# The Design of Photovoltaic Scroll Surface Cleaning Robot

**Yueyi Chen[1,a], Yansong Deng[1,b,*] and Weihua He[2,c,*]**

[1]Institute of Electrical and Information Engineering, Southwest Minzu University, West Terminal Street, Chengdu, China

[2]Department of Communication Engineering, Southwest Minzu University, West Terminal Street, Chengdu, China

[a]997822116@qq.com, [b]342547288@qq.com

*corresponding author

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**Abstract:** In order to reduce the clean-up cost of floating garbage in small water areas such as artificial lakes, and to improve the efficiency of salvage and prevent the environmental damages caused by artificially salvaging, we developed a scroll cleaning robot based on photovoltaic power supply, which is aimed at cleaning floating garbage on the water surface. This robot is mainly composed of cleaning system, driving water wheel, floating platform and other subsystems. This robot uses water level difference as the power source, recycles the floating garbage into the bucket via remote control. It can be widely used in reservoirs, artificial lakes and other floating garbage cleaning work .This all-weather robot works with low energy consumption and clean energy, without personnel guardian, and is close to the environment. With its advantage of using in a wide area, it is of high commercial value.

## 1. Introduction

With the improvement of people's living standards, there have been more and more garbage in recent years, due to some people's weak awareness of environment protection, a large part of the garbage was abandoned into the river, resulting in a lot of garbage floating on the rivers, lakes. Part of the regional pollution is particularly serious, such as the shipping channel, power station, if these garbage are not cleaned up timely, it will affect the normal operation of the channel, the generating units; on the other hand, due to the discharging of domestic sewage and industrial waste, there is a large number of floating surface algae, which will lead to a major issue of breaking the regional ecological balance.

In order to clean up the water surface floating garbage, there have been a variety of surface clean-up boats, which can be divided into fuel-driven boats and artificial driving boats [1]. Relying on fuel-driven can not only cause the existence of air pollution, noise pollution, but also lead to other issues such as oil pollution. Besides, huge bulky, high operating costs and energy consumption make it difficult to promote the popularity. The method of using artificial driving boats to clean up the garbage causes high labor intensity, low efficiency, and security is difficult to protect. Therefore, how to use water as a power source, and how to design and manufacture green environmental clean-up garbage cleaning robots without fuel consumption, noise and air pollution, becomes the goal of competing of manufacturers.

 

## 2. The Structural Design of the Robot

In recent years, there have been numerous methods and equipment to clean up the water surface floating garbage both at home and abroad, which can be divided into two types,

### 2.1.Cantilever Type

The floating salvage part is installed in the hull, salvage part and the hull are two separate parts, salvage part [2], whose structure is complex, needs to provide an independent power source, and it is of large size, thus, installation is difficult, and the salvage efficiency is low, while mechanical failure rate is high, so it is not conducive to long time continuous work.

### 2.2. Mechanical Grill

It is a kind of mechanical equipment which is installed in the hydropower station, or at the entrance of the pumping station, combining with sewage and cleaning, it can achieve continuous cleaning. But there exist a lot of shortcomings such as complex structure, high requirements of the installation location, limited cleaning capacity, when the amount of floating garbage reaches a certain value, it is prone to block, thus affecting the normal flow of water.

