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Research paper

An FPGA based autonomous robot navigation in unknown environment using grid mapping

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Abstract

Assistive robotics can be designed to support the physically disabled persons in numerous ways. They are trying to reinstate human capabilities which has been condensed or lost by accident, at old age or disease. But physically disabled persons facing some troubles in their moments with the existing assisted devices. To give the support for Old age and disabled persons by developing an intelligent Robotic wheel chair, to improve the complex navigation techniques in mobile robotics replacing the existing assisted devices like wheelchair with the automated one. A new algorithm is developed depend onbetter reality which replaces the existing system and improves effective localization with high accuracy.This technique is mainly developed by blob analysis, pattern and color matching. We designed the total prototype on national instruments Robotic starterkit2.0. It is important to design a robot in such a way which avoids obstacles automatically when collision takes place. These types of robotic wheel chairs are very efficient and enable the user to move around easily and also gives the independence to one who have motor disability can easily move without others help.

Keywords: *Intelligent Robot; Blob Analysis; FPGA; Robotic Starterkit2.0.*

1. Introduction

In present technology robotics is designed to control computer systems, sensory feedback and data processing unit.In large manufacturing industry to process or assemble the task these robots are used in place of humans. In traditional technology robots are utilized for programming and only to do repetitive work. In present technology Autonomous robots are designed which is having capacity to decide itself by using some Decisions making algorithm. To achieve this allocated task it should have intellectual and it should select own action.

When the self-directed robot selects its action, it is essential to plan to choose shortest path to avoid collision to reduce distance, time and energy. The major task is to design intellectual control self-directed mobile robot is Motion planning. It is frequently disintegrated into trajectory planning and path planning. In an environment to avoid collisions from obstacles Path planning algorithm is to be implemented and enhancedto some principle.

Though, for investing artificial intelligence problem the suitable tool is mobile robot which relates to world understanding and taking a suitable action, such as, avoiding obstacles, fusing data, and planning missions.

2. Literature survey

Path planning is the technique of deciding the best way to move in a particular path to accomplish the desired task. Robots are much useful for human needs in various fields like domestic, industries and military sectors etc. Path planning acts major role in robotics for navigation process. Industrial robots are the autonomous robots, which have to perform tasks without human guidance. These types of robots should provide by self-intelligence about the environment, and how to discover the shortest path in ordered to reach the destination. When a navigation task is assigned to the robot it is essential to discover a possible path with no obstacles to move towards the destination. The path is much preferable which reduces the total time taken and reduces the cost of transportation where time and cost valued a lot in industrial works.

Many algorithms has come in to existence for calculating the shortest path, which has some merit and demerits. The (TWO-Q) algorithm i.e; Pallottino's graph growth algorithm was implemented for path routing and networks. If the path is comparatively short this algorithm consumes a lot of time on unusable work. JinFuLeng, proposed Mild-TWO-Q algorithm which is enhanced version of TWO-Qalgorithm which consumes less time to arrive the path. [1]. In an environment of convex polygonal to discover appropriate shortest paths a new parallel algorithm is designed to avoid the problems in visibility graph and its FPGA implementation is surveyed in [2]. Several real time applications is needed for high-speed shortest-path calculations are implemented by FPGA-based accelerator to attain high performance with low cost.Later Bellman-Ford modified the problems of shortest path algorithm by resolving the single-source shortest-path algorithm in effective manner [3].

In 3-dimensional path planning algorithm has so many issues, in that situation like airplane traveling in circular hazard regions. Solutions to this problem is before it leaves from the ground it should follow optimal path.The problems and solutions of path planning in aerospace applications are studied in [4].

However conservative quad tree-based path planning method is simple robust and effective. It has some limitations. A fast path planning defeat the limitations of quad tree by performing path graph optimization for both accuracy and efficiency is projected in [5].

In practical applications, path planning in unknown or known environments is problematic job. By using sensor information D * algorithm is used for path planning in moderately known environments.

