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МАТЕРІАЛИ

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Analysis of Existing Zoomorphic Mobile Fish Robots

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Annotation: This paper analyzes the characteristics and parameters of existing zoomorphic mobile robots - fish. During the analysis, the authors set the task of considering the possibility of using them to solve the problems of monitoring the environment in the event of man-made disasters.

Keywords: zoomorphic robots, fish robots, mobile robots.

I. INTRODUCTION

The modern development of advanced technologies makes it possible to develop and implement mobile robots in the fields of human activity. One of the basic aspects that are embedded in the concept of the fifth industrial revolution (Industry 4.0) is the development of "collaborative robots". A collaborative robot (cobot) is an automatic (intelligent) device that can work together with a person to achieve a goal. Based on this, many world leaders such as Festo [1], ABB [2], KUKA [3], RobotiQ [4], Yaskawa [5] and many others are engaged in research in this direction. However, it is worth noting that most of the research is focused on the development of manipulative mobile platforms that are designed for production systems, while not paying attention to the development of mobile robots for natural exploration and study of the environment. Conducting an analysis, it can be noted that not so many companies pay attention to the development of zoomorphic mobile robots, a striking example is the development of Festo as part of the Bionic program. BionicAnts - research in the field of group decision-making by a group of robots to achieve a given task or SmartBird - an ultralight ornithopter that flies by flapping its wings. [6,7] PowerVision is a division of Xiaomi that develops automated drones with computer vision systems. [8] One of the directions of their development is the PoweRey underwater drone, which allows underwater shooting, but unfortunately it has control through a wired system with a cable length of 50 to 70 meters, therefore it has limited mobility.

Based on this, we can conclude that the development of zoomorphic mobile robots is an urgent task that will allow not only the natural study of the eco-environment, but can also be used in man-made disasters, to assess damage to ships, as well as to assess the damage caused to the environment.

II. ANALYSIS OF ZOOMORPHIC ROBOTS-FISH

BIKI is the first bionic wireless underwater drone, or simply fish robot, created by the Robosea team. [9,10] The general view of BIKI is shown in Figure 1.



Figure 1. – Bionic fish robot BIKI

The BIKI fish robot features a nine-axis sensor, which makes it possible to self-stabilize in water and provide dynamically soft descent and ascent. The features of this model include that the control of this mobile robot is carried out based on the closed Robosea algorithm. The main technical characteristics are presented in table 1.

Table 1. Main technical characteristics robot fish BIKI

Parameter	Values
The weight	1 kg
Dimensions	27*10*15cm
Speed	1.9 km/h
Maximum immersion depth	60 m
Video	4K (3840x2160)
Noise level	55db
Autonomous robot time (up to 60 m)	150 min
Price	~1350\$

Also, the BIKI fish robot is equipped with a lighting system and a GPS system for returning to the starting point.

Research group The Center for Automation and Robotics (CAR) is a joint center of CSIC and the Technical University of Madrid (UPM) (CAR CSIC-UPM) researchers, together with the University of Florence, have developed a zoomorphic mobile water quality monitoring robot. [11,12] The laboratory layout of the developed zoomorphic fish robot is shown in Figure 2.

A feature of this zoomorphic robot fish, developed by CAR CSIC-UPM, is an attempt to partially imitate both external and interleaving methods of a real biological object. According to the authors of this development, this will minimize inconvenience and stress in live fish, this is achieved by an adaptive control system for swimming modes depending on the state of the water. The following characteristics are available from open sources of information: the length of the robot fish is 30 cm, drives

made of shape memory alloys, 1 mm thick, are used. According to the developer Claudio Rossi, the developed robot will provide early information about environmental changes in water quality and the operation of fish farms.

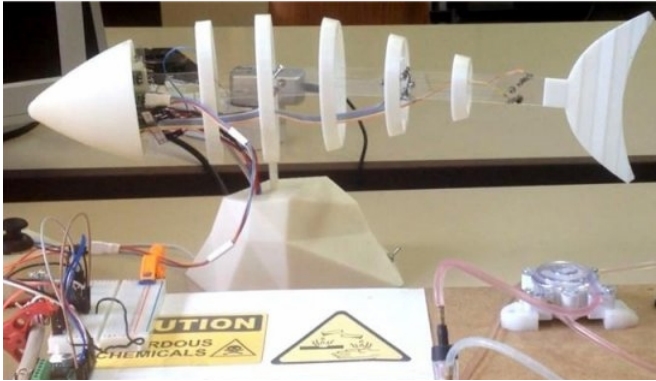


Figure 2. – Zoomorphic robotic fish developed in CAR CSIC-UPM. [11]

As part of the Naro project from ETH Zurich (Swiss Federal Institute of Technology), a Nanin Naro fish robot was developed, a general view of which is shown in Figure 3.

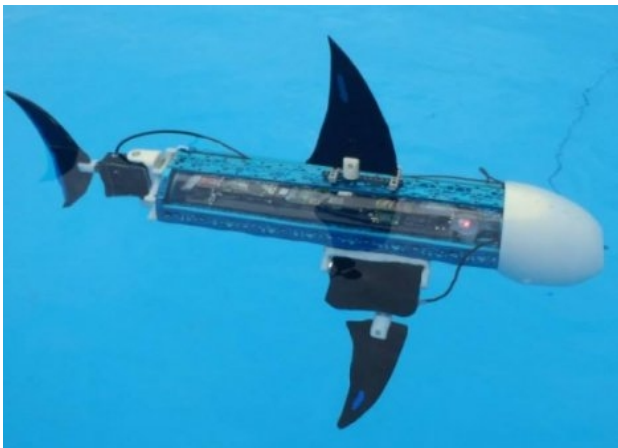


Figure 3. – Robot fish Nanin Naro. [12]

The design of Nanin Naro fish robot is based on anodized aluminum surrounding polycarbonate tubes, inside of which there is plexiglass. The control system is designed based on Raspberry Pi with OS Robot Operating System (ROS) installed on it. Main technical characteristics are presented in table 2.

