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Implementation of Fuzzy-Logic Control System for Bionic Robot Underwater

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Abstract:

The bionic robotics or the environment inspired robots are widely studied and used in different fields to be researched more with increasing accuracy rate day by day due to rapid growth of robotics in Artificial Intelligence (AI), Machine Learning and various growing fields of technology. In this paper a special kind of Bionic robot is discussed and implementation of fuzzy logic control system is introduced for obstacle avoidance underwater. The fuzzy logic control for this kind of robot specially designed to avoid obstacle occurring in the path of the robot especially while surveying underwater. The mechanism is inspired from fish like structure for easy movement under the water. Method of avoiding the obstacle used is known as VFF (Virtual Force Field) which is widely used in the field of mobile robotics. Using this method robots can move along the ideal path to the target based on the fuzzy control system in different environment, especially in unknown environment. The bionic structure helps the robot to obtain highest accuracy as possible while moving underwater and the design is been studied in many fields for providing more accurate results, for example: Theo leg mechanism model for 4 legged robots, automated robotic arm using fuzzy logic control, etc.

Keywords: bionic, fuzzy, environment, Artificial.

Introduction:

The proposed model is an environment inspired robotic design that can be operated by remote control system or can also function autonomously in and above the surface of the water. The main objective of the model is to make underwater observations where humans face risks to reach there. The features of the model make the work easy because it avoids any obstacle in the path and multiple sensors provides the reading of the surrounding. The sensors can also be helpful for the divers to scout the area before they go, the pictures captured by the model depends on the camera used which can be easily replaced area to area for different water bodies [1][2].

In the real world the models used for underwater observation faces many difficulties due to the strong waves and surrounding aquatic animals, but this model is designed by keeping the bionic features in mind so that it become the part of the aquatic life so that their will be no disturbance and the shape also helps to avoid the problems from the environment like waves and water plants. Use of sonar sensors helps in detection and measurement, it also helps to provide the depth of the region so that precautions must be taken before. The direction is controlled by the tail design of the model which leads to change the path of the robot so that can be independent in moving throughout the region. The fuzzy method make the model easy to make quick decision so that in measurements and in obstacle avoidance their will be no issues and the accuracy in the movement of the robot will be precise and the material used for the body of robot can be replaced according to the region [3][4].

According to the design and functioning this model can be used in multiple manners like in mining industries for giving it a shape of snake or rodents, heavy lifting underwater can also be done, bird like structure can be very helpful for Unmanned Aerial Vehicle (UAV) i.e for large area surveillance. The model hardware works with the help of microcontroller ATmega which can be known as the brain of the device to control the robot and give commands to every part like motor, sensors and provide power-supply throughout the model wherever needed. Servo motor is been used for tail to change the direction so that the angle can be selected properly for changing direction for the robot [5][6].

The concept of computer vision is discussed for the role of observing using specific hardware capable of capturing images in difficult environment so the captured data can be used as the dataset for machine learning model while studying

animal science. The behavior of underwater creatures are marked by the observer for further studies and the obstacle avoidance system plays a vital role while navigating underwater because of this feature the robot or model itself become the part of the environment and it depends on the range and functionality of the particular hardware for its working like if there is use of ultrasonic sensors, the distance of detecting objects can be increased as per the command provided to the control system and if infrared sensors are plotted on the model only close objects can be avoided which can lead to an accident while navigating at same speed. Therefore, selecting sensors and hardware is very critical for the creator so that frame can handle the hardware and navigate freely in the environment like underwater or in some cases places where pressure is high as compared to normal environment. These physical aspects should be measured correctly by measuring environmental features or the surrounding environment.

