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COVERAGE PERFORMANCE ANALYSIS OF AN AUTONOMOUS SALOON CLEANING ROBOT

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Abstract: *This paper presents the coverage performance of newly developed robot which has been designed to clean the floor around/near the barber's chair in a saloon. An efficient cleaning is a desirable characteristic of cleaning service robots. This paper includes the schematics, scheduling algorithm, vacuum suction ability and trajectory concept of the robot. The coverage performance analysis suggested the optimization of mobility in the last section of the paper.*
Key words*: service robot, cleaning robot, scheduling algorithm, coverage performance*

1. INTRODUCTION

Human friendly service robots such as personal robots, home service robots, cleaning robots, entertainment robots have taken great attention in order to create new markets for robots since the markets for conventional industrial robots are saturating. It is a step to change the working environments of robots from industries to homes and offices, and to extend markets for robots from industrial markets to commercial home appliance markets. In order to provide efficient cleaning services in autonomous robots, path planning constraints and natural interface between the robots and human beings is essential and there have been proposed several research results on such applications (Betke, M. et al.,1997; Seop Oh et al., 2003). The most desirable characteristic for such cleaning robots are to provide best coverage performance, combine the knowledge of a smooth drive control, obstruction handling and a synchronized cleaning mechanism. However, commercially available robots as the *Roomba* by iRobot, *RC3000* by Karcher, and *Trilobite* by Electrolux are based fully or partially on random decisions or random path-planning. The main objective of this work is to evaluate the coverage performance of the mobile cleaning service robot and to provide optimal cleaning solutions. The proposed system has been designed to work autonomously in particular area near the barber chair as shown in Fig. 1.

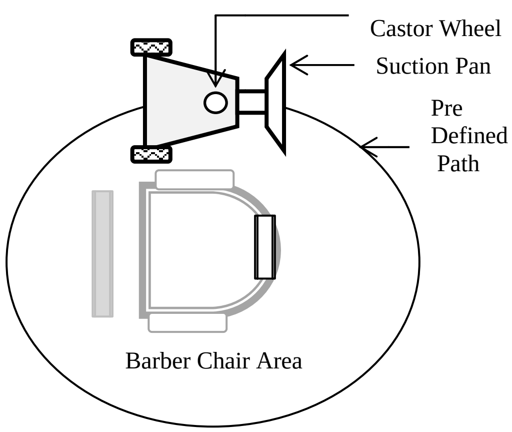

Fig. 1. Schematics of robot

2. ROBOT SCHEDULING ALGORITHM AND SCHEMATICS

The main objective of this work is to prepare scheduling algorithm and to evaluate the coverage performance of an actual cleaning robot. The robot scheduling and its trajectory determination is based on line following technique developed by programming a microcontroller as per the logic developed for the light sensors to sense the pre-defined path (white or black strip). Floor cleaning in a particular environment seems to be a natural task for a mobile robot although complete coverage of the floor faces certain problems: the hindrances and errors accumulated due to various parts of the robot performing movement. Along with its ability to follow a pre-defined path, the robot is capable of sensing obstacles on its path like human beings or any other mechanical obstruction. The schematic of the algorithm is given in fig. 2. The front of the robot is fitted with contact sensors which are used for collision detection. The robot has redundant sensors to detect collisions: a very sensitive frontal collision area, interrupt generating circuitry for the microcontroller, and motor current monitoring. Robot mobility is another important issue along with its scheduling. The mobile part of the robot should be able to support its weight and maintain stability while the robot is in operating mode (Palacin, J. et al., 2003). The schematics show that on facing an obstacle it waits for its clearance for duration of given the given delay.

