The Design and Application of Water Jet Propulsion Boat

Weibo Song, Junhai Jiang3, a, Shuping Zhao, Kaiyan Zhu, Qihua Wang

1College of Information Engineering;

2Key Laboratory of Marine Information Technology of Liaoning Province,

Dalian Ocean University, Dalian 116023, China

3Department of Computer Science and Technology,

Changchun University, Changchun, China

email: lunwenemail@163.com, a Jjh_changchun@163.com

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Abstract . With the continuous application of science and technology in the ship fields, the new technologies of ship have a rapid development. The water jet propulsion boat technology also has continuous update. Therefore, the technology of water jet propulsion is a hot area of research. This paper mainly designs a circular water jet propulsion boat. This boat can move flexibly on the complex environment of the water surface with a new kind of driving mechanism.

This paper analyzes the main technologies of the system including hardware and software. The main subsystems were described. There are some experiments including Basic experiments and extended experiments. The results of experiment have proved that the theory and method in the system are correct and feasible.

1 Introduction

Researchers have begun to study the technology of water jet propulsion for a long time. Water jet propulsion method and the propeller propulsion technology are equally important [1, 2]. In many countries, there are the massive researches to the water jet propulsion which has been rapid development. At present, the application of water jet propulsion boat has penetrated into many fields. Moreover, there are lots of patents and articles about the technology of water jet propulsion [3, 4, 5, 6, 7].

However, the previous methods have some limitations such as low efficiency in backward movement and large turning radius which are reducing movement flexibility. In order to solve the above problems and to meet the kinematical condition and mechanical constraints, we designed the circular water jet propulsion boat. The novelty of this design is that the boat can move flexibly under our laboratory conditions [8, 9, 10, 11]. Due to the good manoeuvrability on the water surface, it will be applied to many fields such as boat games and research applications etc.

This paper is organized as follows. After this introduction, section 2 describes the system architecture of circular water jet propulsion boat. Then we discuss key technologies of this system. Section 3 shows results of experiment, and followed conclusion and acknowledgment.

2 System Architecture Overview

Our control system is composed of main control circuit and driving mechanism (see Figure 1) [12, 13, 14]. Main control circuit includes main control board, expansion board of peripheral circuit and wireless transceiver equipments. Driving mechanism is part of the chassis of boat [15, 16].

According to the different channel environments and movement requirements, the operator by using the remote controller send control commands to the Bluetooth receiving device of remote boat. Main control board analyzes control commands and controls driving parts.

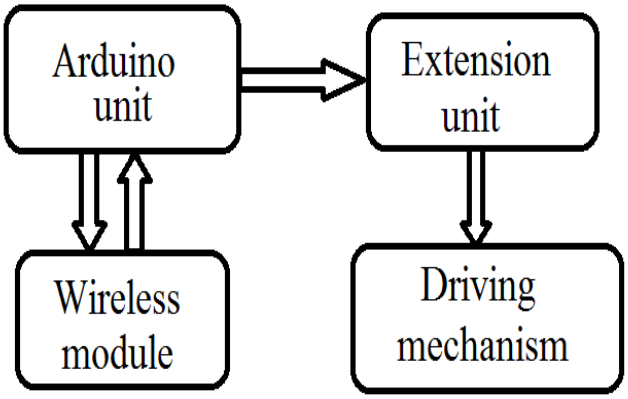

Figure 1: Control system

2.1 Main control board

Main control board is the Arduino platform including hardware and software (see Figure 2, 3). The Arduino development platform is easy to use. In this design, expansion board and wireless module connect to the Arduino hardware platform.

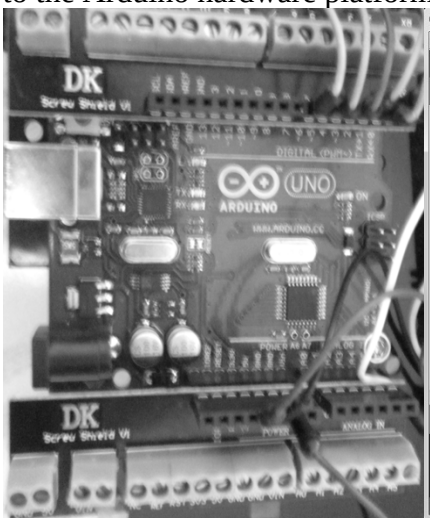

Fig.2. Arduino hardware Fig.3. Arduino software

2.2 Expansion board

In the process of system design, we will connect many peripheral devices to the master control board to increase the system functions. Because the number of pins on the Arduino control board is limited, it cannot meet the increasing requirements of system function. Therefore, the Arduino expansion board is used in the system (see Figure 4).