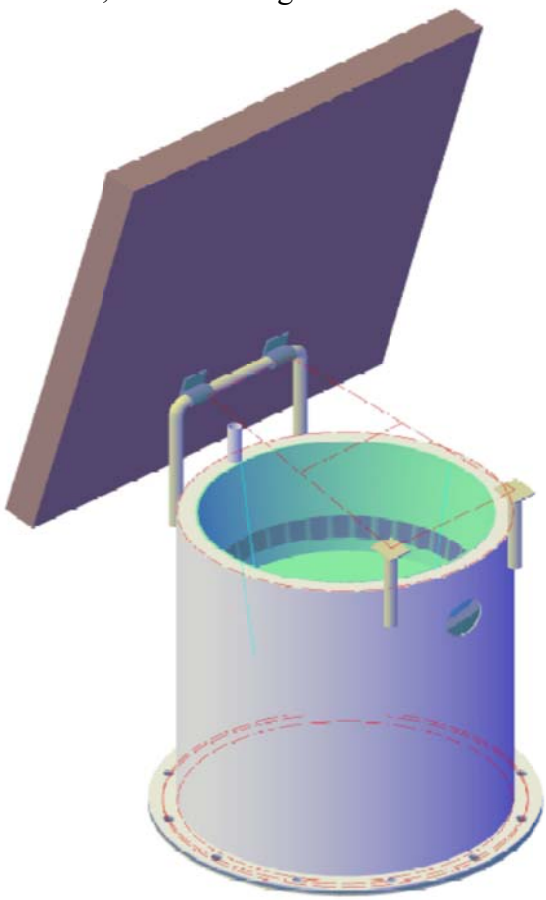

Fig.1 The Schematic Diagram of the Overall Structure

## 3. Power System

This robot uses two 12V underwater propulsion as motor power, the main control board Arduino and electronic governor on the two propeller adjust the speed to achieve the steering, the maximum speed can reach 2200r / min, the maximum thrust is about 10 cattle , Propellers meet a low power, high reliability requirements, and its structure diagram is shown in Fig 2.

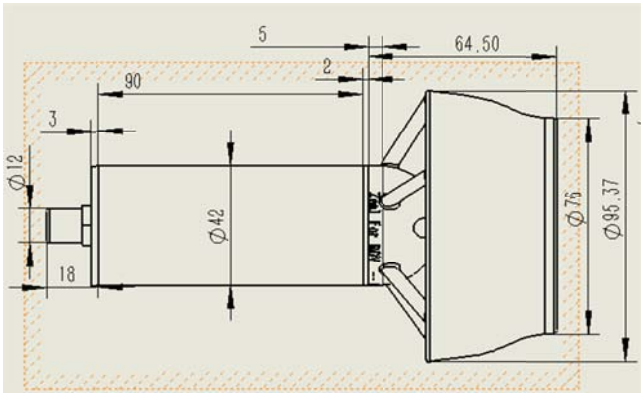


Fig. 2 The Structure Diagram of the Propellers

Our project team combined with mechanical mechanics, fluid mechanics, and designed the propeller fairing, and then we used 3D printing technology to create it with light material, high mechanical strength characteristics. The details are shown as follows:

We calculate the hydrodynamic performance of the propeller in combination with the V-DART model [3]. Based on the theory of lift line, the blade is divided into infinitely small segments, and we set an attached vortex on the middle arc of each small segment blade to replace the corresponding blade [4]. As the attached vortex changes, the strength of the tail vortex is equal to the change in the intensity of the attached vortex. When the vortex is replaced by a discrete free vortex, the vortices conservation theorem of the attached vortex and the discrete tail vortex is satisfied, which can be expressed as:

$$F_w^k + F_f^k = F_f^{k-1} \quad (1)$$

In which, $F_w^k$ represents the tail vortex intensity at the kth time step, $F_f^k$ and $F_f^{k-1}$ respectively represent the vortex intensity of the kth, k-1 time step.

At the same time, we used Kutta condition to correlate the lift of the unit leaf and the lift coefficient of the leaf profile [5]. The method was shown as follows

$$F_f = \frac{1}{2} C_l C V_R (2) \quad (2)$$

In which, $C_l$ is the experimental value of the lift coefficient of the leaf profile and $C$ is the chord length of the leaf profile.

In this way, the intensity of the vortex and the tail vortex can be obtained, and the velocity of the points in the flow field can be obtained from the Biot-Savart law according to the intensity and position of these distributions [6]. The blade load and the rotor performance can also be gotten.

Strickland et al.'s V-DART model is a Free-Wake Vortex Model developed by the Larsen computational model in 1975, the model of Fanucci and Walters in 1976[7], the Holmes model as well as the Nguyen model in 1078. Its main improvements are:

1) Considering the conditions associated with the lift coefficient, the blade stall is taken into account into the calculation model, making the leaf load calculation more accurate;

2) The method of calculating the blade orientation to the segment makes the model able to be used for three-dimensional calculation and hydrodynamic calculation of the vertical axis wind turbine with curved shape blade.

3) It is an unsteady calculation model without fixed the shape of the tail vortex.

In summary, we determined the theoretical accuracy of the propeller to ensure that the robot running underwater freely.

## 4. Clean System

The cleaning system of the robot is one of the key technologies, composed of DC submersible pumps, garbage filters and other components, the structure is shown in Fig3 and Fig4.

