Autonomous Eviscerating BOT using ANT Colony Optimization

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Abstract-Autonomous grid/obstacle solving robot counters a number of problems related to tracking and planning of path that consumes the least time and energy in real-world phenomena. Ant colony optimization (ACO) is used to track and optimize the shortest path used by various robots like ASIMO (Advanced Step in Innovation and Mobility) which is made by Honda for reducing human efforts. ACO and Artificial Intelligence (AI) is used to attain the best results. In this paper, a system is proposed which uses ACO and reduces human efforts by finding energy and time-efficient solution. The aim is to try to counter one such kind of problem that is not to follow the same path. In this paper, a BOT is proposed that works on two autonomous systems that are used for cleaning purposes in the industry and other public places like malls, etc. These two BOTs will be using their separate path with the help of the ACO algorithm and will be in touch with each other through a communication medium.

***Key Words*: Ant Colony Optimization (ACO), Artificial Intelligence (AI), Communication, Robotics**

1. INTRODUCTION

A system is proposed that uses ACO and reduces time and energy efficiently and gives us an optimal solution for real-world problems in the field of robotics and Artificial Intelligence [3], [4]. A small prototype proposed on edge/obstacle avoiding BOT that will learn from its previous experiences (the previous path followed) as well from its surrounding robots that will simplify many human efforts example: People go to a mall and they have 4-5 people at least for cleaning the floors. To reduce human interference in such kind of a system and this cleaning task can be done by simply installing two BOTs on a floor, these BOTs will clean the floor as well as the sensors installed on that will avoid the obstacles as well as edges [4],[7]. These two BOTs will be communicating and interchanging the information (optimal path) and reduce time and energy efficiently [1].

This paper consists of five sections. Section 2 describes Methodology and Working, Section 3 explains the Algorithm and Approach, Section 4 explains the

Shortest Path Iteration Technique and Section 5 discusses the Conclusion.

2. METHODOLOGY AND WORKING

2.1 ANT Colony Optimization Algorithm (ACO)

ACO is a technique in robotics to optimize the shortest path between two paths A and B, build from a combination of several paths, this algorithm is derived from watching the behavior of ants in the real world to find food [6]. In this technique, ants secrete a special kind of liquid called "pheromone" which is used to track the path for finding food. Once an optimal path is being found by avoiding all kinds of obstacles and other constraints, the maximum No. of ants follows the same path, so the pheromone level gets thicker. This results in attaining an optimal solution to a real-world problem by ants.

2.2 Working

In this proposed system, ACO is applied for making a robot that will be used for cleaning purposes in commercial buildings [8]. There will be two BOTs that are interconnected wirelessly for efficient cleaning of the floor. The two BOT's will intercommunicate with each other for getting time and energy-efficient cleaning system. Suppose BOT A has followed a path and has cleaned it then it will avoid that path and will be cleaning a different path. Here both the BOT's will be avoiding obstacles like humans, walls, staircases, etc. which are commonly present in our day-to-day workplaces [2], [9], [10].

2.3 Block Diagram

The block diagram shown in Fig. 1 and Fig. 2 represents two sides where each side is a separate autonomous unit. Each side has a sensor unit, controller unit, motors and a transceiver. These units will be helping us to clean the floors of our workplace.

Each unit has its importance, coming to the first unit as a sensor unit. Here I will be using mainly two types of sensors; a color sensor for detection of the area and three ultrasonic sensors for the detection of obstacles.

Before the installation of this system different colors need to be used to distinguish between the area defined which will be acting as a pheromone for the BOTs.

An ultrasonic sensor senses the obstacle and the edges to avoid any sort of collision. The controller unit will be used for all sorts of computation and other controlling purposes. Motors will be used for moving this system in a different direction. For this purpose, a motor driver IC is chosen according to the load/torque requirement. Use of any controller starting from AVR family to ARM family according to the financial and power requirements can be made. The best-suited system according to the use and from an economic point of view will be from Microchips PIC family. For prototyping purposes, the Arduino controller from the AVR family can also be used.