To enhance path planning, upgraded version of D* algorithm based networks is studied in [6]. [7].
To identify colors with webcam two methods are there, the first method is developed using NI Vision Development Module v8.6 and NI IMAQ for USB. The second method is developed in Lab Windows/CVI with an external library for vision but in the first method Lab VIEW helps only costly IEEE 1394 and Ethernet cameras taken from National Instruments' supported vendors [8]
FPGA based robots are used for different applications due to its high performance onboard processing unit with less power consumption and reconfigurable characteristics. The upgraded version FPGA-based control system uses the software/hardware re-configurable characteristic of the highly developed FPGA device is surveyed in [9].
Bremen Autonomous Wheelchair and the Maid (Mobility Aid for Elderly and Disabled people) robotic vehicle is designed by changing present power wheel chair system [10]. These data structures organize sensor information into a coarse map, which is then used to inform speed and direction decisions [11]. An intelligent machine is a mechanical device capable of processing information received from internal and external sensors, before using actuators to perform useful tasks within its environment [12].
The Maid wheelchair is highly autonomous. Its specialty is movement through Crowded, changing environments. In one test the device crossed the floor of a busy Railway station without colliding with anyone or anything. Some smart wheelchairs [13]. The level of autonomy provided by a robotic wheelchair is an important evaluation Criterion. At one extreme are manual designs that do not provide any control assistance to the operator. It may be argued that these are not robotic wheelchairs at all. However, they can still involve sophisticated processing; require specialized hardware and current compound control problems [15]. Spend the best part of their time contained by the same controlled environment. Versatile navigation algorithm is hardware efficient to perform in a smart environment which is confined with different static and dynamic (human movement) objects. [27]
One evident way to organize smart wheelchairs is form aspect. Early smart wheelchairs (e.g., Vehicle Autonomy pour Handicap Motor [VAHM] [16], Mister Ed [17]) were actually mobile robots to which seats were added. Most of the smart wheelchairs have been residential to date have been based on greatly modified, commercially existing power wheelchairs (e.g., NavChair [18], Office wheelchair have high Maneuverability and Navigational Intelligence [OMNI] [19], Mobility Aid for elderly and disabled people [Maid] [20], SENARIO [21]); a less number of smart wheelchairs (e.g., Smart Wheelchair Component System [SWCS] [22], Smart Power Assistance Module [SPAM] [23], Hephaestus [24], Tin Man [25], Samoa [26].

3. Proposed algorithm

a) Flow Charts for path planning Algorithm

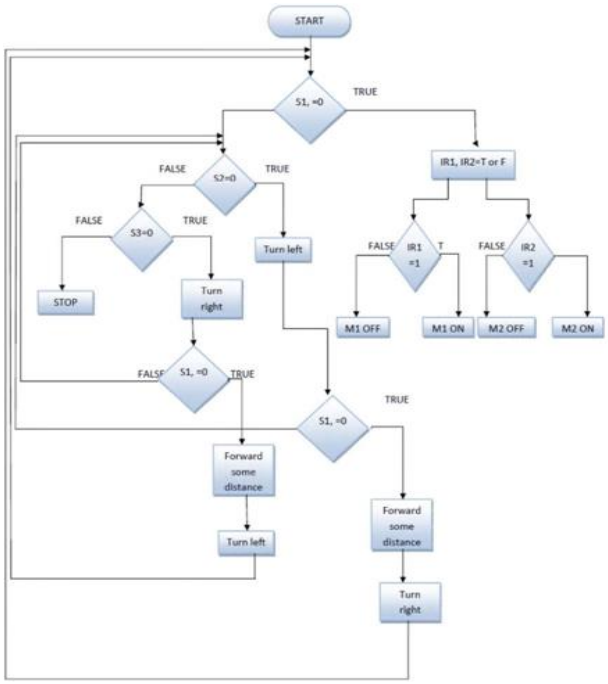

Fig. 3.1: Flow Chart of Algorithm.

