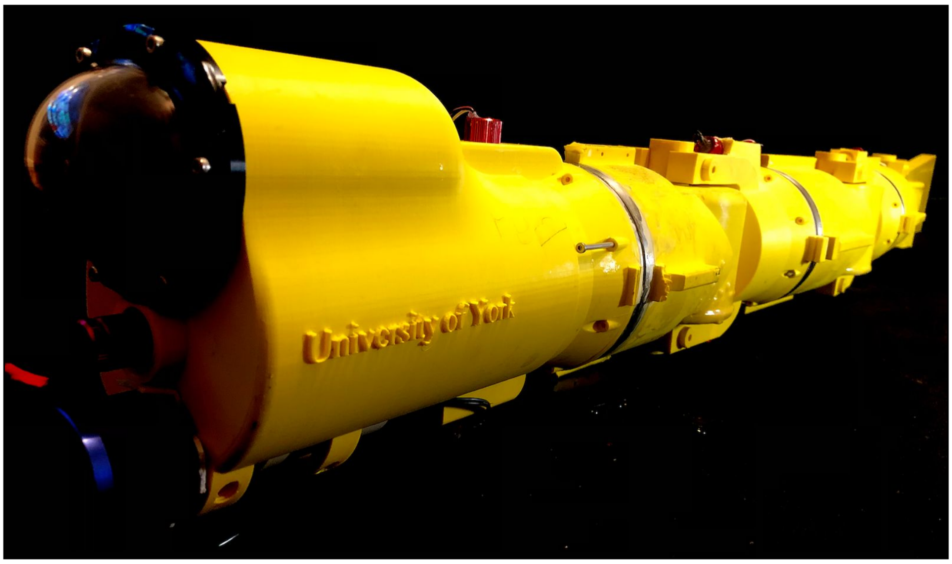
Robotic Fish for Inspecting Offshore Wind Farms

This robotic fish can loiter around complex structures with a camera & won't bother living fish.



Mark Post et al (Photo: Wael Gorma), University of York

The Supergen ORE Hub Flex Fund project "Autonomous Biomimetic Robot-fish for Offshore Wind Farm Inspection" has produced a robot that aims to enable underwater robots called "RoboFish" to continuously inspect and monitor offshore wind farms. Led by Dr. Mark Post of the Intelligent Systems and Nanoscience group in the Department of Electronic Engineering at the University of York, and Dr. Qing Xiao in the Department of Naval Architecture, Offshore and Marine Engineering at the University of Strathclyde, this project began in October 2019 and focuses on an autonomous marine robot which mimics the full-body movement of a fish. Building upon advances in acoustic communication, computer vision, electronic and autonomy technologies, RoboFish aims to apply autonomy to otherwise costly and dangerous offshore wind farm inspections with higher maneuverability and ability to build 3D reconstructions and visual maps of the inspected area.

The Challenge

The role of offshore wind, including floating offshore wind energy, will grow significantly over the coming decades. It is forecast that by 2050, 12 percent of the world's primary energy supply will come from wind energy, and 20 percent of this will come from offshore wind. However, ongoing wear and corrosion from the harsh sea environment drives up cost and introduces downtime to this supply. Material corrosion is currently being inspected using underwater remotely operated vehicles which generally need tethers and a human operator, and are limited in their accessibility and manoeuvrability, or divers, which in sea conditions can be dangerous to human safety.

First RoboFish Prototype

Despite the chaos caused by the COVID-19 pandemic, the first RoboFish prototype was built successfully and went on lake trials. With particularly extensive and invaluable contributions from PicSea CEO/Founder Andrew Durrant and Strathclyde Computational Fluid Dynamics and Fluid Structure Interaction Research Group (CFD & FSI-RG) led by Dr Qing Xiao, the first RoboFish prototype featured novel magnetic joints developed by PhD student Marvin Wright at Strathclyde was built mostly at home by the project Research Associate Dr Wael Gorma at York using off-the-shelf components and cost-effective additive manufacturing techniques.

How RoboFish swims?

Robofish can articulate like a robotic arm by several separate body segments, and it has a head at one end and a tail fin at the other end, to enable the agility of a fish. It can move very precisely by aiming its head and undulating its body. It does not have propellers to be fouled by obstacles and marine growth. In order to make sure that these articulated segments are completely watertight and can work for long periods of time without potential failure of seals, a novel design of a magnetic joint was designed to connect segments together. Teaching RoboFish how to swim is also an important and challenging task. A high-fidelity model of swimming vehicles was developed at the University of Strathclyde. CFD models of Robofish were used by Strathclyde PhD student Marvin Wright to design the control algorithms that control the joints, and fin and buoyancy models to balance the fish were developed by PhD student Yang Luo. Based on these models and algorithms, several swimming gaits are enabled with very high agility for efficient inspection and autonomous docking.

How RoboFish operates?

Using a modular software and hardware architecture, each segment is self-contained and includes self-managed battery power, internal and external sensor data, and actuator control using a low-cost microcontroller. Communications and power transfer between segments are performed through a customised 100Mbit Ethernet bus, and it can charge autonomously underwater by docking with a source such as EC-OG Ltd's Subsea Powerhub. The head segment contains a powerful Xilinx Zynq SoC board, designed by University of York PhD student James White, that serves as a master control node, communications router, and FPGA-accelerated vision platform with an acoustic rangefinder for position detection. RoboFish can also communicate at low rates underwater and be remotely controlled by an acoustic modem. It currently uses vision for close-range navigation and inspection of structures, with the ability to build complete visual models of the structure by using visual odometry and 3D SLAM methods.

What RoboFish's Future looks like?

Future versions of RoboFish will use a range of on-board sensors to record data as well as localising and communicating using underwater modems. Future versions of a smaller size RoboFish, with particular focus on the modularity of the body design and easy connect/disconnect magnetic joints, provide a flexible platform for numerical data validation and experimental investigation within a towing tank. Anticipated investigations include the analysis of the flow field influenced by different fin and body geometries, smart soft materials for passively deformed body parts as well as analysis of different actively controlled body kinematics using linear and nonlinear control. This will provide further insight to disseminate the hydrodynamic performance under different flow conditions to prepare for use within chaotic and harsh ocean environments in applications that include inspection and monitoring of infrastructure, aquaculture, and the environment..