Floating Garbage Collector Based on OpenMV

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Abstract. Due to the high cost of human labor for maintenance, garbages in rivers often do not receive immediate cleaning, resulting in severe water pollution. Those floating garbages simultaneously strip the aesthetic of rivers and threaten the local marine ecosystem. Thence, we developed an unmanned vessel based on Arduino's platform, capable of auto-collecting garbage. The vessel includes two modes: the human operational mode allows individuals to manipulate the vessel and to collect garbages through Bluetooth connection; the auto-collecting mode is based on OpenMV's video processing function, enabling vessels to detect garbages nearby and transport the garbages into the vessel's interior through a rotating caterpillar track. At the end of this project, the vessel remains large rooms for improvements, such as increasing the efficiency and effectiveness of garbage collection and garbage detection. The vessel is suitable in small size rivers or ponds were artificial cleaning faces obstacles.

Keywords: Garbage Collector, OpenMV, Arduino.

1. Introduction
Nowadays, garbage pollution is prevalent in many small and medium-sized rivers in China. Without regular cleaning, those pollution manifest a significant impact on people's living environment. The flotsam has worsened water quality in many areas, damaging biodiversity and the ecological balance in the local environment, resulting in the blackening, rotting, and blockage of many water sites. Floating garbage gathered in "hordes" accumulated in various water sites, which has affected both the quality of life of local habitats and the safety of water conservancy facilities and presents a significant threat to the aesthetics of those waters. Those pollutant is causing considerable economic losses on agriculture, aquatic, and tourism industries. Therefore, it is an urgent need to clean up the floating garbages efficiently and effectively.
Figure 1. Garbages in lakes.

The vessel's hull equips two water ejecting engines, which utilizes the different injection rate to achieve direction control, eliminating the need for a rudder. The primary collecting method utilizes the Arduino Uno motherboard, combined with a caterpillar track and gear motor, which rotates the track, and with assistance from other electronic parts, to detect and collect garbage from the water surface. This project aims to achieve high efficiency of garbage collection through the atomization of floating garbage collection with a combination of footage process and auto controlling of vessel's direction.

2. Theoretical Designs
The project can be disintegrated into three parts: garbage detection, garbage collection, and vessel control.

(1) Garbage detection is responsible for the vessel to detect garbage and sail toward garbage patches. Technologies such as camera and infrared detection can both achieve garbage detection. To better identify garbage, we choose to use OpenMV to accomplish image recognition and assist Arduino in automatizing garbage collection.

(2) Garbage collection: there are two ways to salvage floating garbage and store them in the vessel's interior: garbage float with waves to the vessel's interior and sail with the vessel; collect garbage and stored it into vessel's interior without exposure to water. Considering the former solution requires a medium or large vessel to achieve collecting efficiency (many necessary components will occupy too much volume inside a small boat, leaving little space for storing garbage), it is only responsible for using the latter method.

(3) To manipulate the vessel, two instructions must be achieved: going straight and turning around. Traveling in a straight line is relatively easy to manipulate, as two engines need to rotate at the same rate. Changing in direction requires a special component, such as a rudder. Considering the complexity of the vessel's interior structure, we installed two water ejecting engines to fulfill the requirement, as changes in direction are achieved through changes in the rate of water ejection of one engine.

3. Structure Design
To better accomplish the waterproofing and the collecting capability of the vessel, this project uses laser cutting technology to shape acrylic boards into specific shapes and utilizes acrylic glue and hot glue to "connect" the integrity of the vessel. In order to successfully install and operate the caterpillar track on the vessel, we designed a unique structure. To minimize the complexity of installing the tracks, we devise a unique 'buckle' through AutoCAD. Considering the size of the acrylic board is 400mm*400mm, the hull and the caterpillar track of the vessel must be manufactured separately and combined later.

The 'buckle': Since each acrylic board's thickness is 2.8mm, the width of each buckle must also be 2.8mm.

Since the portion of the caterpillar track, which directly exposes the water surface, can transport garbage into the vessel's interior, the caterpillar track must be installed in a slightly tilted. Considering the size of the acrylic board is 400mm*400mm, and excess tilting will result in the gravitation pull of
earth overcoming the friction between the garbages and the caterpillar track, causing unsuccessful transportation of garbages, we decided to set the tilting angle of the track to 30 degrees.

