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Improved Dead Reckoning Algorithm for Obstacle Avoidance and Automated Cleaning

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ABSTRACT
This research presents a detailed account of map generating, comprehensive coverage, path plotting and scheming, as well as control mechanism for a mobile automation robot comprising of the automated ground cleaning of average to small indoor areas as an application objective. The algorithms put forward are centered upon supervised 2D map of the surrounding which is generated during the training phase and have the capacity to deal successfully with unforeseen obstacles which were not determined on the 2D map. The map is generated using dead reckoning algorithm and then an approach relying on templates is used for controlling execution of the path plan. The capability of the robot to deal with generation of the map, detecting unforeseen obstructions inside the work space and localizing itself in the map is the suggested approach's originality. If unmapped obstructions continually block the planned path, the trajectory tracing control inserts these obstacles in the 2D map.
Keywords: Automatic Cleaner, SLAM, Artificial Intelligence, Dead Reckoning.

I. INTRODUCTION

Path planning [1] and path tracking strategies for mobile robot navigation are highly dependent on the target applications. Among those indoor cleaning in extended public or industrial areas raise very interesting research challenges when required to be autonomously fulfilled by mobile robots. Cleaning chores entail a special kind of route to able to cover all the unoccupied areas in the dedicated cleaning environments. Paths that comply with this requirement are known as paths of total coverage. Localization and map generation is required to be achieved by the automated cleaner. We use a template based methodology [1] for planning paths of total coverage. A 2D map of the environment is assumed to be known while cleaning. The 2D map is 1st generated by the system itself using the dead reckoning algorithm. The system exclusively relies on simulations aiming at providing accurate readings that could be evaluated and implemented on a future commercial vacuum cleaner.The empty space to be cleaned is represented by a 2D map, where the border and all the objects are represented, in a global frame, by the set of vertices that define the closed 2D polygon of the corresponding contour. Although it is required that all the identified obstacles in the cleaning area are represented on the map beforehand, the path tracking control copes with unexpected obstacles. For a satisfactory coverage of the entire space, neighbour paths are required to have an overlapping area. Sequences of maneuvers consisting of a predefined number of line segments and arcs will be employed to generate the total coverage path. Each elementary path type is denoted as a template, the total path being a sequence of templates. The redundancy introduced by the overlap of parallel paths of successive templates will account for the error in rotation that exists during turns and for other navigation errors. All templates take into consideration the parameters of the robot such as the minimum turning.

II. SYSTEM DESIGN

The proposed general working of the automated cleaner is shown in the figure 2.1.

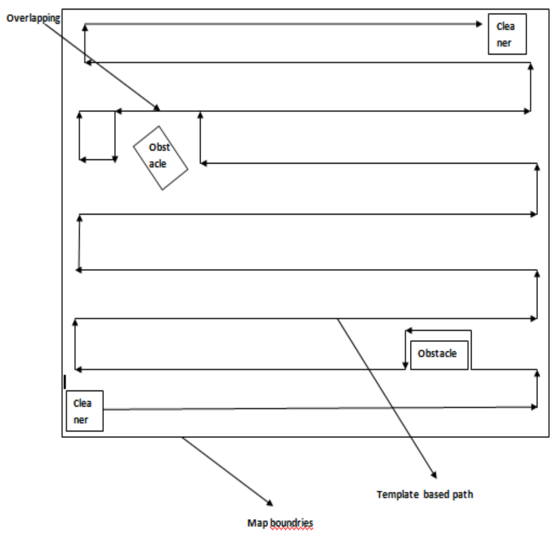

Figure 2.1

The detailed working of the automated cleaner is discussed in the following phases.

1. Map Generation Module

It is responsible to generate a map of an unidentified environment. This is accomplished by characterizing a step size based on the circumference of the wheels of the automated bot. The displacement of the cleaner is traced and respective coordinates generated on completion of a step. In the course of a turn, the angular rotation is documented and the co-ordinates are revised in the map accordingly. The algorithm used is the dead reckoning algorithm [2]. The flow of the algorithm is specified in the figure 2.2

2. Average Coverage Module

It is responsible for covering the entire ground for cleaning. The templates are generated throughout the supervised learning phase of the cleaner and then proceeds to these predefined templates during the cleaning phase.

