing the Dijkstra algorithm.

The shortest path generated by the method is very fast and hence can be enhanced.

In (Tharwat et al, 2018) a model based on Bézier curve is proposed for path planning. The control points present in Bezier curve impacts altogether the length and smoothness of the path. A new algorithm named specific Chaotic Particle Swarm Optimization (CPSO) algorithm is proposed to enhance the control points of the Bézier curve. The proposed calculation gives two variations specifically CPSO-I and CPSO-II. The selected points enable the ideal smooth path to limit the absolute distance evaluated between the beginning and ending points. The conventional PSO algorithm is compared and checked with results generated by CPSO-I and CPSO-II algorithms to assess the CPSO calculation.

(Mo & Zu, 2015) consolidated another hybrid optimization algorithm BPSO with accurate Voronoi boundary network to propose another robot path planning approach. The method for condition modelling shown. Following this the Modified BPSO decides the best method dependent on AVBN. In comparison to other algorithms, the proposed method comprises of much faster convergence speed and there is minimum failure rate. Further an intelligent optimization proposes a new approach to solve RPP (Robot Path Planning).

(Ghosh,Panigrahi & Parhi,2017)employs an autonomous mobile robot to achieve optimal path by proposing two efficient intelligent optimal controllers consisting of bat algorithm (BA) and flower pollination algorithm (FPA) in an unfamiliar condition . FPA is designed by taking into consideration the process of pollinating flowering plants where various pollinators transport pollen.BA solves different kinds of optimisation problems in engineering through echolocation and frequency tuning. A fitness function is considered autonomously for achieving the path-planning task of mobile robot , by taking into consideration the distance existing either between the robot and the obstacle or between the robot and the goal satisfying the criteria of obstacle avoidance where the robot shows the goal=achiever's behaviour. The mobile robot considers the values provided by the objective function to avoid obstacles in an unfamiliar environment and arrives at its goal.

(Das, Behera & Panigrahy, 2015) employed hybridization of improved particle swarm optimization (IPSO) in combination with an improved gravitational search algorithm (IGSA) for multi-robot to determine the optimal trajectory of the determined path in a clutter environment. IPSO possesses social characteristics which the proposed approach incorporates into the movement of IGSA. The developed hybridization IPSO-IGSA maintains the suitable equilibrium between searching and overuse due to the adoption of co-evolutionary techniques for enhancing the expedition of IGSA and particle positions combined with IPSO velocity together. The algorithm diminishes the maximum path length. It also reduces the time of arrival of each robot to its distinct destination in the environment. The robot generates individualistic decisions by implementing the proposed hybrid IPSO–IGSA to understand, and communicate with each other to identify the next positions from their current location in the world map.

(Zhang, Chen and Liu, 2016) proposes a modified ant colony optimization algorithm to do the arranging of the path of a mobile robot in a perceived stable condition. The modified ant colony algorithm expands the searching through a range that debilitates the local minima issue, enabling the algorithm to focus quickly. The turning element is likewise considered in the optimal path searching process.

