International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-4, February 2020

Effective Aquatic Waste Removal through Lake Cleaning Robot for Smart city Environment

S. Arun Kumar, S. Sasikala

Abstract*: Water sources are contaminated by garbage, weeds and plastic wastes. Effective waste removal in the water sources such as lakes, ponds and rivers is essential for waste management and control. In Indian setting, Aquatic waste management and control is of main concern for implementing smart city and achieving clean India mission. Therefore the proposed work, aims at developing intelligent solution towards automating the waste removal in lakes. Lake cleaning robot system for removing the surface wastes is experimented in this work. This lake cleaning system uses Raspberry Pi along with proximity sensors for detection and DC motors for movement. Raspberry pi controls the movement of the robot along with gripper, motors, ultrasonic sensor and IR sensor. The working prototype model of the proposed system exhibits good accuracy with reduced computational time. Henceforth, the developed lake cleaning robot could be used towards reducing water pollution through efficient waste removal for implementing smart city environment.

Keywords: Garbage control, intelligent Trash, Lake cleaning robot , Raspberry pi, smart city.

I. INTRODUCTION

Water is an important natural resource vital for all forms of life in this planet. Despite of having blessed with enormous amount of water, water pollution is a major crisis in many countries. As per 'Water aid', an organization striving towards attaining fulfillment in hygiene and water sanitation has reported that 80% of the India's water sources are polluted. Water bodies are being polluted by floating garbage, weeds, debris plastic, sewage, effluents, toxic materials from industries. Water pollution with floating garbage is a serious issue needs immediate attention in developing countries.

In Indian context, the union government is keen on projects such as 'Swachh Bharat' and 'Smart city' for achieving Clean and Smart India mission [1]. Further projects like 'Namami Gange', 'Narmada Bachao' focus towards rejuvenation of rivers through effective pollution control and management. River surface cleaning, to remove the solid floating waste is one of the prime objective of the above projects. Indian government has invested enormous amount towards river cleaning project.

Revised Manuscript Received on February 28, 2020.
***** Correspondence Author
S. Arun kumar*, Department of Electronics and Communication Engineering, Kumaraguru College of technology, Coimbatore-49, Tamilnadu, India. Email: arunkumar.s.ece@kct.ac.in
S. Sasikala, Department of Electronics and Communication Engineering, Kumaraguru College of technology, Coimbatore-49, Tamilnadu, India. Email: sasikala.s.ece@kct.ac.in

As per the statistics of Central Pollution Control Board (CPCB) [2], there has been a significant rise in water pollution in water bodies over the past few years. Furthermore, the water quality index also claims that the river water is unfit for bathing, drinking and fishing.

An article in 'The Hindu' titled 'Cleaning up the Cauvery' [3], describes the importance of rejuvenation of the river which is being contaminated by floating wastes and plastics. A report published in a newspaper [4] states that, the state of Indian rivers are bad and worsening, owing to high levels of pollution. As a result biological oxygen demand has dropped beyond the required limits. The current scenario of indian rivers, calls for nationwide strategy for cleaning rivers.

Manual cleaning of water bodies is inefficient, time consuming, laborious and expensive. In addition, health and hygiene of the laborers doing manual cleaning becomes severely affected. Health impacts also include musculoskeletal, intestinal and vector borne diseases in addition to injuries caused as a result of work related accidents. This demands techniques, to automate the existing infrastructure for river surface cleaning, at low cost with minimal hardware used by layman and general public.

Hence to overcome this major problem of waste collection Lake Cleaning Robot is developed. This project aims to provide automatic control to collect the garbage. This lake cleaning system uses Raspberry Pi along with proximity sensors for detection and DC motors for movement. When the sensor detects static obstacle, the rotating blades start and the garbage is pushed into a bin which is placed right behind the mechanism. The performance of the baseline prototype model of the proposed system tested in a real time emulated environment, justifies the use of lake cleaning robot towards control and management of aquatic waste.

The significant contributions in this work are:

1. To collect nonliving garbage wastes from water bodies through lake cleaning robot.
2. To provide a cost effective embedded system based solution for river surface cleaning and garbage dissemination.
3. Towards improving the efficacy of aquatic waste management and control, thereby achieving smart city and clean India mission objectives.

The proposed lake cleaning robot is tested on a real time prototype by emulating a similar test environment.

The paper is structured as follows: Section II reviews existing works in literature. Section III describes the methodology employed.