3. Obstacle Avoidance Module

It is responsible to create an alternate path when an obstacle is encountered. Primarily the obstacles are mapped for the period of the supervised learning phase while the generation on templates and subsequently an alternate path is chosen if an obstacle is encountered. Apart from the static objects that are mapped during the training phase, the cleaner is furthermore able to avoid dynamic and moving objects. The flow of static obstacle avoidance is shown in the fig 2.3.

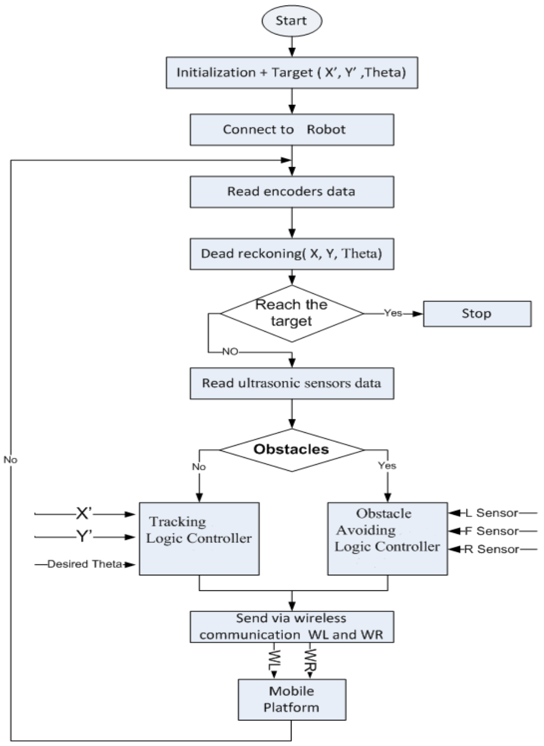

Fig 2.2 Dead Reckoning Flowchart for Step Calculation

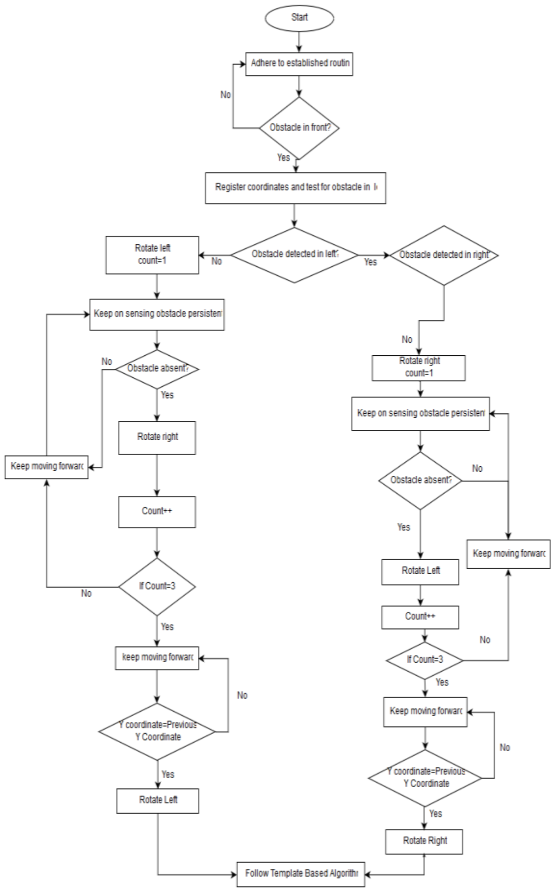

Fig 2.3 Static obstacle avoidance Algorithm

The entire flow of the system is shown with the help of a data-flow-diagram shown in the figure 2.4.

