Integrated Digital Marine Image Analysis and Management - new solutions to handle large image collections in environmental monitoring and exploration

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The growing interest in mapping and monitoring marine environments is driven by an increasing demand for marine resources, including gas, oil and also minerals. To render a first descriptive model for an environment, different sensor technologies and platforms (such as AUV, ROV, OFOS, landers or crawlers) are used and imaging is applied more intensely due to substantial progresses in camera development. And since most industrial ventures towards harvesting marine resources do not only require an extensive mapping study in advance to any drilling and mining activity but also a monitoring procedure as well (for instance required due to administrative restrictions of the government and/or defined by the ISA), huge amounts of data are and will be collected, reaching *big data* dimensions. Thus, like in other big data scenarios the application of standard desktop software to interpret these image collections, i.e. classifying, counting and sizing objects of interest (OOI), is neither efficient (since it is too time consuming and expensive) nor effective (because of the considerable inter-/intra-observer disagreement). OOI can for instance be some biological taxa like calcareous algae (Osterloff et al. GEOHAB 2014), shrimp (Purser et al. BIOGEOSCIENCES, 2013), megafauna (Schoening et al. PLoS ONE, 2012) or it can be litter as well (Pham et al. PLoS ONE, 2014), as we and our collaborators have considered in recent studies. But in these studies, computational tools were applied to semi-automatically detect and classify OOI or just to assist the manual labelling with a collaborative web-platform like BIIGLE (see left screenshot below showing a new mobile BIIGLE version with labeled sponges). In this workshop contribution we want to demonstrate, how we move computational marine image analysis on a next level by increasing the information content by integration, standardization, collaboration and distribution on the one hand and substantially accelerating the image processing to real time speed. We will demonstrate real time image segmentation using of-the-shelf computer hardware (Intel 3rd gen Core i7-3770, 32GB RAM, Nvidia GTX 670), which allows an immediate semi-manual image interpretation during the cruise, using valuable ship time. One important feature of the segmentation is an automatic highly flexible and adaptive laser marker detection which is used to compute pixel scale information per image (see white circles in the right screenshot), which allows to extract size estimates for the OOI. Flexibility and adaptivity for the laser marker detection is achieved using a learning algorithm that is fed by a small number of example images showing hand labeled laser markers (LM). The algorithm automatically learns the number of LM, the LM's geometrical pattern (e.g. triangle) and color appearance. The accuracy of the LM detection will be demonstrated using two example image transect data sets from our collaborators. Using modern sophisticated GPU compute power and parallelization we were able to shorten the computation time for preprocessing (color normalization, illumination cone correction) from 6 sec / image to 87 milliseconds / image. Image segmentation (see right screenshot below) is accelerated to 9 milliseconds / image from originally 18.1 seconds / image. Thus an image can be processed in less than 0.1 seconds now. This new throughput rate of 10 images per second now paves the way to a higher throughput in posterior data analysis and maybe to real time processing in smart AUVs of the future.