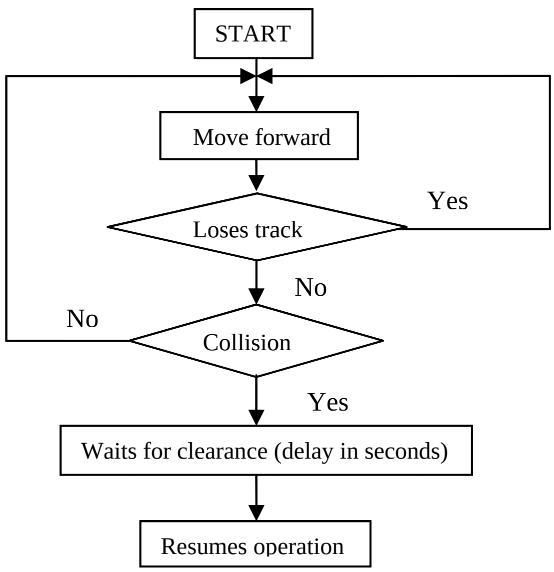

Fig. 2. Scheduling Algorithm of the mobile robot

3. COVERAGE PERFORMANCE

The coverage performance of the robot has been analyzed assuming that the cleaning area is obstacle free and is devoid of any sort of obstruction. The suction pump used in this autonomous robot is quite similar to an ordinary domestic vacuum cleaning unit. The suction depends on the maximum pressure difference that the pump can create. A typical domestic model has a suction of about negative 20 kPa.

The first step in the analysis is to obtain the effective area that the robot will cover while following the pre-defined path meant to be cleaned. Various path planning considerations can be considered. The effective area that comes under the cleaning hose in any directional sweep has been determined by simple mathematical calculations. The width of the hose in this particular case is about 15cm and the path length is varying, depending upon the design and requirement of the cleaning scenario. S. X. Yang et. al. concluded that the effectiveness of cleaning depends upon the linear velocity of the robot and the nature of the environment (Yang et al., 2003). In first experiment it is found that the robot must move on optimal speed so that vacuum suction operation is accomplished smoothly. The optimization has been computed after performing series of such experiments. It has been analyzed that the normalized speed for effective cleaning operation is about 0.1m/s. It has been accomplished that its catchment area that comes along the path varies as per the robot trajectory. Running at a normalized speed, the minimum area cleaned for a linear drive and goes on increasing as undulations are introduced in the track. Further the cleaning characteristics have been evaluated by running it both on a linear as well as for a zigzag path. The characteristic graph has been plotted between the linear displacement and the area swept by the robot from the starting point is given in fig. 4.

Fig. 3. Robot working in a saloon

4. CONCLUSION

In this work coverage performance of a vacuum cleaning robot using line following technique in a robot has been studied. The analysis of cleaning ability of the mobile robot suggests that it is better to represent the cleaned area against displacement of the robot rather than using an area-time scale as it gives a better comparison with other mobile cleaning robots.

The results show that making the mobile robot to follow a pre-defined path gives more accurate cleaning performance and moreover the coverage performance can be enhanced by modifying the robot trajectory as per requirement. It is also concluded that a zigzag path provides greater catchment area to the mobile robot.

The developed robot if given a commercial touch could prove to be of great usage as compared to other mobile cleaning robots based on following a random path in a particular cleaning area.

This autonomous robot can be taken a step ahead by equipping the developed robot with an automatic sensor selection mechanism. Research in this field is proposed such that obstacle sensing works on sensors based on infrared radiations other than contact sensors when light in surroundings is insufficient.

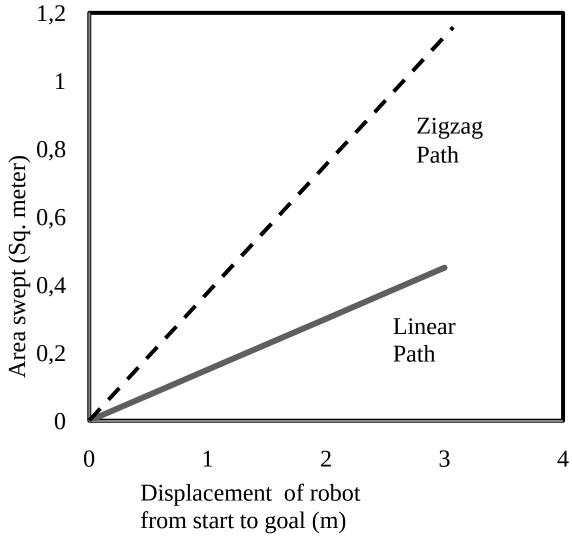

Fig. 4. Area swept by the robot on two different paths

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