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Development and Motion Mode Analysis of IPMC Bionic Jellyfish Based on App Bluetooth Remote Control

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Development and Motion Mode Analysis of IPMC Bionic Jellyfish Based on App Bluetooth Remote Control

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Abstract. This paper mainly studies a kind of bionic jellyfish driven by IPMC remote control based on mobile APP. The bionic jellyfish has four bionic tentacles made by IPMC. The shell preparation, internal circuit connection and control system design process of bionic jellyfish are introduced. Finally, the paper discusses the implementation of the bionic jellyfish first-class fixed-speed cruise, secondary fixed-speed cruise, acceleration, deceleration, and steering modes.

1. Introduction

With the advancement of technology and the innovation of science and technology, people slowly shifted their eyes from the land to the ocean. The exploration of the ocean from the shallow sea to the deep sea, from the offshore to the distant sea, in order not to damage the marine biological environment, researchers invented Bionic robot. In order to reduce the impact of sound on marine life, a new type of driving material came into being - IPMC, which is characterized by fast response, small size, light weight, no noise, etc. [1-2]. Therefore, in order to further explore the marine animals, an IPMC bionic jellyfish based on APP Bluetooth remote control was designed. The bionic jellyfish looks like a jellyfish [3-5] and can be whispered or even silently. The rapid development of technology has also made technology advancement. Mobile phones have become a part of people's daily life. Mobile APP has also emerged. The bionic robot is based on mobile APP control applications, which increases the convenience of use.

2. Bionic jellyfish design

2.1. The appearance and internal structure design of bionic jellyfish

A three-dimensional model of the bionic jellyfish shell was drawn using the three-dimensional drawing software NX. The 3D model was imported into a 3D printer, and PLA (Poly Lactic Acid) material was selected to print a bionic jellyfish shell. The internal composition of the jellyfish mainly includes power supply, single-chip microcomputer, Bluetooth communication module, balance block, and antennae in four directions (the antenna is made by IPMC). As shown in Fig. 1.



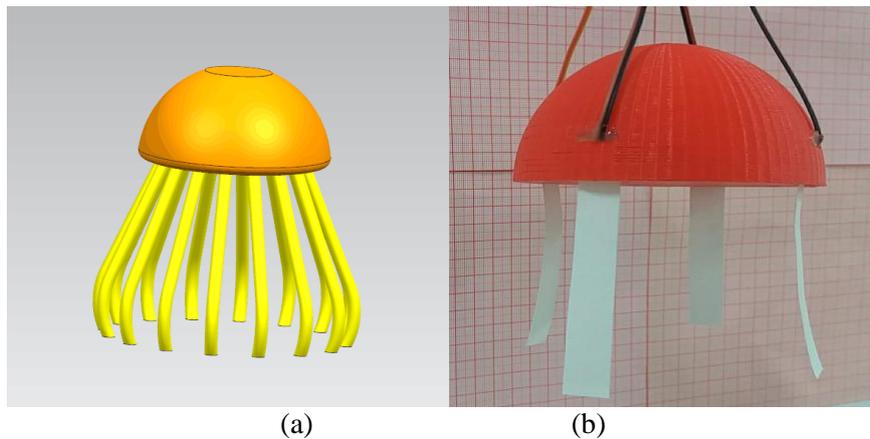


Figure 1. (a) Bionic jellyfish 3D design (b) Bionic jellyfish physical map.

2.2. Circuit design of bionic jellyfish

The STC98C51 microcontroller is required in the micro control system, so it needs to be powered by a 6V power supply and powered by the IPMC tentacle with 2.5V. In order to obtain a stable output voltage, it is decided to use AMS1117 voltage regulator device. AMS1117 is a forward voltage drop regulator device. AMS1117 integrates overheat protection and current limiting circuit to minimize the pressure caused by overload of regulator and power circuit. Is the best choice for battery power.

