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# Intelligent exploration strategy for a mobile robot to reduce the repeated searches in an unknown environment

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**ABSTRACT**

To significantly minimise the effort required to seek in new environments, it is critical to choose an effective search strategy. In mobile robotics, random search is the main search method due to the lower processing capabilities of mobile robots, which result in the detection of only local features. If you're looking for random-walking techniques that emulate social insects' self-organized behaviour, then Levy's struggle approach is very popular. Robot searches are often ineffective since the suggested methodology is very restricted. This article offers an enhanced random walking technique in which each robot's stride size is adjusted to minimise the amount of repeated searches. To find out if the suggested approach was successful and whether it performed as an intelligent exploratory strategy, simulation tests and experiments with real robots were undertaken. The research found that the suggested approach was more successful over a wider area.

**Index Keys:** Mobile robot, Exploration strategy, Random Walk method, Repeated search, unknown environment.

## INTRODUCTION

Across the last ten years, in a number of areas, autonomous mobile robots have grown increasingly common. In the industrial sector, collaborative robots are being utilised, and mobility fleets are swarming logistically. But their usage in civil applications presents extra difficulty[1]–[3], owing to their interaction with people and their deployment in possibly unexpected contexts. Search and rescue (SAR) are a major scenario in which mobile robots may save lives by allowing for quicker responding times,[4][5] supporting dangerous environments[6]–[8] or offering, among other opportunities, real-time mapping and monitoring in an event area.[9] [10] In this paper, we are doing a literature evaluation of SAR scenarios multi-robot systems.

In everyday life, it is a practical issue to locate a permanent object of interest in a recognised or new setting. Exploration of areas is a challenging robotics problem which has received much study. They are used in areas like as planetary exploration, search and rescue[12], food foraging[13] and delivery of nanoscale medicine[14]. Having effectively exploring a foreign place is the primary research issue in area exploration. In an especially large environment, the entire area is wasted with only one robot exploring. Most current search processes depend on sensor systems with a delicate mapping methodology (e.g. odometers and radar for ultrasound)[16, 17]. Rather than utilise a multi-robot approach, a multi-robot method should be used due to its robustness, its flexibility, and its scalability. Because of these three reasons, robots are often used in the investigation of this kind of region. For mobile robots, individual capabilities (e.g. local sensing and low processing capacity) constrains their usage of sophisticated positioning and mapping. The two main kinds of RWs are: I unrelated RWs, in which the step directions are completely random, and (ii) RWs in which the step directions are connected. The major distinction between a goal-oriented RW and an objective-oriented RW is that the prior step orientation is influential in both types of RW. The methods described here include mostly unrelated RWs, the most popular being the Levy battle (LF).

**HISTORICAL OVERVIEW**

Different multi-agent coordination methods for environment exploration are included in the creation of intelligent exploration algorithms and coordination mechanisms for multi-agent systems used to target seeking.

The most frequent deliberative technology is the exploration algorithm on a frontier basis [19], according to occupancy maps. The method is based on the border or boundary of the region covered by the map; the next agent should travel on the appropriate boundary. The aim is to reach the border with the least number of movements while avoiding obstacles, if the objective limit is given to an agent. Probable methods, such as probability road map and rapid random trees, may be used to design the route to approach the frontier effectively[20]. This route planning is a difficult issue with non-polynomials (NP), and may take extensive calculations in crowded settings. In addition, a single robot was exploring the creation of an exploration algorithm based on a utility function. The utility function, for example, may be built to accomplish new navigation objectives by the agent, taking into account short distances and better possibilities of improving map knowledge. Some parameters (factors) include the cluster, distance, clearance and inaccessible spots utilised for increasing the implementation of the algorithms and thus decision-making by the agent[21].

Single robot scanning to enable cooperative scanning has been extended. Multi-agents have to exchange their local maps to identify the global borders collectively to allow such a scan via border-based algorithms. If agents can be found inside the environment, they may communicate their results and integrate them with each map by adding or multiplying the status values[22]. If the position is insufficient, however, the agents should utilise probabilistic methods to integrate information on the local map. Particle filters can enable the merging of local maps by a collection of agents under the uncertainties of the agent, for example[23]. In addition, when local maps are combined to a global map, agents may negotiate to assign boundaries to more appropriate agents. In [24], each agent may choose the nearest frontier to approach using a potential field-based method. In addition, a greater priority for a visible boundary is provided to prevent an agent trying to go to a close but unreachable border. The agents may choose borders progressively using an optimum method for the limit assignment. Once an agent has chosen its target border, the relative border weight decreases to prevent the following agency from selecting this border [25].

