SMALL SCALE UNDERWATER CHANGE DETECTION

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Automatically detecting changes between images is nowadays of common use in remote sensing. It is used with aerial imagery to monitor and understand our environment, with medical imagery to help doctors to diagnose, or using video surveillance cameras to detect movements in a scene. Unfortunately, change detection algorithms suffer from different constraints. They require highly accurate geometric and photometric registration and for this reason, they have never been used with underwater imagery in the past.

Several underwater application fields would benefit from automatic change detection, e.g. benthic habitat monitoring, deep water geological exploration, mapping of archaeological sites, supervision of geothermal and volcanic activities, or area monitoring after sudden impacts from natural or human catastrophes. The study of benthic areas benefits from recent progress in underwater technology, allowing the deployment of optical cameras for systematic surveying. However, the underwater environment can significantly degrade the quality of the acquired images. Scattering effects and non-uniform lighting result in differences in intensity levels of the same scene point in the images. Moreover, because of the rapid attenuation of light and the scattering effects, the images have to be taken at short range, and the area of interest cannot generally be acquired in one single view. Therefore, it is necessary to acquire a sequence of images covering the interest area and register them into a photomosaic to gain a global perspective of the sea floor. Unfortunately, acquiring images at short range also emphasizes the parallax effects of the 3D relief. Also, the source of artificial light in deep water or the sun flickering in shallow water makes the illumination of the scene non-uniform. These constrains are in opposition with the requisites of the change detection algorithms.

In this paper, we present a method to deal with the constraints of the underwater medium for finding changes between sequences of underwater images.

One of the main problems of underwater medium for automatically detecting changes is the low altitude of the camera when taking pictures. This emphasise the parallax effect between the images as they are not taken exactly at the same position. In order to solve this problem, we are geometrically registering the images together taking into account the relief of the scene.

In fact, the relief of the benthos and the camera poses (positions and orientations) are estimated from one sequence, the modelled sequence, using a structure from motion algorithm developed by our group. This algorithm allows recovering the accurate position of a large set of 3-D points but requires high overlap among the images and a good calibration of the camera. Once the 3D model obtained, a new image, the target image, can be matched with the 3D model in order to find its camera pose. With the pose of the target image and the 3D model known, it is possible to interpolate a 3D position for each pixel of the target image. These 3D positions can then be back-projected into to the modelled sequence in order to generate a set of new registered images. This is warping the textures of the modelled images as if they were seen from the target camera pose. These images are aligned with the target sequence taking into account the computed 3D relief. With this method, each target image can be compared with all the images of the modelled sequence.

Another problem of underwater medium is the different intensity response of a scene point. This can be due to non uniform lighting from the source of artificial light or sun flickering effect within a sequence but also to the usage of different camera when acquiring the sequences. In order to solve this issue, we developed a photometric matching technique that locally specifies the histogram of the registered images by taking the target image as reference.

Now that for each target image, a set of registered images that are corrected for illumination has been generated, it is possible to compare them. The different changes masks obtained are combined together by a voting scheme in order to obtain one more accurate change mask per target image. The accuracy of these change masks is strongly dependant on the accuracy of the 3D model.

In the final masks, some false positives may be triggered. False positives are changes detected in areas that did not change, due to inaccuracies of the 3D model. With a perfect 3D model, the images would be perfectly registered but the structure from motion algorithm is not able to model moving structures. Moreover, when no points can be match in the images due to low contrast, no 3D points can be estimated. Fortunately, the areas that are not properly modelled can be detected. In fact, when back projecting the non accurate 3D positions of the target image pixels, they will be in different scene points in the modelled sequence. This means that the differences between the registered images themselves are telling us what are the areas poorly modelled. The changes detected in these areas can be discarded.

Finally, two masks are generated for each target images. One is representing the areas that have changed and the other one is representing the areas that are not properly modelled. As the target images are most likely overlapping, there is redundant information in the masks. As the 3D positions are know for each pixel of the target images, these masks can be combined in two 3D masks of the whole surveyed area. This is also improving the overall accuracy of the change detection and makes it easier to analyse large sequences of images.