Section IV presents the experimental results and discussion. Section V focuses on conclusion and future scope of the proposed work.

II. RELATED WORKS

Many works in literature have focused on building embedded systems for ensuring safe [5] and clean India mission [6-14].

Towards achieving Smart city mission in India, a smart E-dustbin has been designed in [6]. IoT based solution was proposed for monitoring the status of the dustbin and e-mail notification is sent to the user.

In [7] an automatic robot was designed for garbage collection in water bodies. A robot was implemented using AT- MEGA 16 micro controller with DC and servo motors and sensors. Testing was done on all the modules to check the effectiveness of the proposed robot.

A metallic waste collection robot was proposed in [8] for automating waste removal in factories. An end to end robotic system was developed using Arduino Mega micro controller interfaced with sensors and actuators. Grippers, motors, wheels and chassis are used for locomotion of the robot. Object detection and sensing is done using IR and ultrasonic sensor.

An Automatic garbage segregation robot to classify waste was developed in [9]. Image processing is employed to classify the wastes into degradable/bio-degradable, followed by which the robot dumps the waste into the specific bin. Software implementation is done using MATLAB and the robot is programmed using PIC micro controller supported with motors, relay circuits and sensor.

A remote controller based sewage cleaning embedded system is done using Radio Frequency (RF) transmitter and receiver modules in conjunction with relays, switches, motors and a metallic casing setup [10].

A multi robot aquatic system for lake cleaning using various sensors and communication technology was proposed in [11]. The robot is autonomous and traverses the path and collects the waste using recruitment navigation algorithm. The proposed algorithm is tested on simulation for varying lake sizes using C++ Enki robotic library and MATLAB.

A low cost automation framework for cleaning river surface using RF Transmitter and receiver is experimented in [12]. A Computer Aided Design (CAD) model of river cleaning machine is simulated using motors, collecting plates, chain drives and conveyer belt. Furthermore, a clear requirement specification for the proposed CAD model is also explained in detail.

A mechanical model for drainage system cleaning using propeller, cleaner, belt drives and pan is proposed in [13]. The system was tested on rainy days in three different months to evaluate the effectiveness of the developed system. The system performed to a considerable extent in all possible test conditions.

A pedal operated boat to clean the surface wastes and debris is described in [14]. The setup consists of a pedal operated boat with propellers attached to the shaft and conveyer belt for collecting the wastes. A prototype model with design specifications is also explained.

III. METHODOLOGY

A. Hardware architecture

The architecture of the proposed lake cleaning robot for surface cleaning and waste removal is shown in Fig 1. The proposed hardware architecture consists of a Raspberry pi 3 board, that control the movement of the robot along with gripper, motors, ultrasonic sensor and IR sensor. The sensors and hardware modules used in the lake cleaning robot is specified in Table I. Raspberry pi 3 is a miniaturized computer with processor, memory and input/output ports and associated peripherals capable of performing the tasks as a functional computer.

