ID31- A VISUALLY-GUIDED POSITION CONTROL METHOD, IN UNDERWATER CONDITIONS, USING AN INEXPENSIVE REMOTELY OPERATED VEHICLE.

ALEJANDRO SOLIS[1], RAÚL MARIN[1], PEDRO J. SANZ[1], JOSÉ V. MARTÍ[1]

1 CIRTESU (Underwater Robotics and Technology Research Center), University Jaume-I, 12071 Castellón de la Plana, Spain

Underwater interventions have become a trend in the past years, from industrial applications like installing oil pipes, to rescue applications like retrieving a black box from a sunken plane. The increasing interest in underwater exploration has led the scientific community to put efforts into developing new technologies to enhance underwater operations. The idea of giving the vehicle a semi-autonomous behavior comes from the fact that sometimes manual teleoperation can be inaccurate if the operator does not have enough skill to manipulate the robot. Even if the operator is skilled enough, in an underwater environment where the currents can cause some disturbances and the vehicle needs to perform a task that requires precision, such as grabbing an object, it is safer that the vehicle can aid the user by positioning itself at an optimal location to execute the desired task. To provide autonomous position control with respect of an object to an underwater vehicle, a proper recognition of the object and a way to measure its features is required, amongst other things.

There are three main problems while dealing with underwater image capturing [1]. The first is described as view-disturbing noises, this includes any floating matter that can produce noise in the camera's field of view, such as small fishes, bubbles or sand particles. The second problem occurs due to the refraction of light. Objects are appreciated differently according to the environment where they are placed and their respective refractive index. This causes distortions that affect the measurements of the position and shape of the object. The third problem is the light attenuation. The intensity of the light will decrease as the distance between the object and the camera increases.

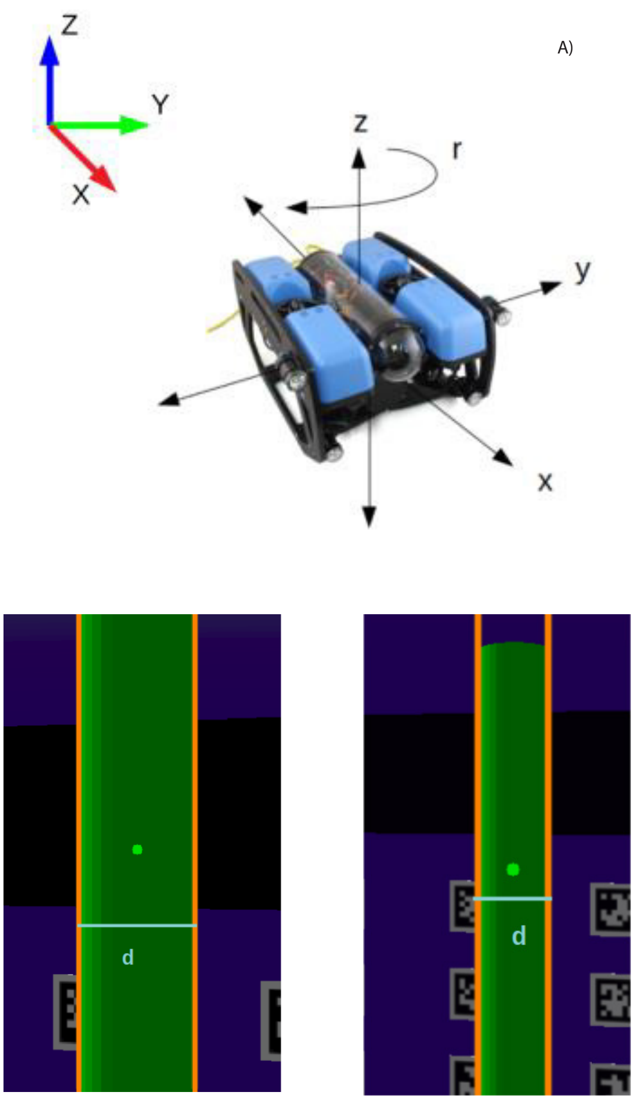
To solve the issues of underwater image capturing some techniques have been developed such as the Multi-View Laser Reconstruction [2] method which uses a laser emitter and a camera attached to the forearm of a robotic arm. The arm allows the camera and the laser to be moved across the scene. While the laser scans the environment, the camera is recording the image, in this way the scene can be reconstructed, and a 3D model of the target object can be obtained. Another proved method [3] to identify objects underwater proposes to use stereo vision or laser reconstruction to obtain a model of the scene. Then using a Random Sample Consensus (RANSAC) segmentation method the background of the object is removed. A second run of the RANSAC algorithm is used to approximate the object to a geometrical figure.