For the transceiver, use of low power consumption devices like NRF transceiver for sending data for the best-suited system. This will be used for communicating with another side to which it has to work with and knowing what its limit is. Use of X-Bee Transceivers for communication is also possible because NRF uses 2.5 GHz frequency that it shares with Wi-Fi as well. This is one of the main reasons behind the interference.

These two BOTs will be having the same configurations and settings apart from one basic difference that is the color configuration of the BOTs will be different.

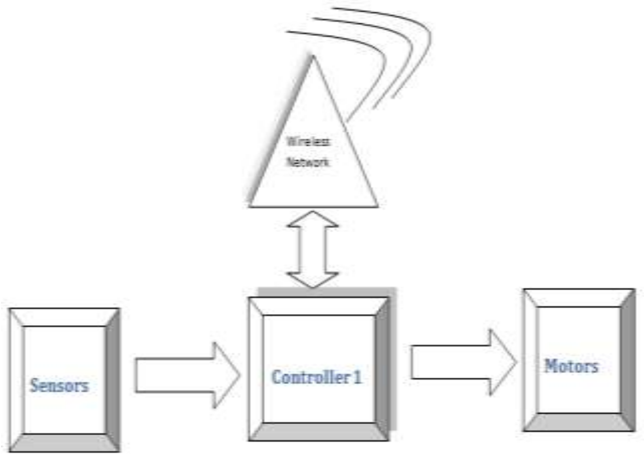

Fig -1: Block Diagram of BOT 1

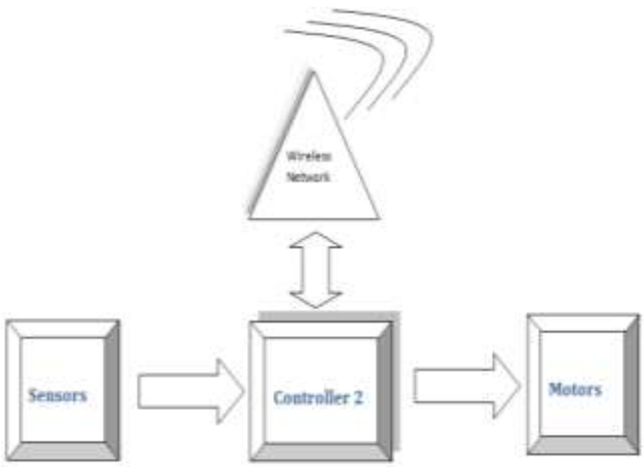

Fig -2: Block Diagram of BOT 2

3. ALGORITHM AND APPROACH

3.1 Flow Chart

The flow chart of the proposed algorithm is shown in Fig. 3.

