https://dx.doi.org/10.4314/dujopas.v10i3c.31
ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 10 No. 3c September 2024*

A Review of Navigation Techniques for Telepresence Robots

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Abstract

Nowadays the need for digital travel has increased more than ever. This is due to the need for social distancing for medical reasons, economy of travelling, and avoidance of risks involved in physical travelling or for convenience. The telepresence robot therefore serves as a surrogate for the pilot user. Telepresence robots are very resourceful and versatile. Their applications include education; medicine; business; research and ambient assisted living. A major consideration for the effective functioning of telepresence robots is the navigation scheme employed which is central to its overall reliability. Depending on the use to which the robot is to be put, several authors have considered various navigation schemes used to effectively control and navigate in workspace consisting of obstacles and/or order robots. This work aims to review the navigation technique that has been employed by researchers for telepresence robots with a view to identifying the strengths and weaknesses of the various navigation techniques and subsequently coming up with a relatively novel system of navigation that attemts to mitigate the various weaknesses of the previous methodologies for telepresence robot navigation. It has been observed that the general path planning and navigation for the usual autonomous robot is also applicable to the telepresence robot but bearing in mind that the robot is being piloted by humans and it is only when in a condition where it would be cumbersome for the humans that autonomous control system takes over. At such times path planning and navigation using AI methods have proved to be of importance. The path planning algorithms have been shown to be categorized into two viz: global path planning algorithms which are used for known environments and local path planning algorithms for unknown or partially known environments. The algorithms for local path planning are majorly reactive in attribute and are more relevant to telepresence robots. In any particular application, an appropriate blend of a number of these algorithms is employed to achieve desired navigation objectives. Furthermore, in this work, we propose the combination of a line follower robot with an obstacle avoidance algorithm for situations where the expected robot paths are foreknown.

Keywords: Path planning; Mobile Robotic Telepresence (MRT); Ambient Assisted Living (AAL); Psychosocial Reality; Digital Travel.

INTRODUCTION

The concept of telepresence has to do with the sense of being in a remote location when one is not there. This sense is made possible by all the technologies involved in enabling the person

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to have a feeling of being remotely present and carrying out activities as if he/she were present (Paulos & Canny, 1998). These activities include audio and video communication. However, when it is a Telepresence robot, in addition to audio and video communication (Hu et al., 2024), the person will also be able to 'move around' with the help of the mobile robot which represents him in the remote location. That is the person will be able to also remotely control the movement of the robot. The telepresence robot therefore acts as a surrogate for the remote pilot use (Seo et al., 2024). Several telepresence robots have been designed with different navigation schemes to suit the application purpose of the robot. Some of these telepresence robots appearing in literature are listed with their navigation modalities with some other characteristic features and information such as availability in commercial quantity; intended application areas; adjustable height; and mode of manipulation or mode of remote piloting (Altalbe & Shahzad, 2023).

The robotic telepresence systems have been designed to enable the user to be remotely present by transmitted video and audio signals. These systems may be mobile or stationary robots. However, in this work, we limit our work to those robotic telepresence systems that are mobile. This cursive overview of Mobile Robotic telepresence (MRT) navigation systems is made in order to realize the best approach for investigating better navigation methods (Kristoffersson, Coradeschi, et al., 2013). In general, when it is a mobile telepresence system, the mobility enhances the ability of the robot for social interaction(Tuli et al., 2020) (Kristoffersson, Severinson Eklundh, et al., 2013).

The ability of the robot to undergo translational motion tends to enhance the psychosocial reality of digital travel(Hedman, 2022) and the sense of immersion (Hedman, 2022).
Table 1.0 An overview of common appearing telepresence robots in the literature. . (Kristoffersson, Coradeschi, et al., 2013)(O et al., 2022).

