ID37- IMPROVING VISUAL ODOMETRY FOR AUV NAVIGATION IN MARINE ENVIRONMENTS

BO MIQUEL NORDFELDT FIOL[1], FRANCISCO BONIN-FONT[1], YOLANDA GONZALEZ CID[1], GABRIEL OLIVER CODINA[1]

1 Systems, Robotics and Vision Group (University of the Balearic Islands, ctra de Valldemossa, km 7,5, 07122 Palma de Mallorca, bo-miquel.nordfeldt@uib.es, francisco.bonin@uib.es, yolanda.gonzalez@uib.es, goliver@uib.es)

Abstract

Visual odometry is usually integrated in the localization and control modules of underwater robots, combined with other data coming from diverse instruments and sensors, such as, Doppler Velocity Logs (DVL), pressure sensors or inertial units, to compute the vehicle motion and pose by means of death reckoning. Dead reckoning is subject to cumulative drift, and, in underwater scenarios is specially affected by the challenging structures, color textures and environmental conditions (currents, haze, water density, salinity, wind, etc...), increasing the need of specific improvement or adjustment to this media. This article presents preliminary results of an evolution of the well known VISO2 stereo odometer, modified in order to improve its performance when run online in marine scenarios, and from a moving Autonomous Underwater Vehicle (AUV) equipped with cameras pointing downwards to the sea bottom.

Keywords

Visual Odometry, Underwater Robots, Marine exploration.

INTRODUCTION AND OVERVIEW

Visual Odometry can be an important element to improve the navigation of mobile robots. However, if its quality is inadequate due to, either the software itself or the difficulties inherent to the environment, these motion estimates can be more damaging than helpful. In the last years, several visual odometers, such as VISO2 [1], FOVIS [2] or the ORB tracker [3], have shown high accuracy in the velocity computation as well as minimal accumulated drift, when used in terrestrial or aerial robots. However, the application of these odometers in marine sites with cameras pointing to the sea bottom questions their suitability in this media. Although Wirth et al showed the advantages and good results of VISO2 in front of FOVIS, experiments were done in very controlled underwater scenarios. Negre et al [4] showed the improvement of underwater visual SLAM in certain marine sites when using VISO2 instead of the ORB tracker, and Bonin et al [6] determined that SIFT feature detection and tracking outperformed the tracking of other types of visual features in marine areas colonized with seagrass, in terms of number of inliers between consecutive and loop-closing images. The VISO2 stereo feature tracker is circular, bucketed, and based on minima and maxima of a blob and corner filter responses, concatenated with the comparison of Sobel filter block responses. According to [6], this strategy is clearly inadequate to detect and track features in marine images with extremelly irregular and complex textures (seagrass combined with stones, algae, peebles and sand). Furthermore, VISO2 was tested on a terrestrial vehicle, with a camera facing ahead and smooth motion and minor rotations or changes on scale in consecutive frames. Contrarily to the latter original VISO2 assumption, images of the sea bottom are usually taken with the camera lens axis perpendicular to the vehicle logitudinal axis, when the vehicle is moving at a constant height. This situation can generate changes in scale, if the navigation altitude is not strictly constant due to the hysteresis in the height controller, or intense rotations in consecutive frames when the underwater vehicle modifies its heading in surveying operations.

In the context of the regional (DETECPOS-PRD2018/34) and national (TWINBOT-DPI2017-86372-C3-3-R) projects, one or several robots need to move over marine areas of special ecological interest, mostly colonized with seagrass, for observation, inspection or intervention. In order to complement the self-motion estimations computed from the onboard sensors, the original VISO2 stereo odometer has been integrated in the vehicle control architectures and tested in the natural marine environments where the underwater vehicles have to operate. Results have been dissapointing, motivating an improvement of the VISO2 stereo odometer to be applied in this kind of situations. To this end, we have replaced the VISO2 original circular feature detection and tracking module by a new one based on SIFT features, and left intact the rest of the algorithm. Although SIFT features need more time to be computed, the slow velocity and dynamics of the AUVs make the online execution of this new visual tracker, at 2.5 fps, completely viable. To assure a minimum number of robust trackable SIFT features between consecutive images, the new versions of the VISO2 (VISO2-SIFT) odometer have been tested activating and deactivating the bucketing process that is executed after the circular feature tracking task. VISO2- SIFT has been integrated in a ROS [7]-wrapper and soon will be available for the scientific community.

