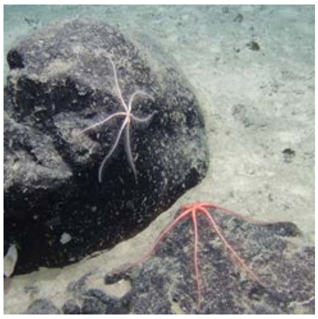
Master Theses

The **DeepSea Monitoring Group** at GEOMAR studies short- and long-term changes of seafloor processes. We use hydroacoustic and optical gear on board autonomous and remotely controlled marine robots linked with computer vision, pattern recognition and machine learning methods.



Video tracklet features for species behavior description

Video sequences of marine species can show behaviour of individuals in their natural habitat. A numerical encoding of movement of the animals shall be constructed that first allows to discriminate between living objects and artefacts. This encoding shall incorporate colour / morphology aspects as well as the temporal evolution of those aspects to accommodate for object-specific movement patterns (e.g. contraction of jellies). By comparing those temporal feature variation of image patches or *tracklets* of individuals of the same species, differences in animal behaviour shall be examined numerically.

Rapid extraction of semantics from Terabyte-scale image data sets

With current state-of-the-art marine robots, Terabytes of image data can be created per deployment. Rapidly extracting semantic and/or quantifiable information from those data sets is an important task on board research vessels to adapt the cruise schedule to new findings in due time. In this project, GPU computing and sea-going compute clusters shall be linked with marine robots' camera platforms to provide a rapid overview of the acquired data to field experts.

Deep learning for Deep Sea Imagery

State-of-the-art classification performance for image analysis tasks is being achieved by deep learning systems. First results have been reported for marine imagery data sets, yet without being able to explain limits of applicability of those systems in terms of image resolution, robustness to common marine artefact, scarcity of training samples etc. This project shall explore those limits by applying proven deep learning methods to a variety of marine imagery data sets obtained by various marine robots and other camera platforms.

Natural Underwater Image Statistics

It has been shown that deep learning architectures and auto-encoders can construct data-set specific feature representations of imagery. The simplest of those representations describe corners, edges and gradients in images and resemble elements of the mammalian visual system. It is yet unclear whether the visual environment underwater expresses the same characteristics as terrestrial environment. This project shall thus explore the results of deep learning derived image features in relation to diverse marine imagery datasets from shallow to deep sea environments.

Multi-Classifier Fusion

When developing classifier systems for computer vision tasks, a clearly defined training set of classes is used. Following the costly feature extraction, classifier tuning, and test data classification, a confined system is developed for one specific purpose. In case that a further class shall be added, the entire tuning process needs to be conducted again. This project shall develop more flexible classification schemes that can incorporate various feature descriptors and classification algorithms. By creating ensembles of easily replaceable and extendable modules, rapid adaptation to new tasks and data sets is being aimed for.

Hierarchical Classification

Species are categorized into a hierarchical phylogeny by taxonomists. This hierarchy shall be exploited to construct an ensemble-based classification scheme that can dynamically adapt to the visual diversity of different sub-trees. Standard classification algorithms shall be combined, rather than one single classifier be developed. It is important to adapt current classifier statistics (e.g. Precision/Recall) to such hierarchies to quantitatively assess the classifier result. Based on this quantification, limits of “classifiability” of species (families, genera, etc.) regarding the employed features shall be determined.

Visual Taxonomy

The tree of life is a regularly updated view on the genetic relationship of species. In marine environments it is often hard to determine to which part of the tree an individual belongs as genetic samples are hard to obtain and many samples are singletons. Imaging has been widely used to explore marine habitats but objects in the images are sometimes impossible to link to those phylo-genetic categories. In this project a “phylo-visual” tree shall be constructed that exploits visual features of objects in images to construct a hierarchical relationship among them. This phylo-visual tree shall resemble the phylo-genetic tree where possible, yet focus on image based features.

Minimum Effort / Maximum Gain Annotation

When annotating objects for machine learning algorithms, it is unknown how many samples are required to provide a robust ground truth. This project shall look into different feature descriptors and supervised classifiers to i) develop objective criteria that allow to determine whether a suitably diverse training set has been created. Based on the selected training sets, ii) classifiers shall be tuned and applied and the results re-evaluated by the annotator. The final goal is then to iii) develop a “meta-classifier” that iteratively adapts the initial criteria to optimize future annotation tasks based on the quantitative criteria defined in i) and their numerical expression regarding specific data sets.

Please contact Dr. Timm Schoening (tschoening@geomar.de) for details. To apply for one of the topics or to suggest your project, send a brief CV as well as the targeted time frame.