MRT system	commercial	Intended application Area	Adjustable height	Manipulation/expression	Navigation/sesor
PRoP	No	Research	No	Laser pointer, 2 DOF	No
Giraf	Yes	Elderly	No	No	No
QB	Yes	Office	Yes	Laser pointer	Motion pointer for platform stabilization Laser Range finders, bumper
Texer	No	Office	No	No	No
Beam	Yes	Office	No	No	Cliff sensor
VGo	Yes	Office	No	Handheld remote for local control	No
PEBBLES	No	School	No	Hand	Infra red obstacle detection, tip detection using accelerometers
	Yes	Office	Yes	Laser Printer	

MantaroBot classic					Infra red obstacle detection, tip detection using accelerometers
	Yes	Office	No	Laser Pointer	
MantaroBot TeleMe					Infra red obstacle detection, tip detection using accelerometers
	Yes	Unspecified	Yes motorized	No	
Double					Infra red obstacle detection, tip detection using accelerometers
	No	Research	No	No	
mObi					Gyroscope and accelerometer for balance. Kick-stands whan static.
	Yes	Office	No	No	
Jazz connect					Kick-stands for safty
	Yes	Health Care	Yes	Yes	
iRobot Ava					Obstacle detection, 8 ultrasonic sensors, 4 IR sensors and high end 30m range telemetric laser for autonomous navigation (optional)
9th sense Helo and Telo	Yes	Unspecified	No	No	Laser sonar, 2D/3D Imaging for autonomous navigation, cliff sensor and contact bumper. Omnidirectional navigation
RP7	Yes	Health Care	No	No	No, but ports for navigation are available.
MeBot	No	Research	No	3 DOF arms and 3 DOF neck	Omnidirectional navigation. Obstacle detection via +30 infra-red sensors
					Obstacle and cliff detection.

The mobility is a feature that makes the digital traveler able to virtually interact with others in a more seemingly real manner and able to demonstrate a relatively higher level of social interaction.

Various systems and application areas for such socially interactive robots exist. These include: education and teaching (Jaman & Schoen, 2020)(Ham et al., 2016)(Johannessen et al., 2022), health(MacHaret & Florencio, 2012), libraries (Tella & Ogbonna, 2023) and care for the elderly (Smith et al., 2021) (Banerjee et al., 2024) (Gonzalez-Jimenez et al., 2013), entertainment(Living, 2019), research(Alers et al., 2013), businesses and management (Kristoffersson, Coradeschi, et al., 2013). Kristofferson et al., also delve into the challenges found in literature concerning MRT use and implementation these include the challenge to achieve the required immersion experience (Fuchs et al., 2014), obstacle avoidance and navigation, and the challenge of communication protocol for the system. The communication protocol should be as reliable as possible so that transmission and reception of information signals and control signals would be efficient. To this end, Yanco et al., attempt to develop a robust and reliable protocol that is user-friendly by incorporating an algorithm that enables the robot to learn different meanings for vocabulary elements in different runs of experiments (Yanco & Stein, 2020). Artificial intelligence therefore is a veritable tool in the communication protocol to achieve reliability, autonomy and efficiency in the communication process (Fareh et al., 2020) (Ruan et al., 2019). Apart from communicating audio and video signals, there is often the need for the pilot user of the telepresence robot to receive information relating to the location and orientation of the robot at any point in time- this is termed localization (Park & Park, 2020). Proper localization would enable effective control, path planning and navigation (Pokle et al., n.d.)(Lopez et al., n.d.). The success of the safe navigation task depends closely on localization accuracy. Therefore many methods of localization have been developed to find accurate solutions to determine the position and orientation of mobile telepresence robots (Alhamdi, 2022). This leads to achieving the desired results in navigation and the whole process of digital travel for the pilot user. Aiming at the challenge of the robustness of mobile robots in performing its function, a more dependable scheme is required to carry out long-term work with changing conditions. A new method of long-term visual localization is the hybrid descriptor concatenated by generating a semantic image descriptor extracted from semantic segmentation images and an image descriptor from the image of a picture taken with certain weight and then trained by convolution neural network (CNN) (Shi et al., 2022).

Rajapaksha et al conducted research work on the use of applications to simultaneously control a number of robots in a place working to complement each order. There are times when multiple robots are utilized in a place such as a home environment (Sanyal & Mandal, 2022)(Parhi & Mohanty, 2016); and a synergistic control is required. In these cases, there are research works on heterogeneous multiple robot path planning, navigation control and communication(Mavrogiannis et al., 2015). To design a robotic application with autonomous robot registration and control is the aim. The development of Robot Operating Software (ROS) aimed to decrease the complexity of heterogeneous multiple robot programming and enhance interoperability (Rajapaksha et al., 2022).