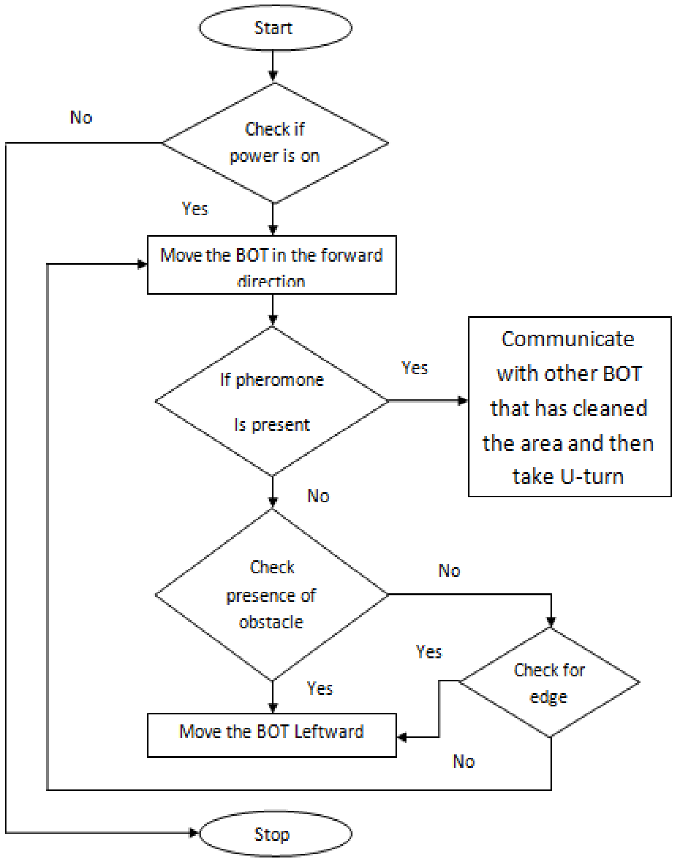

Fig -3: Flow chart of the proposed algorithm

3.2 Algorithm

The proposed algorithm is carried out in the following steps

- Step 1: START
- Step 2: Power is ON go to Step 3 else go to Step 10.
- Step 3: Move both bots in the forward direction.
- Step 4: If any of the BOT sense pheromones of the other BOT go to Step 7 else go to Step 5.
- Step 5: If BOT senses obstacle goes to Step 6 else go to Step 3.
- Step6: Move BOT in the left direction.
- Step7: Communicate with another BOT that this area is clean take a U-turn and go to Step8.

- Step8: If the BOT finds the edge, go to Step9 else go to Step3.
- Step9: Move BOT backward for 1 sec and go to Step5.
- Step 10: STOP

4. SHORTEST PATH ITERATION TECHNIQUE

Fig. 3 shows the horizontal projection of the floor of a building. The nodes represent starting and arriving locations allowed (sources and destination), and edges represent the possible path on which our robot can move according to the algorithm we run in it from node to node. Here minutes represent a unit, numeric in the boxes assigned to each pair represents the cost of travel along with them. For simplicity, numerical values are used. Here, the use of non-complex shortest or trivial shortest path problems for the computation of the most optimal path between a source and destination along with the ACO algorithm is made. Taking an example from Figure 3, finding the shortest path between node 1 and node 7, or node 9 and node 10. The following paragraph represents a more complex shortest path problem. Imagine the robot is performing cleaning operations at different locations in a building (figure 3). Let us assume that this robot who is presently at node 1 needs to clean the floor at node 13, node 11, and node 8 following the availability of the pheromone, then stops and waits at node 7 until it cleans the floor. From here, the cleaning robot must start at its initial position (node 1), finish at node 7 and visit 13, 11 and 8 in such a way that the sum of the costs of optimal paths lying between these five nodes must be optimized to a minimal value. Such itineraries or tours is the robot's mission. The robot requires a two-stage optimization algorithm as an iteration or tour. For any cleaning mission of the robot, this is the most optimal sequence or concatenation of trivial shortest paths. The illustration given above represents the optimal concentration of the shortest path amongst all the tours made by the robot. This practical difficulty is known as NP-Complete. (In the NP-Problem, the solution to my desired problem is checked by polynomial times. If any problem is solved by a polynomial worst case-time algorithm, then each problem can be solved by worst case-time algorithms, this is the main property of NP-Complete problems. This property of NP-Problems is accepted universally but still is not proven that it can be solved by the polynomial time [12]).

The cleaning robot problem is similar to the Travelling Sales Person (TSP) problem, although with an important distinction (for example, see [11] chapter 9). A Typical TSP problem is very much similar to the cleaning BOT problem, in TSP salesperson has to optimize the path by visiting every city exactly once to reduce the cost and avoid sub tours. Figure 3 represents 16 ' towns' but only 5 must be visited, the other 11 are transitory nodes/towns that may or may not be visited. An analogy can be made for a given problem of cleaning robots. Given the problem can become more complex and difficult to handle some edges (in this case obstacle) are present, which should be avoided during a tour, for instance, because of construction in corridor $x_{(1,5)}$ and $x_{(5,1)}$. The Dijkstra's Shortest Path algorithm is not enough to solve such regressive problems like this according to the security run scenario. The NP-Complete problems are considered the best algorithmic availability to solve such a regressive problem like finding an optimal path with the help of ACO in cleaning robot that is an example of exponential running time on nondeterministic machines [13]. Because of 11 transitory nodes in this problem, it is difficult to find a perfect algorithm to solve this problem at once. A distinct algorithm is needed for computation of the final solution since

Dijkstra's algorithm alone is not enough to solve such a complex problem. The algorithm used apart from the regular Ant Colony Optimization technique to make the movement more accurate and optimize the path finding.