Literature Survey:

Sr.no	Author	Title	Method introduced
1.	Tomoyoshi Takeuchi	Fuzzy control of a mobile robot for obstacle avoidance	The feedback management method keeps the speed somewhat consistent even in the event that there are distracting torques. Consequently, the left and right wheels' speed control systems are instructed by the control inputs used to avoid obstacles, which are the fuzzy controller's outputs. The floor image in front of the robot, captured by a CCD camera, is processed to provide inputs for the fuzzy controller.
2.	Jincong Yi	Intelligent Robot Obstacle Avoidance System Based on Fuzzy Control	The investigation of the discrepancy between the simulation results and the real consequences was the main emphasis of the paper. According to the analysis, the robot can handle the issues associated with mobile robot intelligent obstacle avoidance by avoiding obstacles with a better security way. The comparison results also show that the mobile avoidance obstacle system's enhanced features of robustness, stability, and flexibility have a positive navigational impact.
3.	Sng Hong Lian	Fuzzy logic control of an obstacle avoidance robot	Three sub-controllers are used by the controller that is shown here. The outputs are added together to generate a coordinated effort to steer the robot's motors away from obstructions. A tiny robot was fitted with this fuzzy controller. This robot can follow a left wall while staying close to it, avoid obstacles in front of it, and determine whether a gap is large enough for a "side-step" manoeuvre despite its limited range accuracy.
4.	Junzhi Yu	Coordination of Multiple Robotic Fish With	This paper focuses on developing a hybrid centralised system for the

		Applications to Underwater Robot Competition	coordination control of multiple biomimetic robotic fish in highly dynamic aquatic environments. A radio-controlled multijoint robotic fish and its locomotion control are developed with the help of the outcomes of biorobotics and control techniques. A visual subsystem that tracks numerous moving objects is built and put into operation in real time in order to facilitate a closed control loop.
5.	Koichi HIRATA	Development of Experimental Fish Robot	The domains of marine environmental protection, ocean research, and ocean development all make extensive use of underwater robots. They require a more effective propulsive performance. To achieve a high propulsion efficiency underwater robot, we have investigated a swimming mechanism akin to fish and created a fish robot prototype. Its body length is approximately 600 mm, and its three tail joints are moved by two servomotors using an original link mechanism. It has the option to simulate different moving patterns. This paper presents the experimental results of swimming speed measurements with two different kinds of tail fins. Research areas are also discussed in order to achieve fish robots with higher performance.

Methodology:

1) Fuzzy Logic Control System:

The fuzzy logic control system is the method introduced for controlling multiple aspects for a particular system with decision making process while controlling any autonomous system or any controlling module used for multiple applications. Here, two applications of fuzzy logic control system is discussed instead of bionic robotics or nature inspired robots [7][8].

Application 1: Robotic model are used in various field including mining, surveillance, manufacturing, transportation, research and guiding missions, etc. for navigation control it is necessary to study and observe the positioning of the robot or model in the surrounding environment. In all this different ground the need of avoiding obstacle is the task which is mostly required of the robot therefore fuzzy logic controller is designed for improving the movement control autonomously for a robot in order to avoid an obstacle coming in the path of movement. The robot prioritized and designed so that the autonomous behavior works as a collision free path vehicle in unknown environment too. Membership functions in fuzzy logic, fuzzy logic rule, fuzzy inference system and defuzzification are the methods introduced for the implementation of fuzzy logic control in an autonomous robot designed as per considering the need and area in which it should be functioning like fish structure for underwater, snake model for small region or mining grounds, bird structure for the high altitude region etc [9][10].

Application 2: The structure, modelling and functioning of wall-following robot is explained for studying fuzzy logic control using hardware like ultrasonic sensors, micro-controller i.e microchip PIC16F877 to analyze the data and direct the robot for the necessary control signal. The main feature of fuzzy logic control is that the control action is been

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controlled along with the predefined path as per the data provided to the robot. Matlab Simulink is been used to create the model of the robot first and then there is an optimization of fuzzy logic rules for best possible result. Then the microcontroller is programmed in C language according to the board like Arduino UN, PIC, etc. The reading are also presented by the robot to showcase the performance of the model and the controller.

2) VFF (Virtual Field Force):

The term "Virtual Field Force" usually describes an idea or system that allows remote or virtual teams to work together and accomplish tasks as though they were in the same physical field. This phrase is frequently linked to businesses or institutions that conduct field activities, like teams who handle data collecting, sales, service, or maintenance [11].