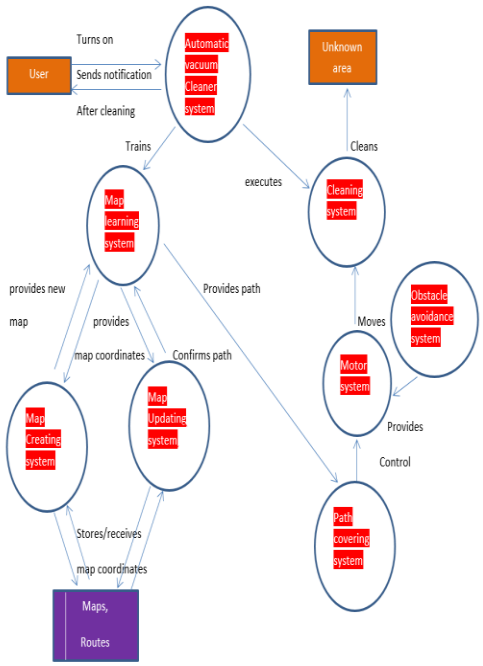

Fig 2.4 Data Flow Diagram (Level 2)

III. RESULTS

The proposed algorithms were assessed and evaluated with respect to quality, performance and reliability using programs developed in java with aims to simulate the actual conditions on the respective platforms for the desktop simulation and developed android app (for mobile simulation) to compute their average efficiency irrespective of the platforms.

The map generation algorithm was analysed before implementation making practical and effective use of the dead reckoning algorithm[2]. Following the generation of the map boundaries and their realization, the template based area coverage algorithm[1] was examined for efficiency.

Both the algorithms were tested in desktop as well as the android simulator. As shown in the fig 3.1 &3.2, the map co-ordinates are generated along the boundaries of an unknown area using the dead reckoning algorithm. Followed by the usage template centered approach which is used to cover the floor and detect obstacles in the same area with the newly generated boundaries as shown in fig. 3.1 & 2.2.

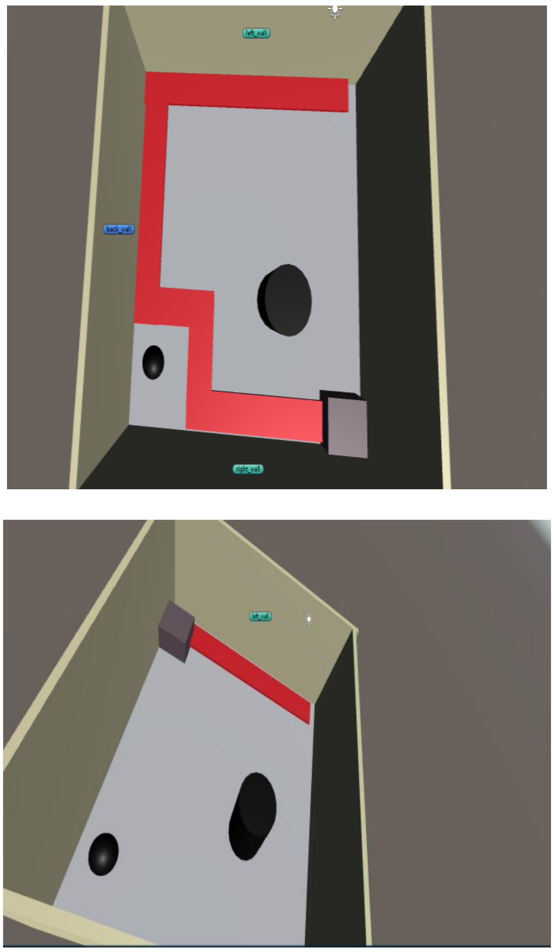

Fig 3.1 Generation of map boundaries using dead reckoning algorithm (Desktop simulator).

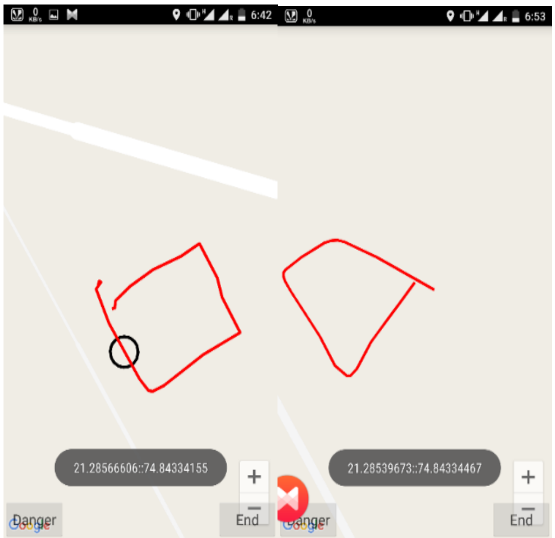

Fig 3.2 Generation of map boundaries using dead reckoning algorithm (Android app).

