Movement Mode Analysis of an IPMC Bionic Bluetooth Turtle

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Abstract: This paper mainly introduced an APP remote-controlled bionic Bluetooth turtle using 4 IPMC strips as the actuating device. Bluetooth bionic turtle consisted of three parts: the bionic shell, the internal circuitry and control systems. At last, sports mode of bionic bluetooth turtle was also discussed.

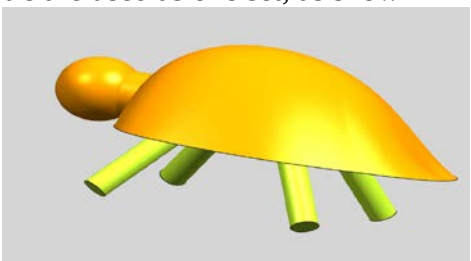
1. Introduction

With the advancement of science and technology as well as the overexploitation of terrestrial resources, the exploitation of marine resources is an ineviTable result of historical development. Moreover, the surface area of the Earth is 510 million square kilometers, of which 71% are oceans and 29% are land. There are abundant resources in oceans. To explore marine resources without destroying the marine environment, researchers invented bionic robots. To reduce the impact of sound on marine life, a new type of driving material came into being-IPMC, which was characterized by fast response, small size, light weight and no noise [1-2]. Driven by this material, an IPMC bionic Bluetooth turtle controlled by a mobile APP is designed. The bionic Bluetooth turtle looks like a turtle and can move forward almost silently. With the rapid advancement of science and technology and the rapid development of communication technologies, mobile phones have become an indispensable part of people's daily life. Mobile APPs have also emerged. The bionic Bluetooth turtle is controlled by a mobile APP, which increases the convenience of use.

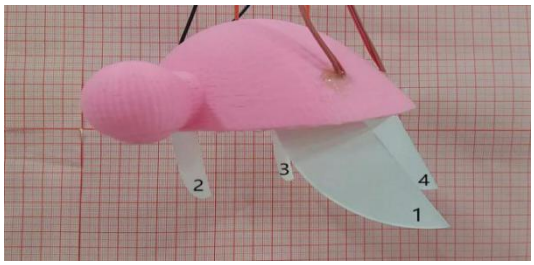
2. Design of bionic bluetooth turtle

2.1. The appearance and internal structure design of the bionic Bluetooth turtle

The 3D model of the bionic Bluetooth turtle's shell is drawn by using the 3D drawing software NX. Import the 3D model intoa3D printer and choose the PLA (Poly Lactic Acid) material. Then bionic Bluetooth turtle's shell can be printed. The internal composition of the turtle mainly consists of a power supply, a microcontroller, a Bluetooth communication module and driving propellers. For the driving propellers (the propellers are made by IPMC), Propeller 1 and Propeller 2installed in front of the bionic turtle are used as one set, Propeller 3 and Propeller 4 installed in rear of the bionic turtle are used as one set, as shown in Figure 1.



(a) 3D Design Drawing of the Bionic Bluetooth Turtle



(b) Physical Diagram of the Bionic Bluetooth Turtle

Fig.1. Design Drawing and Physical Diagram of the Bionic Bluetooth Turtle (1-left front propeller, 2-right front propeller, 3-right rear propeller, 4-left rear propeller)

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2.2. Circuit Design of the Bionic Bluetooth Turtle

As required in the micro control system, the STC98C51 microcontroller needs to be powered by a 6V power supply and the IPMC propellers need to be powered by a 2.5Vpower supply. To obtain a sTable output voltage, it is decided to use the AMS1117-2.5 voltage regulator device. The AMS1117 is a forward voltage dropout regulator device. The advantage of the AMS1117 is that the minimum voltage difference is guaranteed to not exceed 1.3V at the maximum output current and it can gradually decrease as the load current decreases.