Telepresence robot technology is a relatively new area of research with room for research and innovation in its various sub-systems and aspects. This journal reviews the navigation systems of telepresence robots. Modern navigation consists of four basic steps, which include: sensing, locomotion or positioning, and motion control route planning. There is always a need for a navigation system since the robot is often expected to avoid obstacles in its way as it travels in the direction of command signals from the pilot user end (Beraldo et al., 2024). These navigation schemes help to relieve the pilot user of the trouble of having to continuously focus on the task of remote navigation so he can concentrate on the principal task the robot is supposed to be used for. Basically, collaborative control is often adopted in which the control signals from the pilot user are being obeyed; however, in the event of an obstacle which the pilot user does not take into cognizance, the robot avoids such obstacles with the help of artificial intelligence built into it (Naseer et al., 2023).These artificial intelligence schemes therefore are the brains behind the control and navigation schemes. We therefore consider the AI schemes for navigation in this work. This navigation method is also called shared intelligeince system of navigation combined with Robot Operating System (ROS) (Bacchin et al., 2024). When we consider robot navigation in general without limiting it to telepresence robots in particular, the same navigation schemes used are also employed in telepresence robots except for the concept of collaborative control in the telepresence robot such that the autonomous control only comes into play at the moment an obstacle is in the direction of command(Du et al., 2021). One of the most important and noticeable aspects of autonomous robot navigation and it is also applied to telepresence robot navigation(Altalbe & Shahzad, 2023). A collision-free path between two points is found while minimizing the corresponding costs in path design. The essence is to achieve efficiency in terms of time, distance, energy and other factors which translate to optimization in cost.(Karur et al., 2021) Depending on the environment, path planning can be classified as static or dynamic. In static path planning, obstacles change position and orientation over time(Harwin, 2019). A dynamic path planning process occurs when paths are designed dynamically. In this situation, a number of moving robots and obstacles are considered in terms of their positions and orientations. The interactions between many navigating agents can be modelled using physics, for instance, as socially acceptable and human-like motion produced by several interacting potential fields that reflect agents, goals, and intentions. This knowledge can be further separated into offline and online algorithms. Online path planning uses locally installed, separately attached robot sensors to gather environmental information. By feeding information from locally attached sensors, the robot constructs a map of the environment. Without the use of sensors, the robot has full awareness of its surroundings when determining its course offline. In telepresence robot, the online path planning is utilized. This often involve intelligent motion planning which involve obstacle avoidance, search for the best path to take (Altalbe & Shahzad, 2023)(Altalbe & Shahzad, 2023) and sometimes orientation control design to determine the direction the robot faces in order to to carry out the supposed task at the point in time (Altalbe et al., 2023). To ensure satisfactory navigation, several strategies have been proposed.

Before navigation can be achieved there must be consideration of some related concepts, including workspace, configuration space; forbidden space; free space; global navigation(L. Liu et al., 2021); local navigation; position navigation; reactive navigation and bug navigation algorithms. Three general methods of navigation for a robot in the ground plane are used and will be reviewed in this work: combinatorial; sampling-based and potential fields (Qi & Sun, 2020)(Huski et al., 2018). However, the general concepts and notions employed in telepresence robot navigation would first be considered.

GENERAL CONCEPTS AND NOTIONS EMPLOYED IN TELEPRESENCE ROBOT NAVIGATION

In order to realize a successful navigation process, it is required to be familiar with some conceptual notions related to the process. We need first to understand what is meant by workspace. It is the description of the environment in which the robot. This space also contains the obstacles to be avoided in the course of motion. Next to this concept is configuration space which describes the complete specification of position of each point of the robot. Configuration is the set of all possible positions with respect to the different degrees of freedom of the robot. In contrast to this, we have a concept called forbidden space. Forbidden spaces are those configurations q in configuration c which lead to a collision with obstacles or self-collisions. The rest of the configuration space is referred to as free space.

The scale of requirement is broadly categorized into Global Navigation; local navigation; position navigation and Reactive Navigation. Global navigation has to do with the ability to determine one's position in absolute or map-referenced terms and to move to a desired destination point getting between end locations. Local navigation is the ability of the robot to determine its position relative to objects (either stationary or moving) in the environment and to interact with them correctly while carrying out a task at a location.