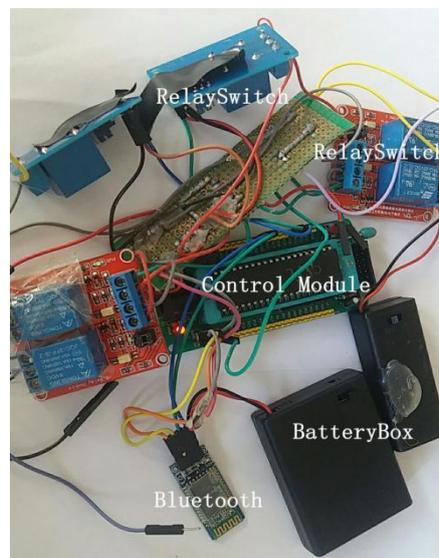


Figure 2. Bionic jellyfish internal circuit connection.

The internal components of the bionic jellyfish have a single-chip control module, a Bluetooth communication module, a power supply module, and an H-bridge circuit. The single-chip microcomputer converts the direct current of the battery box into alternating current by controlling the conduction and the off inside of the H-bridge circuit.

2.3. Bionic jellyfish control system design

The movement status of the jellyfish is controlled in real time through the mobile APP. To control the motion state of bionic jellyfish, it is necessary to realize this function through the wireless communication network as a platform. In the design of bionic jellyfish system, Bluetooth is used as the communication platform of bionic jellyfish. The frequency of the electromagnetic wave generated

by Bluetooth is between 2.40 GHz and 2.480 GHz. The advantage is that there is no special communication angle of view and direction, and its small size, low security and low power consumption. Based on the research content of this paper, the design establishes the data transmission and reception of the APP and the main control chip STC98C51 through the HC-05 Bluetooth module, so as to control the motion state of the bionic jellyfish in real time. This experiment uses the MIT App Inventor development platform to independently design a mobile APP as a host computer. App Inventor is a sub-project of Google Labs. It is software that completely develops the Android programming environment online. It discards complicated code and uses building blocks. Stacking to complete programming for Android, and having a visual programming interface is more intuitive. Moreover, the operation interface made is beautiful and convenient to use, and the specific scheme is as follows:

(a) PC design: The design component layout is shown in Fig. 3.

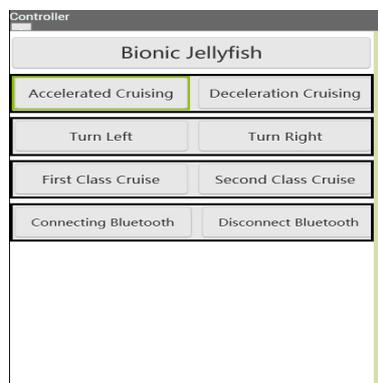


Figure 3. Mobile phone APP control component distribution map.

As shown in Fig. 3, it is a control interface of a mobile phone APP designed independently. This interface was developed and developed by the components in the MIT App Inventor mobile APP development software.

(b) The design and logic diagram of the PC design is as follows:

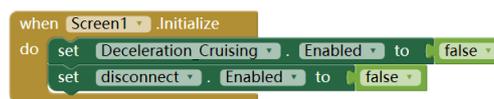


Figure 4. Screen initialization procedure.

As shown in Fig. 4, the screen initialization program of the self-designed APP logic designs. The program first defines the screen1 interface as the initialization interface. When entering this interface, the program will automatically disconnect the Bluetooth client and define the btlist (Bluetooth connection selection list) as the on state.

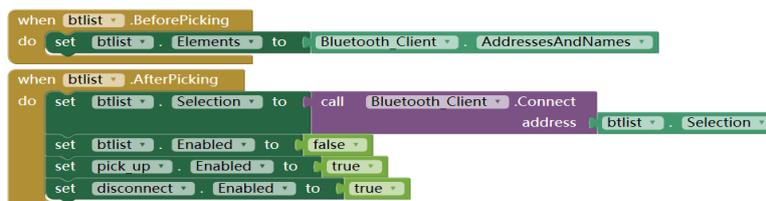


Figure 5. Bluetooth program.