Although the state of art methods provide a novel and successful approach in the object recognition task, they require high-end technology such as lasers. Thanks to the fast-paced growth of open-source software and hardware communities, underwater teleoperated drone technology has recently become accessible to a wider public. The develop of low cost Remotely Operated Vehicles (ROV) has allowed institutes and universities to support the research in the underwater exploration and intervention topics. The BlueROV2 is a low-cost underwater vehicle that relies only on a video camera as a visual input and its LED lights as a brightness variable control input. In this case it is necessary for the case study to use algorithms and methods which can be implemented using just a camera. Given the architecture of the BlueROV it can be easily programmed using python, which also gives us access to the OpenCV library, a free access library that contains a large compilation of algorithms for computer vision applications.

The goal of this case study is to propose and test a vision algorithm using the OpenCV library that can segment a specific object, in this case a cylindrical tube, under the water and provide a setpoint that can later be used for a control task. This abstract reports the preliminary results of implementing such algorithm.

The main idea is to use the moments of a segmented image where the object is outlined to mark the center of the object, this way it can be used as a reference for the vehicle to move along the z and y axis. (See vehicle coordinate system, Fig. 1a).

For the reference across the x axis, we can take advantage of the shape of the object and use the Hough lines algorithm to trace two vertical parallel lines on each side of the cylinder. The distance between the lines (d) will be used as the reference for the robot to move along axis x. Depending on the distance from the camera to the object, the lines will be more separated or close to each other (Fig. 1b, Fig. 1c).

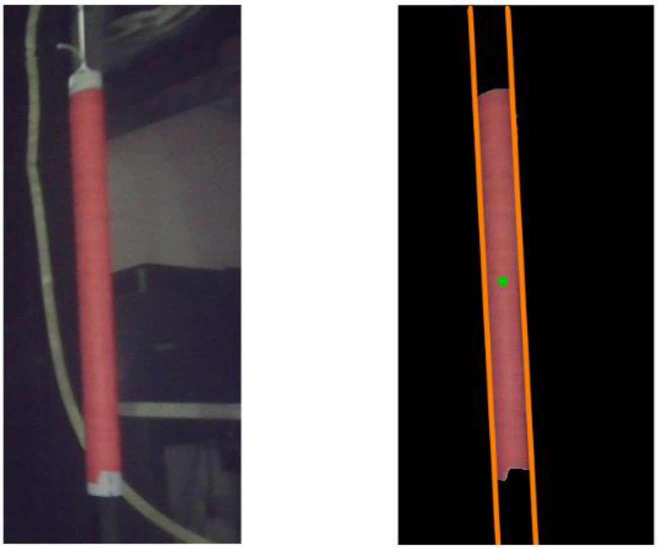


B) C)

Fig 1. a) Coordinate system of the BlueROV2. b) Distance between the Hough Lines when the vehicle is closer to the object. c) Distance between the Hough Lines when the vehicle is farther from the object.

The proposed method to perform the object segmentation task consists in the implementation of a series of image processing algorithms available in the OpenCV library. Firstly, the original image is converted into the HSV color space, then the corresponding color mask is applied to cut out the object from the rest of the scene, afterwards the canny edge detection algorithm is implemented to highlight the edges of the image. To find the contours of the image and calculate its center, the moments of inertia algorithm is used and finally the Hough Lines detection algorithm is executed to find the vertical lines that can describe the sides of the object. This data then can be used as a setpoint for a controller in order to keep the vehicle at a certain distance and position with respect of the object.

The algorithm was first tested in an underwater simulation environment (UWSim) [4], and then a real-life scenario experiment was executed using a 150x150x200cm water tank, a 3.5cm diameter PVC tube covered in red tape and the BlueROV2 underwater vehicle. Preliminary results of the implementation of the algorithm in a real-life scenario can be seen in Fig.2



A)

B)

Fig 2. a) Original image. b) Proposed method, under execution in water tank conditions

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