In (Das et al, 2016) a new methodology to solve optimization problem is proposed along with several evolutionary algorithms including Genetic Algorithms, Differential evolution algorithm gravitational search algorithm, PSO and Bee colony Optimization for application in the problem of planning of multi-robot path .There are two parts in the fitness function of the GSA to avoid the impact which occurs when robots collide with static obstacles. They are the fitness function depicting the way toward choosing the next position. They utilizes an optimal trajectory through the estimation of speed, and different incorporates the restrictions on acceleration. Newtonian's law of gravity and movement helped to make the design of the heuristic algorithm PSO. There are various changes in GSA and these changes have several applications. Currently the original version is improved by the different variants of GSA. The algorithm has also found application in many areas .There are apparent targets of the separate robots, and these robots have PSO where an all-around fitness function is created in a multi-robot way arranging the issue. This fitness function decides the accompanying position of the robots which are remaining in ideal directions and moving towards the individual objectives. The path-planning problem emerges in the circumstance when an iterative algorithm gets a request to decide the accompanying position of the considerable number of robots by settling every one of the imperatives existing in the multi-target work. The algorithm continues repeating until each robot arrives at its destination. In the molecule swarm streamlining algorithm, various new highlights are added to improve it with the goal that it can decide the way direction for different robots which uniquely characterizes beginning positions to explicitly picked objective views in the earth to limit the way length of the considerable number of robots. The outcome uncovers how the algorithm has improved the arrangement quality inside a plausible timeframe. The particle swarm optimization algorithm (IPSO) gets enhanced with the goal that it can deal with the way arranging issue of the multi-robots, which is leaving all around through expansion of the combination rate. Ultimately, the recreation has demonstrated the productivity of the IPSO with Khepera condition and the outcome is contrasted and different algorithms including a PSO and DE.

IPSO method offers vigorous execution, self-deterministic interaction, and deals with a problematic domain in the multi-robot framework dependent on a dynamic structure.

IPSO proposes a path-planning plan to ideally get the accompanying states of the robots from the present position in the intended condition.

(Zheng, Xi & Xao, 2016) proposed an improved ant colony algorithm where the infinite step length exists to estimate the optimal path. It focuses mainly on the drawbacks of the standard ant colony algorithms such as the determination of the single step length to recognize the optimal path inclined towards the local optima and feeble convergence. There exists an increased chance of selecting a path of ant along with optimizing the results .The heuristic information adopts a huge priority together with utilizing choose/ grid mode to adopt a modified update mode of local information.

(Sudhakara & Ganapathy, 2016) determines the best path for moving from a start state to a destination state through a newly optimization technique for a robot having no collision with obstacles. Modifications are carried out on the existing A-star algorithm so that the robot is able to travel in an unfamiliar environment which comprises of static obstacles. The robot is assumed to move to the destination position without colliding with any of the obstacles present. The Enhanced A* algorithm follows an optimal path to help the robot to reach the target.

(Parhi,2018) performed a review analysis on navigational methodologies of robots through different artificial intelligence techniques including Neural Network, Particle Swarm Optimisation (PSO),Fuzzy Logic, Genetic Algorithm and additional Artificial Intelligence techniques. During the survey analysis the review was carried out systematically and the role of several artificial intelligence techniques were utilized to control and navigate different kinds of robots facing different environmental conditions.(Song et al., 2017) uses η3 -splines along with a modified particle swarm optimization (MPSO) to propose a new approach. At first, the η3 - splines are utilized for including an arbitrary arrangement of points where the kinematic parameters are chosen to relate with the movement and the control of mobile robots. The MPSO algorithm comprises of adaptive random fluctuations (ARFs) and is for the most part created to control the frequently oversaw local convergence. The issue is the system of arranging the smooth worldwide way. The MPSO algorithm has shown the evolutionary state incorporating classification averagely at each iteration as provided by the evaluated evolutionary factor. There exists a switch in the velocity improving dynamics for the varying modes as per the evolutionary state along with the ARFs .Theses are imposed on the global/local best particles in a way suggested by the existing iteration.

B. Network Robots:

(Naz, Piranda & Tucci, 2018) describes the networks of few modular robots which are lattice-based and only use neighbour-to-neighbour interactions. These networks develop into sparse and huge breadth networks. Furthermore, we give tight limits to the diameter and the breadth of these networks. There exists a crucial design issue through complicated distributed networks due to the large diameter and the vast average distance of massive-scale lattice-based networks.

(Huang et al., 2019) reviews a variety of techniques associated with mobile robots in WSNs. It helps scholars understand the flow within every category, the relationship among different solutions along with accurate information as well as in-depth analysis. The distinctions and likenesses between the accessible approaches are compared past various classes as far as scientific formulation, application, and so forth.

