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Hardware Modeling of Solar Energy Based Water Cleaning Robot

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ABSTRACT

The present paper describes the design and working of a robot for cleaning garbage floating on the water surface. Three important issues for designing the aquatic robots are a cost-effective solution along with robustness and durability. Due to the nature of the cleaning work, a vehicle structure has been designed that can provide high stability, good ability in maneuver and can easily collect all the waste flowing in between. For removal and collection of surface waste, a motor-driven collection conveyer system has been designed for collecting the wastes and redeploying it into a rectangular basket on the back. This design provides simple and effective waste removal and accommodates large amounts of waste within a small space. For the prototype, the body of boat is made up of PVC sheets. This light and tough structure support the total weight of the system. The propulsion system based on a D.C. motor drive mechanism has been designed, which allows the robot to take a 360 degree turn on the spot and provides high thrust. Electronic circuit and motors have been placed on top of the hull, in order to protect them from water. The robot is manually controlled based on mobile application. The testing of the robot prototype is proved to be effective in waste collecting and removal.

Keywords : Water Pollution, Boat, Solar Energy, PVC, Motors.

I. INTRODUCTION

Water is an important resource to survive on the earth, it covers over 70% of the earth's surface, amongst only 3% of that is drinkable water. Water is called a universal solvent that means it can dissolve most of the substances including toxic materials from factories, sewage, chemicals, etc. Because of this, water is completely polluted by human activities. The major problem that living organisms facing is water pollution which means the introduction of foreign materials into water bodies [1]. Waste is an environmental problem that always arises from year to year and still cannot be resolved entirely. It is frequently found that the garbage from various places is dumped into rivers, waterways, or reservoirs. The rubbish can clog the flow of water, causing water to become dirty and smelly so that it often overflows and causes disasters, including flooding. This study aims to provide an alternative solution to the

problem of waste in water areas by developing robotics technology capable of operating in water areas. Robotics technology developed in the form of eco-robot with the main task of collecting waste. The robot is designed to be controlled manually by remote control. This method includes analyzing the robotic cleaning system, designing the robot, developing the robot, implementing robot to clean waste in limited water areas, evaluating the effectiveness of robot in cleaning up trash for the more extensive area.

Indian rivers like Ganga contribute over 40% of water for the Indian population across 11 states, serving around an estimated population of 500 million people which is very high compared to any other rivers in India, but it was ranked second most polluted river in the world in 2017 [2]. The government had undertaken a project called 'Namami Gange program' in 2014 with a budget of around 20,000 crores to clean the holy river Ganga [3]. Similarly, there are a lot of problems regarding water pollution under the Godavari River, which affects the human life and beauty of the Godavari River. Likewise, many of the projects have been undertaken by the government to control water pollution. The impact of water pollution is widespread. It causes many severe water-borne diseases such as diarrhea, trachoma, hepatitis, etc., to humans. According to WHO, 22% of all communicable diseases are water-borne diseases [4]. The maximum impact is on marine animals because their survival is completely dependent on water. Due to the abundant growth of algae, the oxygen content in the water becomes lesser, which may lead to the death of fishes and other marine organisms. To address the issues mentioned above, the project proposed in this article aims to develop a water boat with a robotic arm that can detect, pick, and place garbage from water-bodies and thereby clean the water bodies.

II. LITERATURE REVIEW

This Section describes the previous works on the water cleaning boats based on different technologies designed by other researchers around the world. Chen Su, et al. [5] described "An Autonomous ship for cleaning the garbage floating on a lake". The structure and principle of an autonomous ship for cleaning the garbage floating on the lake has been proposed in the article. The ship was programmed to operate both manually and run automatically with a motion control strategy based on ultrasonic distance measurement. The major drawback observed was, movement of the ship was not smooth and no control over the collection of garbage. In [6] introduced a new concept of flexibility crawling mechanism in designing an industrial underwater cleaning boat, which is capable of working underwater, scanning the desired surface, and recording biological reactions. The system design was limited to clean bio-fouled in water surfaces. "Efficient Lake Garbage Collector by Using Pedal Operated Boat" was described by Aakash Sinha et al. [7]. The proposed work was based on human pedaling, the system was mechanical in nature. Since no electronics involved in the design, there is no automatic control over the garbage collection. In [8] a method was presented for cleaning the floating debris present in the water bodies. The function of the designed robot is to pick up the garbage particles from the water surface and dispose of them into the tray provided. But the system was not automated to detect the trash. Soumya et al. [9] proposed "Pond Cleaning Robot", the machine is operated using a smartphone to remove the debris from the lake. The machine is designed based on the AT89S51 controller. The system had no sensors for automatic detection of garbage and guide the robot [9]. 'Water Surface Cleaning Robot' was developed by Raghavi et al [10]. The main aim of the work proposed was to develop a surface vehicle. The robot was employed with water quality monitoring sensors. The major limitation observed

with this method is -it is not cost efficient and the process of manufacturing is complex.