The above algorithm flow chart is representing the flow of path plain depending upon accuracies of the path. The cases are representing here s0, s1, s2.

b) Vision based Path planning Algorithm

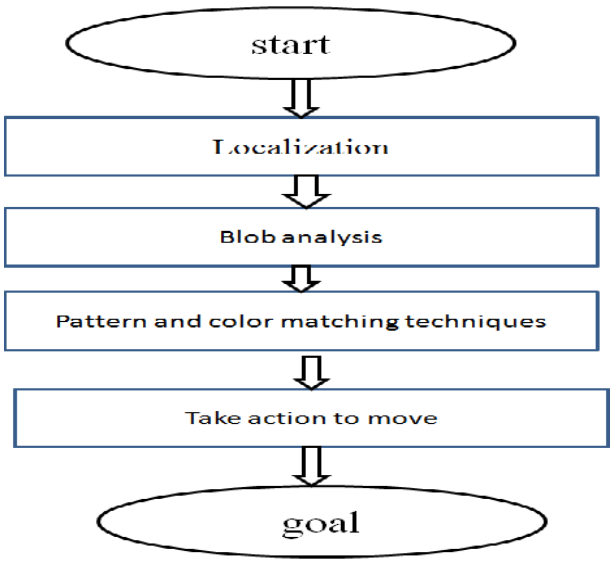

Fig. 3.2: Path Planning Algorithm.

STEP 1: A task is assigned to the robot to reach one particular place to another place. (For ex: red colored circle to green colored triangle). Robot checks for initial and destination locations i.e red colored circle and green colored triangle.
STEP 2: Initially the robot localizes its current position using blob analysis and IP camera.
STEP 3: Robot moves on priority based. The highest priority is given to the shape of the pattern and then to the color. Based on the priority robot moves to reach the triangle shaped pattern.
STEP 4: After reaching the triangle shaped pattern, it now checks for the color. Using blob analysis and IP camera the robot matches the patterns and moves towards the destination.

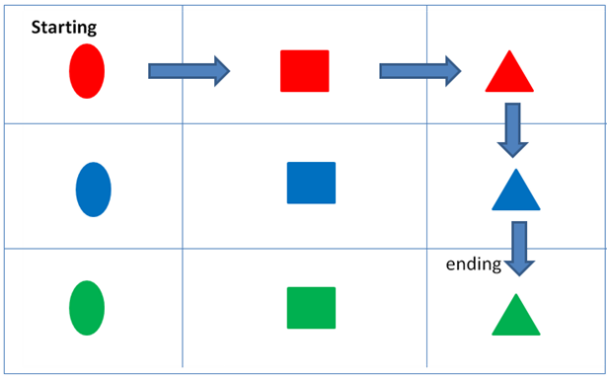

Fig. 3.3: illustration of Indoor Environment.

The proposed algorithm presents the augmented reality for assistive method is shown in the above fig 3.4. This can be implemented in assistive appliances like wheel chair to help the ALS patients. This assistive system can help the disabled or senior citizens to do their individual works in an efficient manner. This algorithm is developed based on NI SBRIO (Spartan 3E FPGA) to perform various tasks. In indoor environment the robot has to navigate from one place to other place. The robot plans the path according to which it has to reach the destination. To complete the task in a short period, the robot has to follow a shortest path which reduces the cost of transport, time and resources.

The shortest path based on better reality is proposed to perform various tasks. The robot has to localize its position before attempting a task. This robot should provided with sufficient knowledge of initial position and target position. The localization can be performed by using IP camera. After completion of localization process it moves in the path according to the proposed algorithm.

The algorithm uses blob analysis to achieve the required algorithm. In the above indoor environment three different patterns with different colors are placed. Each row consist of different patterns with same color and column consists of same pattern with different color. Each pattern with unique color represents the different locations in an indoor environment. The given task in the indoor environment is to reach the green colored triangle from the red colored circle. Now the robot checks for the initial position i.e red color circle by using IP camera. After localizing its position at red colored circle it plans the path to reach the destination. The robot follows an priority based algorithm. Highest priority in this algorithm is patterns and then color. According to the priority, the robot initially checks for pattern. Blob analysis is used to recognize the location and then matches with pattern. Initially the robot moves from the red colored pattern to search the triangle pattern. It navigates for some distance until it reaches the triangle. As soon as it reaches the pattern it checks for color. Using camera it recognizes the color and reaches the destination.

