

UNDERWATER OBJECT DETECTION AND RETRIEVAL

The Underwater Object Detection and Retrieval project is a research and design senior capstone project being conducted by two Computer Systems Engineering students at the University of Alaska Anchorage, Wolfram Donat and Zach Mildon. The project's goal is to design and build a fully autonomous underwater vehicle (UAV.) This vehicle will be capable of navigating a closed body of water, locating a user-defined object on the bottom of that body of water, and then diving to retrieve the object. The vehicle will be tethered so as to limit the weight; batteries and processing power will be kept onshore. Onboard systems will be limited to motor controllers and a camera for the computer vision portion of the research.

Much research has been done regarding applications of computer vision from the air; UAVs (Unmanned Aerial Vehicles) often rely on computer vision to identify targets, stay aloft, and return to base, particularly if they are completely or partially autonomous [1, 2, 3, 4]. The ability to identify objects in a surrounding area by an unmanned vehicle such as a UAV can have a tremendous effect on the success (or failure) of a mission. In these systems, processing power remains onboard, as the time it takes to identify an object can be mission-critical, and offloading that task to remote computers is not always feasible.

However, underwater computer vision is also receiving a good deal of attention [5, 6, 7]. Underwater vision presents some unique difficulties, including water clarity, salinity gradients, temperature gradients, rapid attenuation of electromagnetic radiation, and problems with geometric distortion. In order to avoid many of these difficulties, SONAR (SOund Navigation And Ranging) has been used with varying degrees of success to approximate vision underwater. Sound is reflected from underwater surfaces, and onboard systems decode the information received. Sonar tracking, however, while good for obstacle detection/avoidance and for distances of up to 200 m, is limited in its resolution, even at relatively close distances. At shorter distances, computer vision is preferable, and it can be used quite effectively for tasks such as following undersea pipes, staying on station in front of targets, and constructing mosaic representations of undersea features [8].

Another difficulty that arises from underwater object detection is feature tracking. Aside from the optical difficulties inherent in underwater searching, tracking objects becomes difficult, as the combination of water currents and the submersible's low coefficient of friction with the water makes it difficult to stay on target or remain motionless in the water [9]. Any vision system must be designed to cope with these difficulties.

Because of the problems with backscatter and low light scenarios, it is especially difficult for an autonomous vehicle to systematically scan an underwater area, as different lighting angles from the submersible's light sources (necessary in low-light conditions) and lack of visual landmarks can make it extremely difficult for a computer vision system to register images either spatially or temporally. Area mapping algorithms typically use a mosaic approach, in which images of successive passes over an area are stitched together to form a larger image. Underwater areas are particularly difficult to

map this way, as even areas that are right next to each other are difficult to distinguish [10].

The goal of this project is to design a submersible able to do the following autonomously:

1. Progressively search an area by following available landmarks
2. Locate and identify an underwater object
3. Home in on that object
4. Dive, navigate to and retrieve the object, and resurface

Applications for this research are varied and numerous, as the following examples show:

Law Enforcement: It is not uncommon for authorities to be called upon to search bodies of water for bodies, weapons, or drugs. Having a small, autonomous submersible to help with that task would be highly advantageous.

Earth Science Research: As Hogue and Jenkin point out, coral reef health is an important indicator of climate change, and monitoring those reefs is a time-consuming, often dangerous job [11]. An autonomous vehicle with vision capabilities could help with that task.

Industry: As offshore oil drilling continues, and as that drilling occurs in deeper and deeper water, human divers can no longer perform the tasks necessary to anchor rigs to the ocean floor or to maintain those rigs or the drill pipes. Other offshore energy-related activities are also becoming more common, from offshore wind farms to wave-energy technology. Both of these also require deep-water maintenance that could well be provided by an autonomous submersible. Again, computer vision capabilities would significantly improve such a submersible's usefulness to industry.

Space Exploration and Research: It is well known that among NASA's planned voyages is a trip to either Jupiter's moon Europa or Saturn's moon Enceladus to search for signs of life in the deep oceans that are theorized to exist deep under the ice covering those moons [12, 13]. The best way to do this seems to be by utilizing a robotic probe capable of drilling through the ice and exploring the ocean underneath [14]. This probe will have to be autonomous, as it may be cut off from communicating with mission control once it submerges (barring other methods of remaining in contact, such as an antenna left on the surface to which it is tethered.) The probe will also need to navigate the ocean, whether that navigation relies on visible light, sonar or some other wavelength of electromagnetic radiation. Mapping algorithms developed on platforms such as this may be applied to extraterrestrial situations.

Project design has begun, with building and programming already in the early stages.

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