## THE PROPOSED IMPROVED RANDOM WALK METHOD

Because the swarm robots do not allow more complex search methods, random search is a basic search strategy for both animals and robots. Levy Flight is one of the most often utilised RW techniques (LF). An LF is a RW with a heavy-tailed probability distribution for the step size, which may be stated as follows:

$$P(s) = s^{-\lambda} \quad (1)$$

where s denotes the step size $1 < \lambda \leq 3$LF It generates a smaller, high-frequency step size and rare times a larger step size. This larger size allows the robot to achieve a global search with an intelligent scan technique across the range of the search space whereas a robot with a smaller size wants the local search to be finished.

Since the present paper provides an improved way for the employment of Random Walk methods for completing this smart approach, which are ineffective and unsuitable for mobile robotic exploration.

The most effective technique of increasing search efficiency is the reduction of repetitive inquiries. The items are organised into two groups: (i) the same mobile robot was responsible for making itand (ii) Due to many robots. When the step size of category I increase, repetitive searches of a robot with a small step size are reduced. As seen in Figure 1, less repeated searches are made by a robot of a high-stage size. When several robots investigate an area at the same time, a huge number of repeated searches are conducted using Levy Flight (LF). Repeated research is inevitable in the vicinity of two robots; nevertheless, in the case of more distant robots, a person who has the larger step size may produce many searches of the category (ii). To control the search frequency, the robots should maintain a specified distance and adjust the step size to an acceptable level. If the mobile robots are positioned evenly in the unknown area, every robot investigates just its tiny zone, there will be less recurrent searches.

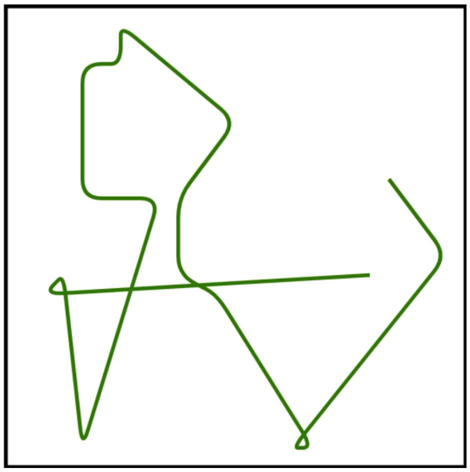

**Figure 1:** Random stroll with the mobile robot with Levy flight $\beta = 1.5$.

As may be deduced from this approach, a random walk method in an unknown environment, with consideration of the density of mobile robots, is provided here. To search small areas in high-density environments, mobile robots should use smaller step sizes; in low-density environments, they should use larger step sizes. Robots must rotate in the opposite direction to avoid conflict if they encounter another robot and obstacle avoidance occurs between them. Instead of attempting to position all of the robots in one specific location, it is suggested that each robot is distributed among the area in a random manner, but that also involves guiding each robot to perform local search in a step-size-adaptive manner by gradually increasing the step size for each robot, as well as regulating the direction of obstacle avoidance.

A clever exploration technique incorporates randomness, so the environment is seldom understood and the number of robots may fluctuate. In addition, due to robot density restrictions, it is impossible to determine the density of mobile robots. robots crowding each other, resulting in collisions (e.g. preventative obstacles between robots). The degree of physical interference that is a global variable cannot be assessed since the robots do not interact. Additionally, the average time delay $t$ between two physical interference occurrences may be used to calculate the robot density.