4. System design

a) Control Unit

The proposed system mainly consists hard ware components those are FPGA Spartan 3E board ultrasonic sensors, IP Camera, voltage regulators, rechargeable battery and TP link router. The voltage regulators are used to step down the voltage from battery and give the required amount of voltage to all the components. Ultrasonic sensor senses the obstacle by emitting ultrasonic waves and feeds the signal as input to the FPGA .The IP camera use to the acquiring pattern and color in localization, blob analysis techniques are mainly used in this project to read the particular pattern, and after acquiring the color, the colors are mean support to move to all places in that environment and help the robot to move in all required directions.

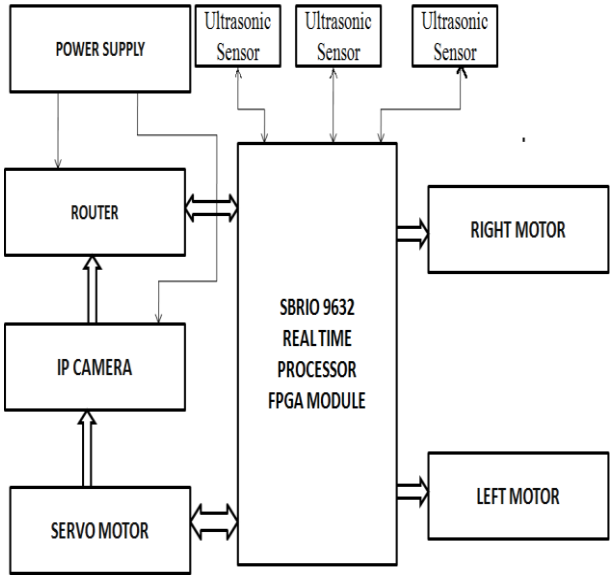

Fig. 4.1: Block Diagram of Control Unit.

The main theme of this proposed system is to develop a self-intelligent FPGA based robot which can assist in indoor environment to perform various tasks by a land mark path algorithm. When a robot receives a navigation task by color and pattern techniques, it evaluates all the colors are RGB that are red, green and blue color. The path is evaluate by blob analysis technique and pattern technique. In this 3- types of pattern are used. Patterns are square, circle and triangle. Robot collects all the data of path probabilities and then compares them to detect the path. The main issues to arrive the destination effectively is obstacle avoidance and detection. By using ultrasonic sensors robot can easily avoid all the obstacles in the path and move towards the destination point. The mobile robot carries ultrasonic sensors in all four directions and IP Camera is placed at the top of robot. By using these two devices the robot localizes its position and moves towards the destination.

Robot navigation is the capability to find out its own position in its situation and to plan a path towards some goal location. in sequence to find the way in its indoor environment, the robot or any another mobility device requires illustration i.e. a map of the indoor environment and the capability to interpret that illustration. Path planning is an important issue as it allows a robot to get from red circle to red square, the color are mainly acquired by the IP Camera. This camera is mainly fixed at servo motor, the servo motor is rotating with -90to 90 degrees. Path planning algorithms are measured by their computational complexity. The probability of real-time motion planning is reliant on the precision of the map (or floor plan), on the number of obstacles and on robot localization Topologically, the problem of path planning is related to the path problem to finding a route between two patterns with same color. Here we used national instruments robotic starter kit 2.0. First of all the robot has to follow the line because we select the known path in our indoor environment to reach from starting point to goal point.

Servo motor is mainly rotating the IP Camera; servo motor angle is mainly controlled by SBRIO board. This is internally connecting to the board.

b) Robotics Starter Kit 2.0

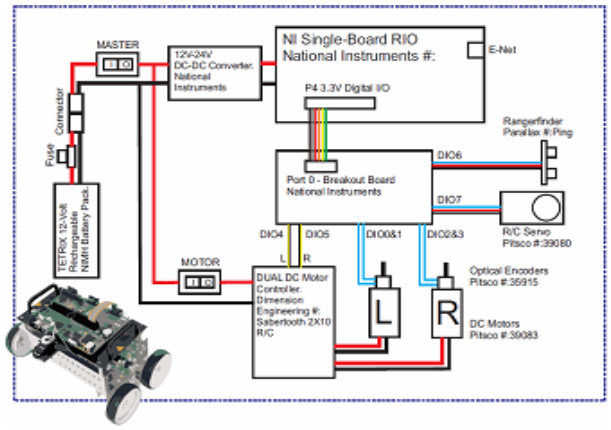

Fig. 4.2: Starter Kit Internal Diagram.

