PhD Abstract
Texture Discrimination of SAR Sea Ice Imagery

David A. Clausi
Department of Systems Design Engineering
University of Waterloo
Waterloo, Ontario
Canada N2L 1V4

The differentiation of textures is a critical aspect of SAR sea ice image segmentation. Provision of images that identify pertinent ice types is important for the operational (ice breakers, ships, oil platforms) and scientific (ie. global warming monitoring) communities. Although a human is readily able to visually segment any textured image, no unsupervised machine method has been designed that consistently and robustly performs the same task.

Two steps are followed to perform image texture segmentation. First, feature vectors representing local characteristics are determined for each pixel. The more distinct the features, the better they are able to distinguish different classes. Second, the feature vectors are grouped together according to class similarities or dissimilarities. During this clustering, human intervention should be minimized. Optimizing each of these steps is important for achieving the overall task.

Many different approaches have been proposed for texture feature extraction. Three popular methods are investigated and optimized for their supervised classification ability: cooccurrence probabilities, power spectrum, and Gabor filtering. This information is necessary to serve as a platform for image segmentation testing. The methods perform well under supervised classification experiments. The Gabor filters capture the same beneficial information as the power spectrum features, however, the Gabor filters have the ability to capture information with an effective window size that matches the desired frequency (multi-resolutional ability).

There exists only limited published research comparing different texture segmentation approaches. Cooccurrence features, although extensively used in classification studies, are rarely applied to full image segmentation. This is probably due to the exceptional computational demands of the traditional approach (the grey level cooccurrence matrix or GLCM). To calculate cooccurrence texture features orders of magnitude faster than the GLCM, a linked list algorithm is designed and implemented.

Two clustering approaches are performed: one that assumes the number of classes *a priori* (mixture analysis) and one that automatically determines the number of classes (cluster analysis). Mixture analysis is performed by applying K-means (with the correct number of classes) and then iteratively applying the Fisher linear discriminant to improve the clustering (K-means Iterative Fisher or KIF). Cluster analysis is performed using the KIF in a binary divisive hierarchical tree where nodes branch or stop as a function of the cluster separability determined by the Fisher criteria. For operational purposes, the user indicates when the nodes branch or stop based on visual cues. The idea is to provide an easier method to segment the image to reduce operator

fatigue and increase throughput.

When cooccurrence and Gabor features are applied to unsupervised image segmentation of Brodatz and SAR sea ice imagery they are demonstrated to have different abilities. Images containing regions with different textural resolutions are not segmented properly using cooccurrence features. Gabor filters, with inherent multi-resolutional ability, are able to perform this task. When all textures have the same resolution, both methods are able to distinguish the textures. While other issues such as tone and ice floe shapes must be included for a robust operational SAR sea ice identification system, incorporation of texture is a necessary component for successful image segmentation.