Table 2. Main technical characteristics robot fish Nanin Naro

Parameter	Values
The weight	7 kg
Dimensions (length)	50 cm
Speed	1,9 km/h
Maximum immersion depth	~20 m
Autonomous robot time (up to 60 m)	160 min
Price	~2550\$

In the article, Qunhong Tian from the Harbin University of Engineering Qingdao Ship Science and Technology Co and his team [13] conducted a series of mathematical studies of building a path for moving a bionic robotic fish, the layout of which is shown in Figure 4.

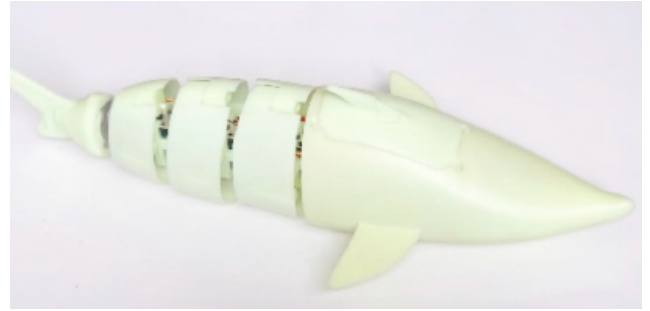


Figure 4. – Layout of the bionic robotic fish Qunhong Tian [13]

The feature of this robotic fish, developed by the Qunhong Tian team, was that it was designed to build a path in difficult ocean conditions. The main technical characteristics are presented in table 3.

Table 3. Main technical characteristics robot fish Qunhong Tian

Parameter	Values
The weight	2 kg
Dimensions	67x23x15 cm
Speed	0,4 km/h
Maximum immersion depth	~10 m
Autonomous robot time (up to 60 m)	~30 min
Price	-

Renxiang Wu from the School of information Engineering, China University of Geosciences, [14] developed a research model of a zoomorphic mobile fish robot based on the Arduino control system, a general view of which is shown in Figure 5.

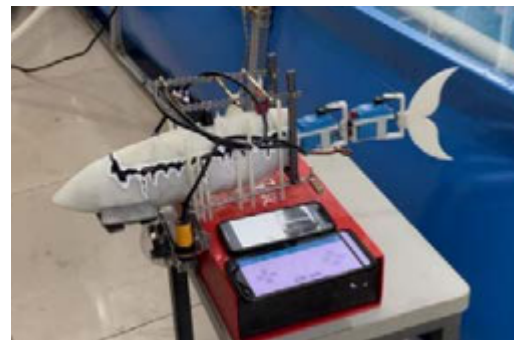


Figure 5. – Zoomorphic mobile robot fish Renxiang Wu [14]

The features of this development include the fact that the control is carried out using the Bluetooth module, that is, at short distances, the OpenMV module is also used to transmit the video signal and the streaming video signal is transmitted via Wi-Fi.

In the works of Jiayong Chen from the South China University of Technology [15], a model of a zoomorphic mobile robot is proposed, which is shown in Figure 6.

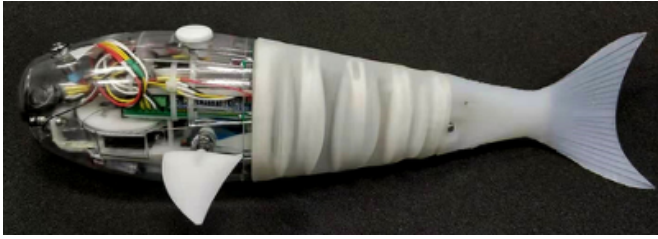


Figure 6. – Zoomorphic mobile robot fish Jiayong Chen[15]

A feature of this robot is that it is implemented based on the STM32F103 microprocessor and is controlled via radio frequency (module E62-433T20D). The main technical characteristics are presented in table 4.

Table 4. Main technical characteristics robot fish Jiayong Chen

Parameter	Values
The weight	до 1 kg
Dimensions	47x23x11 cm
Speed	0,2 km/h
Maximum immersion depth	~10 m
Autonomous robot time (up to 60 m)	~10 min
Price	-

In addition, the GP2Y0A21 module is used to detect obstacles, which makes it possible to analyze obstacles at a distance of 10 cm to 80 cm. Unfortunately, this robot is designed to study the movement of the tail, to build a more natural movement of the robot in the aquatic environment, as a result of which there is no video camera.

III. CONCLUSIONS

Based on the analysis of modern zoomorphic mobile robots, we can draw the following conclusions:

- research in this area is an urgent task that allows you to solve a number of problems related to the study of the aquatic environment and biological species;
- when managing mobile robots, there are problems with the transmission of information through the separation of air and water;
- at the moment, many researchers in this field are studying methods of moving biological species in water and, based on the knowledge gained, are developing mobile robotic fish;
- there are no methods for constructing routes and trajectories of movement of mobile fish robots in the aquatic environment, in which undercurrents, pits, etc. are taken into account;

Despite all of the above, we can conclude that research in this area is only in the initial phase and there are many interesting tasks, the solution of which will allow using the developed zoomorphic mobile fish robots to control, monitor and study the water expanses of our planet, and also provide an opportunity use them in rescue operations in man-made disasters.

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