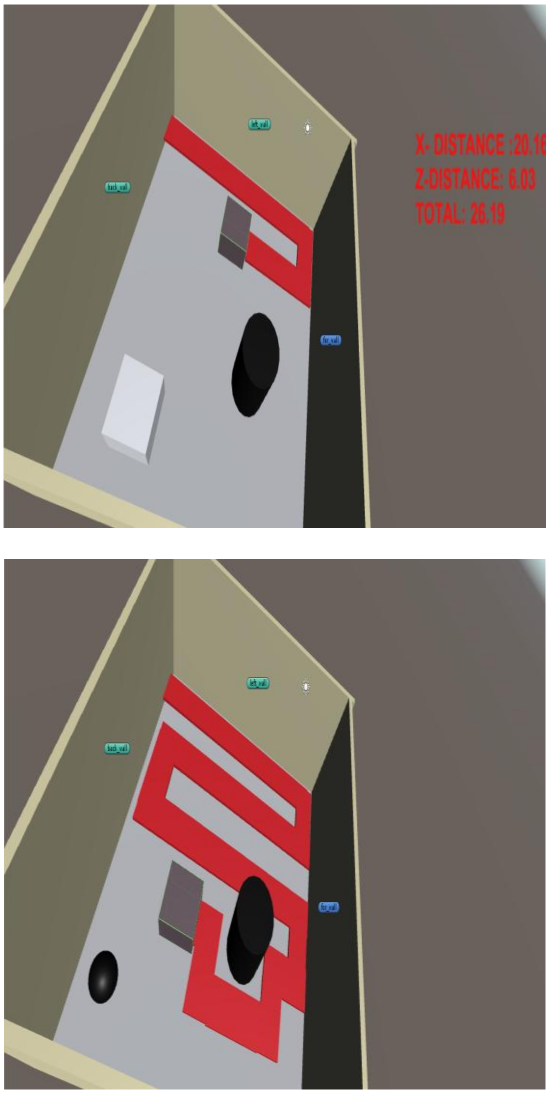

Fig 3.3 Area coverage using the template based algorithm (Desktop Simulator).

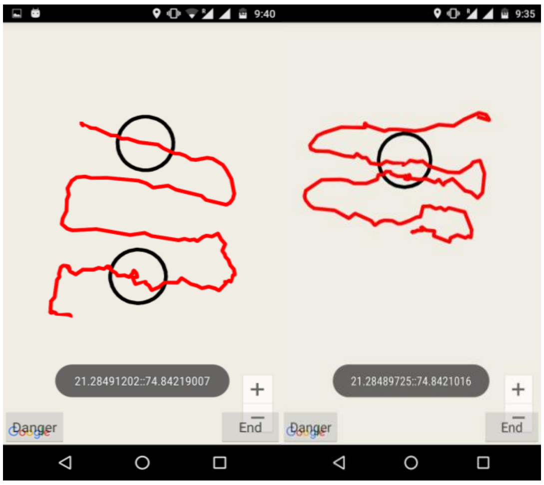

Fig 3.4 Area coverage using the template based algorithm (Android app).

IV. CONCLUSIONS

The model proposed above is extremely efficient in automated cleaning providing an assortment of features like remote operation and automatic map generation and updating map for of an unknown environment.

Over and above that, it traverses the entire area to be cleaned, discounting minor areas which were left uncovered. However, it is restricted to the environmental conditions inclusive of the category and basic features such as static or dynamic nature of obstacles in addition to the shape of the cleaning area.

In order to start the cleaner during training phase, it is under an obligation to be placed at a fixed position (i.e. corner of the room).

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