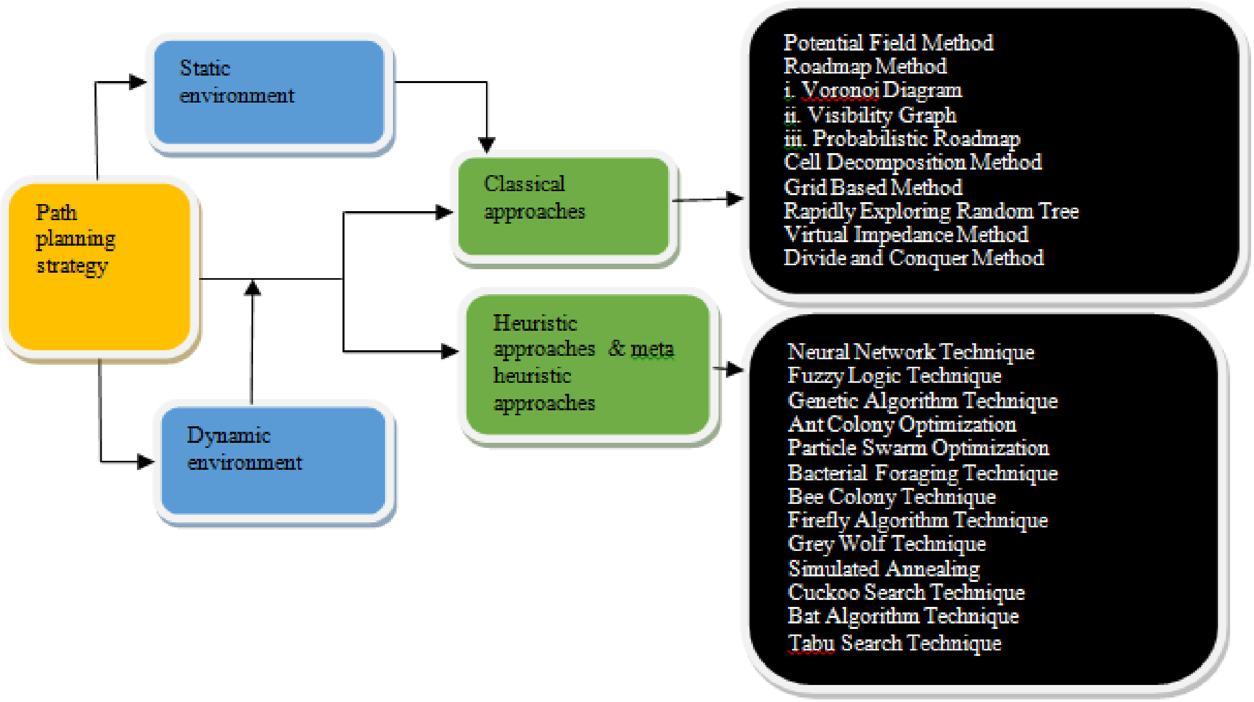

Figure 1.0: Illustration of the interrelationship between various path planning and navigation algorithms and their nomenclatures (Kumar & Tibor, 2020) moves or operates.

Position navigator is being aware of the positioning of various parts that make up oneself in relation to each other and in handling objects. It entails monitoring of individual robot parts and anything in contact with it. Another navigation concept is reactive navigation which refers to the ability to respond appropriately to current sensing inputs. It is the modification in motion or path as the sensor information. Of these four navigation modules, two are very critical in path planning viz: Global and local navigation and these will be considered in this review.

A. Path Planning *and Navigation*

The main aim of navigation and path planning is to optimize the robot motion process by achieving the shortest path within the minimum possible time, smooth path and minimum power consumption, collision-free motion, and low cost (Kumar & Tibor, 2020). Before effective navigation often time, there is the need to conduct adequate path planning to ascertain the intended route to be taken by the robot. This path planning is a function of the category of the environment type in which the robot operates. The environment types include: known environment; unknown environment and partially known environment. In the known environment, the geometry and topology of each object including the obstacle in the workspace are known. An unknown environment is one in which no prior information about obstacles or the geometry of the environment. Generally, to ensure robot translational motion from the start end to the goal configuration while remaining in the free space configuration, numerous approaches have been proposed and applied over the years. Such approaches include the classical methods for the unknown environment, the partially known environment and the fully known environment as well as the use of the artificial intelligence method which is more reliable, viable and robust (Mohanta & Keshari, 2019). Such methods include fuzzy logic techniques(Benbouabdallah & Qi-dan, 2013)(Mohanta & Keshari, 2019)(Mitrovic & Djurovic, 2010), optimization techniques such as genetic algorithms, potential field-based methods, neural network approaches, human behavior-based algorithms and hybrid methods. Each technique has its own merits and demerits over others in certain situations. Fuzzy logic is usually a potent technique for the controller; this involves searching targets and path planning with obstacle avoidance (Benbouabdallah & Qi-dan, 2013) (Gul et al., 2019). In any case, the algorithms employed for navigation can be classified under two navigation methods viz: global navigation method and local navigation method.

