Autonomous Lavatory Cleaning System

Arun Kumar C *carunkumar_1994@yahoo.co.in*
ECE Department
SSN College of Engineering
Chennai,600017,India

Adithya Bharadwaj A *adibharadwaj13@gmail.com*
ECE Department
SSN College of Engineering
Chennai,600017,India

Balasubramanian R *b.ramesh07@live.com*
ECE Department
SSN College of Engineering
Chennai,600017,India

Gowtham P *gowthamp151@gmail.com*
ECE Department
SSN College of Engineering
Chennai,600017,India

Abstract

The application of integrated robotics is becoming increasingly commonplace in day to day applications. The idea presented in this paper seeks to provide a convenient and a hassle-free means of cleaning public toilets whilst maintaining hygienic and sanitary standards. By using a counter to record the number of times of usage, a line follower mechanism to guide the robot and an RFID module to initiate the auto-flushing, the cleaning operation is fully automated and requires low operational power. Furthermore, a robotic arm is part of the module, so as to thoroughly clean the toilet bowl. Such a provision will curtail the role of manpower in maintenance of public toilets to a great degree, and thus, serves as a win-win situation; a revolting objective is accomplished with considerable ease.

Keywords: Line Follower, RFID Module, Auto-flushing, Low Operational Power, Robotic Arm.

1. INTRODUCTION

Urban sanitation is of prime importance in today's society and there exist a number of obstacles that need to be conquered. An easy to implement, yet effective method to facilitate the preservation of hygienic standards would be a welcome idea, and help overcome the various hurdles faced, such as human reluctance to engage in such a task. With this in mind, a viable idea would be to design a robot that is fully automated in functioning is competent in performance. Other considerations include ease of operation, power requirements and financial effectiveness. Using a low power microcontroller and a simple yet adequate line follower robot, this idea is very much practically realizable.

2. COMPARATIVE STUDY

In the present day scenario, there are a host of robots that aid us in domestic cleaning, which are similar to the one proposed in this paper. For instance, the 'Roomba' by iRobot Corporation is a home cleaner which incorporates vacuum cleaning techniques. While both the Roomba and the Autonomous Lavatory Cleaning System(ALCS) share the same purpose of indoor cleaning, they employ vastly different cleaning methods. Unlike the Roomba, ALCS has an approach that can be termed as targeted. Hence it has a more explicit path which enables it to adopt a simpler traversal algorithm. This reduction in complexity facilitates ALCS' low power operation. The presence of RF sensing technique also makes the cleaning action of ALCS more precise. The cleaning robot presented in [N] is another one of the existing systems to perform the task under study. This robot and ALCS share many design features. But the ALCS utilizes a cubicle selection algorithm which eliminates redundancies and paves way for a more concentrated and efficient cleaning approach. The operation of toilet cleaning being integrated into a mobile, self-operational robot is something that has not been attempted before and is what makes this system unique. On the whole, by improving upon existing concepts and by incorporating new features, the Automatic Lavatory Cleaning System becomes a highly effective and utilitarian system.

3. RELATED WORKS

The concept of using a robot for the purpose of sanitation can draw many parallels to present day technologies: robots are now used to serve a range of purposes, such as firefighting, dishwashingand search and rescue missions, to name some. At present, the cleaning process is entirely manual and not very productive. There exist very few methods similar to the one proposed.

4. IMPLEMENTATION

The robot is realized with the help of two microcontroller units (both MSP430).The first one (referred to asMCU-1) is present on the robot and helps in the movement and cleaning action of the robot. The second MCU (referred to asMCU-2) is interfaced with all the 4 cubicles and helps keep track of the counters. To initiate the cleaning mechanism once the robot reaches the desired cubicle, an RFID module is used. The robot is powered by a 12V DC battery and each of the MCUs by independent 5V sources. The components are assembled as shown in the block diagram in Figure1.