It estimates its step size according to how far ahead it goes, or according to how close it is to meeting another robot in the random walk method.

$$S_t = \begin{cases} v * \bar{t} + k * S_{t-1}, \Delta t \geq \bar{t} \\ v * \bar{t} + k * S_{t-1}, \Delta t < \bar{t} \end{cases} \quad (2)$$

When $S_t$. is the number of steps to move the robot, $S_{t-1}$ is the last step size derived from the robot, v is the speed at which the robot move and k (0 < k < 1) is used to modify the contribution of the previous step size, $S_{t-1}$. The variable t is the average interval of time between two physical inference occurrences and is used to estimate the robot density across the search region; t. varies with time and is updated when an obstacle is avoided. The Variable $\bar{t}$ is used to estimate the robot density in the local search zone between the current physical inference and the prior occurrence. In this instance, the local region has less robots and thus the robot in question should be using a bigger step to search its area. In this case, the local area is less robotic than the worldwide one. If the density of a local robot is $\Delta t \geq \bar{t}$ then the local region has more robots and thus the robot in question should take a smaller step to explore its area. When the density of the robot is $\Delta t < \bar{t}$.

The suggested RW technique simply becomes the linear search method when there is only one robot. Figure 2 demonstrates that a robot search less repeatedly using the linear search technique. The suggested method distributes the robots uniformly throughout the environment by changing the step size. The step sizes of the robots progressively converge as the exploratory mission progresses. Also, because each robot just searches the immediate region, the search is less frequent.

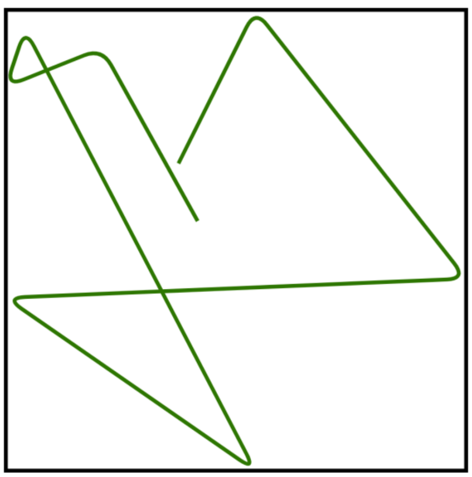

**Figure 2:** The suggested random walk technique is used to navigate a mobile robot.

**RESULT AND DISCUSSION**

In order to determine the viability of the suggested RW technique, a simulation experiment was performed on the webots platform. The projected efficacy of RW technology was compared to the LF approach's outcomes. To determine the coverage ratios, MATLAB was utilised after each simulation test (i.e., the ratio of the explored area to the total area). To simulate conditions and keep things fair, we ran experiments on one, 20, 30, and 10 robots. The testing area was a 4x4 metre square, with sides that were 22.0 metres long (650 seconds). Initially, all robots were positioned in the centre of the testing area. The robots' travel speeds were set to the parameter k, which was equal to 0.11m/s. To find the finest approach for covering a large region, the primary goal of the area investigation was to identify the best way to do so. A robot's sensing range was restricted, and only if the robot's footprint had completely covered the corresponding domain did the robot consider that space to be covered. Coverage ratio: The proportion of space investigated compared to the total space. To calculate the average coverage ratio, a series of 30 tests were conducted on each RW technique and the results averaged.