The diagram in Figure 1.0 seeks to demonstrate the interrelationship between the various path planning and navigation schemes adopted for robot navigation. These schemes have been identified as applied to autonomous robots however, for telepresence robots, schemes relating to local navigation are mostly applicable (Atiyah et al., 2021). Furthermore, the use of a particular scheme is dependent on the purpose of the robot's level of expected versatility of the robot (Ren et al., 2022).

B. *Global Navigation*

Algorithms for path planning can be divided into groups based on the environmental information at hand. In global navigation, the robot should have prior knowledge of the environment (Alhamdi, 2022) (Karur et al., 2021). This is offline navigation (Kumar & Tibor, 2020). However, there are situations when the robot only has a limited understanding of its surroundings. In these cases, path planning, which finds the best route given almost all available environmental data, works best in static environments that the robot is familiar with. In this instance, before the robot begins travelling the intended route, the path planning algorithm generates a complete path from the start point to the destination. The methods employed in global navigation include Artificial potential field (APF); Dijkstra Algorithm; A*(A-Star) Algorithm (Karur et al., 2021) and Firefly Algorithm.

1) *Artificial potential field (APF)*

Artificial Potential Field (APF) is one of the classical approaches to path planning. It is a nature-inspired technique. APF is utilised to create an artificial potential field around the robot. In this field, obstacles are repelled through repulsive force and the robot is attracted toward the goal using attractive force. Both an attracting force and a repulsive force are necessary for the potential field to exist. The robot experiences an attractive force from the goal and a repulsive force from the obstacles. These forces are inversely correlated with the robot's distance from the obstacles and its direction of travel. In APF robots travel from points of high potential to points of low potential. The potential function for attractive and repulsive forces shows the vector sum of the two forces as follows:(Sanyal & Mandal, 2022)

$U(q)= Uatt(q)+ Urep(q)$

For attractive potential, the expression is given as:

$Uatt(q)=1/2\zeta\rho^2(q.qgoal)$

Where ζ is gain and (q.qgoal) is the distance between the robot and the goal (Gul et al., 2019). The attractive force is given as the negative gradient of attractive potential and the attractive force tends to zero as it approaches goal.

$Fatt(q)=V\ Uatt(q)= \zeta(qgoal-q)$

For the repulsive potential function, we have:

$Urep=(q)[1/2h[(1/p(q.qobs))-1/po]^2]$

The main issue with APF is that robots can become immobilised at local or global minima, which means they become stuck at a point where the pressures and fields cancel each other out and prevent the robot from moving forward or even backwards.

2) *Dijkstra Algorithm*

Dijkstra's shortest path algorithm was invented by the famous Dutch computer scientist late Edsger W. Dijktra (Dijkstra, 1972). The algorithm's goal is to determine the shortest path between each node in a graph and every other node. The easiest technique for determining a robot's path is said to be the graph-searching method. When it comes to finding a non-obstructive path, it is said to be a well-defined, efficient, and effective strategy that requires less time and computing complexity. The robot-friendly environment is designed with a path connected by lines that allow the robot to reach its destination with ease. From one node to another, the procedure is repeated until the best and most optimal answer is obtained. The robot is permitted to move on to a new place after it has reached the intended goal. The Dijkstra algorithm is a graph-searching technique that finds the shortest path while solving the optimal path issue with non-negative edge path costs. The path cost from a single point to a single destination can be found using it. (Hewawasam et al., 2022). The algorithm is very applicable for traffic information systems where tracking of source and destination is required. The algorithm's primary benefit is in its ability to repeatedly calculate the shortest path between a starting point and an endpoint while avoiding longer paths. (Alija, 2015).

