Navigation for Autonomous Cleaning Robot in Indoor Environment

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Abstract- *This paper proposed navigation and cleaning methods for indoor applications. To reduce the human efforts especially for the working men and women a special cleaning robot is designed to clean the floor of a room. This deals with the development of the Sensing and Control system to allow the robot to move around its environment, using Infrared Sensors to detect solid waste particles and RFID is used to navigate the robot to perform cleaning functions for the required room. Sensors play a vital role by helping to navigate and detect the obstacles. The Sensing and Control system receives instructions from the robot's Decision System, and passes sensor data back over the same channel. The sensor can detect small and large wastages as well as dust particles in the room to be cleaned and it sprays water to clean the floor. The principle task of this project was to program the AVR microcontroller interfaced to a radio packet controller module which would enable us to wirelessly control the Robot. The communication protocols dealing with transmission and reception of data and wireless control. Our proposed technique would be useful for real-world robotic applications such as intelligent navigation for motorized wheelchairs and in Nuclear power plants where humans are prone to harmful radiations.*

Keywords- Autonomous mobile robot, Robotic Vacuum Cleaner, Robot sensing system, safety beam sensor, obstacle avoidance sensor. Proteus 7.7

I. INTRODUCTION

Researchers in artificial intelligence and robotics have made huge efforts, but it is still an open problem because of the unstructured environment of the cleaning operation. In this paper, a new robot for floor-cleaning operations in a household environment is proposed. There are a huge number of articles dealing with different problems associated with mobile robots, most of which are applicable to the floor-cleaning problem. However, there are a small number of papers dealing specifically with floor-cleaning robots. These tend to be rather specialized, with the coverage algorithm as the main subject of interest. Conversely, this paper describes the integrated use of different competencies oriented toward the design of a complete floor-cleaning mobile robot, the most feasible domestic robotic operation even in absence of human in man-made environments such as hallways in a building global path planning is to dictate a direction to a goal at a particular place such the intersection of two hallways in a building. The local path planning plays a role of moving the robot along walls avoiding obstacles. The navigation system, therefore, requires a mechanism for recognizing such particular places in the building and locating them on a world map that gives course directions to a goal additionally, it requires a function of generating a free space map in a hallway.

A. RFID TAGS AS LANDMARKS

RFID tag and the antenna box of the RFID tag sensor system mounted on a mobile robot. The RFID tag (shielded in a 12cm square plastic plate) is an IC memory (115 Bytes) with a built-in antenna, which is pasted on a wall near particular places in a building. Each IC memory has a unique ID number which can provide information on its location within the building. The RFID tag sensor consists of an RF transceiver and an antenna. The RF transceiver illuminates an RFID tag with a short pulse of electromagnetic waves (2.45GHz, 0.3w). The tag receives the RF transmission, rectifies the signal to obtain DC power, reads its memory to get the ID number, and modulates the antenna backscatter in response to the interrogation. The RF transceiver obtains the ID number and reports it to a host computer through an RS-232c serial port. Since the induction area of a tag is 40cm wide and 100cm depth from the antenna the robot does not need precise positioning mechanisms to locate and access the tags. The robot just passes by tags without the accurate control of position for sensing their numbers.

B. MAP FOR NAVIGATION

If a tag is detected while the robot is moving the navigation system recognizes the robot’s location on the topological map from the tag number and then decides the next direction the robot turns to the left or to the right, goes ahead or turns back. While in an intersection the rangefinder is invoked frequently. In the case of turning to the right, for example, the robot moves forward measuring distances to the right side wall and stops at a big change of the distance. At the center the distance changes greatly because of no walls.

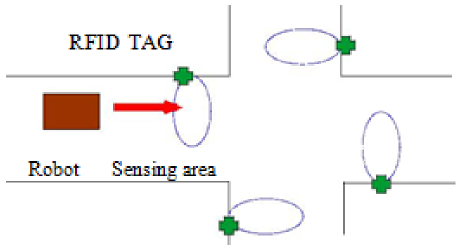

Figure 1.Layout of RFID tags at an intersection

C. ROBOT'S MECHANICAL DESIGN

The practical implementation of a cleaning robot is an interdisciplinary problem but in this paper, the attention is focused on the actuators, sensors, and electronics and their usability. The mechanical design of a cleaning machine for domestic use must be ergonomic and small enough to move around the typical obstacles in a household room and as well as light enough for easy transportation in case of unexpected problems. In its design, several different problems have to be solved: the efficiency of the cleaning device, the placement of the motorized wheels, the on-board sensors, and the battery recharge operation.