As shown in FIG. 5, the Bluetooth connection logic program in the self-designed mobile phone APP. The program is: the first part is a Bluetooth connection logic program. When the user opens the mobile phone Bluetooth receiver and clicks “Select Linkable Bluetooth Device” in the mobile APP interface, the program automatically activates btlist (Bluetooth connection selection list). Program, this program will automatically capture the Bluetooth address that the phone is connected to or linked to. Then link the corresponding Bluetooth, when the Bluetooth connection is completed, the second program will be activated. At this time, the “Select Connectable Bluetooth Device” on the mobile APP interface will become light gray, indicating that it is not available at this stage, and the mobile APP interface is “broken”. The on button will turn light gray to indicate that this stage can be used.

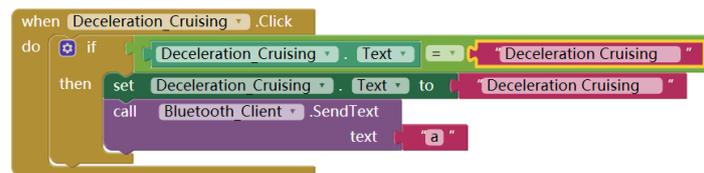


Figure 6. Constant speed cruise mode.

Fig. 6 shows the motion logic program in the mobile phone APP. Under the condition of Bluetooth connection, the user clicks the corresponding motion mode on the main page. Currently, the cruise speed mode is taken as an example. When it is clicked, the motion mode is activated, and the Bluetooth client is activated, and Bluetooth is used. Previously set to "a" sent to the microcontroller microcontroller, the microcontroller processed the received text, by controlling the on and off of the four switches in the H-bridge inverter to energize the IPMC tentacle, thereby achieving the straightening and bending of the IPMC tentacle, The corresponding movement tentacles of the bionic jellyfish are started to oscillate and stroke.

3. Analysis of bionic jellyfish movement mode

3.1. Cruise control mode

The movement tentacles IPMC material strip of the bionic jellyfish is not energized, and the tentacle keeps the stationary jellyfish fixed. When a certain frequency sinusoidal driving voltage is applied to the side tentacles (as shown in Fig. 7), it will reciprocate at a constant speed to generate an upward thrust, and when it is equal to the resistance of water and its own gravity, cruise control can be achieved. There are two types of cruise control: one-stage fixed-speed cruise and two-level fixed-speed cruise. The first-level cruise is to swing one of the opposite tentacles, and the other pair of tentacles is still. As shown in Fig. 8, 2, 4 pairs of side tentacles swing, 1, 3 pairs of sides tentacle still. The second-level fixed-speed cruising is to make the two sets of opposite-side tentacles swing at the same frequency at the same time to realize the secondary fixed-speed cruise of the bionic jellyfish. As shown in Fig. 9, 1, 2 and 3, 4 pairs of side tentacles simultaneously swing.

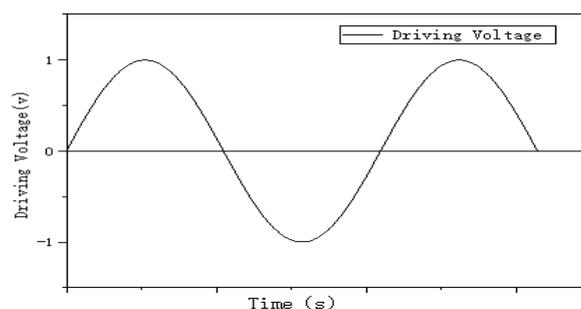


Figure 7. Driving voltage waveform diagram during cruise control.

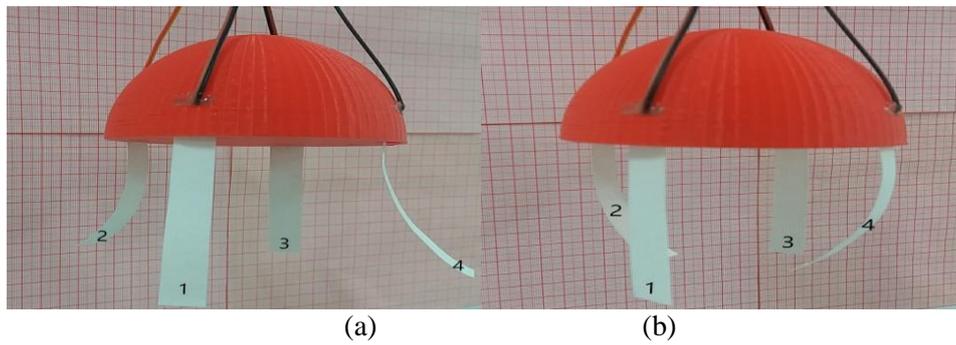


Figure 8. (a) 2, 4 tentacle applied forward voltage (b) 2, 4 tentacle applied negative voltage.