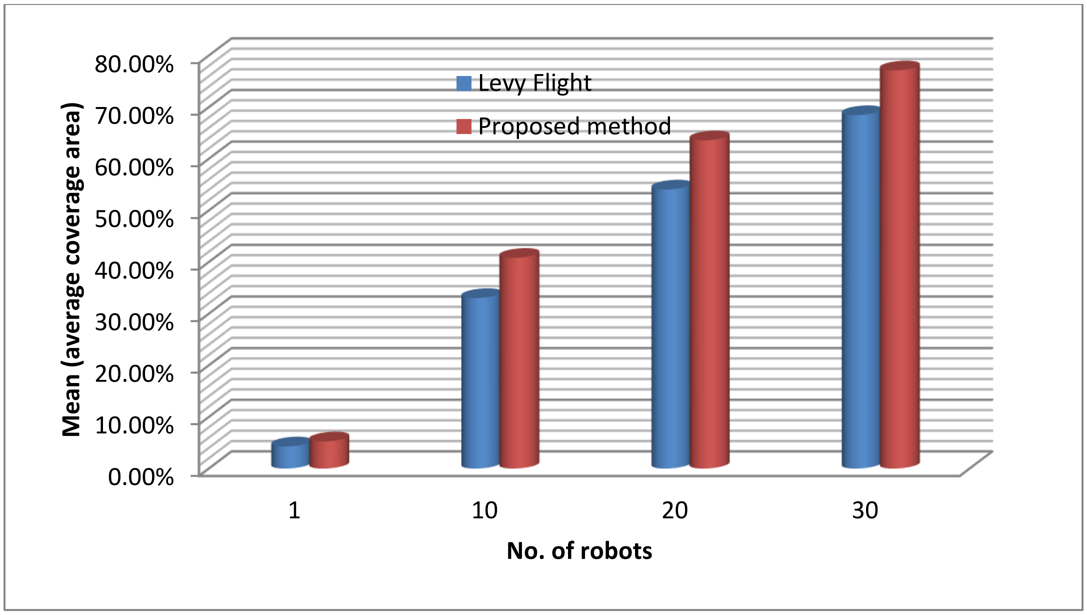


**Figure 3:** Comparison of the proposed method with Levy Flight in terms of mean.

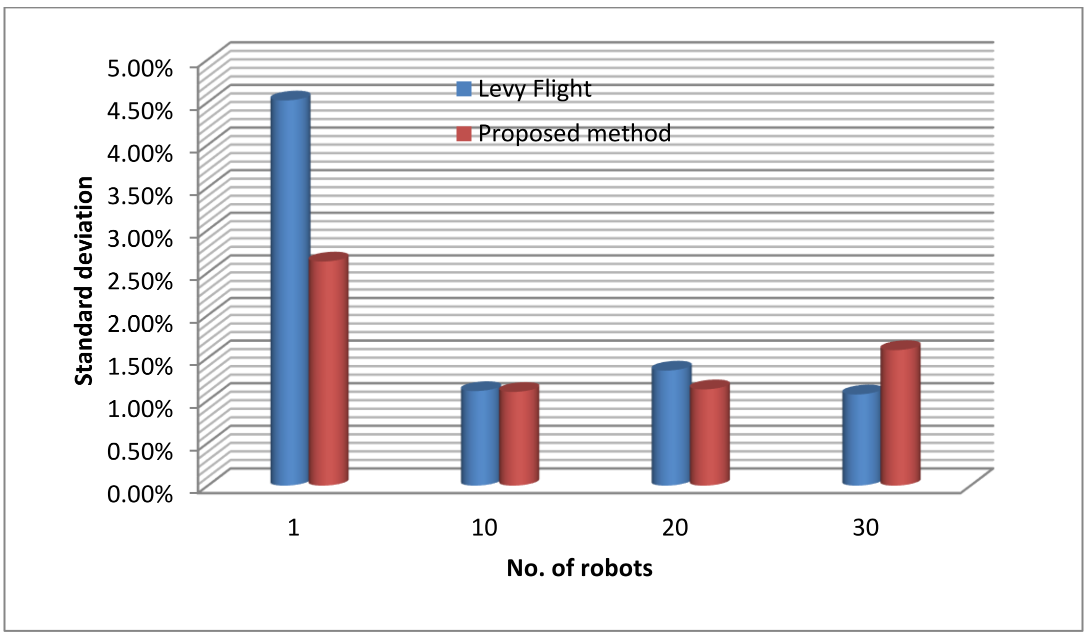


**Figure 3:** Comparison with the average Levy Flight technique suggested.

In the following charts, see how the mean and standard deviation vary when adjusting for the number of robots. In each instance, the techniques were implemented and out-performed many orders of magnitude higher coverage ratios. This means that the three RW techniques provide similar results and the efficacy of each method is consistent.

**CONCLUSION**

A new Random Walk (RW) technique that considers robot density was suggested in this article for use in areas with little or no prior investigation. To keep searching to a minimum performed repeatedly, each mobile robot adjusts its actions to various places and equally distributes the robots in an unknown area. The results of the experiments showed that the proposed method provides better search coverage than Levy Flight (LF). However, there is presently no theoretical evaluation of the proposed approach's efficacy. As a result, a future research will directly explain the mathematical theory of RWs and theoretically assess the efficacy of the proposed RW method.

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