The proposed system is processed using controller based on NI SB-RIO. It is fully assembled mobile robot based starter kit. It has motors, ultrasonic sensor, battery, encoders, and charger. It can execute Real-time assessment making and FPGA based I/O processing. It easily connects to a variety of robotic sensors and actuators.

c) Color and Pattern Matching Block Panel

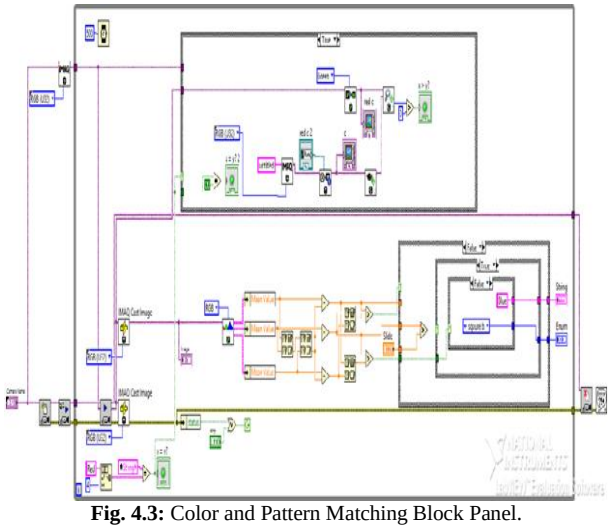

Fig. 4.3: Color and Pattern Matching Block Panel.

The above code is grab the image or pattern in that range of camera that can matched to previous patterns in memory, after that is next step for matching Opens a camera, queries the camera for its capabilities, loads a camera configuration file, and creates a unique reference to the camera. Use the IMAQ dx Close Camera VI when you are finished with the reference.

5. Results

This proposed system is reaching the destination point, the destination point of environment is triangle pattern with blue color, the robot is started at circle pattern with red color.

Fig. 5.1: The Environment for Implementing the Task.

This robot is starting at circle pattern with red color, therefore distance between color pattern and IP camera nearby 30 cm, that time take action for their step, starting point of the robot.

Fig. 5.2: The Robot is moving from Red Color Circle to Triangle.

In this robot first checks the pattern i.e; move towards to triangle and then color i.e.; red.

Fig. 5.3: The Robot is Reached to Green Triangle.

Here robot move towards to green triangle based on path planning using bob analysis.

Fig. 5.4: The Robot Reached the Destination Point in Blue Triangle.

This robot reached the destination ie; initially assigned it as blue triangle every time it checks the pattern first then colour if it reaches the target, Then it stops.

6. Conclusion and future work

Robotics and its automation becomes an essential part in our daily lives. Every robot consist three concepts those are sensing, thinking and acting. Making use of these concepts different applications can be designed based on our requirement. As per research survey in navigation the major problem of mobile robot is to reach destination without obstacle in its environment .To eradicate these difficulties

we chosen to go GVD type of robotic investigation with the LAB-VIEW interfacing program it make some more easy to develop complex robot navigation algorithms like obstacle avoidance and path following techniques. And by interpreting these concepts to different assistive devices we can get the more useful automated things. This present design is based on 3 ultrasonic sensors and its distance measurements; used blob analysis techniques and pattern and color matching techniques here we need not to calculate any complex computations based on sensor and IP camera information by controlling the motors robot will moves from one point to another point safely.

This proposed system can be extended to further level by introducing Partial Re-configuration concept for high accuracy. The proposed algorithm can be used especially for single tasks with single robot. So, using partial reconfiguration this algorithm can be modified further to perform multiple augmented reality with multiple robots.

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