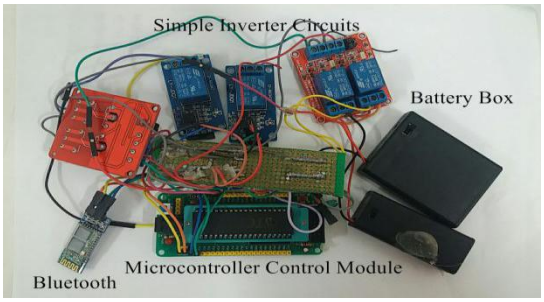


Fig.2. Internal Circuit Connection of Bionic Bluetooth Turtle

Figure 2 is an internal connection diagram of the bionic Bluetooth turtle. The bionic Bluetooth turtle consists of a microcontroller control module, a Bluetooth communication module, a battery box and simple inverter circuits. The microcontroller controls the flow direction of the current by controlling the conduction and shutdown of the internal switch of the simple inverter circuits, thus controlling the driving device.

2.3. Control System Design of the Bionic Bluetooth Turtle

This experiment uses the MIT App Inventor development platform to independently design the mobile APP as the host computer. The software abandons the complicated program codes when writing the APP and uses the stacking method of building blocks to complete the programming. The visual programming interface is more intuitive. Moreover, the operation interface made is beautiful and convenient.

3. Analysis of Motion Modes of the Bionic Bluetooth Turtle

3.1. Constant Speed Cruise Mode

The driving IPMC material strips of the bionic Bluetooth turtle are not energized. The propellers keep stationary and the turtle has no motions. When the front set of propellers is applied with a triangular driving voltage at a certain frequency (as shown in Figure 3), it will oscillate back and forth at a constant speed, generating forward propulsive force that pushes the bionic Bluetooth turtle forward to achieve the constant speed cruise. As shown in Figure 4, the first set of Propeller 1 and Propeller 2 oscillate back and forth and the rear set of Propeller 3 and Propeller 4 are stationary.

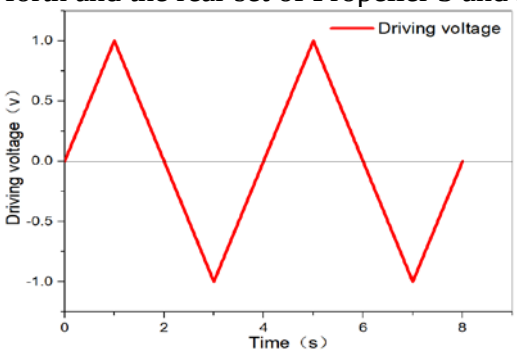
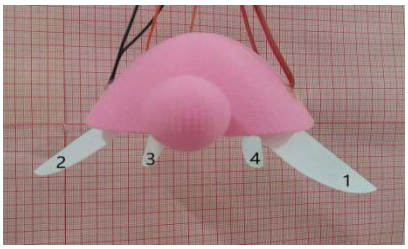
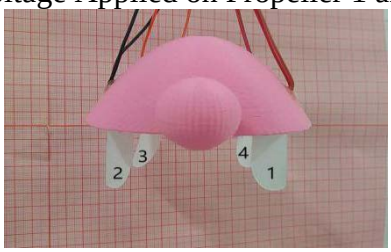


Fig.3. Driving Voltage Waveform Diagram during the Constant Speed Cruise



(a) Forward Voltage Applied on Propeller 1 and Propeller 2

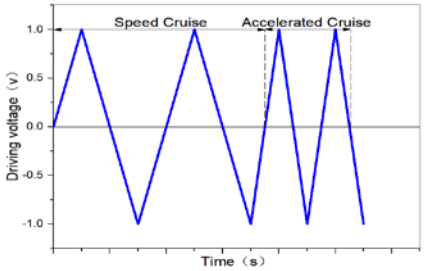


(b) Negative Voltage Applied on Propeller 1 and Propeller 2

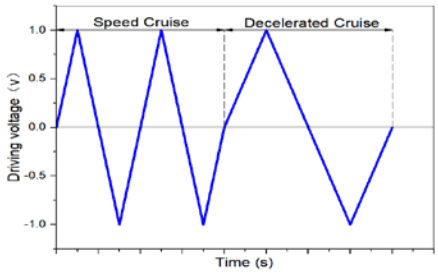
Fig.4. Physical Diagram of the Constant Speed Cruise

3.2 Accelerated Motion Mode and Decelerated Motion Mode

Figure 5 is the driving voltage waveforms of the accelerated mode and the decelerated mode. Figure 6 is the physical diagram of two bionic turtles. When the driving voltage frequency is increased (as shown in Figure 5a), the oscillation frequency of the propeller is increased, the propulsive force is increased and the accelerated motion mode is realized (Figure 6a). Conversely, when the driving voltage frequency is reduced (as shown in Figure 5b), the decelerated motion mode is realized (Figure 6b).

