Singapore-MIT Alliance for Research and Technology

News release

SMART researchers develop Whisker-like Sensors that can potentially replace expensive 'eyes and ears' of AUVs, submarines and boats

SMART researchers are first in the world to produce Harbour Seal Whisker-like Sensors that embody undulations and exploit the workings of the follicles to help marine vehicles manoeuvre, navigate and even track objects underwater.

1. Singapore, 20 Aug 2013 – Researchers at the Singapore-MIT Alliance for Research and Technology (SMART)[新加坡-麻省理工学院科研中心] have invented a marine robotics device that would certainly garner the 'seal' of approval from those in the industry and beyond. Dubbed 'Whisker-like Sensors', these sensors can enable an Autonomous Underwater Vehicle (AUV) to intelligently assess the state of its immediate surroundings by 'feeling' the flow, and hence detect important flow features that would be otherwise hidden in the 'blind spots' of current marine flow sensors especially while trying to manoeuvre.

2. In addition to this ability, the sensor readings can also be used to track moving objects. Like the seal whiskers, these sensors can be used to track the wakes (underwater tracks) left by other moving objects. For example, when a fish swims the tracks they leave behind form a series of interlaced vortices. These faint tracks can be picked up by the Whisker-like Sensors - something Acoustic Doppler Current Profilers (ADCP)* and other standard marine current sensors cannot do. The Whisker-like Sensors can effectively track several minutes-old wakes, regardless of operating depth.

3. As such, these sensors can potentially replace or enhance the expensive 'eyes and ears' on AUVs, submarines and boats that currently rely on cameras, sonars and current profilers to gather information about their surroundings. This first-of-its-kind, low-powered, compact (Whisker-like Sensors come in sizes ranging from a couple of millimetres up to fractions of a metre depending on the intended application) and low-cost (approx. USD$50/sensor to produce) sensors provide an advantageous alternative to traditional underwater sensors like underwater cameras which cannot see in murky waters; or sonars whose sound waves pose danger to some marine animals.

Sensor Technology

4. To develop the technology behind these sensors, the researchers mimicked the geometry of real seal whiskers, while exploiting the dynamic properties of their follicles. They created whiskers made of polycarbonate with the same lengthwise undulations that are characteristic in Harbour Seal whiskers, so as to minimise Vortex Induced Vibrations (VIV) as they are dragged through the water. Without this flow-induced noise, these devices are able to provide great sensitivity to environmental flow disturbances.

5. SMART researchers also discovered that the whisker follicles themselves played a pivotal role in the creation of an effective sensor. The researchers' creation of a flexible silicone membrane encapsulated in a solid mould, allowed the whisker to have just the right fluid interaction, giving it greater sensitivity. The combination of these two factors – the minimisation of noise and

amplification of the right signals - renders the Whisker-like Sensors a highly sensitive and effective device for marine vehicles.

6. SMART research scientist at the Center for Environmental Sensing and Modeling [(CENSAM)(环境监测及模拟中心)], Dr Pablo Valdivia y Alvarado (帕布罗 瓦尔迪亚艾瓦拉多), said: "Currently, SMART researchers are testing the sensor capabilities by attaching them at the base of their autonomous kayaks (SMART's multi-sensory ocean vehicles) which are used to collect data for environmental research. These Whisker-like Sensors will enable our vehicles to manoeuvre more efficiently given their limited power supplies, while ensuring they can detect and track objects or structures ahead of their paths and avoid collisions."

7. Professor Michael Triantafyllou (迈克尔 崔昂塔夫罗), who is the William I. Koch Professor of Marine Technology, Professor of Mechanical and Ocean Engineering, Director of the Center for Ocean Engineering at MIT and SMART Principal Investigator, leads the project which includes close collaborations with the Nanyang Technological University. He said: "The possible applications of these seal-inspired Whisker-like Sensors are enormous, especially for use in AUVs and other marine vehicles. I'm confident that SMART, being the first to produce these Whisker-like Sensors that mimic so closely the function of the whiskers of the Harbour Seal, will translate this research into a practical device for industries, such as oil and gas offshore industry, and for research."

8. Other methods like underwater lights and cameras, acoustic navigation and sonars also work underwater but are very expensive and require very high levels of power that drain the batteries. These Whisker-like Sensors are not only inexpensive, but they also use much lesser power. And unlike the loud and invasive sonars, these sensors do not harm aquatic animals in any way.

9. The AUV operations at SMART support environmental sensing, detect environmental pollution, contaminants and monitor the overall water quality in Singapore's waters. SMART's robotic fleet (comprising underwater, surface, and aerial robots) can provide measurements of water quality (salinity, chlorophyll, dissolved oxygen, temperature, turbidity, and several other relevant properties) as well as collect samples at target locations.

10. The research paper entitled 'Performance Analysis and Characterization of Bio-inspired Whisker Sensors for Underwater Applications' will be available in November 2013 in the proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems and will be available online at http://ieeexplore.ieee.org/ shortly after. This research was funded by the Singapore National Research Foundation (NRF) through SMART at the Campus for Research Excellence And Technological Enterprise (CREATE).

**ADCP measures how fast water is moving across a large and far entire water column.*

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About SMART

The SMART Centre is a major research enterprise established by the Massachusetts Institute of Technology (MIT) in partnership with the National Research Foundation of Singapore (NRF) in 2007. It is the first entity in the Campus for Research Excellence and Technological Enterprise (CREATE) developed by NRF.

The SMART Centre serves as an intellectual hub for research interactions between MIT and Singapore. Cutting-edge research projects in areas of interest to both Singapore and MIT are undertaken at the SMART Centre. SMART comprises an Innovation Centre and five Interdisciplinary Research Groups (IRGs): BioSystems and Micromechanics (BioSyM), Center for Environmental Sensing and Modeling (CENSAM), Infectious Diseases (ID), Future Urban Mobility (FM) and Low Energy Electronic Systems (LEES).

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