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# Image Processing for Detecting Sea Ice Floes

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***Abstract*— An unmanned aerial vehicle was used as a mobile sensor platform to collect sea-ice features and several image processing algorithms have been applied to samples of Sea-Ice images to extract useful information about sea-ice. The sea-ice statistics given by the floe size distribution, being an important parameter for climate and wave and structure ice-analysis, is challenging to calculate due to difficulties in ice floe detection, particularly the separation of seemingly connected ice floes. Gray scale and OTSU algorithm will be applied to solve this problem. To evolve the Gray Scale and OTSU algorithm automatically, an initialization based on the distance transform is proposed to detect individual ice floes, and the morphological cleaning is afterward applied to smoothen the shape of each identified ice floe. Based on the identification result, the image is separated into four different layers: ice floes, brash pieces, slush, and water. This makes it further possible to present a color map of the ice floes and brash pieces based on sizes, and the corresponding ice floe size distribution histogram.**

***Index Terms*- Image Binrization, Image Processing, Image Segmentation**

## I. INTRODUCTION

SEA ICE which is defined as any form of ice that forms as a result of seawater freezing, covers approximately 7% of the total area of the world's oceans. It is turbulent because of wind, wave, and temperature fluctuations. Various types of sea ice can be found in ice-covered regions. Ice floe, which is the flat pieces of sea ice, can range from meters to kilometers in size. The floe size distribution is a basic parameter of sea ice that affects the behavior of sea-ice extent, both dynamically and thermodynamically. Particularly for relatively small ice floes, it is critical to the estimation of melting rateHence, estimating floe size distributions contributes to the understanding of the behavior of the sea-ice extent on a global scale. In addition to this, the floe size distribution is also important n ice management for Arctic offshore operations, for example:

- Quantify the efficiency of ice management for Arctic offshore operations and automatically detect hazardous conditions, for example, by identifying large floes that escape the icebreakers operating upstream of a protected structure. The size and shape of managed floes can be identified by the image processing system, compared with limit values, and further processed by the risk management system.
- Estimate the ice loads on stationary Arctic offshore structures by empirical formulas.
- Initialize high-fidelity numerical models and validate these at various moments in time by matching the simulated ice fields with the actual ones.
- Provide an early warning of an ice compaction event, which can be dangerous if the ice-structure interaction mode changes from a "slurry flow" type to a "pressured ice" type.

Despite its importance, however, the useful information retrieved from observational data sets are still limited because of difficulty in analysis and lack of efficient post-processing tools for such data sets. Therefore, the development of temporally and spatially continuous field observations of sea-ice conditions and determining corresponding ice floe size distributions are necessary.

One of the best ways to observe ice conditions in the oceans is by using aerial imagery and applying digital image processing techniques to the observations. This method can reduce or suppress ambiguities, incompleteness, uncertainties, and errors regarding an object and its environment, yielding more accurate and reliable information. Cameras are typically used as sensors on mobile sensor platforms in ice-covered regions to characterize ice conditions. Cameras can collect precise spatially continuous measurements, which are particularly suitable for providing detailed localized information of sea ice. However, an important prerequisite is a clear sky and sight during missions.

## II. ICE IMAGE PROCESSING METHODS

### *A. Ice Pixel Extraction*

Due to the fact that sea ice is whiter than open water, the pixel values differ under normal conditions., for example, ice pixels have higher intensity values than those belonging to water in a uniform illumination ice image. Therefore, ice pixels can be extracted by using the thresholding method. Most of the ice can then be identified, Of the ice pixels identified, however, only light ice has larger pixel intensity values than the threshold. Dark ice, with pixel intensity values between the threshold and water, such as ice pieces under the water surface, may not be identified and thus considered to be water, according to the thresholding

Fig. 1. Original sea-ice image.