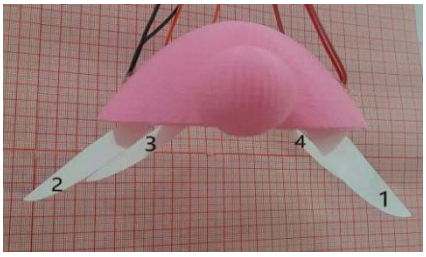


(a) Driving Voltage Waveform in the Accelerated Motion State

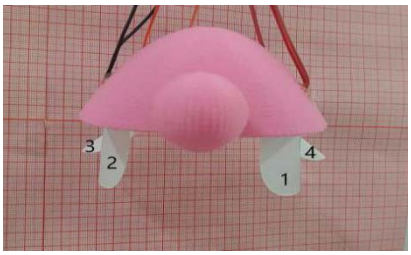


(b) Driving Voltage Waveform in the Decelerated Motion State

Fig.5. Driving Voltage Waveform



(a) Physical Diagram of Accelerated Cruise

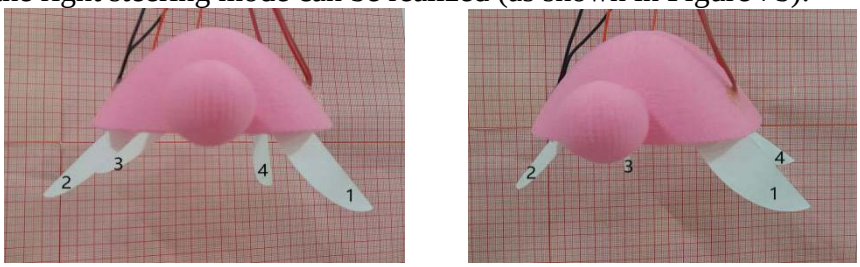


(b) Physical Diagram of Decelerated Cruise

Fig.6. Physical Diagram of Motions

3.3 Steering Mode

The front set of Propeller 1 and Propeller 2 are energized to keep the turtle moving normally. The rear set of Propeller 3 and Propeller 4 are applied with a driving voltage at the same frequency (see Figure 3 for the waveform diagram) to achieve steering. When Propeller 1 and Propeller 2 are applied with a driving voltage at a certain frequency, Propeller 3 is applied with a driving voltage at the same frequency, Propeller 4 is stationary, then the left steering mode can be realized (as shown in Figure 7a). When Propeller 1 and Propeller 2 are applied with a driving voltage at a certain frequency, Propeller 4 is applied with a driving voltage at the same frequency, Propeller 3 is stationary, then the right steering mode can be realized (as shown in Figure 7b).



(a) Left Steering Mode (b) Right Steering Mode

Fig.7. Left-Right Steering Physical Diagram of the Bionic Bluetooth Turtle

4. Conclusion

The shell of the bionic Bluetooth turtle is prepared by the 3D printing technology. The IPMC material strips are used as the driving propellers of the bionic Bluetooth turtle.

The mobile APP is independently designed and developed by using the MIT App Inventor development platform.

The IPMC material strips are used to drive and realize the four motion modes the bionic Bluetooth turtle, such as the constant speed cruise and the steering motions.

Acknowledgements

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References

[1] Zhang Mingjunl,Liu Xiaobail,Xu Jian'anl,Chu Dinghuiz,YAN Na. Bionic Research on Turtle's Flexible Forelimb Propulsion[J]. ROBOT, 2011, 33(1):229-236

[2] Guo Shaobo. Propulsion Technology and Experimental Research of Biomimetic Turtle Underwater Vehicle[D].Harbin,Harbin Engineering University,2010

[3] Ding Hao. Reseach on Propulsion and Motion Characteristics of Biomimetic Flapping-foil Unmanned Underwater Vehicle[D].Xi’an,Northwestern Polytechnical University,2014

[4] 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

[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