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Pursuit Algorithm for Robot Trash Can Based on Fuzzy-Cell Decomposition

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Article Info

ABSTRACT

Scooby Smart Trash can is a trash can equipped with artificial intelligence algorithms that is able to capture and clean up garbages thrown by people who do not care about the environment. The can is called smart because it acts like scoobydoo in a children's cartoon in that the can will react if there is garbage thrown and it catches and cleans them up. This paper presents pursuit algorithm that uses cell decomposition algorithm in which algorithms are used to create a map of the robot's path and fuzzy algorithm as one of the artificial intelligence algorithm for robot path planning. By using the combined algorithms, the robot is able to pursuit and chases the trash carelessly discarded, but it has not been able to find the shortest distance. Therefore, this paper considers a second modification of the algorithm by adding a potential field algorithm used to add weight values on the map, so that the robot can pursue trash by finding the shortest path. The proposed algorithm shows that the robot can avoid obstacles and find the shortest path so that the time required to get to the destination point is fast.

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1.   INTRODUCTION

Humans are living beings who want everything looks clean and beautiful including a healthy environment. Many people are concerned about the cleanliness of the surrounding environment but many others are not. It is shown that there are much garbage cluttering around houses, streets and in the city parks. The situation is certainly troubling themselves and users of public facilities.

Having various reasons, many of us are lazy to dispose of trash by walking toward the trash can located. Throwing rubbishes in the bin then becomes one of the ways to dispose them. Sometimes it works, but frequently the garbage thrown on do not go into the trash can and it makes the environment look messy and dirty.

Therefore, some previous researchers have developed a smart robot to dispose trash as practiced by Koyachi et al., [1] developing a robot litter box shaped Hexapoda which is controlled remotely by a camera sensor and an arm that is used to take out the trash. The other researcher named Simoes et al., [2] has developed a medical robot to take out the trash. This wheeled robot is equipped with a camera and a robot arm used to retrieve medical garbage. While Nishida et al., [3] developed a sensor used for robot trash can. Sensors such as camera and laser rangefinder are used to detect trash and the robot autonomously moves toward and takes the trash out and then throw them in the can that has been provided.

In addition some other researchers have developed robots trash can such as Yamaji et al [4] who developed a robot as a trash can equipped with sensors such as proximity, pyroelectric infrared, infrared and camera sensors. Proximity, pyroelectric infrared, and camera sensors are used to detect people who throw garbage. While the infrared sensor is used to detect the trash that goes into the can. Yang et al. [5] has conducted a research on robot trash can equipped with cameras that enables robot to move autonomously indoors.

The other researcher such as Chiang [6] has embedded a vision camera on the robot trash can used for navigation using two algorithms namely navigation algorithm using genetic algorithms with Simple-Rule and path planner algorithm using Boustrophedon algorithm. Kulkarni & Junghare [7] have developed a trash detection algorithm by using two ultrasonic sensors embedded on the robot. By using servo motors, the robot can detect tash in a distance range of 2.5 meters with 90 degree angle.

One of the algorithms used by robots to pursue trash which has been investigated by several researchers is cell decomposition algorithm implemented by the diagram Foderaro et al. [8] for pac-man game. The algorithm used to split the map in the game Pac-Man into the grid. The pursuit algorithm was applied to the ghost to chase pac-man.

Cell decomposition algorithm was first investigated by Zhu & Latombe [9] used for new heuristic path planning algorithm. Cell decomposition algorithm divides the map into similar size grids. The map is configured using c-obstacle algorithm to create three-dimensional obstacles before it is devided into grids. Once a map is created, Search of a Connectivity Graph is used to connect the map paths that have been created with cell decomposition from the starting point to the destination point. This algorithm merely seeks and finds the path, but does not find the shortest path.

The other researchers such as Janchiv et al [10] has examined cell decomposition algorithm used to divide the map into several cells as coverage search areas. In addition, coverage algorithm was used to search in areas that have been mapped. By combining the two algorithms, robots can avoid obstacles and conduct a search in the area.