(Chen & Chiu, 2015) developed a map, planned optimal paths and designed mobile robots through an optimal robot path planning system. A grid-based map is designed by the system by collecting the information from several locations of the origin and static obstacles. The system estimates the optimal trajectory by utilizing a simplified neural network model and developing a mobile robot. The mobile robot determines the ambient conditions for dynamic obstacles and avoids possible collisions.

(Yuan et al.,2019)develops the advancement of a mobile robot collision avoidance algorithm by utilizing the characteristics of improved ACO and APF and figuring a novel GRU-RNN system model to finish the dynamic path planning of mobile robots in a new domain. The GRU-RNN system has recognized the arranging approach of the principal framework, and there exists an all-out presentation in light of the use of the improved ACO and APF calculation.

C. 3d Environment Modelling with the Proposed Algorithm:

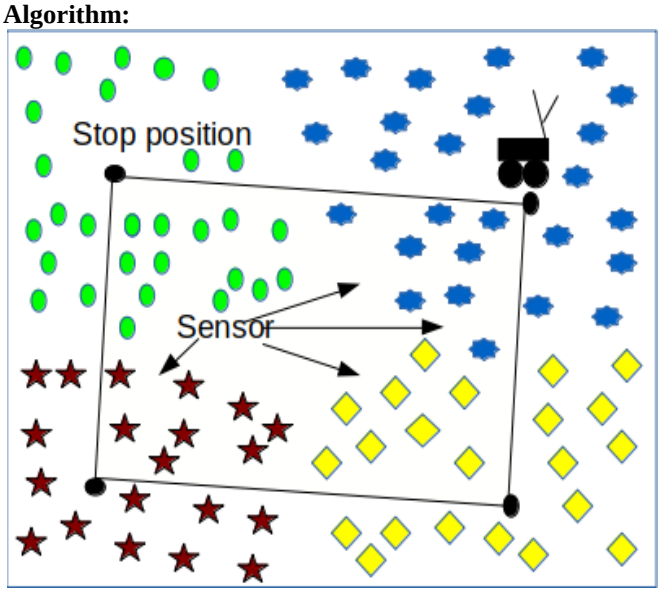

Fig 1: A robot is gathering information from the sensor network.

Fig.1 shows a case of our considered scenario. The cost of movement can generally increase as the volume of clusters increase as the robot has to travel a lot in each period.

Then again, the price of communication may decrease as the number of clusters increases, as the separation of the sensors from the transmission decreases. Subsequently, in this problem, the volume of clusters, the clustering of the network, the stop position, and the robot's arrangement and movement technique must be mutually enhanced to limit the all-out energy cost of the stop position of the sensor. The cost of movement can generally increase as the volume of clusters increase as the robot has to travel a lot in each period. Then again, the price of communication may decrease as the number of clusters increases, as the separation of the sensors from the transmission decreases. Subsequently, in this problem, the volume of clusters, the clustering of the network, the stop position, and the robot's arrangement and movement technique must be mutually enhanced to limit the all-out energy cost of the stop position of the sensor..