II. EXISTING SYSTEM

D. MOBILE ROBOT

Different from the industrial robots, mobile robots can move around to different locations and interact with the large scale environment. Meanwhile, they can also be equipped with different sensors, tools or manipulators (even industrial robot, named industrial mobile manipulator) to afford various tasks like supervising, exploring, manipulating, etc. Therefore, the mobile robot can be applied to a variety of scenarios like industrial, military, and home care. An autonomous mobile robot should be able to acquire the following information the current position/where is the robot(Localization) and the destination/where to go (task assignment) and the guidance/how to go. We will focus on the problem of localization and navigation in the typical indoor environment.

As a highly abstracted knowledge expression form, compared to the other maps, the topological map is simple, effective, and compatible with human knowledge. A topological map is a graph-based representation of the environment. Each node corresponds to a characteristic feature or zone of the environment, and can be associated with an action, such as turning, crossing a door, stopping, or going straight ahead. This kind of map is suitable for long distance qualitative navigation, and specially for path planning. In general, they do not explicitly represent free space so that obstacles must be detected and avoided online by other means. Topological maps are simple and compact, take up less computer memory, and consequently speed up computational navigation processes.

System structure is shown in Figure 2. The key for realizing topological indoor localization and navigation is to identify the heading corridor. With this ability, the mobile robot can navigate itself freely inside the indoor environment and learn the map by itself like what a human does when he goes into an unknown building. In this framework, we treat nodes as the vertices like intersections and treat links as the corridors connecting the vertices.

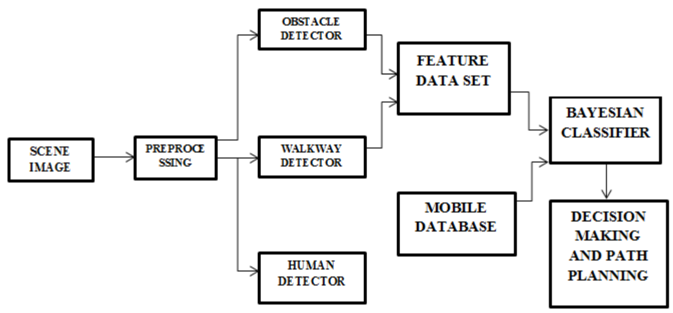

Figure 2 Topological indoor localization and navigation for mobile robot

The map building functionality is divided into two subtasks, topological map generation and landmark detection. The first task aims to build the skeleton of the topological map and the later task aims to add interesting places into the skeleton. With these abilities, a topological map containing rich information can be obtained. Considering the fact that landmark detection is a standalone process and has been investigated by many researchers, in this paper, only the topological map generation task is presented.

E. ENVIRONMENTAL EXPLORATION

Since the indoor environment is consisted of different rooms and connected by different corridors, it can be abstracted into a topological map containing vertices/nodes (rooms, intersections) and edges/branches (corridors). Such abstraction is compatible with human knowledge and can be easily integrated with human guide information such as the turning direction or the target location. Compared to other map-based localization and navigation methods, it is not necessary to integrate precise guide information such as "Turn Left at 3.5 m" or "The target is located at." Furthermore, the ability of directly identifying the corridor type can greatly decrease the difficulty of constructing such a topological map.