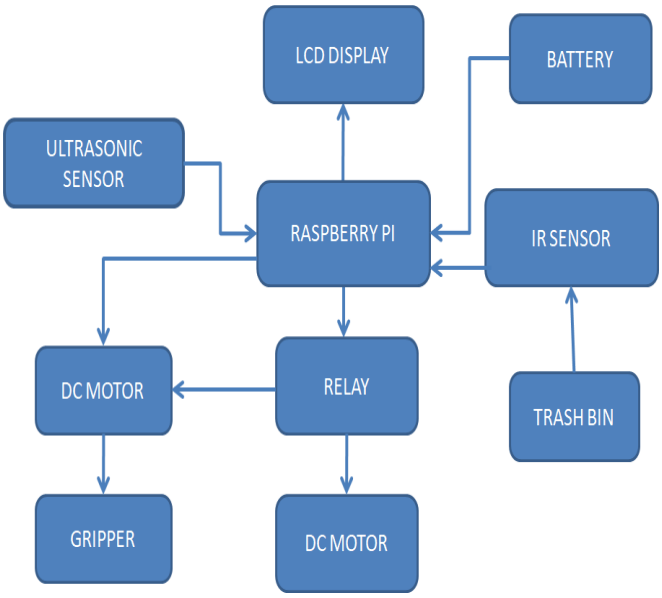

Fig. 1: Hardware architecture of Lake cleaning Robot

B. Principle of Operation

The Lake Cleaning System robot can travel in water with the help of DC motors connected to Raspberry Pi. The robot consists of two DC motors of 30 rpm each, relay, ultrasonic sensor, gripper, IR sensor, 6V battery, trash bin and transistor. The motors are connected to the Raspberry Pi through the relay which helps in the movement of the robot. The speed of the motor is kept at nominal value to get proper movement.The ultrasonic sensor which is connected to the Raspberry Pi is used for the detection of objects when the robot moves on the water surface. The output from the sensor acts as the input for the gripper. This gripper is mounted on the front side of the base with an appropriate ground clearance. After receiving the input from the ultrasonic sensor, the gripper picks up the object after a delay. This gives time for the living organisms like fish to escape. The garbage collected by the gripper is now pushed into a bin which is placed right behind the mechanism.

The robot continues to collect the garbage until a certain height of the bin is reached.

The IR sensor in the bin detects the level of the collected garbage and sends the information back to Raspberry Pi. The collected garbage is then disposed manually in a particular place.

TABLE I: Hardware Modules used

Component Name	Purpose
Raspberry Pi 3	Main minicomputer board.
Ultrasonic Sensor	To detect objects during the movement.
DC motors/Chassis	To help the movement of the robot and the gripper.
Gripper	To pick the surface wastes and garbage in lake.
IR sensor	To detect the waste limit in the trash bin.
LCD 16 x 2	To display messages or warnings.
Trash bin	To collect the wastes.
Relay	To change the state or movement of DC motors.
Power supply	Battery source for powering the robot

C. Workflow of the Algorithm in Lake Cleaning Robot

The algorithm used in proposed Lake Cleaning Robot is discussed in this section. In Fig 2, the workflow used in the work is clearly explained through a flowchart.

1) STEP 1 : Start
2) STEP 2 : Import the main function from the GPIO pins.
3) STEP 3 : The timing constants for the delay of the gripper and rotational motor are specified.
4) STEP 4 : The GPIO Broadcom mode is set. This mode involves ARM architecture.
5) STEP 5 : The input and the output pins are setup.
6) STEP 6 : Initially the relay is OFF.
7) STEP 7 : The message is displayed on the LCD and the process enters the while loop.
8) STEP 8 : The ultrasonic sensor detects the object, then the Raspberry pi measures the distance and displays on the LCD.
9) STEP 9 : After a delay of 1 second, it checks if the distance is less than 15 cm. If true, the LCD displays the message and the front motor stops.
10) STEP 10 : The gripper motor will start to open for 15 seconds. After a delay of 5 seconds, the gripper motor will close.
11) STEP 11 : The rotational motors will then start and stop after 2 seconds.
12) STEP 12 : The gripper motor again continues its process after a delay of 5 seconds followed by the rotational motor. Else, the front motor will continue to run.
13) STEP 13 : If IR sensor is low, 'Garbage Full' is displayed on the LCD.
14) STEP 14 : The LCD functions and the commands are specified. The distance functions are defined. It is used to call the messages from the ultrasonic sensor and return the values.
15) STEP 15 : End.

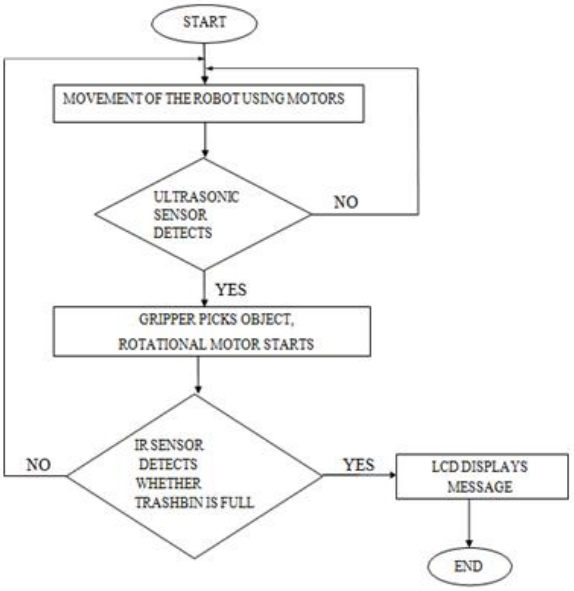

Fig. 2: Flowchart of the workflow of a Lake cleaning robot.

