COLLISION AVOIDANCE BETWEEN UUV AND SURFACE VESSELS

PROBLEM

Any collision between a cruising vessel and an un-crewed underwater Vehicle (UUV) or glider is likely to damage or destroy the vehicle and may also damage the vessel and injure its crew. Both types spend the bulk of their mission durations underwater and move slowly relative to motor-powered surface vessels: gliders typically cruise at between 0.3 and 1 knot and UUVs cruise at between 2 and 5 knots. They also surface at intervals when they require a position fix from GPS or need access to a satellite network such as Argos or Iridium. At such times, they drift with the surface current and they are difficult to see due to their partially submerged state. Additionally, the vehicles can take ten seconds or longer to begin diving from the surface increasing the chance of collision.

At present, very few UUVs or gliders are fitted with systems that allow them to sense and avoid a collision with a vessel whose pilot has not detected them. Systems with appropriate space, weight and power (SWaP) characteristics are required. Such systems should be capable of passively detecting, tracking and localising vessels that present a collision risk with sufficient lead-time to enable the vehicle to plan and execute an avoidance manoeuvre. Such systems must be operable in shallow waters and potentially in cluttered environments. Ships at anchor can also be a danger to surfacing vehicles.

The underwater environment poses difficult problems for the development of such systems; methods based on electromagnetic radiation (e.g., cameras, radar) that are functional above-water are not applicable underwater. UUVs also have limited manoeuvrability and capacity to accelerate; hence, to avoid collisions, candidate systems must detect vessels at significant distance.

Currently, acoustic methods appear to be the best suited for underwater applications over representative distances, and have certainly received the lion's share of attention in previous research projects where underwater signal detection is required. Signal detection, classification and tracking in the shallow underwater environment acoustically presents its share of problems. Busy waterways mean many signals to decipher and track, and there are multiple other noise sources. The closed undersea environment and the high impedance of water when compared to air means that reflections are numerous, causing such phenomena as the Lloyds mirror effect and reverberation patterns that can make signal processing difficult and complicated. Moreover, ambient noise can partially or completely obscure the presence of vessels or make signal processing difficult; such noise can come from multiple sources such as:

- Biological - Snapping shrimp and other marine fauna can overwhelm vessel signals for spectra up to 200 kHz.
- Weather- Rain and wind can create noise sources on the surface of the closed environment.

Optical inputs may also be useful, especially when a UUV is on the surface, but waves may obscure moving vessels. Ultimately, innovative research will be required to solve this problem and solutions do not need to be limited to acoustic methods, researchers should be willing to look outside the box to solve this problem.

In conclusion, this proposed fundamental research project aspires to explore innovative options to develop systems for passive vessel and object detection, classification and localisation, to be used on UUVs with a view to increasing their autonomous capability.

NEED/RELEVANCE TO DEFENCE

The Royal Australian Navy (RAN) is currently in the process of acquiring un-crewed autonomous and remotely operated maritime vehicles to augment and in some cases, replace its crewed vessels. Submersible variants include autonomous or un-crewed underwater vehicles (commonly referred to as UUVs) and autonomous underwater gliders (referred to as gliders). While they are potentially vulnerable to vessel strike while they are submerged and invisible, their vulnerability increases when they on the surface. At such times, they drift with the surface current and they are difficult to see due to their partially submerged state.

Any collision between a cruising vessel and a UUV or glider is likely to damage or destroy the vehicle and may also damage the vessel and injure its crew. The financial and reputational cost for Defence could be significant. Gliders are most likely to suffer collisions when they operate in areas with high vessel traffic. Military UUVs tend to suffer collisions during training activities, when commercial and recreational traffic can access their operating areas. The collision risk associated with surveys of congested areas, such as harbours and marinas, is currently too high for safe use of UUVs.

RESEARCH QUESTION

This proposed fundamental research project aspires to explore innovative options to develop systems for low power vessel and object detection, classification and localisation, to be used on UUVs or gliders with a view to increasing their autonomous capability.

It has been pointed out that many classes of problems can be associated with this question and an overall solution addressing the question may be very difficult to achieve. Therefore, the response should consider the aspects described in the problem section and address at least one combination of the following subclasses:

- Vehicle Class, with associated SWaP constraints

  - Hand Deployable UUV <= 70 kg
    - Space 2 L , Weight 2 kg, Power $15W_{ave}$, $<50\ W_{peak}$
  - Medium UUV- up to 400kg
    - Space 4 L , Weight 4 kg, Power $30W_{ave}$, $<150\ W_{peak}$
  - Large UUV >400kg
    - Space 10 L , Weight 10 kg, Power $50W_{ave}$, $<1\ kW_{peak}$
  - Underwater Glider
    - Space 1 L , Weight 1 kg, Power $5W_{ave}$, $<20\ W_{peak}$

- Operating depth band
  - When vehicle is on the surface
  - submerged <=10m from surface
  - submerged > 10m from surface

Generic Constraints:

- Max Operating Depths = 50m
- Minimum Detection range 100m but preferably 350m
- Above water sensors can be located at most 1 vehicle diameter above the water when the vehicle is on the surface unless the sensor is retractable
- Active system with restricted duty cycles are permitted but passive systems are preferable.

EXPECTED OUTCOMES

The expected outcome is a TRL 3 proof of concept system that can be further developed at a higher TRL in the future or a reasonable indication that the considered detection system is unlikely to be viable under the relevant circumstances.