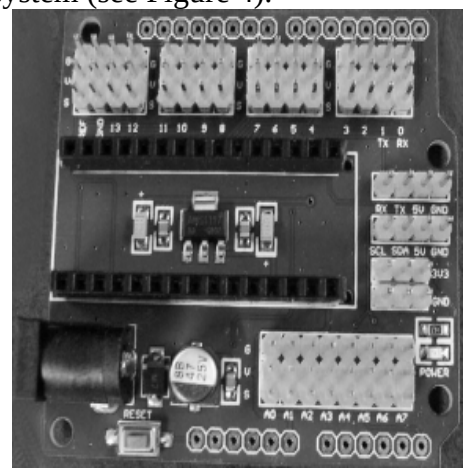

Fig.4. Expansion board

2.3 Wireless transceiver

In fact, many kinds of wireless transceiver can be adopted. With the release of Bluetooth v4.0

Low Energy (BLE), and its application field has a broader trend [17, 18].

Intelligent terminal equipment with low power Bluetooth technology will be more popular. We can easily use these portable devices as controller to control the remote devices. At the same time, this technology can make the data transmission between intelligent sensor and intelligent terminal equipment. In order to keep pace with new technologies and meet the demand of experiment, this design uses the wireless Bluetooth v4.0 Low Energy modules [19].

2.4 Driving mechanism

In order to drive the boat, we design a kind of device (see Figure 5). Part A is a suction and drainage pump which is installed on the chassis of boat by the vertical downward way. Part B is suction hole belonging to the bottom of A. Water is sucked into the pump and sent to the part C. Part C is a y-shaped water separator (1 way to 2 way). Then the water is sent to part E with two outlets in the opposite direction. Part D is the electronic switch which is used to control water flow from C to E. Each branch of water separator has an electronic switch.

In the using process, the part B and the tail of part E of the driving mechanism are under water. The remaining parts run at the interior of the boat.

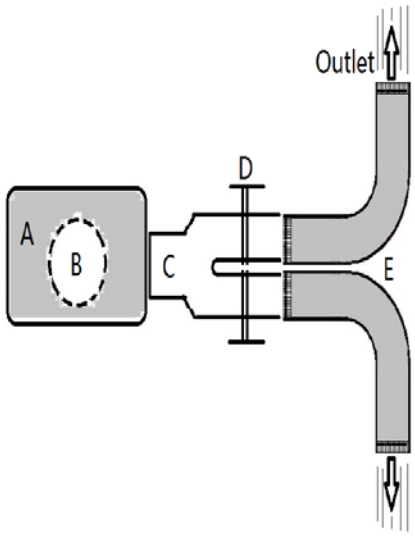

Figure 5: Driving mechanism

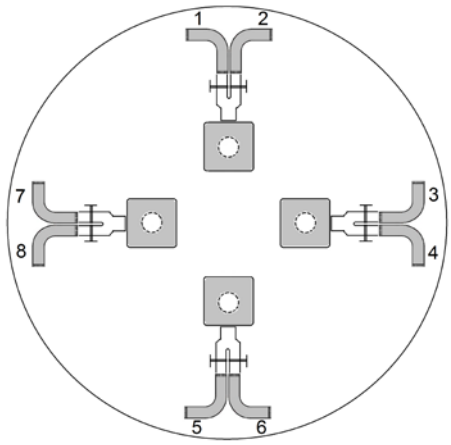

Figure 6: Full driving mechanism

Finally, the same four driving mechanisms are installed on the four directions of the chassis of boat. The full driving mechanism is shown in Figure 6. There are eight outlets on the boat to control moving direction. At the beginning of design, we considered the water flow may interfere with each other. Because of this design structure, the boat can move in any direction on the water surface. Eight electronic switches can work to make the boat move by the intention of the operator [20].

3 Experiments

We have designed two different experiments to testify feasibility of system. The first is basic experiments, the second is extended experiments.

3.1 Basic experiments

We completed the basic design, and used the remote controller to verify the flexibility of the boat movement. We have achieved the goals to study this system by several experiments.