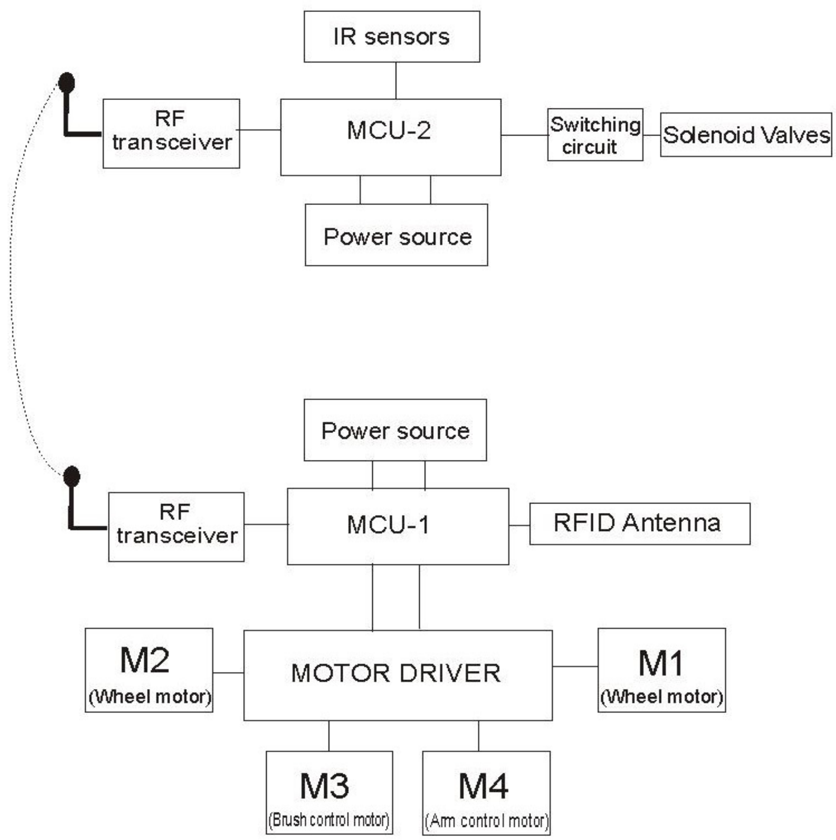

FIGURE 1: Block Diagram.

The working of this robot can be split into four modules as follows:

4.1 Module 1: Cubicle Selection

The cubicle to be cleaned is selected based on the frequency of usage of that cubicle. The number of people visiting a particular cubicle is sensed by an infrared transmitter- receiver pair which is placed at the doorway. Whenever a person enters a cubicle, he crosses this infrared sensor, causing it to become low .In all such instances, the counter corresponding to that cubicle is incremented. All such infrared sensors installed in each of the doorways are interfaced with an MSP430 MCU [1][2]. The MCU-2 monitors the counter values and when one (or more) of the counters becomes greater than or equal to 5,it sends the information regarding that cubicle to the robot (MCU-1) via an RF transmission module. When more than one counter value becomes greater than or equal to 5, then the cubicle with the largest count value is selected. If more than one counter has the largest value, then one of those cubicles is selected at random.Afterthe cubicle is selected,its counter value is reset to zero.

4.2 Module 2: Locomotion

The path from the starting point to each of the cubicles is laid as shown in Figure 2. Based on the data received from MCU-2, the cubicle and its corresponding path are chosen.The robot uses line follower technique [3] to travel in the selected path. The robot has three wheels, two of which are connected to two 12-V DC motors (motor-1 and motor-2).The third wheel is a free wheel. These DC motors are interfaced with MCU-1.By controlling the two motors,the robot can be made to move forwards,backwards,left or right. The path is a black line of thickness 5cm.The robot has 7 infrared sensors on its face. When a sensor faces the black line,it sends a low output. Based on the data received from all the seven sensors, the robot is calibrated and is prevented from digressing. The robot senses the starting/ending point when all its seven sensors go low. Based on the path chosen, the robot makes a call on what turn to take at intersections. For example, if the path chosen is ‘Path II’, then the robot takes a left turn on the first intersection and a right turn on the second. By this procedure, the robot reaches the desired cubicle.

