ATLANTIS PRESS
Advances in Biological Sciences Research (ABSR), volume 6
2017 2nd International Conference on Biological Sciences and Technology (BST 2017)

Water Maze for Behavior Control of Aquatic Animal Robot

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Keywords: Double-layer multi-channel water maze, Aquatic animal robot, Biological behavior control

Abstract. To solve the problem of observing and testing the movement behavior control ability of aquatic animal robot, we have developed a double-layer multi-channel water maze device. The device is a rectangular parallelepiped structure composed of a square bottom, four rectangular side walls .The channel on the four-sided side wall is composed of the upper circular hole channel and the two lower hole channels and the three-hole channel is isosceles triangle. The centers of the four upper circular apertures are in the vertical midline of the sidewalls, at an angle of 90 °to each other and the lower circular apertures of the eight adjacent sidewalls are at an angle of 45 °to each other. In this study, we carried out the experiment to test the behavior control ability of carp aquatic animal robots. The results showed that the device had the diversity in function and had the feasibility in test. Therefore, we believe that the water maze device is easy to made, convenient and effective in use, and has certain practical value in scientific research.

Introduction

At the end of the 19th century, Lubbock first invented the maze method in the pioneering experimental study of insects. Since then, researchers have developed many maze models for various studies. At present, Y maze, T maze and its variant, 8 arm maze and water maze are the most common maze used in various studies.

In the maze, the Morris water maze (MWM) was invented by Morris in 1981[1], which was develped for the study of animal spatial position and sense of direction (spatial positioning) learning and memory ability[2].The Morris water maze has been widely used in the world.The experimental model has become one of the common methods of learning and memory[3-4].The water is poured into the mazein and the rats were placed in the maze. The learning and memory ability of the rats was measured by observing the time, distance, orientation angle and strategy of the rats to find the platform[5-10]. ln the application process of water maze, A. Markowskal used an asymmetric multiple T maze to provide a balanced approach that evaluated the two main forms of navigation learning and memory found in mammals[11]. Sara Rose Guariglia designed a water T labyrinth assay for the determination of mouse repetitive behaviors by combining the elements of the MWM and T maze[12].

The international use of the maze for reptiles, birds and land mammals are more .The water maze device for the ability of aquatic animals to learn and memory has been used, but water maze device which is used in the biological behavior control ability of aquatic animal robot to observe and test has not been reported in the literature so far. We has developed a device for observing and testing the movement control ability of aquatic animal. The device can be used for multi-angle three-dimensional motion observation and testing of aquatic animal robot, and can also be used in the study of learning and memory ability on aquatic animals. Therefore, the device has certain scientific research significance and practical application value.

Design Ideas

According to our preliminary study on the biological behavior control of carp, we invented a double-layer multi-channel water maze. In order to observe the floating and diving motion of aquatic animal robot, the upper and lower two layer hole channels were designed. In the practice of multi - angle control of aquatic animal robot, in order to better observe the steering movement of aquatic animal robot and evaluate the accuracy of control, the upper and lower two-layer circular holes are mutually into a certain angle, and the circular hole between the adjacent side wall also become a certain angle. This water maze is more conducive to observing, testing and evaluating the movement behavior of aquatic animal robot, and has certain practical value in scientific research.

Water Maze Device Structure

As shown in Figure 1 and 2, the water maze is a double-layer multi-channel rectangul ar structure, which is composed of a square bottom and four rectangular side walls.