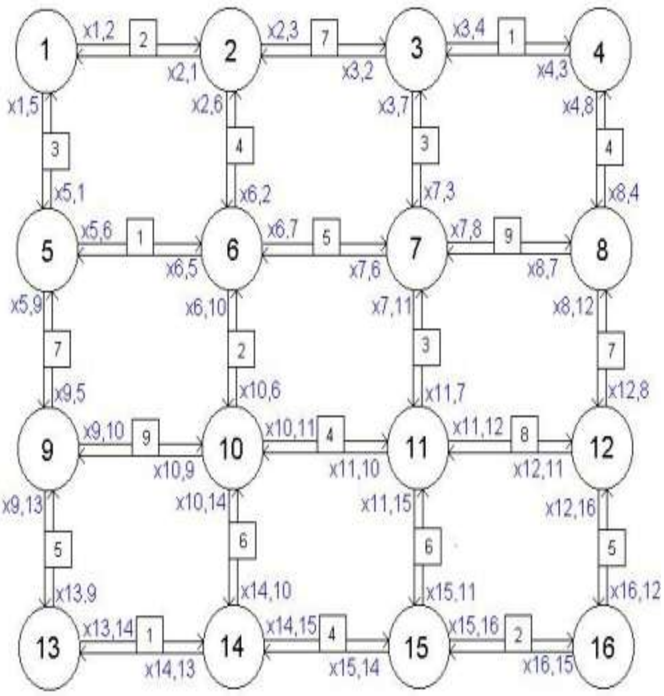

Fig -4: Illustrative path for finding an optimal solution

5. CONCLUSION

An autonomous eviscerating BOT using ACO is proposed to project the effective use of the ACO algorithm for optimal use of a cleaning environment. In this paper, a system is proposed for getting benefits like avoidance of human interference in the hazardous and unnecessary environment with energy and cost-efficiency.

REFERENCES

[1] L. J. DING, X. Liu, Y. ZHAO, et al... "Remote Surface Litter Clean-up ship", Science & Technology Information, 2009, Pp: 108-109.

[2] Tang Z, Wang Y, and Zhu J, "Research on the Autonomous Cleaning Strategy of Cleaning Robot", Computer Measurement and Amp, Control, 2012, Pp: 2270-2272.

[3] .Catlett, "Over Pruning Large Decision Trees", International Joint Conference on Artificial Intelligence, 1991, Pp: 764-769.

[4] Ying-Tung, Hsiao, Cheng-Long Chang, and Chih Chien, "Ant Colony Optimization for Best Path Planning", International Conference on Communications and Information Technologies, 2004, Pp: 109-113.

[5] Bonabeau, M. Dorigo, and G. Theraulaz, "Swarm Intelligence: From Natural to Artificial Systems", 1999.

[6] Cong, Yee Zi, and S. G. Ponnambalam, "Mobile Robot Path Planning using Ant Colony Optimization", International Conference on Advanced Intelligent Mechatronics, 2009, Pp: 851-856.

[7] Song-Hiang Chia, Kuo-Lan Su, Jr-Hung Guo, and Cheng-Yun Chung, "Ant Colony System Based Mobile Robot Path Planning", Fourth International Conference on Genetic and Evolutionary Computing, 2010, Pp: 210-213.

[8] Y. X Zhang, and S. Wang, "Simulation Design and Research on Executive Body of Surface Cleaner" Mzchinery Design and Manufacture, 2011, Pp: 62-64.

[9] J. L. Jones, "Robots at the Tipping Point: The Road Robot Roomba", IEEE Robotics and Automation Magazine, 2006, Pp: 76-78.

[10] Liu Y, Zhu S, Jin B, and Feng S, "Sensory Navigation of Autonomous Cleaning Robots", Proceedings of 2014 World Congress On Intelligent Control and Automation, 2004, Pp: 4793-4796.

[11] Wayne L. Winston, "Operations Research, Application and Algorithms, ITP, (2nd ed.)", 1994.

[12] Kenneth H.Rosen, "Discrete Mathematics and Its Application", McGraw Hill, (5th ed.), 2003.