M6 EVALUATION OF A LASER BASED STRUCTURED LIGHT SYSTEM FOR 3D RECONSTRUCTION OF UNDERWATER ENVIRONMENTS

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Abstract

Structure from motion or stereoscopy are used to obtain 3D from a sequence of still images. However if there is no texture or features in the images, no 3D can be obtained. Featureless environments are difficult to reconstruct in 3D only using cameras. Projected light patterns can be used to measure the shape or an object. However, scattering is the main problem in light based underwater sensors such as light and cameras. Collimated light such as laser minimizes this problems by focusing the light in fewer points. Ranged gated cameras can be also used with pulsed lasers to reduce even more the scattering. In this paper a new structured light laser system is evaluated to solve the scattering and featureless problems above mentioned and to perform a 3D underwater reconstruction. This system is formed by a laser projector and a camera. By means of pattern identification and triangulation, 3D can be reconstructed from a live video sequence.

Keywords – Structured Light, Laser Line Scanning, Underwater Sensors, 3D Reconstruction

INTRODUCTION

Autonomous grasping of unknown objects by a robot is a challenging task. In the last years, is receiving increasing attention in underwater environments. These environments are highly unstructured and limit the availability and effective range of sensors. Grasping an object generally requires the knowledge of a partial 3D structure or prior knowledge of the CAD model the robot is going to manipulate [1]. In order to obtain these data different methods exist. They can be generally classified according to the type of the sensing device: sonar, laser, stereoscopy, structured light. Sonar based methods are the most extended underwater. These sensors can measure distances of hundreds of meters with a resolution of a centimeter, which is not enough for manipulation. Laser rangefinders are common in wheeled robots, but they do not work correctly underwater due to energy absorption of water. Laser line scanning (LLS) is being used to sweep an area while the robot is stationary and, with a camera, the 3D is recovered [2]. This technique depends on a laser line projecting device and a camera. With two cameras 3D can also be computed, however the density of the reconstruction is directly related to the texture of the object. Finally, structured light (SL) projects a pattern that creates artificial texture on the required object in order to solve the stereoscopy problem [3].

Detailed 3D point clouds are needed to perform a correct manipulation or grasping in underwater environments. The sensors that are accurate enough to perform such a task are LLS, stereo cameras and SL. Stereo cameras need texture in order to compute 3D points, and in these environments the object to be manipulated and the surrounding area where it is laying can be featureless because of mud or flora growing [4]. LLS is slow but accurate, whilst SL is fast but in underwater environments suffer from scattering problems. Solutions to these options have been explored by researchers in the last decade, and we would like to introduce a new underwater sensor based on structured light systems and laser light, which is under study.

LASER BASED STRUCTURED LIGHT SYSTEM

The performance of underwater optical imaging systems such as cameras is limited by absorption and scattering. These two terms depend on the turbidity of the water the light is propagating in. When a system has been optimized to reduce backscatter it may become limited by absorption. In this situation, the propagating signal is too weak to be detected by the corresponding sensor, and the system is said to be power limited. If the power is increased the scattering increases. It can increase so much that the sensor cannot differentiate the true signal from the noise. In this case the system is said to be contrast limited. The performance in both cases can be enhanced by choosing the source wavelength to match the optimal underwater wavelength, which is in the blue-green range of colors in the visual spectra. This enhances the range. If a collimated light is also chosen, polarization filters can be also used to discard the light scattered by suspended particles. Advanced systems reduce even more the scattering by controlling the temporal properties of light, gating both the light emitter and the receiver [5].

Fig. 1 shows the proposed laser projector, projecting a 25 parallel line pattern onto a textureless white plastic bottle. On the right image the camera frame can be seen. With this system 3D pointcloud data can be provided at per frame rate, without the need of waiting a laser sweep scan nor having the need of a textured surface.

Until now, this system has been tested in an Underwater Simulator (UWSim, http://www.irs.uji.es/uwsim/) and in a controlled environment.

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Fig. 1: Laser based structured light projector.