EXPERIMENTAL SETUP AND PRELIMINARY RESULTS

Preliminary experiments have been done running the ROS-wrappers of the original [8] and modified versions of VISO2 during the reproduction of ROS bagfiles grabbed from our Sparus AUV in marine areas located in the south of Mallorca. The payload of the Sparus carried a stereo rig pointing downwards, with the lens axis perpendicular to the vehicle longitudinal axis, a DVL, a pressure sensor, an inertial unit, an ecosounder also pointing downwards, and the mobile part of an USBL acoustic modem. All data given by all these sensors were recorded during the mission in ROS bagfiles format, to be reproduced off-line.

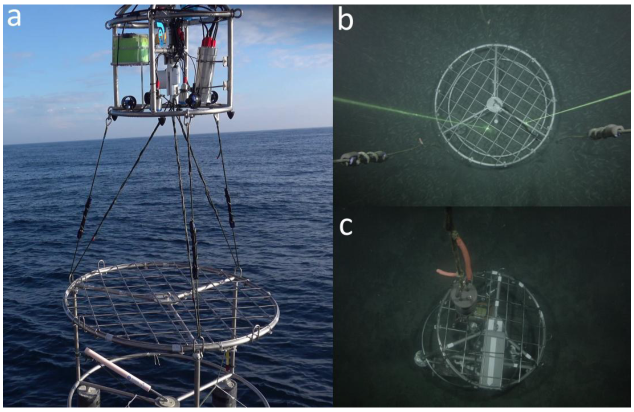

Fig 1.LanderPick vehicle in action, southern Biscay April 2021. a) The Landerpick ready to enter the water with a modestly equipped lander as a payload (include a tilt-current-meter, Lowell instruments TCM-3 and a thermometer, RBR SoloT). b) The lander just after being released on the seafloor of La Gaviera canyon axis at 801 meters depth. c) A fully equipped lander after being hooked by the LanderPick at Le Danois Bank summit (521 m depth).

The navigation module of our Sparus II implements a double stage Extended Kalman Filter (EKF) that integrates the data of all mentioned sensors, plus the absolute vehicle position given by the USBL head to the mobile acoustic modem installed in the AUV, to provide reliable vehicle motion estimates and absolute poses with respect to the North-East-Down (NED) origin of the mission. The data used for the experiments are: the stereo images at 2.5 fps, the vehicle altitude and the output of the aforementioned vehicle navigation EKF, as the ground truth. Figure 1 shows several images recorded by the robot during the mission, and Figure 2 shows the vehicle trajectory, obtained integrating the odometry given by the original VISO2 stereo odometer, the VISO2-SIFT, and the VISO2-SIFT but with the feature bucketing deactivated. Although the reconstruction of the vehicle global pose from the successive odometries usually entails drift, in this case, the improvement of the global odometric trajectory with VISO2-SIFT, in translation and orientation, with respect to the original VISO2, and compared to the ground truth is clear. Since the ground truth trajectory is refered to the NED origin, but the odometric trajectories are refered to the first grabbed image, the reference frames of all trajectories have been unified by means of the corresponding transforms. Ongoing work includes the integration of VISO2-SIFT in the AUV navigation filter, and the calculation of quantitative results, such as the absolute point-to-point errors with respect to the grount truth and comparisons using different feature detectors and/or other odometers such as the ORB tracker.

