Low Power Consumption, Low-Cost Multisensory Based System for Autonomous Navigational Mobile Robot

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ABSTRACT

This work focuses on the collaborations of low cost multi-sensor system to produce a complementary collision-free path for autonomous mobile robots. The proposed algorithm is used with a modified version of A^* searching algorithm to produce the shortest, and most energy-efficient path from a given initial point to a goal point. The experimental results demonstrate that the robot is capable of measuring different distances to obstacles in unknown environments. The proposed model is characterized by its low cost, low power consumption, and its efficiencies in following shortest path while avoiding collisions.

***Index Terms*—** Path planning, mobile robot, collision avoidance, dynamic environment, wireless sensors

1. INTRODUCTION

Mobile robotic systems have gained a lot of considerations in human welfare, where they represent such a complex interaction of high computational processes, outstanding mechanical design, and exceptional hardware. Majority of mobile robot applications are developed to perform some operations that require an extended level of autonomy such as exploration, search and rescue, inspection, etc[1]. These mobile robotic applications are normally subject to the collaboration with the dynamic environment that can be described by its challenging properties. Thus, mobile robots should have the ability to model and communicate with the surroundings in order to achieve safe motions and reliable systems [2].

Collision avoidance systems in autonomous mobile robots should achieve the objective of real-time collision-free path in order to avoid imminent collisions. A reliable and quick detection would allow time to steer away from the possible collision.

A new programming model for optimal path planning in mobile robot is introduced to show how it insulated from the details of the hardware and enable the programmers to use this model in multiple hardware with one controller. This work is the advance of the previous research that is simply relying on the use of low cost resources and minimize the total energy consumption.

2. AN OVERVIEW OF RELATED WORK

The problem of motion planning has attracted the attention of researchers due to the related complexities and the challenges of real time nature. The path planning in mobile robot can be classified into two types: path planning with complete information, and path planning with incomplete information. In the approach with complete information, all information about objects such as size, shape, position) are completely identified and the entire operation is one-time, off-line. The most general algorithms fall within this category are: Probabilistic roadmap (PRM) as in [3] and visibility graph as in [4]. In contrast, path planning with incomplete information is formulated as an element of uncertainty is introduced and all missing information can be provided by using other sources such as sensory feedback. Moreover, the decision is based on the current percepts captured by the sensors as the position of obstacles may change with time. Although several algorithms have been proposed in the literature, very few methodologies have been devoted for using low cost resources and there is no certain model that can be used to formulate the energy consumption of mobile robotic applications. In these algorithms, commonly utilized methods are the artificial potential field (APF) approach [5], vector field histogram (VFH) approach[6], and follow the gap method (FGM) approach [7].

3.METHODOLOGICAL APPROACH

In this scheme, different types of sensors such as infrared reflective sensors, infrared distance measuring sensors, ultrasonic sensor and a camera are used to create a complementary multi-sensor system that has the ability to avoid collisions and deliver a reliable measurements. An overview of the current instantiation of autonomous mobile robot test-bed is shown in figure1.

Figure 1: The test-bed prototype of the proposed model

The proposed model deploys a modified version of A* searching algorithm to find the shortest path from a given point to target. Then, the robot starts sensing the environment for edges through left and right reflective sensors to avoid moving over the edge. In case of possiblcollision, the reflective values are compared with a predefined threshold and the robot will make an action accordingly. In the case of no detected edges, the robot performs obstacle detection using two infrared distance measuring sensors, ultrasonic sensor and a camera. The microcontroller converts all sensors readings into a measurable form to compare them with their detection ranges. If an object is detected through any sensor, the robot spins around the object, compute the new heading angle and moves along the path. The flowchart of the proposed model is demonstrated in figure 2.

