MULTI SENSOR FUSION BASED FRAMEWORK FOR EFFICIENT MOBILE ROBOT COLLISION AVOIDANCE AND PATH FOLLOWING SYSTEM

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ABSTRACT

A new technique for line following and collision avoidance in the mobile robotic systems is introduced. In addition, a fusion model based on fuzzy logic is proposed. Eight distance sensors and a range finder camera are used for the collision avoidance approach where three ground sensors are used for the line or path following approach. The proposed methodology reduced the traveled distance of the robot and minimized the energy consumption and the distance between the robot and the obstacle detected as compared to a non-fuzzy logic approach.

***Index Terms*—** Collision avoidance, line following, fusion.

1. INTRODUCTION

There has been a spurt of interest in recent years in the area of autonomous mobile robots that are considered as mechanical devices capable of completing scheduled tasks, decision-making and navigating without any involvement from humans [1], [2]. [3].

1.1 Research Problem and Scope

It is crucial to develop an autonomous robotic system that is capable of avoiding obstacles while following the path in real time applications [3]. The robot can be mounted by different kinds of sensors to observe the surrounding environment. However, many factors affect the reliability and efficiency of these sensors [4]. To assure efficiency and robustness, the integration of sensor or data fusion is considered a crucial aspect especially in real-time systems. Sensor fusion can be defined as the combining process of sensory data in order to generate improved data that assure robustness and confidence, and diminish ambiguity and uncertainty. Fuzzy logic is an approach used for sensor fusion with small computational load especially in unknown environment. Therefore, using fuzzy logic boosts the robustness of the algorithm required for collision avoidance and path planning in autonomous mobile robotic systems. Many researchers have used sensor fusion which improved the decision making process of routing the mobile robot [4]. A hybrid mechanism was introduced by [5] which uses the neuro-fuzzy controller for collision avoidance and path planning behavior for mobile robots in unknown environment. Moreover, an adaptive neuro-fuzzy inference system (ANFIS) was applied for an autonomous ground vehicle (AGV) to safely reach the target while avoiding obstacles by using four ANFIS controllers [6]. Another sensor fusion based on Unscented Kalman Filter (UKF) was used for mobile robots' localization problems [7].

1.2 Potential Contributions of the Proposed Research

The goal of this work is to design and experimentally implement a collision free-path follower robot with the integration of data fusion. This combination is extremely helpful for obtaining more accurate sensor data and thus enabling the robot to react more efficiently in case of obstacle detection. The performance of the proposed technique has been evaluated using simulated and experimental data. Our framework aims for higher efficiency and accuracy using data fusion while ensuring overcoming obstacles along the path. In this work we are mainly concerned about extracting necessary fused sensor data from multi-modality sensors for vigorous collision free trajectory planning approach.

The proposed methodology reduced the traveled distance of the mobile robot, and minimized the energy consumption and the distance between the robot and the obstacle detected as compared to a non-fuzzy logic approach [4].

2. PROPOSED METHODOLOGY

This section presents the proposed methodology for mobile robot collision free navigation with the integration of the fuzzy logic fusion technique [4]. In this work, Webots Pro simulator is used to develop a line follower and collision avoidance environment [8]. The mobile robot used is called E-puck robot [8]. The environment is modeled with a white floor that has a black line in order for the robot to follow it. It also has solid obstacles where the robot should avoid them [4]. The robot detects the obstacles based on the values returned by the distance sensors that ranged between 0 and 2000 [3]. For the line-following approach, another type of infrared sensor called ground sensors is used [3]. The camera sensor that is used in this work is a range finder type of camera which allows obtaining distance in meters between the camera and the obstacle from the OpenGL context of the camera [4]. The fusion model is based on Fuzzy Logic fusion technique using MATLAB software [4]. The fuzzy logic fusion model was designed for preventing the mobile robot from colliding with any obstacles while following the line. The fusion model composed of nine inputs, two outputs, and 24 rules [4]. Fig. 1 demonstrates the proposed methodology [4]. As shown in Fig. 1, the initialization of the robot and its sensors is the first step. After that, the distance sensors and camera values are fed into the fuzzy logic fusion system for obstacles detection and distance measurements. If an obstacle is found, the mobile robot will adjust its speed for turning left or right based on the position of the obstacle. The decision is made based on defined fuzzy rules. After avoiding the obstacle, the mobile robot should continue following the line by obtaining ground sensor values and finally adjust its speed accordingly. On the other hand, if there is no obstacle detected, the mobile robot should follow the line while it checks for obstacles to avoid at each time step [4].