3.1. Caterpillar Track installation
The necessary components for the installation of a caterpillar track include caterpillar track (adjustable length), rollers (for rolling tracks), and bearings (for the rotation of tracks). Rollers and bearings must be pre-installed on the acrylic board and then measured the length for constructing the appropriate length of caterpillar tracks. Due to the limited length of the vessel, we installed four rollers and one bearing. The installation of rollers requires the screws on acrylic boards followed by nuts for stabilization. The radius of the screw is 2mm, which requires an octagon with a radius of 2mm to be cut on the acrylic board (for better stabilization of screws). Since rollers and the bearing varies in size, and there is interference between two components when functioning when placed closely, appropriate distance between two components must be fulfilled. The rotation of bearing to rotate the caterpillar tracks requires the rotational force for a gear motor. Hence areas on the acrylic board for the installation of the gear motor must be reserved.

Considering the width of each track is too narrow, which makes collecting garbages inefficient, we installed two pairs of caterpillar tracks adjacent to each other. To further stabilize the caterpillar track, we devise two layers of the wooden board for the track's installation and reserved places to the conjunction of two wooden boards.

3.2. Caterpillar Track and the vessel
Through a 'U' shape structure, the vessel's hull will connect various components together (the main body of the vessel and the caterpillar track). And through the pre-designed 'buckle' and hot glue, a rigid and water-resistance vessel will be achieved.

3.3. Garbage Storage
Since the transported garbages by the caterpillar track must be collected in the garbage container, the container must be placed under the track, with an opening to receive garbages. Meanwhile, due to the limitation of the vessel's size, other components such as circuit board, wires, and the brushless electric engine will occupy a large volume of the vessel's interior, the garbage container must be designed small.

4. Software Design
This project uses the OpenMV module with Arduino to achieve automation of garbage detection and collection. First, the vessel needs to distinguish between the water and garbages, which requires the pre-setting of the color of the water environment. Since the project is tested in a white-water tank with transparent water, the Gamut of this experiment will be easily detected and separated. Hence, OpenMV will run the program with the logic of binary filtering: the pixel of watercolor (white pixel) will convert into white pixels, and other colors (garbages) will convert into black pixels. Afterward, the camera will mark every black pixel and calculate the most concentrated area of the black pixel in the footage, which either represents the most concentrated garbages or the closest garbages. Last, the coordinate of the most concentrated area of the black pixel will be located in the footage, and the coordinate will send to Arduino for Arduino to determine the direction of the vessel sailing.
5. Experiments and Analysis

5.1. Experiment 1

The first generation of vessels is a testing vessel. It only installed a brushless motor ejector but does not equip caterpillar track, gear motor, or ant circuits. Through this waterproofing trial, we investigate the vessel's buoyancy and its strength to decide the intensity of water leakage for the ship after a simple waterproofing method. Through the experiment, there are multiple leakages in the vessel, the buoyancy of wooden boards surpasses the expected buoyancy level, and the brushless motor does not provide enough power the propel the vessel. Hence, the improvement of this project includes the use of the acrylic board to replace the wooden board and better waterproofing techniques for the vessel.
5.2. Experiment 2
Through the result from the first experiment, we altered the material of the vessel and perfected the waterproofing technique. In this trial, we installed the caterpillar track, gear motor, and brushless motor ejector. By the end of this experiment, we hope to locate the remaining water leakage issues and enhance them before putting them in circuits. Through this experiment, we find that the connection between the caterpillar track module and the hull, the side face of the vessel, and the connection with the brushless motor all experienced water leakage. In addition, the front part of the vessel is constructed by a wooden board, which provides too much buoyancy, resulting in fluctuation during sailings.

5.3. Experiment 3
Through the result obtained from the second experiment, we upgrade the vessel with all acrylic boards. Meanwhile, we provide multiple layers of hot glue in all possible leakage areas. Through the third experiment, we hope to find all the remaining problems for the vessel when functioning and collecting garbages, including water leakage, garbage collection, and the vessel's kinetic system. After the experiment, the vessel has no signs of water leakages, but the rotational speed of two motors varies, which means under the same value (from 147 to 160), two engines eject water at different rates. Raising the 'presumed' speed of the slower engine by the value of 5 (from 160 to 165) helps solve this issue.
5.4. Experiment 4
This experiment is set in a 4000mm (Length) * 2000mm (Width) * 1000mm (Height) white water tank. Twenty pieces of red-colored garbage are randomly placed in the water tank, and the vessel is given 8 minutes to collect all garbages. Due to the limitation of the size of the testing environment, the vessel is occasionally stuck in the corner of the water tank, which requires manual assistance.