Path planning algorithms such as A* algorithm combined with a cell decomposition algorithm that is used by Nascimento et al [11] for multiple mobile robots. Cell decomposition algorithm is used to create a map of the neighborhood and the A* algorithm used to track path so that the robot can avoid obstacles and move towards the goal. In addition, Qureshi and Ayaz [12] have optimized cell decomposition algorithm by combining it with potential field algorithm. The cell decomposition algorithm was used to create a map by dividing the environment into similar size grids and the potential field algorithm was used for path planning.

This paper presents cell decomposition algorithm combined with fuzzy logic algorithm applied to robot trash can. With these algorithms, robot trash can is able to catch and pick the trash carelessly discarded. Additionally robot is also able to avoid obstacles in the environment if there are any in the form of a table or chair.

2. PURSUIT ALGORITHM

Pursuit algorithm is an algorithm that searched and calculated the curvature path with used missiles to be able to pursut the target from the initial position toward the end position [13]. Parameters is used by lookahead distance will always get the appropriate path and keep the path to the final position of the aircraft. Besides applied to missile control, the algorithm is applied to the mobile robot is done by Dias et al [14]. Besides apply in the aircraft, the algorithm is examined by Massioni et al., [15] used in pursuing agent for formation.
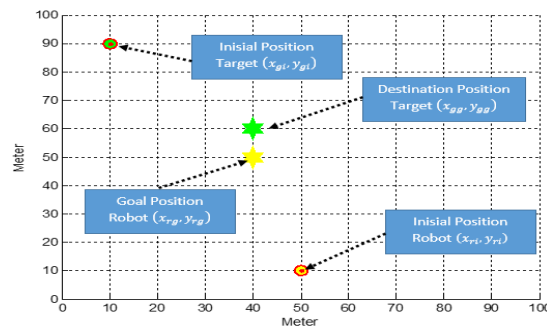

Figure 1. Global view Sensor for pursuit algorithm

This paper presents pursuit algorithm which has been previously mentioned by the researchers to be applied to the trash can robots that is able to pursue and pick up garbage that has fallen on floor. By using a global view of the sensor, the robot detects the initial position of the trash when discarded and detect the end position of it as illustrated in Figure 1 [16]. It shows that to pursue the target, the robot must have initial position data and end position data of the target so that the end position of the target is the goal of the robot.

3. MAPPING

Graph theory have been used by some researchers to create a map of an unknown environment as conducted by Iswanto et al., [16] using cell decomposition methods to create a map of unknown environment by dividing it into several grids and make a robot path planning. Approximate is a part of the cell decomposition method used by Katevas et al., [17] to divide an environment into same grids used for the large wheelchair path planning. A path has been used so that wheelchairs can move to destination position and avoid obstacles.

In this paper, cell decomposition is used to create maps of unknown environments with global view method. With the method the starting position and goal position of the robot, the initial position and final position of the trash and the position of obstacles can be seen as illustrated in Figure 2 [16]. It shows that the starting position of the robot is (x_{ri}, y_{ri}), and goal position of the robot is (x_{rg}, y_{rg}), the initial position of the trash is (x_{gi}, y_{gi}), and final position of the trash is (x_{gg}, y_{gg}), and the position of obstacles is (x_o, y_o). By using the data an environment map is created and divided into grids. The creation and division of the map is carried out by using source code as shown in figure 3 [18].
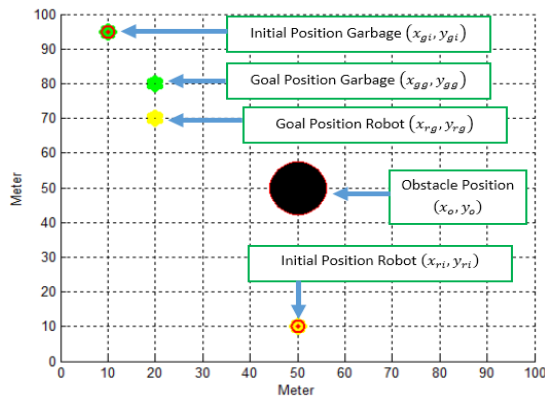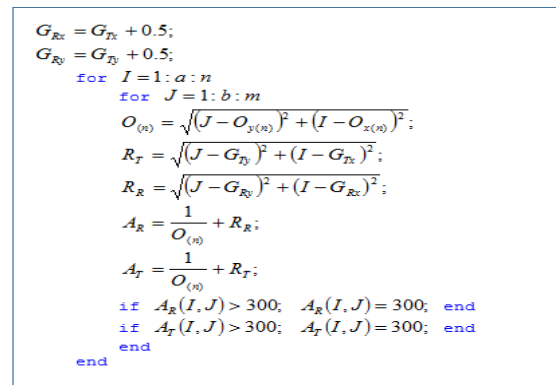