By calculating the shortest path from the source to vertices among the vertices that are closest to the source, the Dijkstra algorithm finds solutions to subproblems. It saves only one intermediary node so that only one shortest path can be identified, and it finds the closest vertex or node by keeping the new vertices in a priority-min queue structure. Dijkstra can compute the shortest path from any starting point to any destination in an acyclic environment. There are various improved Dijkstra algorithm versions, depending on the required applications. Every Improved Dijkstra’s algorithm is variant and demonstrates the diversity of use cases and applications for the Dijkstra algorithm. For path planning, the conventional Dijkstra algorithm uses an avaricious approach. In a graph, it is employed to find the shortest path. Without explicitly considering the solution's pragmatism, it is focused on finding the shortest path. The goal of the modified Dijkstra's method is to identify other paths when producing feasible shortest paths would be extremely costly. With this modified approach, the classical algorithm gains an additional component in the form of probabilities defining the state of freedom along each edge of the graph. This method supports the usage of the reference algorithm in new applications by helping to overcome its computational weaknesses. Through iteration, all potential shortest paths are found and can then be evaluated. An additional improved Dijkstra algorithm reserves all nodes with the same distance from the source node as intermediate nodes. It then searches from all intermediate nodes again until successfully traversing through to the goal node.(Karur et al., 2021).

Other than the nodes that have already been scanned, the Dijkstra method is unable to store data. This delimitation is lessened by implementing a multiple-layer dictionary with a data storage method that consists of two dictionaries and a list of data structures arranged hierarchically. Every single node is mapped to its neighbouring nodes in the first dictionary. Information about nearby pathway paths is stored in the second dictionary. A multi-layer dictionary offers an efficient data format for the Dijkstra method in situations when the Global Navigation Satellite System (GNSS) coordinates and compass orientation are inaccurate. The data structure's path information can be used to calculate the rotational angle that the robot must execute at each node or junction. Although Dijkstra is a dependable path-planning method, it requires a lot of memory because it must calculate every scenario to find the shortest path and is unable to handle negative edges. The Dijkstra algorithm is most suited for static environments and global path planning because the majority of the data needed to compute the shortest path are preset; nevertheless, there are instances where the Dijkstra technique is employed in dynamic contexts as well. (Karur et al., 2021).

3) *A*(A-Star) Algorithm*

Robot navigation and pathfinding can be accomplished with the help of the A* path-finding algorithm. The algorithm looks over the graph incessantly seeking unexplored locations.

When the algorithm reaches the target place, all of the locations are searched in the graph. Additionally, it sends all of the neighbours on an exploration mission to find the shortest path if the target is not met. For pathfinding in games, the A-star algorithm is widely used. It executes more slowly in exchange for less memory usage. We determine the shortest path in each scenario. Finding the fastest route to an empty spot in a packed parking lot is one easy way to use the A* algorithm. In its operation, the A* Algorithm is comparable to the Dijkstra algorithm. This graph traversal path planning approach is well-liked. Its unique feature is that it directs its search to the most promising states, which could result in substantial computation time savings. When given a data set or node, the most common method for obtaining a close-to-ideal answer is A* [28]. It is frequently utilised in static surroundings, although under some circumstances, it can be utilised in environments (Pol & Murugan, 2015) (Qi & Sun, 2020). Depending on our demands, the base function can be modified for a particular application or setting. The way that A* operates on the lowest cost path tree connecting the starting point and the end target point is similar to that of Dijkstra. However, Amani Saleh Alija's 2015 experimental results showed the search time of A* algorithm to be faster than Dijkstra's algorithm with an average value of 466ms and the distance is the same for both algorithms(Karur et al., 2021)(Alija, 2015). Using the function shown below the least expensive path is expanded using the base algorithm.
$f(n) = g(n) + h(n)$ (1)