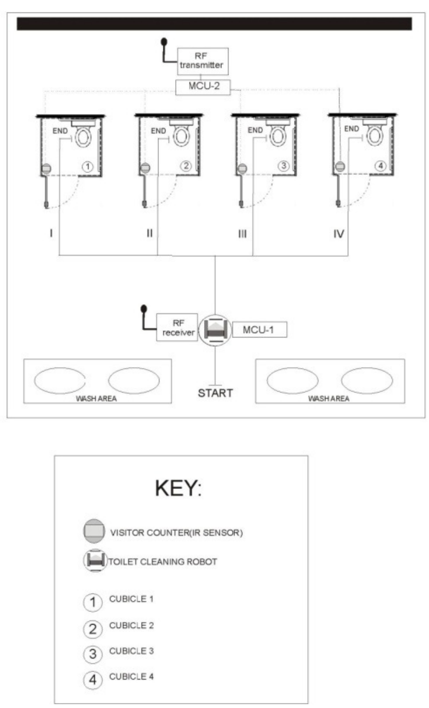

FIGURE 2: Locomotion Sequence.

4.3 Module 3: Cleaning Action

Once the robot reaches the destination it initiates the cleaning sequence. An RFID sensing antenna is affixed onto the robot; this senses the RFID tag placed on the toilet bowl, so as to trigger timers T1 and T2 simultaneously, associated with microcontrollers MCU-1 and MCU-2 respectively. Once the timers are triggered, the cleaning procedure is initiated, as explained below

- The toilet is automatically flushed with the help of a solenoid valve connected to the water supply (interfaced with MCU-2)[4].
- The arm containing the brush is lowered with the help of a 12-V DC motor (motor-3).
- A cleaning liquid is dispensed into the walls of the closet and the axel containing the brushes is rotated using motor 4(12V-DC) to perform cleaning. This action happens for 35 seconds.
- After 35 seconds, the brush is removed and the toilet is automatically flushed again[4].
- The brush is again lowered into the toilet and rotated for 25 seconds to perform thorough cleaning.
- After 25 seconds, the brush is removed and the toilet is flushed again.

Upon the completion of the above six steps, the timer runs out indicating the end of the cleaning action. The counter for this particular cubicle is made zero.

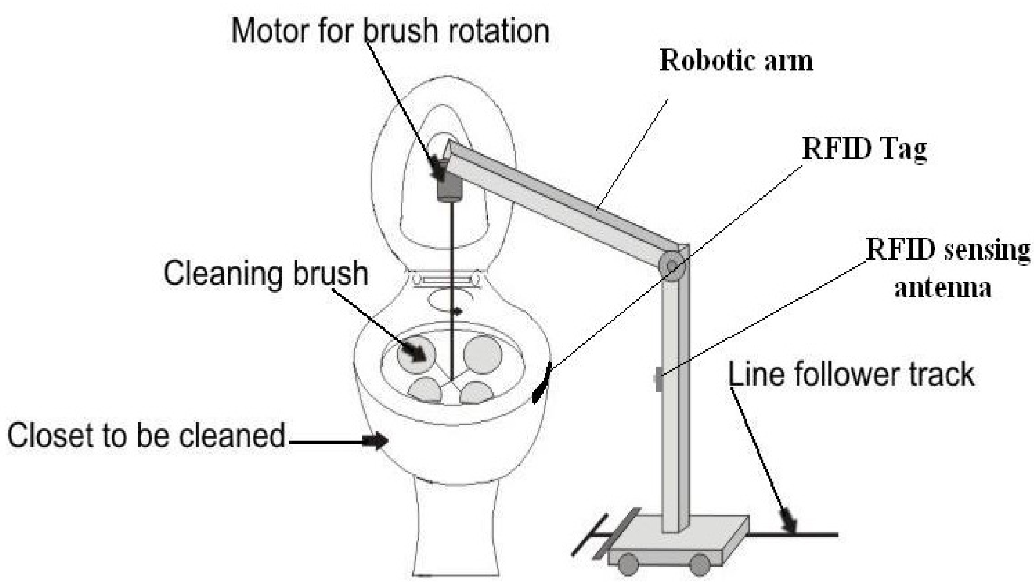

FIGURE 3: Cleaning Mechanism.