Figure 2. Environment Models

Figure 3. Environment Cell Matrix Decomposition

Figure 3 shows that (G_{Rx}, G_{Ry}) is the destination position of the robot, $(O_{x(n)}, O_{y(n)})$ is the obstacle's n[th] position, and (G_{Tx}, G_{Ty}) is a destination position of the robot. R_R is the formula for the distance between the robot position and the destination position and $O_{(n)}$ is the formula of the distance between the robot position and the nth obstacles. Then R_R and $O_{(n)}$ are summed to obtain a matrix environment value.

4. FUZZY LOGIC CONTROL ALGORITHM

Basic behavior in target pursuit in cell decomposition algorithm is that the robot searches the smallest grid and then moves following the grids to reach the destination position. In this study, the trash can robot is controlled by reference values of grid distance obtained from fuzzy algorithm. Fuzzy is an artificial intelligence algorithm [19-22] found by Zadeh that has been used by several researchers to control quadrotor as practiced by Nia Maharani et al [23-24] to control the quadrotor altitude and Mohammad Reza Rahimi et al [25] to control the altitude on the fixed wing UAV type. This algorithm has been widely studied by previous researchers as conducted by Wen et al., [26] using fuzzy algorithm for UAV path planning to fly in dangerous environments at low altitude. In addition, Ge et al., [27] has conducted a research on fuzzy control path planning parameter optimation to be applied to lunar robot which has 6 wheels.

The algorithm applied in this paper for pursuit of targets uses 8 inputs and an output as shown in Figure 4 [18]. It is seen that 8 inputs consist of angles of 0, 45, 90, 135, 180, 225, 270, and 315, while the output consists of a corner.
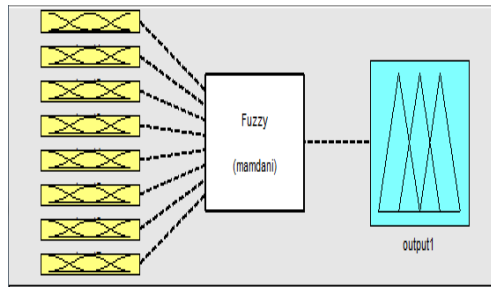
Figure 4. Target Pursuit Design with Fuzzy

The inputs and output of fuzzy sets have different universal set values as shown in Figure 5 [18]. It is seen that the input of fuzzy set has universal values ranging 0-300, while the output of fuzzy set has universal values ranging [-175 175]. There are three members the input set namely Small, medium and big and eight members of the output namely front, front right oblique, left, rear left oblique, rear, rear right oblique, right, and front left oblique.

