Cullen Scholarship: Developing new underwater AI algorithms for real time data analysis, mission planning and investigations (PhD Award)

Background

In recent years, three-dimensional (3D) terrain data and scene reconstruction technology have been gradually applied to underwater imaging applications. Acoustic methods such as scanning sonars, multibeam and side scan sonar are routinely used for underwater mapping and investigation purposes since they can operate in turbid water. Underwater laser or photogrammetry techniques have carved their own space in underwater investigation thanks to their superior precision, data density and level of detail achievable but their effectiveness is limited by water clarity. For example, in terms of underwater engineering construction [1], laser 3D reconstruction technology can provide more accurate and visualized 3D site surveys for underwater construction projects, used to check the structure of subsea instruments and the wear status of pipelines, pylons or any other type of infrastructure. In terms of marine scientific research, laser 3D reconstruction technology can explore seabed resources and map seabed topography [3,4]. In addition, it can also be applied to biological survey [5,6], archaeology [7,8,9,10], sea bottom topography description, etc. [11,12]. During Remote Operated Vehicle (ROV) and Autonomous Underwater Vehicle (AUV) operations, both acoustic and laser 3D scanners are normally just used to collect data but there is plenty of potential to use the same information as part of real time situation awareness monitoring and decision making, in particular when these sensors are integrated with advanced Artificial Intelligence (AI) and Machine Learning (ML) algorithms. Current AUV technology requires operators to pre-plan underwater surveys, but AUVs are not “smart enough” to detect specific targets autonomously based on incoming data, and to then redesign their survey objectives accordingly. Several days or weeks can pass between the data collection and data analysis which is when an operator would detect targets which may then necessitate planning a follow-up more detailed mission.

In a future evolution of this scenario it will be possible to programme ROVs and/or AUVs to autonomously execute a mission such as finding a specific target (e.g. damaged infrastructure, broken pipe, cracks, leaks, unexploded ordnance, wrecks, specific geological features or habitat types etc.) based on real time on-board analysis of data being collected.

The rationale for this research is to conduct a review of current status of integration of sensors (acoustic, photogrammetry and Laser) and AI / ML algorithms in the context of real time ROV and AUV operations, and then develop algorithms capable of analysing real time data and providing decision support to either ROV operators or to AUV on-board mission control software. In the context of AUV operations for instance, as the AUV moves along the pre-planned trajectory, the new algorithm would analyse the incoming sensor data and recognize targeted objects, assign investigation priorities and integrates them into the pre-planned route. In the context for example of a missing airplane, the AUV would be launched with the specific task of searching for wreckage along a pre-planned survey, and once discovered based on incoming data, the AUV would autonomously redesign the survey and conduct a detailed investigation of the target feature/area.

Proposal

We propose **a structured four-year PhD** on a full-time basis to develop new algorithms capable of real time analysis of underwater acoustic, photogrammetry and Laser data or a fusion of all of these with additional abilities to use AI and ML to find and extract potential targets to be used to inform ROV pilots or augment AUV mission plans. The project will aim to:

- Review current status of integration of AI and ML algorithms for underwater acoustic, photogrammetry and 3D laser data.
- Carry out case studies research focused on development algorithms focused on identification of specific targets using acoustic, imagery and 3D laser scanning data.
- Embed newly developed algorithms as part of an ROV / AUV navigation toolset
- Select candidate target wrecks or other underwater infrastructure for scenario testing.
    - Apply algorithms for auto recognition of target features.
    - Assess algorithm effectiveness at recognising different targets based on data source (acoustic, images, laser).
    - Assess ability of the algorithm to influence the decision priorities of the navigation system and develop alternative survey plans.

Location of Scholar

The PhD student will be based in their host Higher Education Institute (HEI) and in the Marine Institute in Galway (split circa 50/50 in modules of time as agreed between the HEI and MI supervisors).

Outcome

The student will undergo a four-year training period learning new research methodologies, resulting in a PhD thesis. The expected outcomes from the project will be;

- Advanced AI and ML enabled algorithms for underwater remote sensing data analysis, extraction, target identification, classification and data fusion.
- Implementation of algorithms in multi sensor technology for real time data analysis and data fusion as part of survey situation awareness and mission planning.
- Journal publications.

Links with Marine Institute Strategic Plan 2018-2022

This proposal falls principally under Strategic Focus Area 3 - Research & Innovation, developing research capacity to support ongoing national and international operational and research programmes. This links to Strategic Focus Area 2 – Forecasting Ocean and Climate Change, specifically through improving our ability to determine seabed character, and in turn improving our benthic habitat, oceanographic & ecosystem modelling capacity. Improving knowledge of the connectivity and interdependence of

seabed type, benthic habitat, and oceanographic and environmental bottom conditions will better support future modelling and scenario prediction ability, as well as resource management.

Specific Requirements

The scholar should have a primary degree in Engineering (Electronic, Computer, Mechanical, Marine, Robotics, AI, Computer Science or Marine Science).

Access to appropriate infrastructure and seabed mapping resources (e.g. Marine Institute Research Vessels and national remote and/or autonomous robotic underwater observation systems).

Field work and offshore survey expeditions at wreck sites will be required.

Financial Details

Scholarships will be up to €27,500 per annum (maximum funding of €110,000 over four years). This amount comprises a maintenance award of €18,500 (Irish Research Council rate effective 1-Jan-21) to the student as well as payment of fees to the host higher education institution (HEI). The maximum fees payable to the HEI will be €6,000 per annum. The scholarship award also includes a budget of up to €3,000 per annum for eligible research costs (travel & subsistence, publication costs, consumables and other costs e.g. laptop) for the sole use of the student, and are payable on a reimbursement basis direct to the host institution where the postgraduate student (scholar) is registered. There are no overheads payable on the scholarship. Publication costs are intended to cover publications on which the scholar is listed as first author and are published under Open Access. Scholars can also apply for additional funding under the Marine Institute's Networking Initiative, which is an annual call.

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