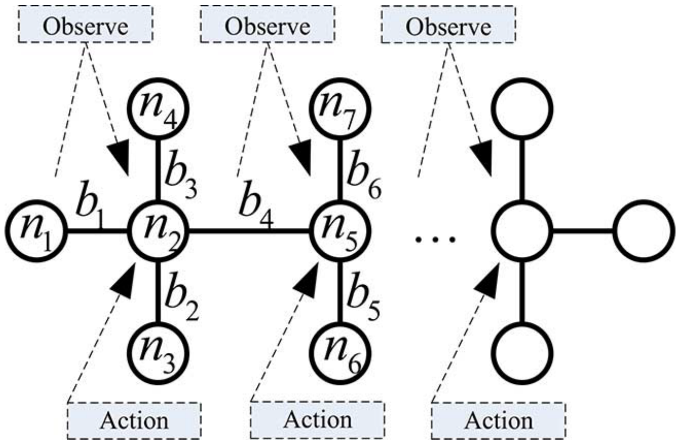

Figure 3. Topological map for mobile robot

As shown in Figure.3, the initial position can be seen as node. When the robot moves ahead and identifies a new corridor type, the current branch, a new node, the corresponding branches and the connecting nodes are added into the map. The connecting nodes are not observed directly, thus the underlying topological information is unknown. The robot has to choose a moving direction to explore the unknown region and repeat the previous steps. According the previous assumption, for each node, there are at most four connected branches and from different point-of views, different corridor type can be observed. The straight corridor is an exception. Because straight corridors are with no outlets, going forward is the only available action. They are actually pure branches with no junctions or nodes. Therefore, in the topological navigation and mapping process, straight corridor is not considered as a node and is not used in the map generation process. The robot needs to explore the environment to find all the nodes and branches. With such a procedure, an acyclic graph (tree) is constructed. However, not all the indoor environments can be described as an acyclic graph and there are possibly different paths connecting two rooms. Thus, a cyclic graph and the loop closing problem have to be considered.

IV. PROPOSED SYSTEM

The paper proposed a new navigation method for indoor mobile robots. We decided to build a robot capable of cleaning the floor of a room or area without any human effort other than just starting the unit. The robot system is composed of a Radio Frequency Identification (RFID) tag. The RFID tags are used as landmarks for global path planning and it to moves overall room at the same time it sprays water and cleans floor as it passes over it. And also have attached a vacuum cleaner on the back side of the robot to clean the dust particles. The robot automatically moves along hallways using the scanned range data until a tag is found and then refers to the topological map for the next movement. Our proposed technique would be useful for real-world robotic applications such as intelligent navigation for motorized wheelchairs, surveillance and security purposes and in Nuclear power plants where humans are prone to harmful radiations.
Block diagram of the proposed system shown in the figure 4

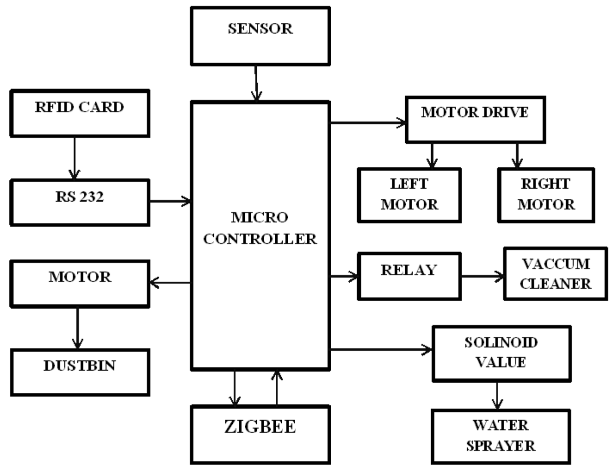

Figure 4. Block Diagram of the System

G. PATH SYMMETRIES

Often appearing as a path finding domain in areas such as robotics and video games, grid maps are a simple yet popular method for representing an environment.

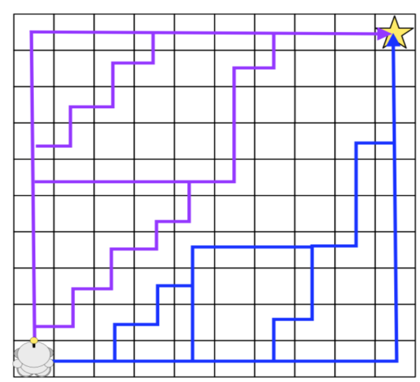
Figure 5 A simple grid-based pathfinding problem

As it turns out, grids are also academically interesting for the following reason between any given pair of locations, there usually exists many possible paths. Sometimes these paths represent alternative ways of reaching one location from the other but more often they are **symmetric** in the sense that the only difference between them is the order in which moves appear. Before proceeding further it is necessary to establish some precise terminology. For example: what exactly is a path Traditionally, Computer Scientists define paths as ordered sequences of connected edges. The conjunction of these edges represents a walk in the search graph from some arbitrary start location to some arbitrary goal location. However this definition is too general to capture the idea of symmetry in grid maps. For that, we need a slightly different notion of a path.