IV. RESULTS AND DISCUSSIONS

The operation of the developed prototype model of lake cleaning robot is explained in Fig 3-6. A test environment has been emulated to verify the working of the robot in all possible test conditions (robot movement, waste detection, waste picking, disposing the waste to bin).

In Fig 3, the gripper will start to open with a time lapse of 15 seconds. After a delay of 5 seconds, the gripper will close with the object. This closing process again occurs with a time lapse of 15 seconds.

The rotational motor attached to the gripper makes a turn of 45 degree in the anti-clockwise direction is depicted in Fig 4. Fig 5 shows the movement of the robot. The motor attached to the back of the gripper now makes a turn of 45 degree in the anti-clockwise direction. The gripper is now positioned right above the trash bin.

In Fig 6, the gripper releases the object after a delay of 5 seconds. After releasing the object, the rotational motor returns back to the original position.

The IR sensor attached above the trash bin gives the signal when the trash bin is full.

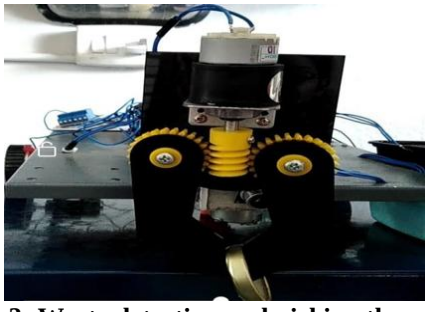

Fig. 3: Waste detection and picking the waste

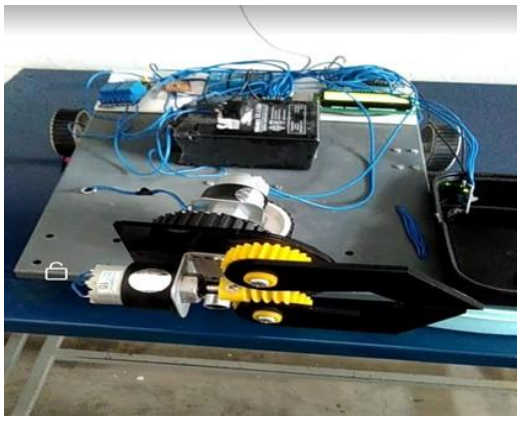

Fig. 4: Motor movement after picking the waste

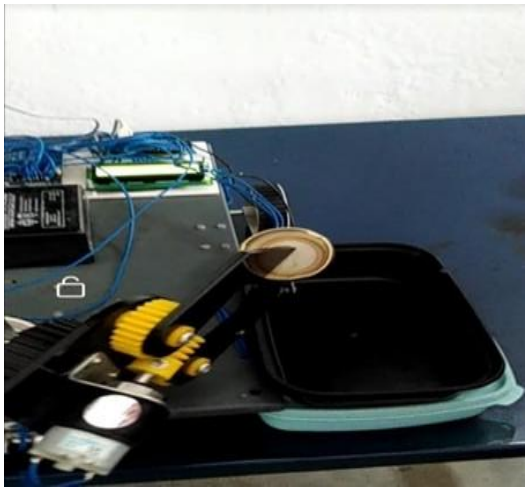

Fig. 5: Positioning of gripper in accordance to the trash bin

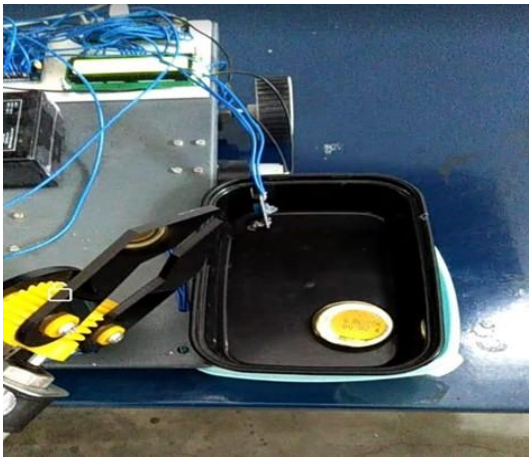

Fig. 6: Waste disposal into the trash bin

The prototype of the developed system exhibits good accuracy with less processing time and high speed for all possible test conditions. Henceforth, the proposed lake cleaning robot could be used for surface cleaning and waste removal in lakes with high degree of accuracy.