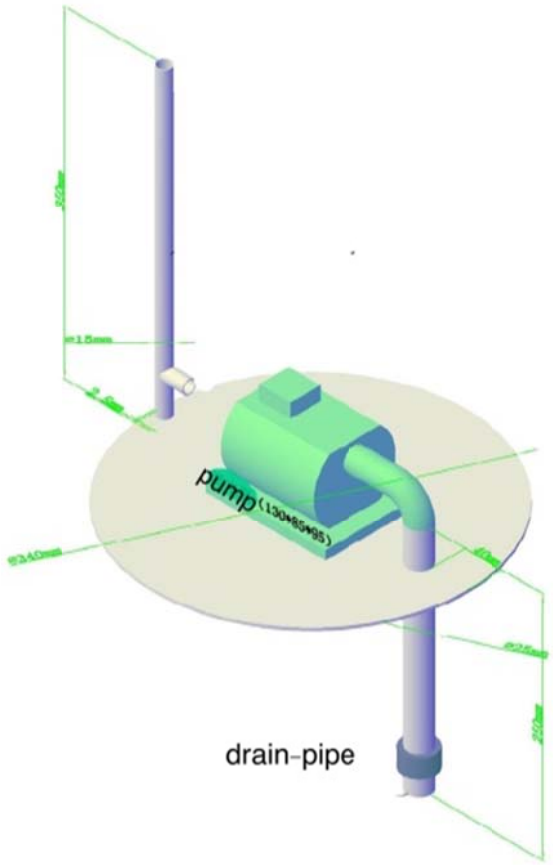


Fig.3 Schematic Diagram of the Submersible Pump Structure

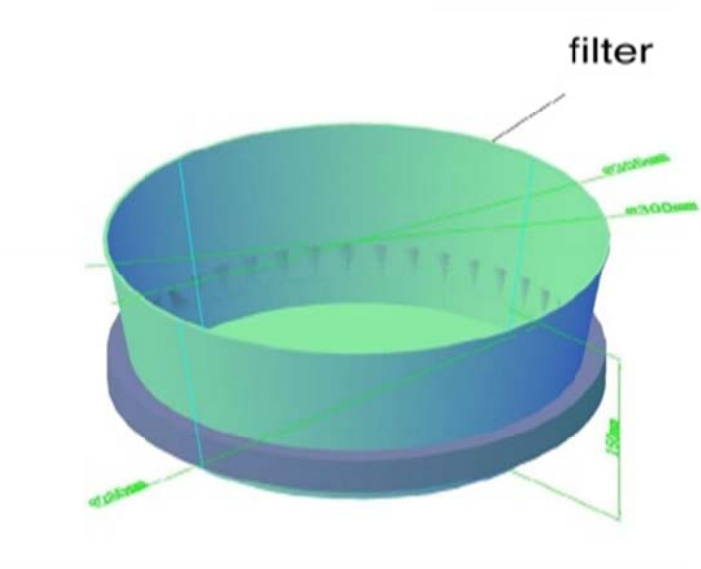


Fig.4 Schematic Diagram of Filter Structure

We designed that the tangent which is below the bottom of the water inlet was below the water level, in this way, the water level difference came into being, resulting in eddy current and the floating garbage will be swirled into the garbage filter via water viscous force. The filter can separate the water and floating garbage, garbage can be stored in the filter while the water body is

absorbed by the submersible pump and is discharged out of the cabin. The filter is made of fine steel wire mesh, which is installed by hanging and can be quickly dismantled; when the garbage is dumped the operation can be continued. The maximum capacity of garbage is up to 7.8L, when the garbage bin is full, the user can manually put the trash out of the filter, which is of great convenience. This design can clean up the floating objects effectively which is difficult to be salvaged by other equipment (such as plastic bottles, etc.) It possessed advantages of high cleaning efficiency and broad cleaning type.

## 5. Conclusion

Having taken field investigation, we found that lentic waters such as the river, vast majority of it with no shelter and the light is adequate, we combined with this feature, using local materials solar power supply for robot to provide energy, solar panels absorb light energy, which is converted into current, rectified by the regulator circuit filter then it is stored in the battery (sealed in the robot compartment), the highest photoelectric conversion rate is up to 12% (laboratory maximum conversion efficiency is 18%). Therefore, the robot can work all day in the static waters, in no light condition it continuous work is about 4.5 hours, eliminating the need of personnel detention, reducing economic expenses, which is environmental protection and energy conservation, and is close to nature.

To enhance human-computer interaction, our team uses the PS wireless controller and receiver as a robot remote control, and the receiver communicates with the robot master chip Arduino Mega 2560. The receiver is used to receive the command signal from the transmitter, after amplification, decoding and other processing [8], it commands the steering gear and electronic governor to make the action which is corresponding to the transmitter command. Frequency is2.4GHz, transmission control distance is up to 15m away, with 3 degrees of freedom.

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