H. Grid Path

A path in a grid map is an *ordered sequence of vectors*, where each vector represents a single step from one node on the grid to an adjacent neighbouring node. The distinction between edges and vectors is an important one as it allows us to distinguish between paths that are merely equivalent (i.e. of the same length) and those which are symmetric. But what, exactly, does it mean to have a symmetric relationship between paths.

I. Path Symmetry

Two grid paths are *symmetric* if they share the same start and end point and one can be derived from the other by swapping the order of the constituent vectors. As a clarifying example, consider the problem instance in Figure 4.2. Each highlighted path is symmetric to the others since they all have the same length and they all involve some permutation of 9 steps up and 9 steps right.

J. Cleaning Method

The CLEAN method are introduced to eliminate side lobe enhancement and significantly improve the target detection performance and image quality of polyphase coded spread spectrum ISAR radar. The effectiveness of the CLEAN method is demonstrated through the experimental results. The hardware results show how excellent performance can be attained by combining the creator and the CLEAN Deconvolver. Thus signal processing methods like cross correlation, FFTs, CLEAN on range data and CLEAN method on target images, are incorporated to improve the radar system performance.

ADVANTAGES

- Fast and efficient removal of dirt and or marine growth.
- Increased productivity, reduced maintenance costs.
- One man operation.
- Cleans horizontal, overhead and vertical surfaces.
- Ergonomic design and user-friendly, wireless remote.

V. SIMULATION RESULTS

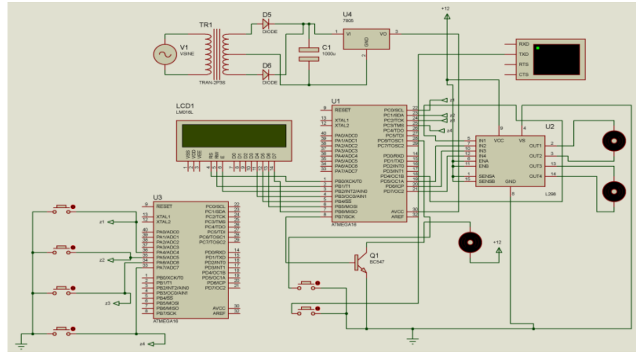

Figure 6 Simulation Diagram

Fig 6 represent the simulation diagram of cleaing robot. This design based on proteus 7.7. Proteus is software for microprocessor simulation, schematic capture and printed circuit board (PCB) design. Circuit Board consists of Atmega 8 microcontroller in two stations i.e., base station and moving station. Wheel of the robot is controlled by motor drive.dust particles sensed by the sensors and dust particles are cleared by the robot.

Step 1:

After the robot is in ON position then it is waiting for the input. Input is given by the base station.

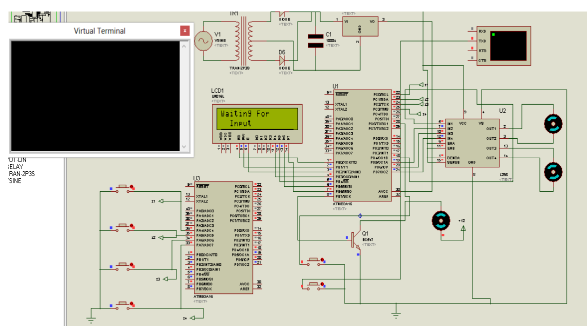

Figure 7 Waiting for Input

Step 2:

In this step, robot received the signal from the base station to clear the room 3. Now the robot moves to room 3.