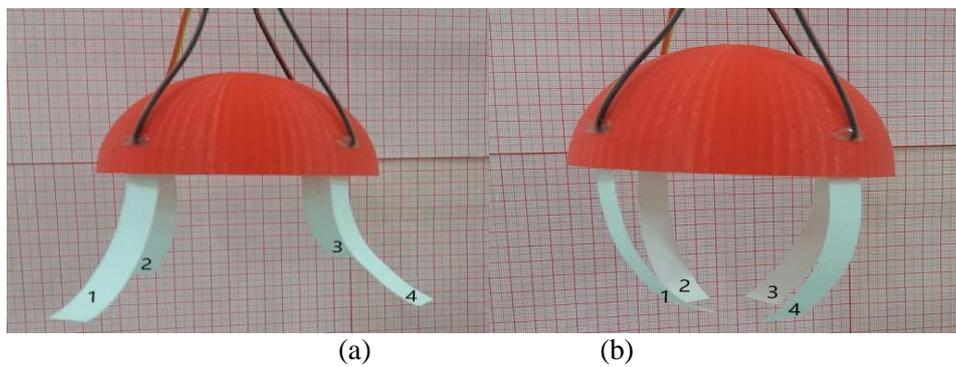


Figure 9. (a) Four tentacles apply forward voltage (b) Four tentacles apply negative voltage.

3.2. Accelerated motion, deceleration motion mode

Increase the driving voltage frequency (as shown in Fig. 10), so that the swing frequency of the tentacle is increased, the propulsive force is increased, and the acceleration mode is realized. Conversely, reducing the drive voltage frequency (as shown in Fig. 11) achieves a deceleration motion mode.

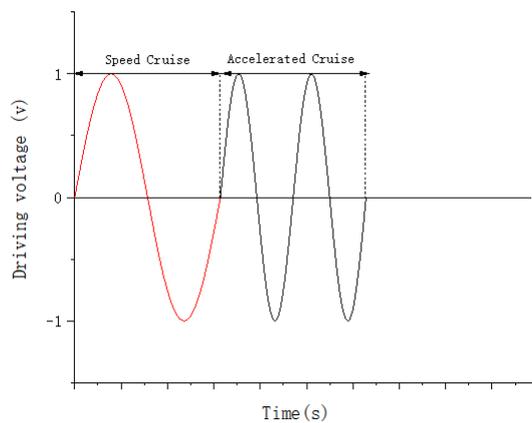


Figure 10. Driving voltage waveform under accelerated motion.

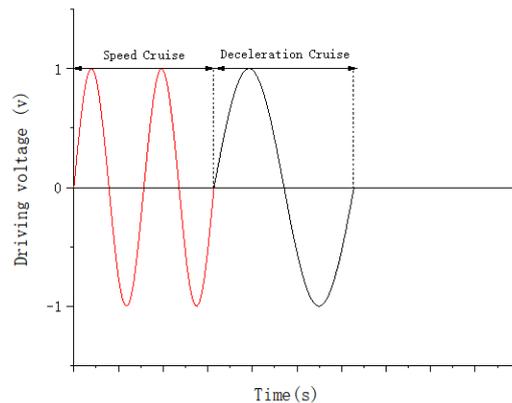


Figure 11. Driving voltage waveform under decelerating motion.