4.4 Module 4: Go Back and Repeat

After the cleaning action is completed, the robot turns around and traces its path back to its initial position.

The above process is repeated for as long as the robot is active.

The systematic working of the above modules can be pictorially represented using a flowchart as follows:

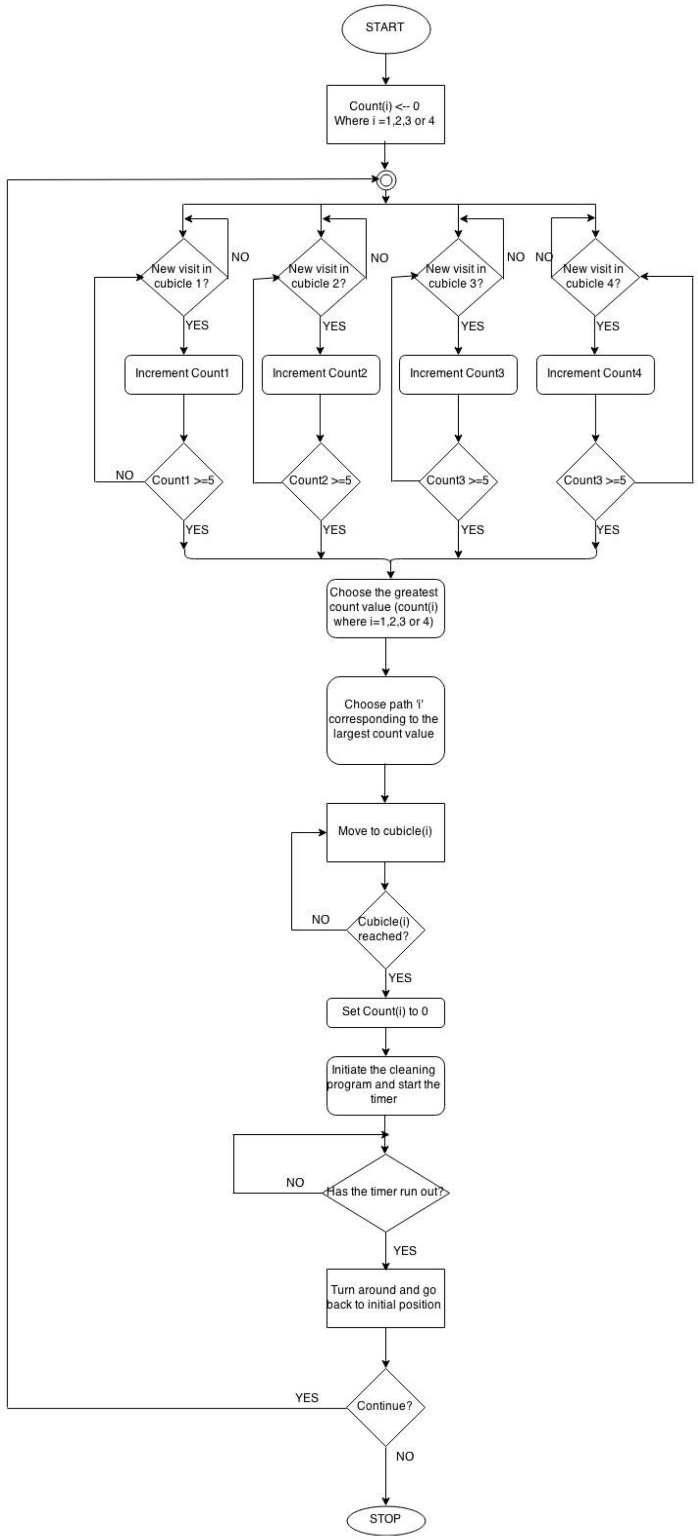

FIGURE 4: Flow of Control.