V. CONCLUSION AND FUTURE WORK

A lake cleaning robot to remove surface wastes and garbage is proposed in this work. The proposed hardware consists of a Raspberry pi 3 board to control the movement of the robot along with gripper, motors, ultrasonic sensor and IR sensor. The developed lake cleaning robot can be used in all lakes and other static water bodies to clean the plastic and other floating wastes. This helps in decreasing the water pollution and thus providing a balanced environment and ecosystem. The more developed future product can also be made to work in flowing waters. It will also help in creating a balanced aquatic population in the lakes and proper utilization of water resources.

Our future work focuses to improve the project by developing the robot to work in any waters bodies like rivers, oceans, etc. Furthermore, the use of image processing to differentiate the wastes as biodegradable and non-biodegradable may also be implemented in future. This will help to protect the aquatic animals, thus maintaining a balanced ecosystem. The project can be further improved by adding a GPS and wireless communication capabilities to give information to respective authority about the place where the wastes are being stored.

REFERENCES

1. Ministry of Jal Shakthi, Government of India (2019) URL: http://mowr.gov.in/schemes-projects-programmes/schemes/namami-gange (Accessed on 7/4/2019).
2. Vikas Dimble and Priyank Hirani "What Can We Do to Clean India's Polluted Rivers ? ", *News 18*, Web, November 2019.
3. Ramakrishnan T, "Cleaning up the Cauvery", *The Hindu*, Web, June 2019.
4. Kum Kum Dasgupta, "To clean rivers, Indian must learn to reduce waste", Hindustan times, Web, November 2019.
5. Kumar, S. Arun, and A. Kumaresan, "Towards building intelligent systems to enhance the child safety and security," in 2017 International Conference on Intelligent Computing and Control (I2C2). IEEE, 2017.
6. Kolhatkar, C., Joshi, B., Choudhari, P., Bhuva, D, " Smart E-dustbin," in 2018 International Conference on Smart City and Emerging Technology (ICSCET), pp. 1-3, IEEE, 2018.
7. Nurlansa, Osiany, Dewi Anisa Istiqomah, and Mahendra Astu Sanggha Pawitra, "AGATOR (automatic garbage collector) as automatic garbage collector robot model," in International Journal of Future Computer and Communication , Vol 3(5), pp.367, 2014 .
8. Nurlansa, Osiany, Dewi Anisa Istiqomah, and Mahendra Astu Sanggha Pawitra, "AGATOR (automatic garbage collector) as automatic garbage collector robot model," in International Journal of Future Computer and Communication , Vol 3(5), pp.367, 2014 .
9. Kannan, S. G., S. Sasi Kumar, R. Ragavan, and M. Balakrishnan"Automatic garbage separation robot using image processing technique," in International Journal of Scientific and Research Publications , Vol 6(4), pp.326-328, 2016.
10. Idhris, M. Mohamed, M. Elamparthi, C. Manoj Kumar, N. Nithyavathy, K. Suganeswaran, and S. Arunkumar, "Design and fabrication of remote controlled sewage cleaning Machine", in in International Journal of Engineering Trends and Technology (IJETT) ,Vol 45(2), March 2017.
11. Agrawal, Pranay, and Bishakh Bhattacharya, "Aquatic Multi-Robot System For Lake Cleaning," in Nature-Inspired Mobile Robotics, pp. 171-178. 2013.
12. Ballade, Abhijeet M., Vishal S. Garde, Akash S. Lahane, and P. V. Boob, "Design fabrication of river cleaning system," in International Journal of Modern trends in Engineering and research (IJMTER) , Vol 4(2), Feb 2017.
13. Daniels, Ndubuisi C. " Drainage System Cleaner A Solution to Environmental Hazards." International Refereed Journal of Engineering and Science (IRJES) 3, no. 3 (2014): 54-60.
14. Jogi, N. G., Akash Dambhare, Kundan Golekar, Akshay Giri, and Shub- ham Take, "Efficient Lake Garbage Collector By Using Pedal Operated Boat," in International Journal of Modern trends in Engineering and Research , Vol 2(4), pp.no 2455-2457, 2016.

AUTHORS PROFILE

S.Arun kumar is an Assistant Professor in Kumaraguru College of Technology. He has about 6 years of Industry and teaching experience and published around 10 papers in international journals and conferences. His area of interests include signal processing and Decision support systems using AI.

Dr.S.Sasikala is an Assosciate Professor in Kumaraguru College of Technology. She has about 20 years of teaching experience and published around 25 papers in international journals and conferences. Her area of interests include signal/Image processing and Biomedical systems.