The first experiment focused on linear movement. In this condition, water is discharged from two outlets in the same direction such as No.4 and No.8. Boat can move in a line. When the water is stopped from No.4 and No.8, and is discharged form No.3 and No.7, the boat can quickly stop and even move reversely. According to the above methods, we may also control the boat in a transverse movement.

The second experiment aimed at controlling the boat in curvilinear movement following operator’s intention. In this condition, water is discharged from two outlets in the reverse direction

such as No.4 and No.7. Boat can move in rotation. When the water is discharged just form No.4, the boat can move in a curve. Finally, the boat will be moving in different ways by water is discharged from different outlets.

We designed some special types of path by comprehensive application of the above experiment results. Under laboratory condition, the boat can smoothly through the prescribed paths (see Figure 7). The results of the experiment were satisfactory.

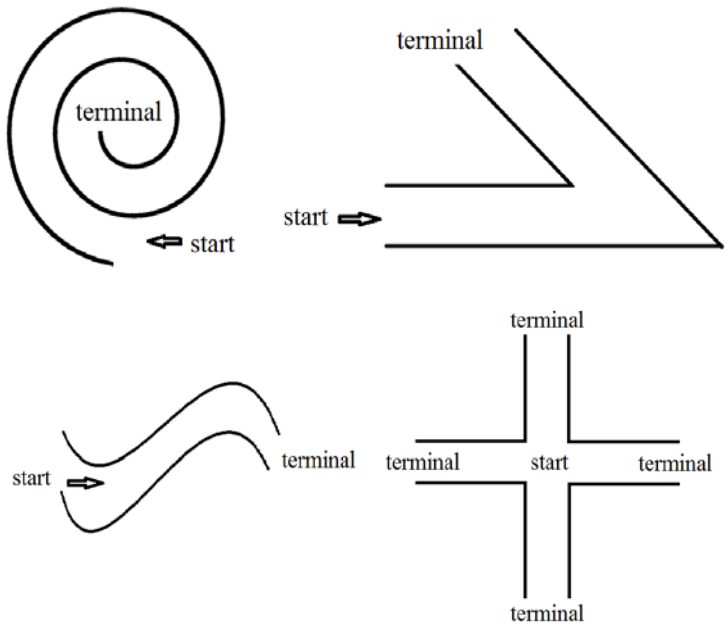

Figure 7: Prescribed paths

3.2 Extended experiments

The first experiment focused on increasing the novel control methods. We also use of a new type of controller which is MYO (see Figure 8). The control system is shown in Figure 9.

Figure 8: MYO control system

This wristband is a motion sensor which can monitor the electrical activity of your muscles such as a wave of your hand or subtle movement of fingers [13]. The gathered data by MYO is transmitted to the controlled object via Bluetooth v4.0 devices in real time. The different arm waves and fingers movements of operator may cause different muscle reactions. The transmitted data will be analyzed and defined into given control commands of boat such as running forward, back and rotation.

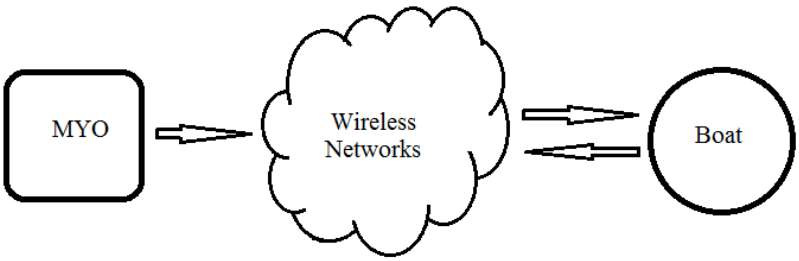

Figure 9: MYO control system

The second experiment aimed at collision-avoidance. There are many uncertainties of the water surface. In order to prevent the boat colliding with obstacles, we installed a collision protection system around the boat. In the operation process, we place obstacles around the boat; it does not collide with any obstacle by deliberate misoperation of operator.

Conclusion

This paper designed a control system of the circular water jet propulsion boat. In order to give the autonomy of the intelligent boat and people's subjective initiative, a new approach for boat's control was proposed.

Experimental results have shown that our approach is practical. The following work will mainly focus on increasing the sensors and detection circuits for more precise control and system stability. Because the MYO sensor has high sensitivity in the process of detecting body electric signals. So the operator needs to keep learning in the process of using wristband to adapt to this high sensitivity.

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