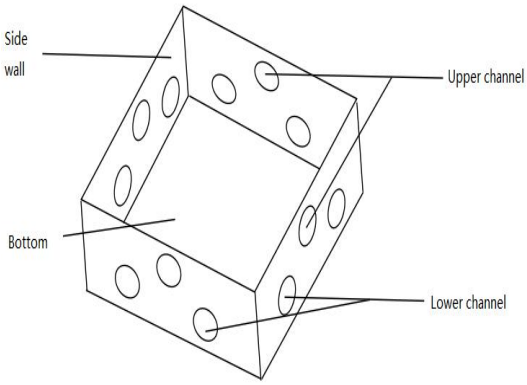

Fig. 1 Stereogram of water maze

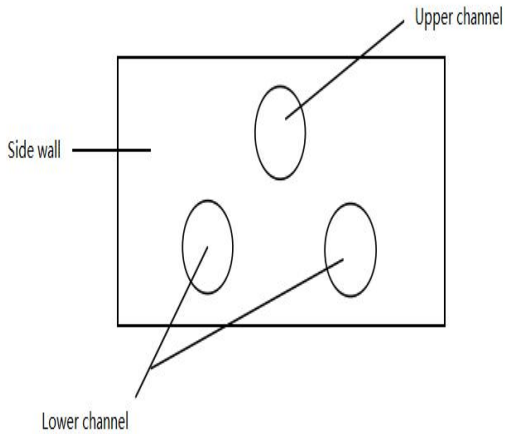

Fig. 2 Side view of water maze

The four side walls of the device have respectively three round holes as the channel.Each hole diameter is the same, the diameter is larger than the fish body height, and the experimental animals can pass through the three round holes of the sidewall. There are three circular holes in the side wall, one is the circular hole of the upper layer and the other two are the circular hole of the lower channel, and the relationship of the circular hole between the one upper layer channel and the two lower channel is isosceles triangle. The center point of the upper circular hole channel is on the vertical line of the side wall. The channels are divided into upper and lower layers, With 4 upper channel round holes and 8 lower channel round holes, being helpful to better observe

the floating, sinking three-dimensional movement of aquatic animal robot.The circular holes of the 4 upper layers of the four lateral walls are 90 degrees each other, and the 8 lower channels of the four side walls are 45 degrees each other, which helps to better observe the forward and the plane movement of the multi angle steering of aquatic animal robot.

According to our need for biological behavior control of carp aquatic robot , we designed a two-layer multi-channel water maze. The device is 200 cm long, 200 cm wide, 55 cm high and round hole diameter is 15 cm. The upper channel center from the top edge of the lateral wall is 17.5 cm, from both sides edge is 100 cm, the lower channel center from the lower margin of the side wall is 17.5 cm, and from the edges of both sides are respectively 58.5 cm and 141.5 cm. The two adjacent side walls, the four side walls and the bottom surface are fixed by the adhesive connection.This water maze device has gained China patent.(ZL 2015 2 0060947.1).

Detection Experiment of Water Maze Device

In order to verify the feasibility of the water maze, we used this device to carry out the detection experiment of the control of carp aquatic robot movement .

Experimental Methods

(1) The water maze device is placed in the pool, and water is poured into the pool. The height of the water surface of the pool is the same as that of the water maze.(2) An experimental carp (weight 920g) was placed in 0.36mol / L eugenol solution for bathing anesthesia.(3) The skull was drilled with a craniotomy, and the stimulating electrode was implanted into brain motor area by means of a brain stereotaxic instrument, and the cranial cavity was closed and the brain electrodes were fixed. (4) The stimulator was equipped on the carp, and this carp robot was placed in the water maze device.(5) The wireless remote control system was used to control the motion of carp robot which the instruction signals were sent by the wireless control device, and the simulated electrophysiological signals controlled the underwater movement of carp robot.

Experimental Results

When the instruction signal was sent out, the carp robot could rotate, advance, float and dive in different directions according to the instruction through the designated circular hole.The results showed that the water maze device could be used to observe, test and evaluate the locomotion behavior of aquatic animal robot.

Discussion

The main maze in the world have Y maze, T maze and its variants, Morris water maze, 8 arm maze and so on, and they are mainly used for reptiles, birds and terrestrial mammals. However, the application of water maze for the observation and testing of the control ability on aquatic animal robot behavior has not been reported so far. For this, we have developed a water maze device suitable for observing and testing the behavior control ability of aquatic animal robots.

We designed the water maze device which has the upper and lower layers of circular hole channel, and the upper and lower layers are formed at a certain angle and the circular holes of the adjacent side walls are also connected to each other. So this device is mainly applied to the observation and test experimental study on the multi-angle three-dimensional motion of the biological behavior control of aquatic animal robot, which can be better used to observe the movement of aquatic animal robot and evaluate

the control accuracy. In the practical application, this water maze device is possible to carry out the motion control experiment of the plane planning path and the motion control experiment of the three-dimensional planning path. The device can be used not only in aquatic animal robot behavior control experiment, but also in the study of aquatic animal learning and memory ability and the experimental study of food selection learning ability, and it can be also applied to the experimental study of the observation and testing of the plane motion of biological behavior control of terrestrial animal robot.

Conclusion

In summary, our experiments show that the design idea of water maze is not only novel but also feasible. The water maze device developed in this study has some outstanding advantages, which can be better used to observe and test the behavior control ability of aquatic animal robots. Therefore, this water maze device has certain scientific research value and practical significance.

Acknowledgements

This project was supported by National Natural Science Foundation of China(project number: 61573305), and Project of PhD Foundation in Yanshan University in China (project number: B702).

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