III. PROPOSED SYSTEM MODEL

To address the issues discussed in the previous section, this paper describes the system in detail. The proposed system design employs sensors to record parameters such as the detection of obstacles & their distance from the boat, and identification of living or non-living organisms. Based on the sensors' readings, the boat and robotic arm are controlled for picking up the floating trashes in the water. The block diagram of the proposed system is illustrated in Fig 1. The system design concept is explained in two stages; the first stage involves the water boat with sensors assembly and the second stage is the robotic arm.

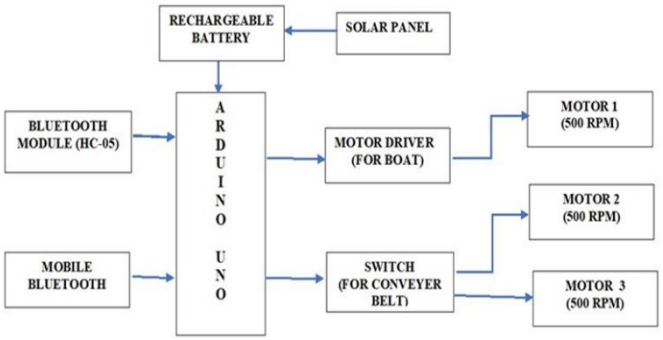

Fig 1 : Block Diagram of Solar Energy Based Water Cleaner Robot

Hardware Requirements:

The hardware of the system is based on the Arduino Uno platform. Two Arduino Uno boards are employed one used for controlling wheels of the boat & taking input from the sensors; another one for controlling the robotic arm. The hardware requirements are discussed in the following section:

• Microcontroller (Arduino UNO R3 CH340G): The controller used is ATmega328 on Arduino UNO platform. The controller takes input from the smartphone & sensors and operates the boat and robotic arm as per the requirement.

Fig 2 : Arduino UNO

• L298N Motor Driver: The L298N is a dual H-Bridge motor driver which allows speed and direction control of two DC motors at the same time.

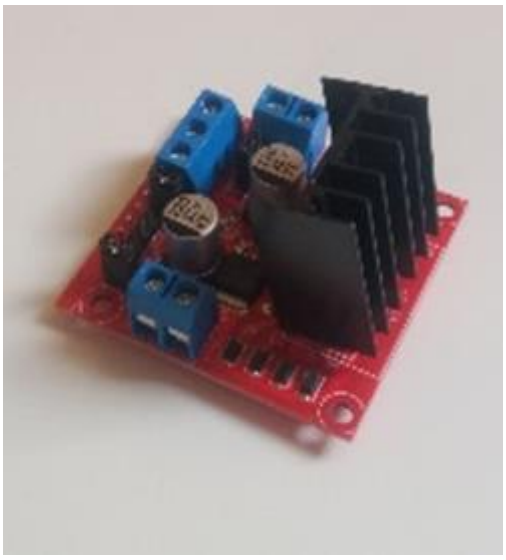

Fig 3 : Motor Driver

• Solar Panel: A solar panel is a device that converts sunlight into electricity by using photovoltaic (PV) cells.

Fig 4: Solar Panel

• Bluetooth Module hc05: HC-05 module here acts as a bridge to control the robotic arm movement and wheels of the boat.

Fig 5: Bluetooth Module

• DC Motor: 2 DC motors with propellers are used to propel the water boat as per the commands given.

Fig 6: DC Motor

• Conveyer Belt: It is equipped with DC motors. Depending on the given instructions, the belt moves in circular direction, picks up the trash, and dumps it to the dumping space.

• Smartphone: Android Smartphone is used to control the motion of the boat and servo motors.

Software Requirements:

The system is designed around the Arduino IDE and Blynk app. These tools are discussed as follows:

• Arduino IDE: It is an open-source integrated development environment (IDE); allows users to program the compatible boards. In the proposed work Arduino boards are programmed using Arduino IDE to read the sensor inputs & control the wheels and robotic arm. It is also compatible with the Proteus app for controlling mechanism.

• Proteus Design Suite: The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation.

IV. IMPLEMENTATION

The proposed concept is still in the development stage to include advanced features; therefore, the work has been implemented virtually. As an alternative to the physical implementation, the functionalities of the proposed system were simulated using an open-source simulation tool Proteus.