The first generation of the vessel's frontier equips no additional device. During the experiment, we discover that as the vessel approaches garbages, garbages will experience a repulsive force as water waves from the vessel, hence propelled away from the vessel, which significantly affects the efficiency of garbage collection. After 8 minutes, the garbage collector can only collect 7-8 pieces of garbage, which is highly inefficient. The main problem, as stated above, is the propelling force provided by the vessel to garbages while sailing.
On the second generation of the vessel, we laser cut two pieces of acrylic board and attached them to the vessel's frontier at 30 degrees, extending outward. Theoretically, this design enlarges the area of garbage collecting and should increase collecting efficiency. Nonetheless, during the experiment, the greater extension of the device provides strong propulsive force than the previous generation, decreasing the collecting efficiency even more. In the 8 minutes experiment, the vessel can only collect 5~6 pieces of garbage on average. In addition, during the experiment, many garbages are collected within the extended acrylic board range yet not transported to the caterpillar track.

In the third generation of the vessel, we considered the water propulsion and replaced the acrylic board with the acrylic framework with a net, enabling waves to flow through the net instead of repelled by the acrylic board, largely reducing water repulsion and effectively collecting garbages. With the new structure, the vessel can collect 15~16 pieces of garbage under the 8-minute constraints, which is a 75%~80% collecting rate, reaching the expected result.
Table 1. First Generation Collecting Data.

| First Generation Vessel | Time (Minute) | Collected Garbages (Piece) | Collecting Efficiency |
|-------------------------|---------------|----------------------------|----------------------|
| 1                       | 8             | 5                          | 25%                  |
| 2                       | 8             | 6                          | 30%                  |
| 3                       | 8             | 6                          | 30%                  |

Table 2. Second Generation Collecting Data.

| Second Generation Vessel | Time (Minute) | Collected Garbages (Piece) | Collecting Efficiency |
|--------------------------|---------------|----------------------------|----------------------|
| 1                        | 8             | 8                          | 40%                  |
| 2                        | 8             | 7                          | 35%                  |
| 3                        | 8             | 7                          | 35%                  |

Table 3. Third Generation Collecting Data.

| Third Generation Vessel  | Time (Minute) | Collected Garbages (Piece) | Collecting Efficiency |
|--------------------------|---------------|----------------------------|----------------------|
| 1                        | 8             | 16                         | 80%                  |
| 2                        | 8             | 15                         | 75%                  |
| 3                        | 8             | 16                         | 80%                  |

5.5. Data Analysis

Through the four experiments, we solve the water leakage and the collecting inefficiency problems of the vessel. Through section 5.4, we discovered that the different devices installed on the vessel's frontier contribute to the different magnitude of repulsive force as waves, which affects the collecting efficiency of the vessel. From the experiment, the device with an acrylic framework with a net structure has the highest efficiency of collecting because the extended opening provides greater surface area, and the net structure allows water to flow by, largely reduce the repulsive force of waves to garbages. Through the data from the experiment, we find that adding additional acrylic board is not very helpful, as the increased repulsive force of waves pushes the garbages away, hence displaying that water repulsion has a strong impact on garbage collecting.

6. Conclusion and Future Prospect

After this project, the vessel is capable of collecting around 80% of floating garbages. The conclusion of this project is listed below:

1. The floating garbage collector is capable of self-collecting garbages, with cheap costs
2. The floating garbage collector is adaptable under various environment, efficient even in small-size water site
3. The floating garbage collector utilizes a net-like structure to produce the repulsive force of waves and largely increase collecting efficiency

Area of improvements after manufacturing and experimenting:
1. Increase the size of the vessel and the width of the caterpillar track to increase the collecting efficiency of various types of garbages
2. Constructing a neural network and increase the resolution of the camera to boost the accuracy of garbage detection

Promising the software program of the vessel, allowing the initiation of caterpillar track and brushless motor only when the vessel detects garbages, otherwise remains standby mode, hence increase the battery life of the vessel, prolongs working hours.

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