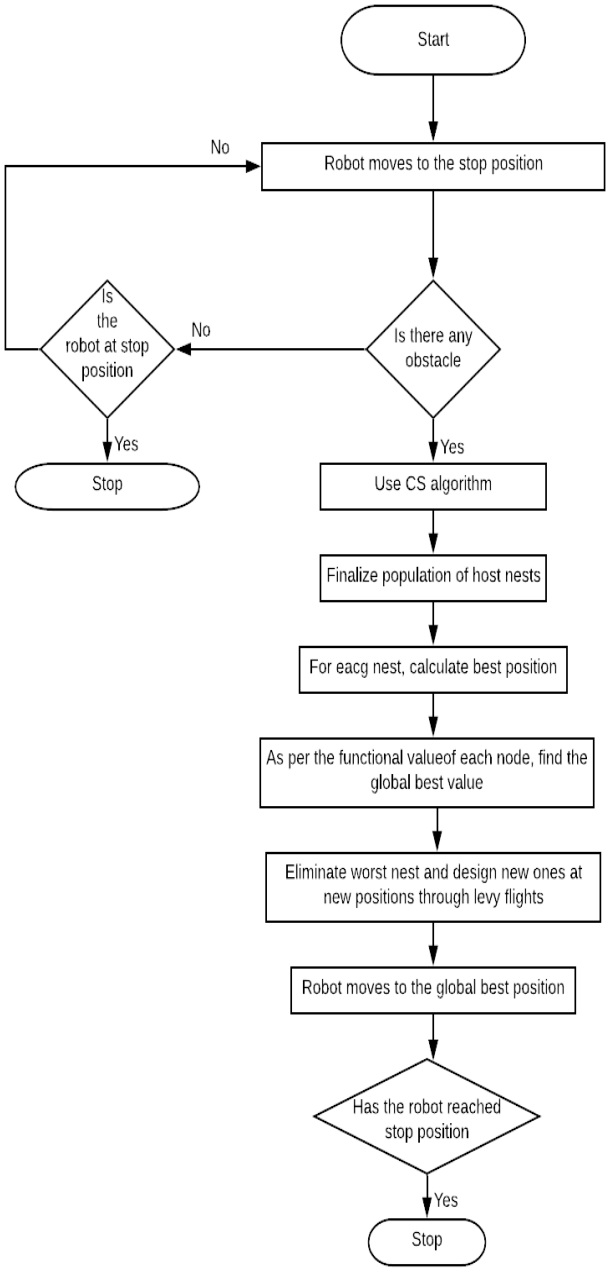

Fig 2: Flow chart of Cuckoo swarm optimisation

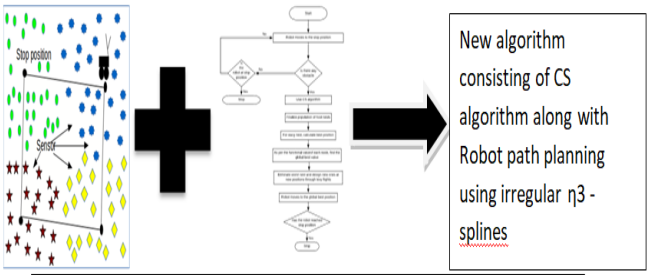

Fig 3: New hybrid algorithm CS algorithm along with robot path planning using irregular η3 - ..

Irregular η3 - splines denotes the Gaussian distribution in 3D environment. It tends to be seen in areas where the density of the sensors is greater, true to shape, we have more clusters. Moreover, the expected complete cost of the whole system is only 9.7 per cent of the cost of the example of no clustering; demonstrating impressive energy sparing achieved by appropriate co-optimization. It is recognized that in cluttered circumstances, the current path framework generates collision -free routes from the start to the end point.

(Maturana and Scherer,2015)introduced a 3D CNN architecture named VoxNet from LiDAR and RGBD guide clouds s toward proficiently and precisely recognize an object, and depicted the effect of different plan accessible on its exhibition quickly. The best framework outperforms the presentation of the cutting edge during characterization in a few benchmarks in genuine time. Future works incorporate the information from different modalities to be coordinated upon separated from including different errands, for example, semantic division.

(Mohanahrajah et al., 2015) develops engineering, parallel calculations, and convention for affiliated 3D mapping in the cloud with low-cost robots. The robots work uses a cell phone class processor on a thick visual odometry algorithm. Key-outlines assembled from the visual odometry are moved to the cloud to perform parallel optimization and blend with maps which are created by different robots. When the optimization is over the cloud drives the modernized demonstrations of the nearby key-outlines back to the robots. A cloud applies autonomy structure to be specific Rapyuta deals with all procedures by working on a business server farm.