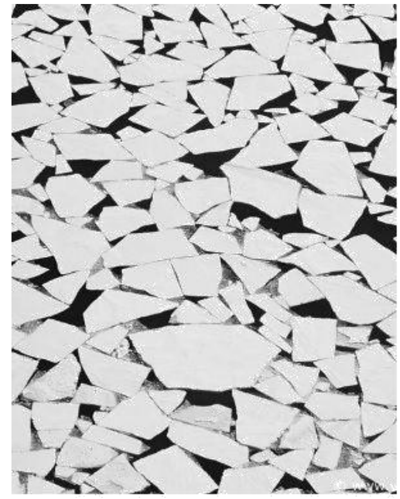

Fig. 2. Gray Scale Image

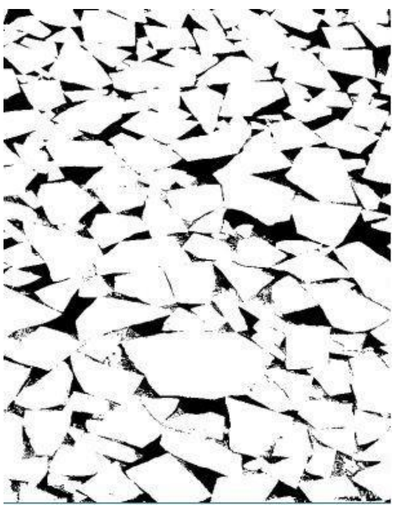

Fig. 3. Binarized Images

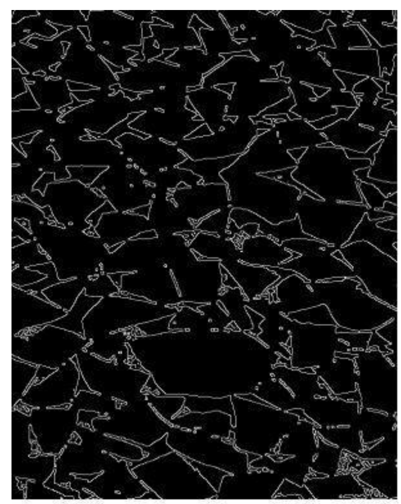

Fig. 5. Canny Image

method. Both "light ice" and "dark ice" pixels are required for an accurate analysis. To distinguish "dark ice" from open water, the k-means clustering algorithm can be applied. This minimizes the within-cluster summed distance to partition a set of data into k clusters.

The image is then divided into three or more clusters, using the k-means algorithm. The cluster with the lowest average intensity value is considered to be water, while the other clusters are considered ice.

To convert the gray scale sea ice image to binarized image, there exist various methods for this conversions. One of the method *k*-means clustering OTSU algorithm.

The OTSU algorithm assumes that the image contains two classes of following bi-modal histogram, it then calculates the optimum threshold separating the two classes so that their combined spread is minimal or equivalently, so that them inter class variance is maximal. Fig.3. shows the converted binarized image.

*OTSU Algorithm: -*

- Compute histogram and probabilities of each intensity level
- Set up initial $\omega_i(0)$ and $\mu_i(0)$
- Step through all possible thresholds *t*=1… maximum intensity
  1. Update $\omega_i$ and $\mu_i$
  2. Compute $\sigma_b^2(t)$
- Desired threshold corresponds to the maximum $\sigma_b^2(t)$
- You can compute two maxima (and two corresponding thresholds). $\sigma_{b1}^2(t)$ is the greater max and $\sigma_{b2}^2(t)$ is the greater or equal maximum
- Desired threshold = $\dfrac{\text{threshold}_1 + \text{threshold}_2}{2}$

### *B. Ice Edge Detection*

The most challenging task is to identify individual ice floes in the sea-ice image, in particular separating the floes that are very close or connected to each other. The boundaries between apparently connected floes have a similar brightness to the floes themselves. The boundaries are too weak to be detected directly, which significantly affects the ice floe statistical result. Therefore, the canny edge detection algorithm is proposed to solve this problem.