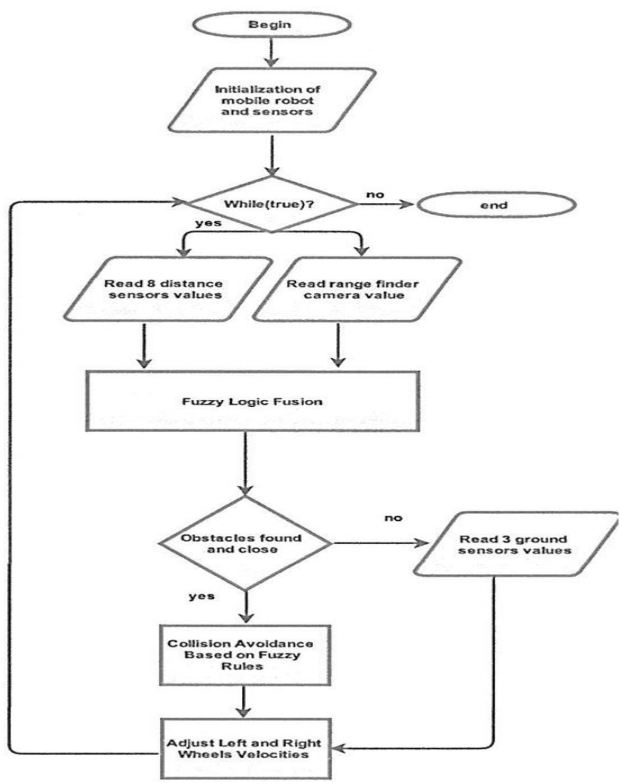

Fig.1. Flowchart of the proposed methodology

3. PERFORMANCE EVALUATION

Fig.2 demonstrates the distance to obstacle measurements by using the distance sensor, or the camera, both with the integration of fusion model [4]. As shown in Fig.2, fusing both sensors outweighs the performance of using each sensor separately [4]. Furthermore, the distance traveled by the left and right robot's differential wheels is observed. As shown in Fig.3 [4], the proposed fusion model has helped in reducing the distance traveled by the robot as opposed to each sensor separately, which saves more energy, time, and computational load [4]. Fig.4 demonstrates the energy consumption level of the mobile robot with the proposed fusion system as compared to a non-fuzzy system. At the beginning of the simulation, both cases have the same level of energy consumption. However, once the mobile robot has detected an obstacle, the energy consumed by a non-fuzzy approach has been increased whereas the proposed fusion system saves more energy.

4. CONCLUSION

A multisensory fusion based model was proposed for collision avoidance and path follower mobile robot. The proposed fusion model has been successfully tested in simulation and real time experiments. The robot detected static and dynamic obstacles with different shapes and sizes in a short distance range, which is very efficient in dynamic environment. The distance traveled by the robot was reduced using the fusion model, which reduces energy and computational consumptions and time.

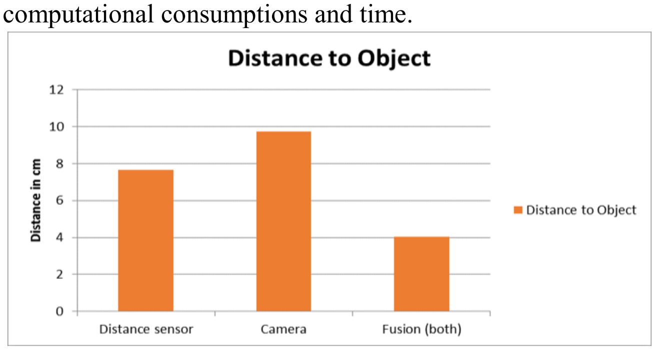

Fig.2. Distance measurements between the robot and the obstacle

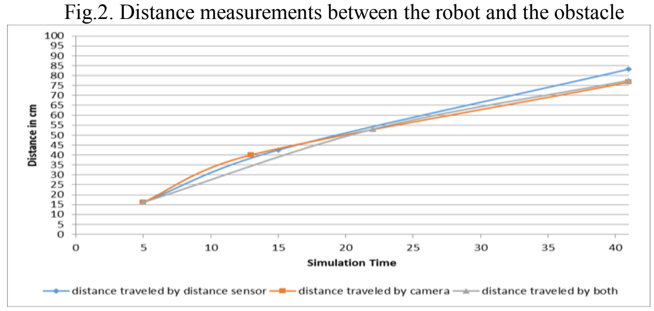

Fig.3. Average of distance traveled by the robot's differential wheels.

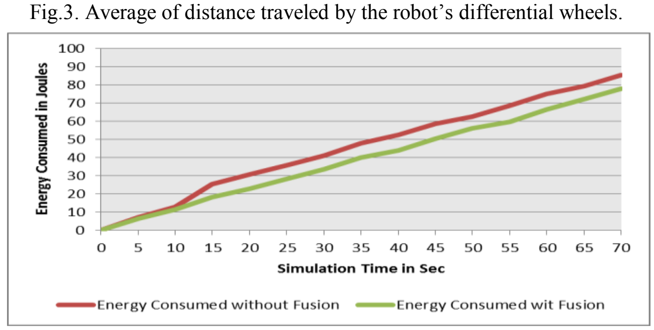

Fig.4. Energy consumption level

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