Extracting scalar quantities from underwater images - a toolbox for image data from fixed observatories

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The number of fixed long-term underwater observatories (FUOs) is increasing (e.g. NEPTUNE, FixO3, DELOS, and LoVe). These observatories enable monitoring of limited areas of interest over long time periods. FUOs are equipped with a variety of sensors measuring turbidity, Chlorophyll, temperature, etc., providing scalar (one-dimensional) data recorded in time series $f_i(t)$ (with *i* referring to the type of measurement). FUOs are often also equipped with digital cameras recording photos in a temporal sequence $I(t)$. These image sequences give insight into the dynamics of ecologically relevant aspects, e.g. taxonomic composition, the change in size and morphology of biota or water properties (e.g. marine snow). However, biological relevant information in form of scalar quantities must be extracted from the images first so they can be interpreted with other sensor data $f_i(t)$ for an integrated environmental monitoring. Computational support for the extraction of information is crucial as a comprehensive manual extraction is time consuming or just infeasible due to the numerous images recorded. Furthermore, manual extraction can be error prone as it is affected by the limitations of human cognition (like change blindness).
We present (semi-) automatic tools to harvest information from time series of images from FOUs. Our algorithms can be employed to transform the image-series to scalar time series $f_i(t)$ driven by a hypothesis (like tracking the number/location and characteristics of particular species) or “hypothesis-free” requiring no information of expected species or events. The latter is important in marine ecosystems where a-priori knowledge is limited. To show the toolbox’s potential, we present results obtained in “hypothesis driven” as well as “hypothesis free” studies of data collected at the Lofoten-Versterålen (LoVe) FUO. LoVe is located in the Norwegian Sea at a depth of 260 m. The digital camera is orientated to face the cold-water *Lophelia pertusa* reef*,* recording images hourly.
The results include automatic detection and classification of single *Lophelia pertusa* polyps (a hypothesis-driven study), an automatic detection and clustering of passing species using a data-driven change detection algorithm (a hypothesis-free approach) as well as results of *Lophelia pertusa* color change analysis, investigated both “hypothesis free” and “hypothesis driven”.