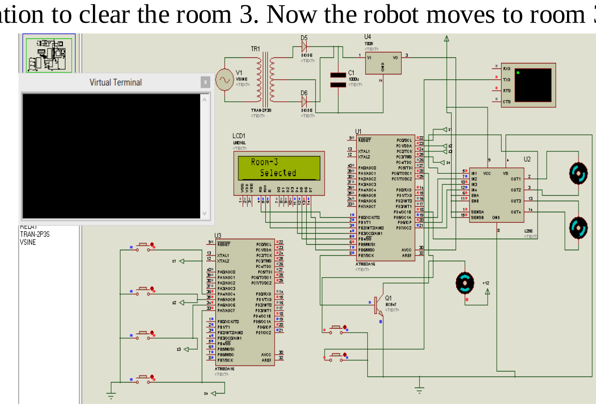

Figure 8 Room 3 Selected

Step 3:

The robot moves to each and every room and check the RFID frequencies or signals.

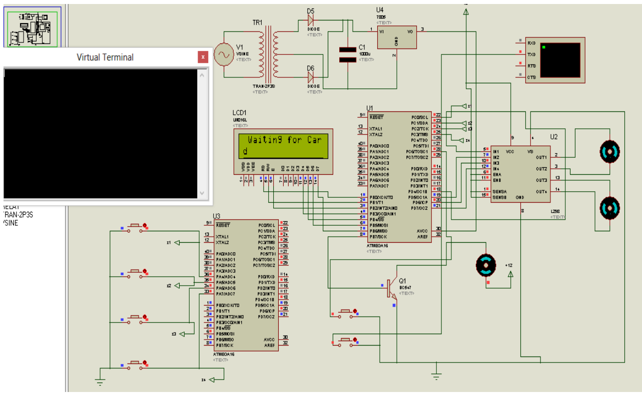

Figure 9 Waiting for RFID Signal

Step 4:

After receiving the signals from RFID card the robot match the frequency for reach the room 3.

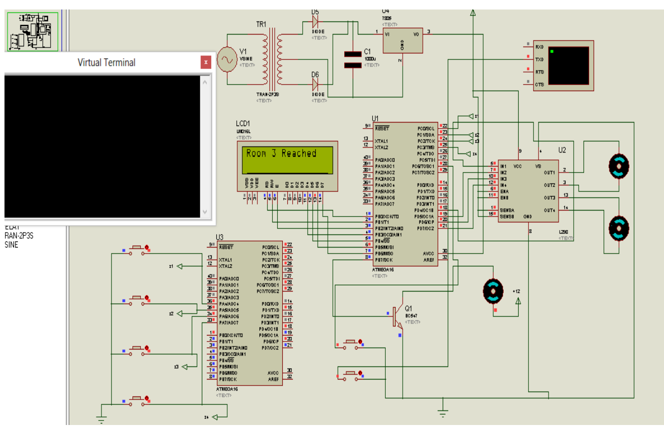

Figure 10 Robot Reached Room 3

Step 5:

After reaching the room robot search the dust particles. Now the robot finds the small dust particles.

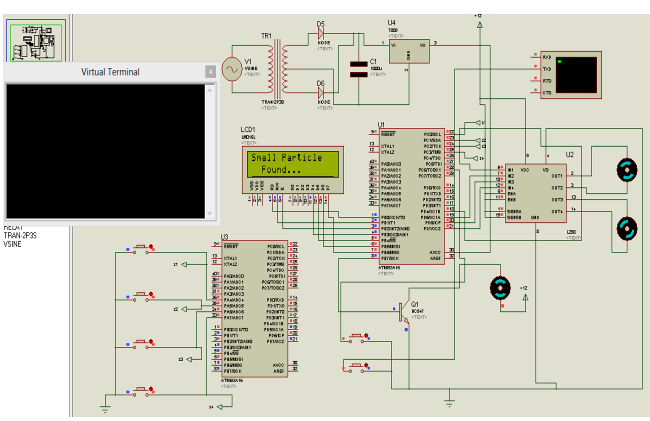

Figure 11 Small Particle Found In Room3

Step 6:

In this step, the small dust particles are cleared by the vacuum clearner and again it search the dust particles.