In fuzzy algorithm, Rule base greatly affects the running proses of a path planning system. This is due to the rule base has a collection of knowledge for decision making in a path planning system shown in Figure 6 [18]. In the picture this basic rule is compared to all the inputs from the global view sensors and the smallest value is determined from the input values to obtain the shortest path.
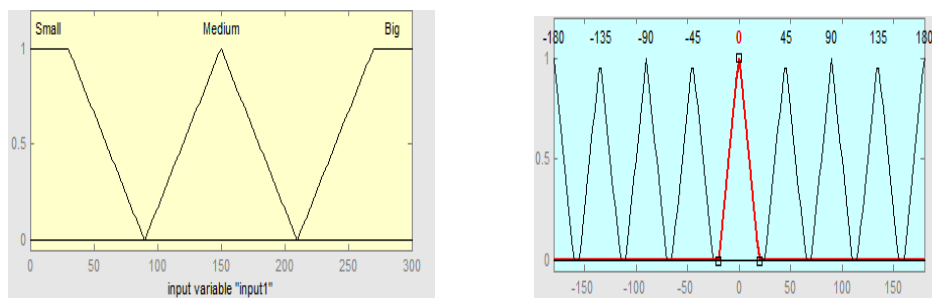

Figure 5. Input and Output Sets of Fuzzy

if $u_1 < u_2$ & $u_1 < u_3$ & $u_1 < u_4$ & $u_1 < u_5$ & $u_1 < u_6$ & $u_1 < u_7$ & $u_1 < u_8$
  $\theta = 0^0$;
else if & $u_2 < u_3$ & $u_2 < u_4$ & $u_2 < u_5$ & $u_2 < u_6$ & $u_2 < u_7$ & $u_2 < u_8$
  $\theta = 45^0$;
else if $u_3 < u_4$ & $u_3 < u_5$ & $u_3 < u_6$ & $u_3 < u_7$ & $u_3 < u_8$
  $\theta = 90^0$;
else if $u_4 < u_5$ & $u_4 < u_6$ & $u_4 < u_7$ & $u_4 < u_8$
  $\theta = 135^0$;
else if $u_5 < u_6$ & $u_5 < u_7$ & $u_5 < u_8$
  $\theta = 180^0$;
else if $u_6 < u_7$ & $u_6 < u_8$
  $\theta = 225^0$;
else if $u_7 < u_8$
  $\theta = 270^0$;
else
  $\theta = 315^0$;
End

Figure 6. Basic Rules of Path Planning Fuzzy

5. MODIFIED CELL DECOMPOSITION

Cell decomposition algorithm has been studied and applied for basic behavior of quadrotorpath planning by Iswanto [16]. By using this algorithm, the robot heads to the goal position by identifying the value of the smallest grid and it avoids obstacles as it get great grid values. The algorithm has been modified

by adding the value of potential on the grid cell decomposition as shown in Figure 7 [18]. It shows that $k_{O(n)}$ is repulsive force constant for n[th]obstacle and k_{GR} is attractive force constant for the goal position of robot trash can.

$$G_{R_x} = G_{T_x} + 0.5$$
$$G_{R_y} = G_{T_y} + 0.5$$
for $I = 1 : a : n$
$\quad$ for $J = 1 : b : m$
$$O_{(n)} = \frac{k_{O(n)}}{\sqrt{(I - O_{x(n)})^2 + (J - O_{y(n)})^2}} \; ;$$
$$R_T = \sqrt{(I - G_{Tx})^2 + (J - G_{Ty})^2} \; ;$$
$$R_R = k_{GR}\sqrt{(I - G_{Rx})^2 + (J - G_{Ry})^2} \; ;$$
$$A_R = O_{(n)} + R_R \; ;$$
$$A_T = O_{(n)} + R_T \; ;$$
$\quad$ if $A_R(I,J) > 300$, $A_R(I,J) = 300$; end
$\quad$ if $A_T(I,J) > 300$, $A_T(I,J) = 300$; end
$\quad$ end
end