4) *Firefly Algorithm*

Yang (2008) noted that the Firefly method is utilised for global optimisation and is inspired by the flashing characteristics of firefly insects [33]. The algorithm is a meta-heuristic inspired by the mating habits of fireflies. This algorithm exhibits great promise and is based on swarm intelligence, which draws inspiration from the cooperative behaviour of insects and animals to tackle intricate problems. Insect colonies function as decentralised, self-organising systems that hinder the actions of a single insect. The approach can be applied to both discrete and continuous optimisation issues. A number of Firefly algorithm variations have been created in order to effectively solve optimisation difficulties. The Firefly algorithm can be used for path planning and operates on large data sets. Because it replaces the Standard Firefly Algorithm's fixed-size step with a Gaussian random walk, the Modified Firefly Algorithm (MFA) has produced superior results and is more suitable for global path planning (SFA). Throughout the iteration process, a variety of checking techniques improve the Firefly movement's success. Slow convergence is one of the shortcomings of the traditional Firefly algorithm that is addressed by the Modified Firefly algorithm. In order to facilitate faster convergence during the last phases of the search, the number of iterations needed is determined by the distance between two fireflies and the intensity of the next brightest firefly.

C. Local Navigation Methods

It is these navigation schemes that are more applicable in telepresence robots; it is a reactive navigation method and reacts to environmental obstacles as they occur in real-time. Some of the methods are here considered.

1) *LiDAR*

LiDAR means light detection and ranging. It is a detection system that works based on the principle of RADAR but uses light from LASAR. Sensors are typically used in local navigation strategies to control the robot's orientation and location. LiDAR sensors are often employed for automation purposes in this regard [43]. LiDAR is capable of mapping the surroundings because it operates independently of GPS technology. LiDAR can be used alone, however, it performs better when combined with additional sensors like a camera, GPS, and inertial navigation system. For example, it works as a strong positioning system in conjunction with the camera. This technology, known as SLAM (Simultaneous Localisation and Mapping), can be used to map the surrounding area in order to find and identify the precise landmark position. This method allows a mobile robot to remotely adjust its orientation and position autonomously. Using LiDAR with motor encoder sensors can further increase and improve accuracy. (Cheng & Wang, 2018). LiDAR could be combined with a reinforcement learning-based robot path planning algorithm [44]. The algorithm designs a continuous reward function so that each action of the robot can be rewarded appropriately, which enhances the algorithm and increases its training efficiency. It also discretises the information of obstacles surrounding the mobile robot and the direction information of the target point obtained by LiDAR into finite states. Finally, it reasonably designs the number of environment models and state space (Z. Liu et al., 2022).

2) *Vector field Histogram*

Another local navigation technique for resolving the path planning issue for mobile robots is the Vector Field Histogram (VFH). Virtual Force Field, or VFF, is the basis for the concept of VFH. Since the term refers to a field, impediments that are identified at a specific distance from the vehicle will apply a repulsive force, forcing the vehicle to move away from them, and an attractive force will be utilised to draw the vehicle towards the destination point. VFH employs a radar screen that resembles a certainty grid, where obstacles detected by the sensor add up to a total certainty value at the associated coordinates in the certainty grid [28]. In other words, a higher confidence number indicates that the sensor range has spotted the real thing. Since the grid is constantly updated in real-time, this technique works well for sparsely moving objects. VFH describes obstacle data using a 2-stage process. First, the VFH constructs a 2D plane using the histogram grid. A histogram grid is treated as an obstacle vector based on the values of each cell. (Vim & Park, 2014).

3) *Rapidly-Exploring Random Trees*

We've talked about static algorithms like A*, which need a path to be given to them beforehand. It is time to discuss dynamic and online algorithms being referred to as RRT that don’t need a predetermined path. Instead, it forms a path from the onset in accordance to the weights assigned to each node by spreading throughout all regions. In order to eradicate a wide range of issues with path planning, in this regards, RRTs were designed. The aim of RRTs was to manage some constraints that cannot be integrated into positional constraints, that is, those constraints that are not holonomic. By using few heuristics and arbitrary parameters, probabilistic road maps (PRMs) and random road maps (RRTs) were both created and possesses the same desirable qualities. This produces better performance and consistency as underlying effects. There is no need for any created connections for RRTs between states in order to identify a solution, unlike PRMs that may need connections between thousands of configurations or states. This is the main reason why kinodynamic and non-holonomic planning uses RRTs. A rapid sampling of the space is how RRTs grow; they start at the beginning and keep going until the tree gets close enough to the destination point. In every cycle, the tree grows to the vertex that is closest to the randomly generated vertex. The closest vertex is identified using a distance measure. It is possible to use any other distance metric, such as Manhattan or Euclidean. Unlike naive random trees, which often grow heavily in areas that have already been investigated, RRT expands heavily in areas of the robot's configuration space that have not yet been studied. RRT is hence biased towards uncharted territory. RRT's vertices are distributed uniformly. Even with a small number of edges, RRTs are always connected thanks to a reasonably simple technique. RRT algorithms can be used with practically any wheeled system since they can handle non-holonomic constraints.