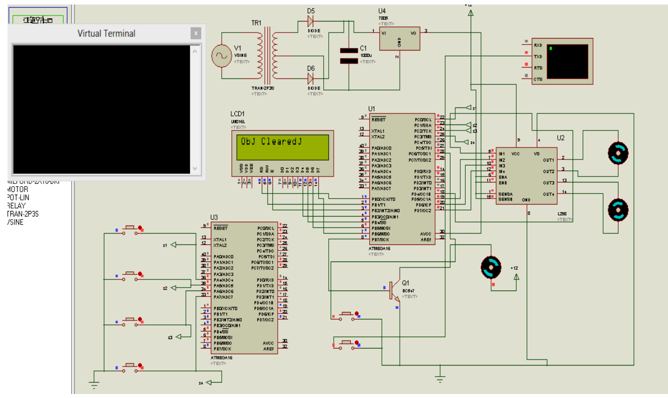

Figure 12 Small Dust Particles Cleared

Step 7:

Robot again search the particles and the sensor finds the large dust particle like papers, covers and etc.

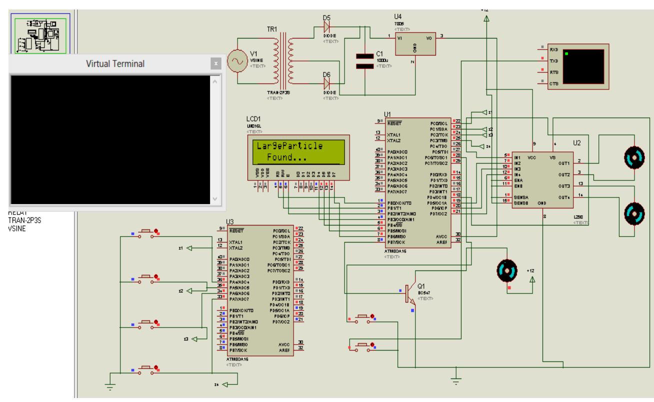

Figure 13 Large Particle Found In Room3

Step 8:

Large particles like papers, covers are found by the robot which is not cleared by the vacuum cleaner. This type of dust particles collected by the robot and stored in the dust bin.

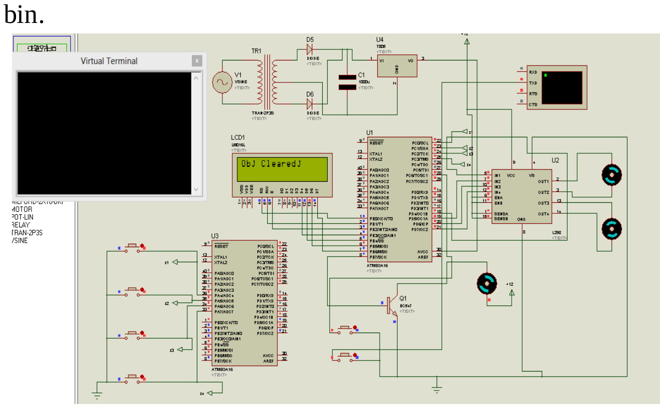

Figure 14 Large Dust Particles Cleared

VI. SAFE OPERATION

The proposed robot utilization on working days without people in the room follows the recommendations of the International Standardization Organization (ISO) that industrial robots should be strictly isolated from operators and workers. However, although it is obvious that domestic robots must be human-safe, the vagueness of the safety definition has limited research in this field .Safe operation can be defined from the point of view of the robot, the objects in the cleaning area, and the people around the robot. The safety of the robot and the objects is usually understood as the collision avoidance problem. In this case, the coverage algorithm uses the on-board sensors to explore the scenario and generate a path for collision avoidance. However, false measurements must be expected when using noncontact sensors and thus mechanical collision sensors are used to improve robot and object safety.

VII. CONCULSION AND FUTURE WORK

This paper describes the integrated use of different fields oriented toward the design of a complete floor-cleaning robot. By using highly advanced IC's and with the help of growing technology the project has been successfully implemented. Alternatively, the use of sensors in cleaning robots is proposed for safety considerations. The proposed scheme can effectively assign a cleaning area to a robot without need for any direct human control. Since this project is a just an idea this robot is developed as an electronic kit. To be implemented as a real time vehicle the individual machineries should be couples to a diesel vehicle and the individual machines are controlled by some specific control mechanism. As the cleaning instruments are available individually there is more usage of fuel. So this is also economically beneficial.

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