Important elements of a virtual field force system could consist of:

Communication Platforms: To enable real-time collaboration, virtual field forces mostly rely on communication technologies. To keep team members in communication, this can involve instant messaging, video conferencing, and collaborative tools.

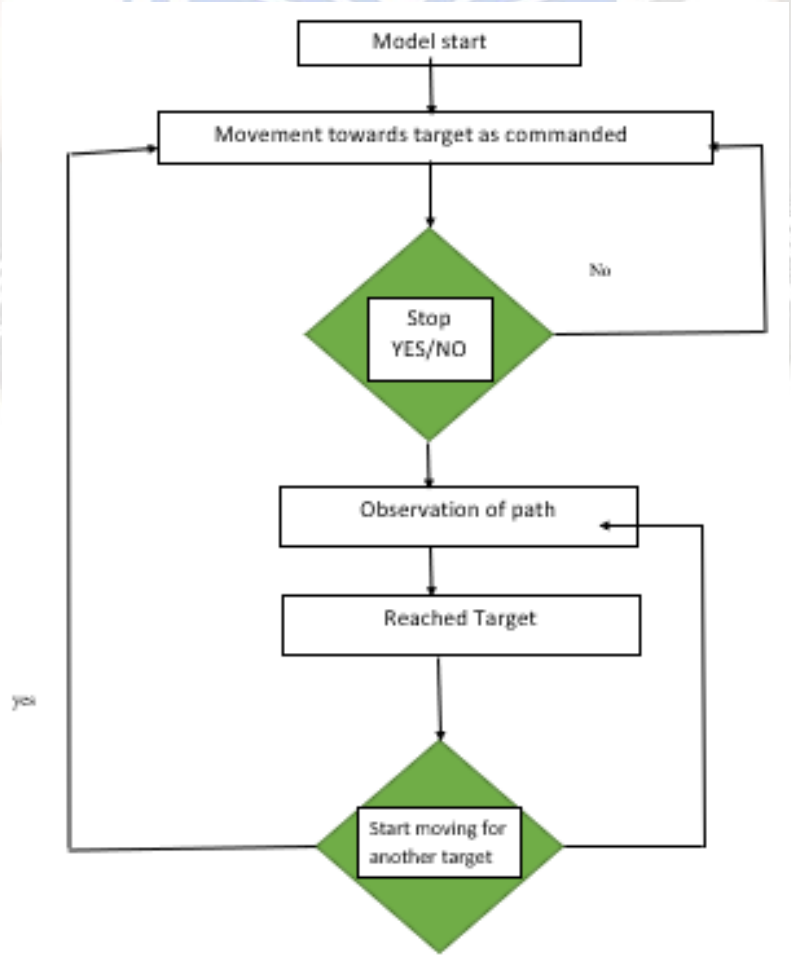
Mobile Technology: In a virtual field force setup, mobile devices are essential. To access data, update information, and communicate with the central team, team members frequently utilize smartphones or tablets that are loaded with pertinent software.

Cloud-Based Solutions: By storing and retrieving data on the cloud, team members can collaborate virtually and share information in real time, allowing for greater flexibility.

Data analytics: Examining field data can yield insightful information. Depending on the type of work the field force does, this may include metrics related to equipment performance, sales information, or customer reviews [12][13].

Putting a virtual field force approach into practice can boost productivity, cut expenses, and enhance teamwork. It is especially important in circumstances when it is not always feasible or feasible to be physically present in the field.

Flow Diagram:



Conclusion:

The method introduced in the paper is the easiest way of implementing bionic robotics in different approaches and application. The control system like fuzzy logic and some relatable methodologies provide better results when there is not a need of accurate numerical value or any numeric precision. In place like Aerial defence , underwater surveillance , mining , manufacturing this method can be implemented . Also the frame designed inspired by nature prove to be helpful in studying different aspects of nature very closely, not only underwater but also studying animal science in forests where humans find difficulties and this method also provide a way which will cost no harm to any creature directly or indirectly connected.

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