3.3. Steering mode

1, 3 antennas are not energized, 2, 4 antenna angles apply different frequency drive voltage (waveform diagram shown in Fig. 12) to achieve steering. When the low-frequency driving voltage is applied to the 2 antennae and the high-frequency driving voltage is applied to the 4 antennas, the 2 antenna angle swing is large, and the 4 antenna angle swing is small, realizing the left-turn mode (as shown in Fig. 13a). When the high antenna driving voltage is applied to the 2 antennas and the low frequency driving voltage is applied to the 4 antennas. 2 The antenna angle swing is small, and the 4 antenna angle swing is large, realizing the right turn mode (as shown in Fig. 13b).

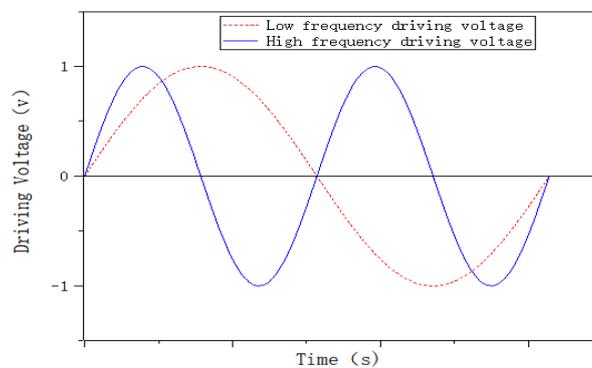


Figure 12. Steering mode drive voltage waveform.

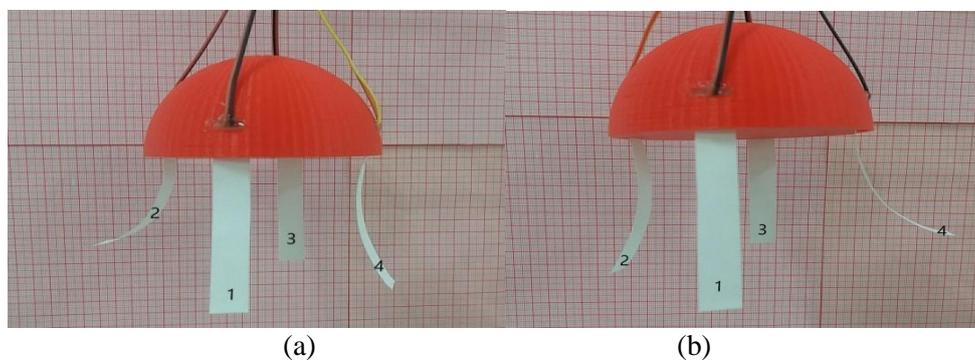


Figure 13. (a) Left turn mode (b) Right turn mode.

4. Conclusion

(1) The outer shell of the bionic jellyfish was prepared by 3D printing technology, and the IPMC material strip was used as the tentacle of the four directions of the bionic jellyfish.

(2) Independently design and develop mobile APP using MIT App Inventor development platform.

(3) The motion mode of the bionic jellyfish's fixed-speed cruising, accelerated cruising, deceleration and turning motion is realized by changing the driving voltage frequency of the IPMC material strip.

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References

- [1] Zhang Peng, Wang Yanqing, Xue Jichen, Du Ye, Liang Bo, Ma Yingjie. Preparation of Ag-IPMC and its application in bionic fish [J]. *Mechanical Engineering and Automation*, 2018(4):28-32.
- [2] Shen Qi, Han Chenxi, Wang Tianmiao, Liang Jianhong. Experimental study on propulsion efficiency of mechanical fish based on IPMC bionics [J]. *Journal of Beijing University of Aeronautics and Astronautics*, 2014, 40(12):1730-1735.
- [3] Li Jian, Guo Yanling, Wang Zhenlong. Touch-propelled bionic jellyfish driven by shape memory alloy wire [J]. *Journal of Harbin Institute of Technology*, 2014, 46(01):104-110.
- [4] Du Ye, Zhao Gang, Sun Zhuangzhi, Gu Yunqing. Bionic structure of shark's gill jet orifice based on artificial muscle [J]. *Journal of Central South University*, 2018, 25(04): 855-865.
- [5] Liu Jiaqi, Liang Bo, Du Ye, Ma Yingjie. Optimization of Ag-IPMC Material Preparation by Box-Behnken Method [J]. *Zhongguo Metal Bulletin*, 2018(06):216-217.