Figure 7. Environtment Matrix Formed by Source Code

6.   RESULT AND ANALYSIS

The experiments conducted in this paper used matlab software to model the trash, environment and robot and simulated the performance of the robot in pursuing and picking up the trash and avoiding static obstacles in an unknown environment model. There were two experiments in this paper to test the proposed algorithms; the first one was without static obstacles and the second was with static obstacles.
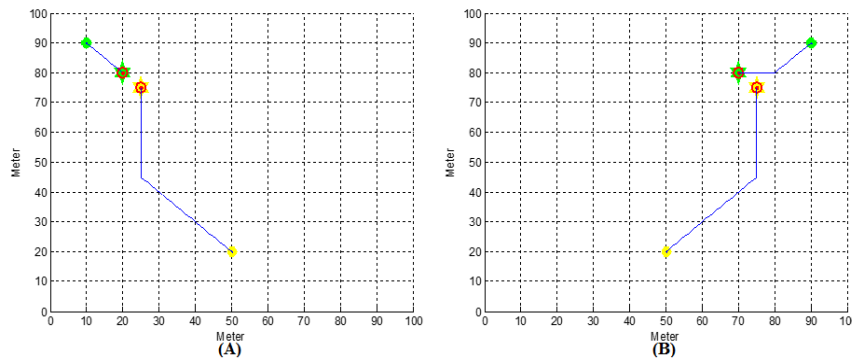

Figure 8. Experiment without Obstacles

The FCD algorithm was tested in the first experiment in an unknown environment without static obstacles as shown in Figure 8. In Figure 8(A) trash can robots is indicated by a yellow dot with the initial position of (50, 20) and the robot starts moving when viewed trash indicated a by green dot thrown from the position of (10, 90) to the position of (20, 80). Then the robot moves toward the goal position of the trash and stop at the position of (25, 75). Figure 8(B) shows that the trash can robot remains at the position of (50, 20) and trash indicated by a green dot is in the position of (90, 80). When the trash fell on the position of (80, 80) the robot moves toward the position of the trash. However, the robot moves back because of the wind and stops at the position of (70, 80), and then continues moving towards the position of (75, 75).

The second experiment, the robot indicated by a yellow dot was placed at the starting position of (50, 20) and there were four obstacles indicated by a black dot placed at four positions of (30, 30), (50, 40), (30, 60), and (70, 60) as shown in Figure 9. Figure 9(A) shows that the trash indicated by a green color in the starting position of (40, 90) is thrown into the position of (40, 80) then the robot pursue it. When heading to the position, the robot encounters some obstacles so it avoids them and continues moving to the nearest position of the trash that is (45, 75). Figure 9 (B) shows that the robot trash can is identifying the nearest path

to catch trash and stops at the position (45, 75). By using the modified FCD algorithm, the robot pursue the garbage littered more quickly compared to Figure 9 (A).
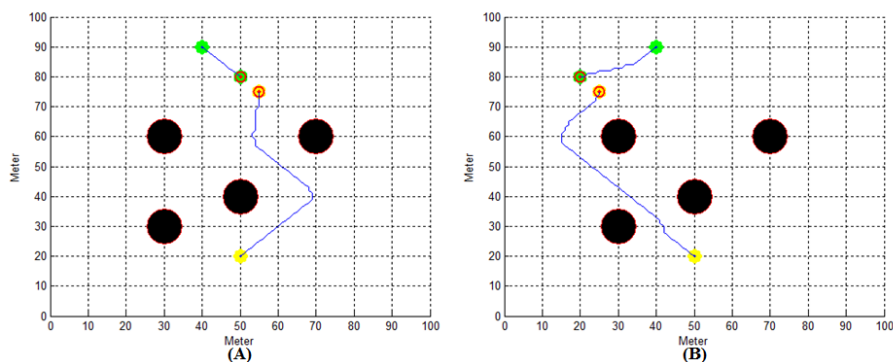

Figure 9. Experiment using Static Obstacles

7.   CONCLUSION
The paper presents a new algorithm used by to pursue littered trash based on the combination of cell decomposition algorithm and fuzzy. Fuzzy algorithm is typically used for path planning which serves to detect an obstacle by using sensors and to steer robots towards the goal position. However, in this study the algorithm has been used to detect trash and obstacles read from global view sensors by using cell decomposition algorithm. By combining the two algorithms trash can robots move towards carelessly discarded trash and avoid obstacles.

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