(Elmokadem, 2018) designs a 3D reactive navigation approach to assure that a mobile robot can arrive its destination with safety without any obstacle. The proposed reactive strategy used sensed information about the obstacles, which addresses it suitable for applications such as mobile Robots in unknown environments. Furthermore, it can be perfect for robots with restricted capabilities due to their low computational complexity.

(Burchfiel & Konidaris, 2018) introduced novel representation for 3D objects, namely Hybrid Bayesian Eigenobjects (HBEOs), which allows a robot to calculate the pose, as well as the class jointly,

and a full 3D geometry of any new object. This observation is made from an appropriate perspective in one practical framework. The direct subspace strategies included deep convolutional prediction so that HBEOs can successfully comprehend speaking to nonlinear particles with assistant relapsing into high-dimensional space. HBEOs additionally kill the complex and generally silly interest of information voxelization before completing surmising.

D. Application of the Proposed Algorithm: Modelling and animation of the networked robot could be a complicated task, that has not been utterly resolved recent times. The model can be integrated with any ready-to-use navigation stack and experimented at intervals and environments in a cluster navigation scenario. The proposed organized robot has the basic capacity of semantic object recognition by working in disturbing, true situations. The dynamic range sensor, for example, LiDAR and RGBD cameras have ended up being a well-known choice of the sensor for current self-sufficient vehicles including autos, quad rotors and helicopters. Notwithstanding the intensive use to void obstacles and mapping, the general potential of these sensors is to date unexplored. The proposed model can be used for object recognition. The issue of foreseeing an object class label in a 3D point cloud section joining foundation mess can be comprehended.

E. 3d Deadlock Free Mechanism: This section discusses how the proposed algorithm is free from deadlock.

(Wang et al., 2019) proposed two techniques to ascertain safety measures. Because of the genuine concern of the path search, a search mode is planned to interface the plane alongside visual fields and restricting the hunt extent of the robot. A 3D deadlock-free mechanism is embraced to the deadlock problem to enable ants to escape the states. For completing the reenactments, several 3D terrains are utilized to perform reproductions and construct diverse introductory and last focuses in every domain under indistinguishable surface settings. As per the improved ant colony algorithm's outcomes in relationship with the fundamental ant colony algorithm, the improved ant colony algorithm gives ways to obstruct the hindrances adequately, and their directions are observed to be smoother when contrasted with the essential ant colony algorithm. The briefest way length has been decreased by 8.164%, overall when contrasted with the consequences of the ant colony optimization algorithm.

III. FINDINGS AND CONCLUSION

In this paper, an economical path designing algorithmic rule is proposed for networked robots using changed optimization algorithms in combination with the η3 -splines. a new method using cuckoo improvement algorithmic rule has been planned to manage the problem of mobile robot path planning problem. The proposed algorithm consists of adaptive random fluctuations (ARFs) which help to handle the usually managed local convergence. In a few military applications, path planning is till date imperative to settle on significant choices in an unmanned self-sufficient framework. Different clever ways to deal with pathfinding and age are acquired inside the previous decade. Energy reduction through pathfinding is a difficult errand. Ideal way arranging recommends that the briefest way as well as moreover discovering one inside the limited cost and time. The proposed strategy recommends another approach to examine versatile strategies for future huge scale 3D displaying through arranged robots.

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AUTHORS PROFILE

Niharika Singh received her M.Tech Degree in 2012-14 from University of Petroleum and Energy Studies. She is currently working as Assistant Professor in School of Computer Science, UPES. Her area of research is AI and Machine Learning.

Manish Prateek, currently working as professor of school of computer science. His area of research is soft computing and wireless network. He had published many research papers on robotics. Currently he is the Dean of School of computer science department Of UPES Dehradun.

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Piyush Chauhan, currently working as an Assistant Professor in School of Computer Science. His area of research is Scheduling Algorithms and Machine Learning. He has published many papers in his area.