The purpose of edge detection in general is to significantly reduce amount of data in an image, while preserving structural properties to be used of further image processing. There exist many edge detection algorithms like, GVF snake algorithm. Even though it is quite old, it has become one of the standard edge detection methods and it is still used in research. The aim of JFC was to develop an algorithm that is optimal with regards to the following criteria: -

- Detection: Theprobability of detecting real edge points should be maximized while the probability of falsely detecting non-edge points should be minimized. This corresponds to maximizing the signal-to-noise ratio.
- Localization: Thedetected edges should be as close as possible to the real edges.
- Number of responses: One real edge should not result in more than one edge.

The algorithm runs in 5 separate steps:

- Smoothing: Blurring of the image to remove noise.
- Finding Gradients: The edge should be marked where the gradients of the image have magnitudes.
- Non-maximum suppression: Only local maxima should be marked as edges.
- Double thresholding: Potential edges are determined by thresholding.
- Edge tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

## III. CONCLUSION

In this paper, sea ice images were converted into gray scale so that it was only left to white and black pixels to process further. Then, OTSU algorithm was used to convert that gray scale image into binarized image. Further, its edges were detected using canny edge detection algorithm and applied post-processing to correct remaining flaws in the image.

## REFERENCES

S. Løset, K. N. Shkhinek, O. T. Gudmestad, and K. V. Hyland, *Actionsfrom Ice on Arctic Offshore and Coastal Structures*. St. PetersburgRussia: Lan Publishing House, 2006.

[1] J. Hamilton *et al.*, “Ice management for support of arctic floating operations,” in *Proc. OTC Arctic Technol. Conf,*, Houston, TX, USA, 2011, pp. 615–626.

[2] Q. Zhang, R. Skjetne, and B. Su, “Automatic image segmentation for boundary detection of apparently connected sea-ice floes,” in *Proc.22nd Int. Conf. Port Ocean Eng. Arctic Conditions*, Espoo, Finland,2013, pp. 303–310.

[3] A. Palmer and K. Croasdale, *Arctic Offshore Engineering*. Singapore: World Scientific, 2012.

[4] C. Daley, S. Alawneh, D. Peters, B. Quinton, and B. Colbourne, “GPU modeling of ship operations in pack ice,” in *Proc. Int. Conf. ICETECHExhib. Perform. Ships Struct.*, Banff, AB, Canada, 2012, pp. 122–127.

[5] WMO SEA-ICE NOMENCLATURE, (accessed 2014-08-31). [Online]. Available: http://www.aari.ru/gdsidb/XML/volume1.php?lang1=0& arrange=4

[6] R. C. Gonzalez, R. E.Woods, and S. L. Eddins, *Digital ImageProcessing Using MATLAB*. Upper Saddle River, NJ, USA:Prentice-Hall, 2003.

[7] Q. Zhang, S. van der Werff, I. Metrikin, S. Løset, and R. Skjetne, “Image processing for the analysis of an evolving broken-ice field in model testing,” presented at the 31st Int. Conf. Ocean, Offshore Arctic Engineering, Rio de Janeiro, Brazil, 2012, Paper OMAE2012-84117.

[8] J. D. Banfield and A. E. Raftery, “Ice floe identification in satellite images using mathematical morphology and clustering about principal curves,” *J. Amer. Stat. Assoc.*, vol. 87,

no. 417, pp. 7–16, Mar. 1992

[9] C. Xu and J. L. Prince, “Snakes, shapes, and gradient vector flow,” *IEEE Trans. Image Process.*, vol. 7, no. 3, pp. 359–369, Mar. 1998.

[10] N. Otsu, “A threshold selection method from gray-level histograms,” *Automatica*, vol. 11, no. 285–296, pp. 23–27, 1975.

[11] C. Xu and J. L. Prince, “Snakes, shapes, and gradient vector flow,” *IEEE Trans. Image Process.*, vol. 7, no. 3, pp. 359–369, Mar.1998.

[12] R. C. Gonzalez, R. E.Woods, and S. L. Eddins, *Digital ImageProcessing Using MATLAB*. Upper Saddle River, NJ, USA:Prentice-Hall, 2003.