To simulate the circuit diagram as shown in Fig 7 the hex file is uploaded of proposed Arduino UNO code in the simulation tool for smooth functioning of it. Although the conveyor belt system is designed practically with the help of bike tube and use of steel rods and ball bearings to provide locomotion and support to the system. The whole system is supported with the use of PVC sheets with the help of which full boat structure is designed.

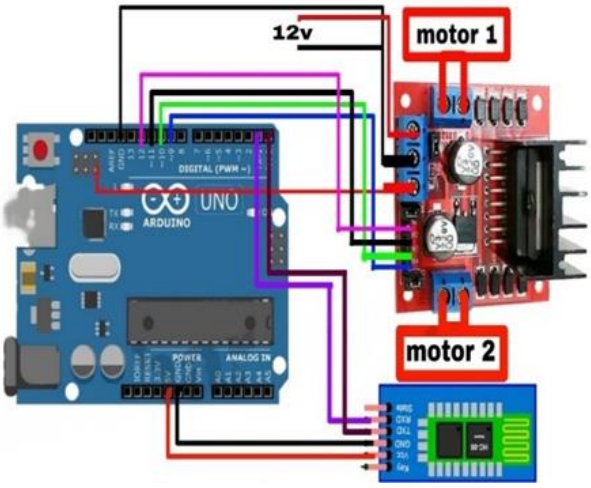

Fig 7 : Water boat circuit diagram

V. RESULTS

The simulation results of the proposed work is discussed in this section (Fig 8). The model is simulated in proteus software. It can be seen in the figure. DC motors for forward and reverse movement of buoy including the left and right direction movement is been programmed and simulated using proteus design suite. When the Arduino code is executed on Arduino 1.8.13 software and its Hex File is copied and uploaded on Proteus Simulation Software an animation of DC motor displaying proper simulation of the circuit. Conveyor belt is manually operated for collecting the trash floating on the water surface. Thus the system works effectively for cleaning the pond/ lake or any other reservoir system.

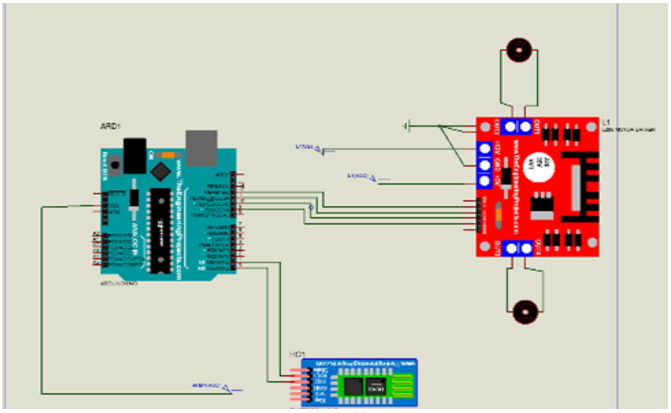

Fig 8 : Proteus Simulation

Fig 9 shows the conveyor belt system which rotates in a circular direction to move all trash in an upward direction towards the garbage collection tank. The belt is operated with the help of DC motor and a system of shaft and bearings to provide locomotion to the whole belt.

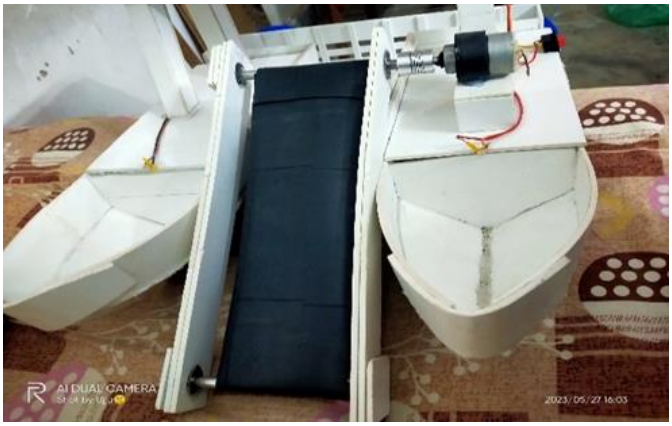

Fig 9 : Conveyor belt system

VI. CONCLUSION

The design and development of a real-time robotic system based on Arduino uno for surface trash collection in the waterbodies is presented in this paper. The proposed work utilizes mechanism to collect the garbage. The proposed concept is simulated using open- source tool Proteus. The simulation results indicate that the proposed low-cost Solar Energy Based Water Cleaning robot will be a potential alternative for surface water trash collection to preserve the quality of water & aquatic life with minimum human efforts. Future work of the authors is focused on to employing machine learning and internet of things (IOT), so that the system will be completely autonomous and operated remotely.

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