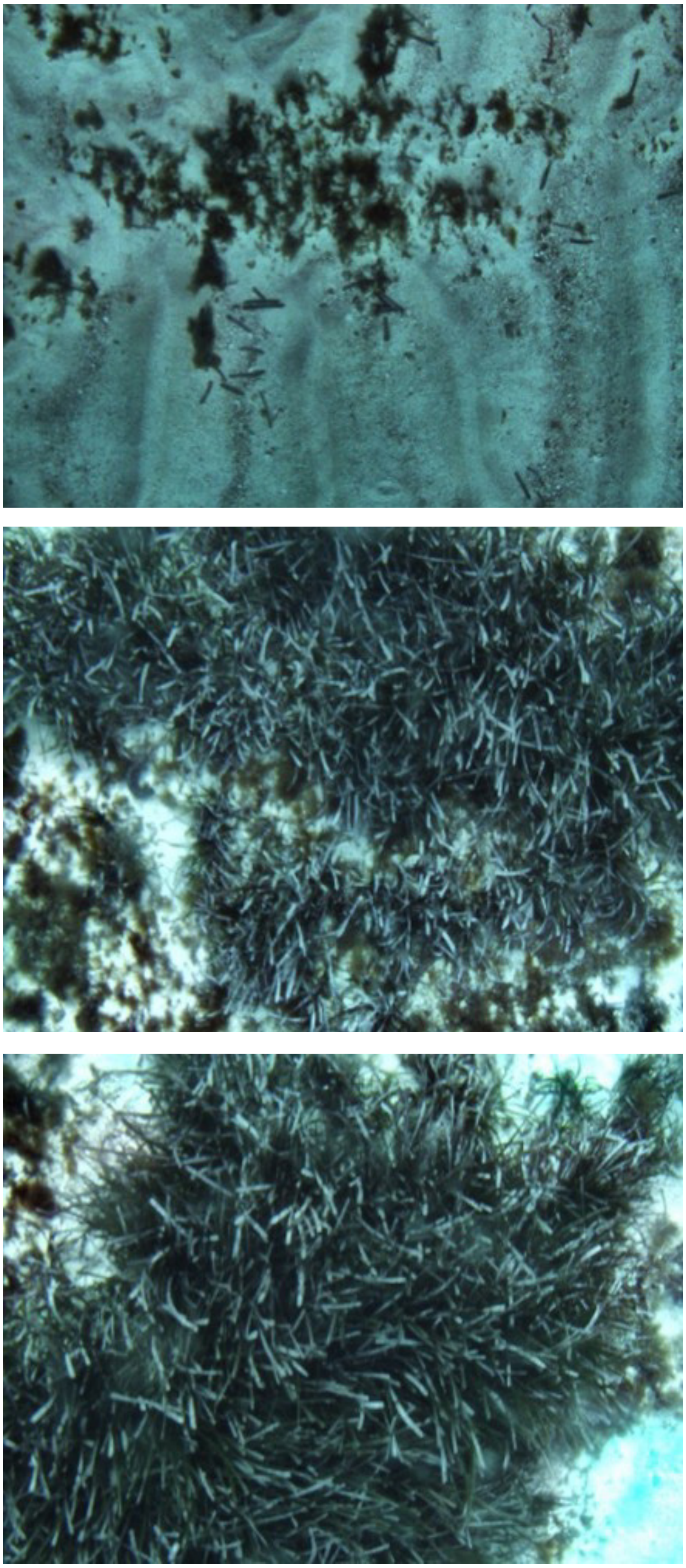

Figure 1. Some images extracted from the dataset of Portals Vells.

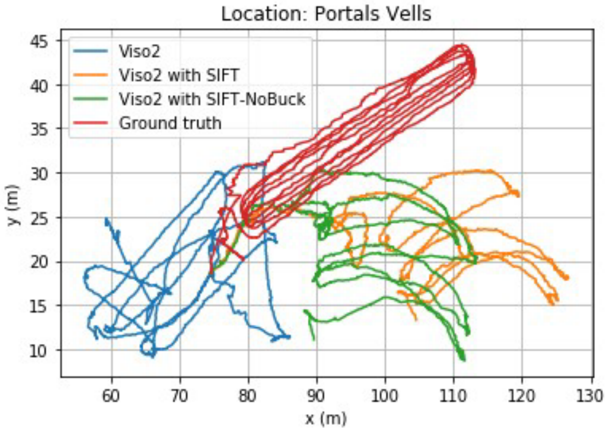

Figure 2. Trajectories estimated integrating the visual odometry obtained by different means.

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