Bielefeld University
Faculty of Technology
The
Applied Neuroinformatics
Group

Use of automated image analysis to detect changes in megafaunal densities at HAUSGARTEN (79N west off Svalbard) between 2002 and 2004

Birgit Lessmann[1], Yongjie Wang[1], Melanie Bergmann[2], Tanja Kämpfe[1] and Tim W. Nattkemper[1]
[1]Applied Neuroinformatics Group, University of Bielefeld, Bielefeld, Germany
[2]Alfred-Wegener-Institute for Polar- and Marine Research, Bremerhaven, Germany

Introduction

- In 1999: Launch of the first and only deep-sea long-term observatory beyond the polar circle, HAUSGARTEN (eastern Fram Strait) [1]
- Purpose: To achieve an understanding of the abundance and spatial distribution of organisms → assess the effects of global change.
- Acquisition of a large quantity of underwater footage → visual analysis is very labour-intensive and time-consuming
- New approach: Application of machine learning algorithms for the automatic analysis of the HAUSGARTEN footage
- Main focus:
  - The detection and classification of the most important biological species.
  - The assesement of population abundances and variations

Material

- Photographic transects from the HAUSGARTEN central station (2500m) (Figure 1)
- Taken by an ocean floor observation system (OFOS) associated to the research vessel Polarstern (Figure 2) in 2002 and 2004.

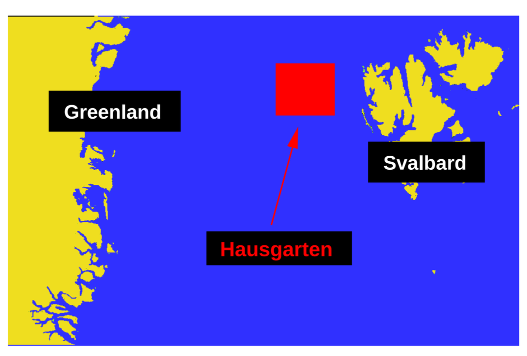

Figure 1

Figure 2

- Each transect contains some 700 photographs.
- RGB TIFF-Format, 3504 × 2336 pixels

Figure 3

- Most important species:

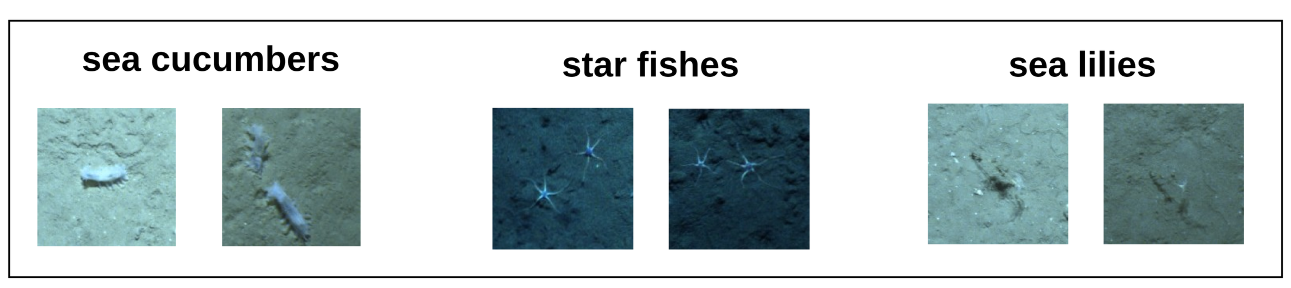

Figure 4

Methods

Training

- Hand labelling of data → determination of occurrence and position of species
- Subdividing images into smaller parts
- Generation of a training set with
  - subimages containing a particular species
  - subimages without this species
- Training of a classifier (Support Vector Machine) [2]

Application

- Segmentation of interesting objects:
  - different algorithms for different species
  - Application of the classifier to the segmented object

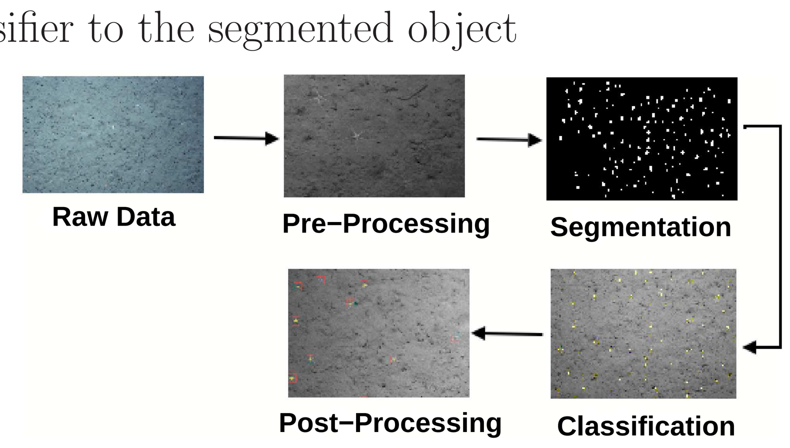

Figure 5

Results

Evaluation procedure

- divide dataset into 5 subsets
- use 4 subsets for training, the remaining subset for testing
- five evaluation steps, each subset is used once as testing set → Five Fold Cross Validation
- the classifier is tested with the training set and evaluated by classifying the images of the testing set

Evaluation measure

- During each evaluation step the several images are counted:
  - those classified correctly as a particular class member (true positive - TP)
  - those classified incorrectly as a particular class member (false positive - FP)
  - those classified correctly as not class member (true negatives - TN)
  - those classified incorrectly as not class member (false negatives - FN)
- Two measures are computed for describing the classification result [3]
  - The Sensitivity (SE) measures the amount of correctly classified class members within all class members:

$$SE = \frac{TP}{TP+FN}$$

  - The Positive Predictive Value (PPV) measures the amount of correctly classified class members within all objects classified as a class member

$$PPV = \frac{TP}{TP+FP}$$

Optimised parameter settings of the particular system lead to promising results of the system performance. The following SE and PPV values for the different species could be achieved.

Species	SE	PPV
Sea cucumbers	85,61 %	78,21 %
Star fishes	74,47 %	74,57 %
Sea lilies	56,34 %	55,45 %

→ Satisfying results for star fish and sea cucumbers
→ Detection of sea lilies still requires improvement

Conclusion and Outlook

- We have proven the general feasibility of our approach for the detection of species
- Two particular species can already be detected and identified reliably
- Results from manual analysis of 66 images taken at the central part of the transect:
  - significant decline in mean density of sea cucumbers (Elpidia glacialis), sea lilies (Bathycrinus cf. carpenteri), burrow entrances and total megafaunal densities from 2002 to 2004
  - This concurs with a decrease in sea ice coverage, particulate flux to the sea floor, sediment-bound nutrients and pigments, microbial biomass and changes in meiofaunal community structure.
  - Results from automated image analysis will increase the spatial resolution and statistical power of our analysis → processing of larger quantities of images.

References

[1] Soltwedel, T. et al.: Hausgarten: Multidisciplinary Investigations at a Deep-Sea, Long-Term Observatory in the Arctic Ocean Oceanography, **18**(3) (2005) pp. 46-61

[2] Schölkopf, B., Smola, A.J.: Learning with Kernels: Support Vector Machines, Regularization, Optimization and Beyond (Adaptive Computing and Machine Learning). MIT Press, Cambridge, MA, 2002

[3] Fawcett, T.: ROC Graphs: Notes and Practical Considerations for Researchers. HP Labs Tech Report HPL-2003-4, (2003)

Contact

Birgit Lessmann: blessman@techfak.uni-bielefeld.de