5. FUTURE ADVANCEMENTS

After the robot is implemented successfully, it can be improved by adding other cleaning modules to focus on other parts of a bathroom, such as the wash basins and walls. This added feature will serve to make the robot a commercial commodity and it can be sold as a wholesome package to substitute manual cleaning of restrooms.

6. ADVANTAGES

i) Low power and cost effective modules:
The MSP 430 used consumes low power and is highly cost effective compared to the higher end ATMEGA controllers used in Arduino platform.

ii) Highly automated system:
The human element in the system is minimized to the level of the sporadic cleaning of the brushes and refilling of the cleaning liquid.

iii) Implementing RFID module is highly beneficial in a number of ways; it is cost effective and does not require a line-of-sight communication, possesses high speeds of operation and is best suited in tough environments.

7. CONCLUSION

The Autonomous Lavatory Cleaning System proposed can greatly eliminate the extent of manual labor involved in the process of maintaining sanitary standards. With municipalities moving towards solutions which can ameliorate the existing problems while being cost effective, this system directly addresses actual concerns and seeks to provide an optimal solution. It can be deployed for cleaning toilets in households, public restrooms and restrooms in malls, stadiums, and supermarkets. Furthermore, it can be used for upholding standards of hygiene in trains and airplanes, where it bears prime importance. The growing emphasis on smart cities and environment friendly alternatives necessitate a technologically competent means of combating the problem of cleaning restrooms and the Autonomous Lavatory Cleaning System seeks to achieve exactly the same.

8. REFERENCES

[1] J.H.Davies.*MSP430 Microcontroller Basics*. Newnes: Butterworth-Heinemann Ltd, 2008, pp. 146-382.

[2] P.D. Gasper, A.E. Santo, B. Ribeiro. “MSP430 microcontrollers essentials - A new approach for embedded systems courses: Part 1 – Overview and tools,” in Proc. Education and Research Conference (EDERC), 2010, pp. 66-70.

[3] M.E.Islam. Design and Fabrication of a Line Follower Robot.LAP LAMBERT Academic Publishing, 2011, pp. 25-65.

[4] S.M. Ashiq. K. Karthikeyan, S. Karthikeyan (2013, Feb.). “Electrical Fabrication of Semi Automated Pressurized Flushing System in Indian Railway Toilet.”International Journal of Engineering and Advanced Technology (IJEAT). [On-line]. 2(3), pp. 778-998. Available: http://www.ijeat.org/attachments/File/v2i3/C1077022313.pdf [Aug. 15, 2015].

[5] D. Kokvin, G.Sziebig, W.D. Solvang. “Design of a Robotic Arm for Automatic cleaning of cargo containers”, presented at the 4th International Conference on Cognitive Infocommunications (CogInfoCom),Budapest, Hungary, 2013.

[6] I. Matijevics. “Infrared Sensors Microcontroller Interface system for Mobile Robots”, presented at the5th International Symposium on Intelligent Systems and Informatics, Subotica, Hungary, 2007.

[7] P. Shukla. S.L. Shimi. (2014, Sept.). “Design Of Inspection And Cleaning Robot”International Journal of Scientific Research Engineering & Technology (IJSRET). [On-line]. 3(6), pp. 970-975. Available:http://www.ijsret.org/pdf/120795.pdf[Aug. 20, 2015].

[8] H. Park. S.Baek, S. Lee.“IR sensor array for mobile robot”, presented at the International Conference onAdvanced Intelligent Mechatronics,Monterey, USA, 2005.

[9] C.H. King, T.L. Chen, A. Jain, C.C. Kemp. “Towards an Assistive Robot that Autonomously Performs Bed Baths for Patient Hygiene”. Internet:https://www.hsi.gatech.edu/hrl/pdf/iros10_auto_clean.pdf, Oct. 25, 2011 [Aug. 29, 2015].

[10] C. Hongakkaraphan. C. Beokhaimook. P. Nilkhet. “Investigation on Detection Accuracy of RFID tags on back-to-back queuing objects”, presented at theAsian Conference on Defense Technology,Hua Hin, Thailand, 2015.