4) *Genetic Algorithm*

Using this method, all possible solutions are represented as individuals of a population, where each gene represents a parameter. A complete set of genes forms an individual. By selecting the best individuals from the S parent generation and applying genetic operators, such as crossover and mutation, new generations can be formed. Each offspring from the new generation is tested with a fitness function devised for that problem. From all offspring, the best individuals are chosen as the parents of the next generation.

Grid-based algorithms and potential fields require substantial CPU performance and/or memory. These limitations can be overcome by genetic algorithms (GA). Genetic algorithms, cover a large search space and use minimal CPU and memory resources (Tsai et al., 2011). Additionally, they are able to adapt to changing environments. An inherent limitation of optimisation is that a global minimum may not always be the solution.

5) *Algorithm for Ant Colony*

Biologists and computer scientists have looked to nature for inspiration when developing path-planning optimisation algorithms [48]. This derivative algorithm uses a heuristic method inspired by trail-laying ant behaviour to discover the shortest and collision-free path. To imitate ant foraging for food in the Ant System (AS) theory, Marco Dorigo first developed this algorithm in his dissertation thesis "Ant system: by colony of cooperating agents" [49] in 1992. To find the shortest path, researchers have created a range of probabilistic heuristic algorithms that take into consideration the different aspects of the problem. As they search for food along the road, ants produce chemicals known as pheromones. Due to the pheromone concentration of the first set of ants, the subsequent ants will select a very suitable path. Ants select a suitable path, and the probability of selecting is the same for each of the ant. Ant will always choose to follow a path with highly concentrated pheromone but evaporation will always reduce the concentration of pheromone. Ants can use the pheromone information to guide their search towards a path with shorter distances when the number of searches for paths rises. More ants will visit the shorter path more often and because of this, the shorter path will be concentrated with high pheromone but the other path's concentration will decrease due to the fact that they are being visited by fewer ants which causes the pheromone to evaporate. On the other hand, the ACO algorithm uses a straightforward modelling procedure to allocate multiple actions to collective outcomes. Positive feedback to locate a goal quickly, distributed computation to avoid premature convergence, and greedy heuristics to aid in goal discovery early on are some of the unique characteristics of the ACO algorithm. Pheromone deposits serve as the foundation for the method (Pokle et al., n.d.), which calculates the likelihood that an artificial ant would move from one path node to another.

CONCLUSION AND RECOMMENDATION.

Having considered some methods for robot navigation in general, which are also applicable to telepresence robot though local navigation methods are particular the most relevant bearing in mind that a blend of these methods work best for a particular telepresence robot application (Juan et al., 2023). These artificial intelligence algorithms are robust and effective when accurately chosen (Sqalli et al., 2017). However, the design process may be unduly cumbersome, too involving and costly for most simple applications of telepresence robots (Xiang et al., 2019). We therefore propose a method that involves the combination of line following robot principle with obstacle avoidance with a remote control systems (Pakdaman & Sanaatiyan, 2009). The motors and sensing systems in line follower robots enable them to move accurately. To control the motors, many algorithms are used to coordinate the line data read by the sensors. A simple and mostly precise control can be achieved with the PID (proportional integral derivative) algorithm (Pakdaman & Sanaatiyan, 2009). At the same time the robot can also be remotely controlled as required by one of the remote control methods such as WiFi or Dual Tone Multi-Frequency (DTMF) signaling. This will make the system robust, reliable and more versatile in applications. This approach would work well for applications where the expected robot path is already known or predetermined. An example is the path expected to be followed by a medical doctor moving from one medical ward to the other in order to attend to his patients. The robot simply traces the path drawn and in the event of any obstacle; it detects it and avoids it autonomously. Such a system would cost less and serve well in such circumstances. However in the case of exigencies requiring that the robot should be controlled remotely without depending on the line follower principle, the robot makes use of remote control applications as employed in other mobile robotics telepresence systems. Furthermore, the robot could many on-board sensors as the case maty require (Rubio et al., 2019).

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