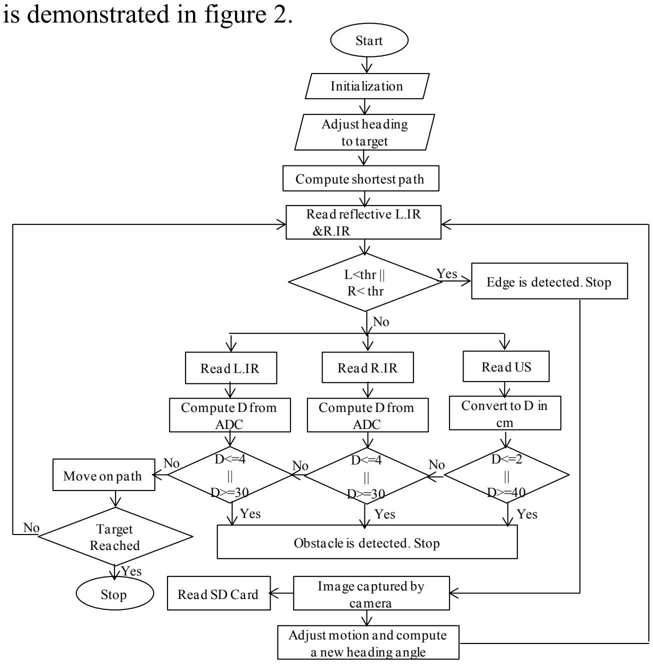

Figure 2: A Flowchart of the proposed motion planning approach

4. PERFORMANCE EVALUATION

The integration of the information supplied by multiple sensors can be the best solution to overcome the spatial uncertainty of unknown environments in several advanced navigation applications. Data acquisition (DAQ) was used to monitor the energy consumption while the robot is traveling from a given initial position to its goal and avoiding different types of obstacles. To illustrate the results, further experiments were conducted with different number of detected obstacles as shown in figure.3. The mobility energy is 397(J) to cover 0.71(m) when no obstacles lies in the path(minimum distance).

The time-distance graphs of the proposed model is depicted in figure 4. The robot travels 0.71 m covered in 149 second when there is no obstacle is detected along the path. Considering obstacles in the path, the time and travel distance will increase as the robot consumes more time and distance to spin around obstacles to avoid collisions.

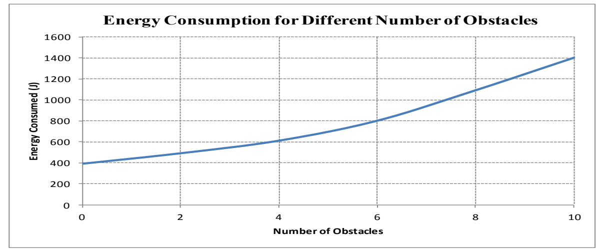

Figure 3: Energy consumption analysis for different number of obstacles

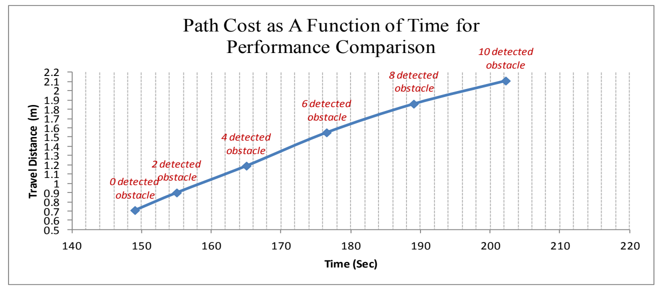

Figure 4: Path cost as a function of time for different number of obstacles

5. CONCLUSION

The path planner with our model is utilized to generate the shortest path from a given initial position to a distention in multiple scenarios of obstacle-rich environments. The proposed model does not require a prior information of the environment as the decision is based on the current percepts captured by the sensors. In addition, there is no need for high memory and a sophisticated processor, a single microcontroller is enough to perform all computations. Furthermore, the proposed model unlike other algorithms, it can easily detects critical shaped obstacles which consider as dead-end scenario for APF, VFH and FGM algorithms.

5. REFERENCES

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