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Flood detection with spaceborne SAR images by using the Active Contour Model

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In this study a semi-automatic flood detection system for spaceborne SAR images has been developed. The system is based on the Active Contour Model that is a snake algorithm, utilising SAR image statistics in the area delineation process. It has been shown that this method can struggle the noise and the wind induced effects in SAR images unlike e.g. the traditional thresholding method. Our system is designed to be nearly automatic, requiring as its only input a configuration file consisting of e.g. of parameters of the SAR scene to process. After that the system will produce a shape file of all detected water bodies in the SAR scene. Both ERS-2 (C-band, VV polarisation) and Radarsat (C-band, HH polarisation) SAR images were used for water area delineation and the algorithm performance was checked visually. An accuracy validation in a metric scale was conducted with a multisensor data set including a high resolution airborne spectrometer image and a Radarsat scene. These tests suggest that our system can reliably detect and delineate with good accuracy all water bodies up to moderate size.

The spaceborne SAR's immunity to cloud cover and darkness, its global coverage with high temporal and spatial frequency makes it a feasible choice to monitor natural hazards. It is possible to extract water areas from a SAR image and thus monitor a certain water body regularly to detect a potential flood. However, C-band SAR-derived backscattering coefficients are sensitive to the surface roughness, thus making the detection of water bodies difficult in windy weather. Especially, during heavy rains and storms water surfaces can be very rough yielding increased backscatter levels on flood plains. Consequently, water bodies are noisy and brighter than normally causing pixel-based thresholding methods to fail.

The Active Contour Model that is used by our system is an expanding polygon of which each node forms a computational unit. First the polygon is initialised over an area that contains water pixels. Then the algorithm deforms the polyline node by node by moving them to the direction that contains desired kind of pixels. More precisely, the algorithm computes sample mean and sample variance from the line formed by a node and its both neighbouring nodes. These statististics are then compared with the ones computed from the initialisation area with a goodness function that uses empirical information about sample distributions in a SAR image to rank them. Moves to each 8-neighbour position are computed and the one with the highest goodness function value is selected to be the next position of the node. Due to the statistical approach the algorithm is able to counteract noise and effects caused by target surface roughness.

For quantitative accuracy validation a high resolution (2 m) airborne spectrometer image and a Radarsat scene (25 m resolution) were acquired for the Kirkkojarvi Lake area in southern Finland. During the 6-hour offset in the acquisition times the weather conditions remained normal and thus all shorelines can be assumed to be within the resolution cell of the spectrometer image. Kirkkojarvi Lakes northern shoreline, in total a 13-km long strip, was selected for the validation. It was vectorised using the spectrometer's near infrared image yielding a reference polyline with 2 m accuracy. Comparison between the Active Contour's result polyline and the reference polyline showed that 70 % of the result line's segments are within 25 m and 90 % within 40 m from the reference line.

The system was also tested qualitatively with eight ERS-2 SAR scenes (25 m resolution) acquired in 2000 and 2001. The scenes were for an area that experiences yearly floods in the spring. These scenes' image quality ranged from black matte to noisy and partly bright spotted water bodies. Two flood cases, 20 April 2000 and 11 April 2001, with ground truth data about the water level were selected for evaluation. Using the recorded water level and a fine resolution DEM, Finnish Environment Institute generated for us the approximate flood boundaries at the time of ERS-2 overpasses. In these two cases, the result waterline agreed quite well with the flood boundaries (at 25 m resolution level), even though the separability of land and water is poorer for C-VV than for C-HH polarisation.

The results show that the developed flood detection system performs well with both good and moderate quality SAR images. In the case of the Radarsat scene that was used for the validation, 90 % of the result waterline falls within 40 m, that is less than 2 pixels, from the reference waterline. Additionally, the qualitative tests with ERS-2 images show that the system is tolerant to noise and wind induced effects.