Supervised Classification Method with Efficient Filter Techniques to Detect Anomalies on Earthen Levees using Synthetic Aperture Radar Imagery

Ramakalavathi Marapareddy [1], James V. Aanstoos[2*], Nicolas H. Younan[3]

[1]Center for Advanced Vehicular Systems, Mississippi State University, MS 39759, USA

[2]Geosystems Research Institute, Mississippi State University, MS 39759, USA

[3]Department of Electrical and Computer Engineering, Mississippi State University, MS 39762, USA

kala@cavs.msstate.edu[1], aanstoos@gri.msstate.edu[2*], younan@ece.msstate.edu[3]

MISSISSIPPI STATE UNIVERSITY JAMES WORTH BAGLEY COLLEGE OF ENGINEERING

Poster: # 2457

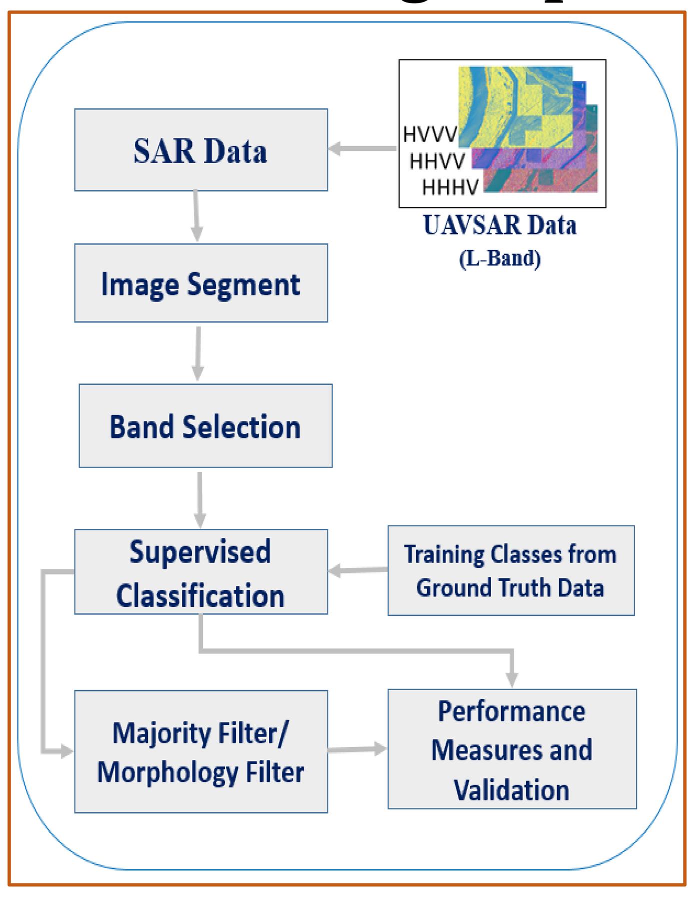
Abstract

One type of problem that occurs along these levees which could lead to complete failure during a high water event is slough slides. On-site inspection of levees is costly and time-consuming, so there is a need to develop efficient and effective techniques based on remote sensing technologies to identify levees that are more vulnerable to failure under flood loading.

Introduction

The roughness and related textural characteristics of the soil in a slough slide area affect the amount and pattern of radar backscatter. The type of vegetation that grows in a slough slide area differs from the surrounding levee vegetation, which can also be used in detecting slough slides. we implemented a supervised classification algorithm the minimum distance classifier with a majority filter and morphology filter for the identification of anomalies on levees using polarimetric Synthetic Aperture Radar (polSAR) data.

Processing Steps



Results

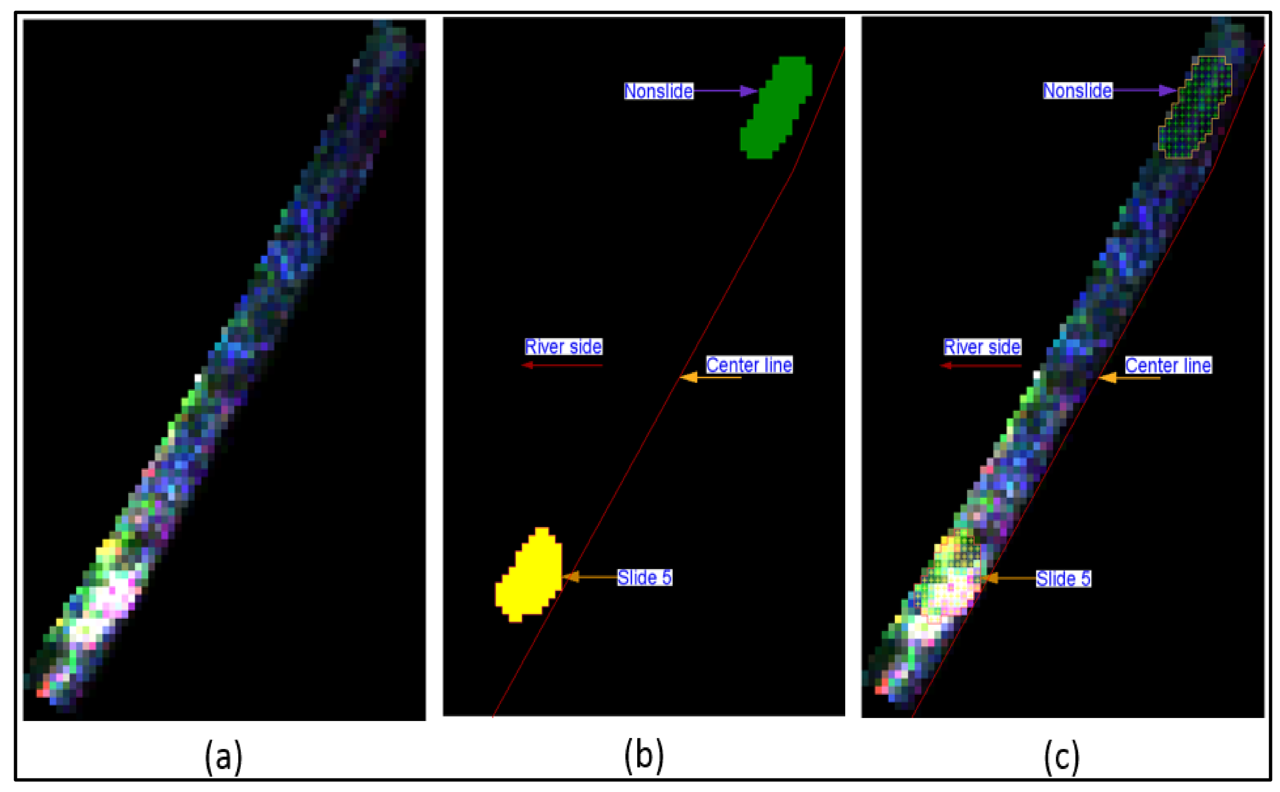
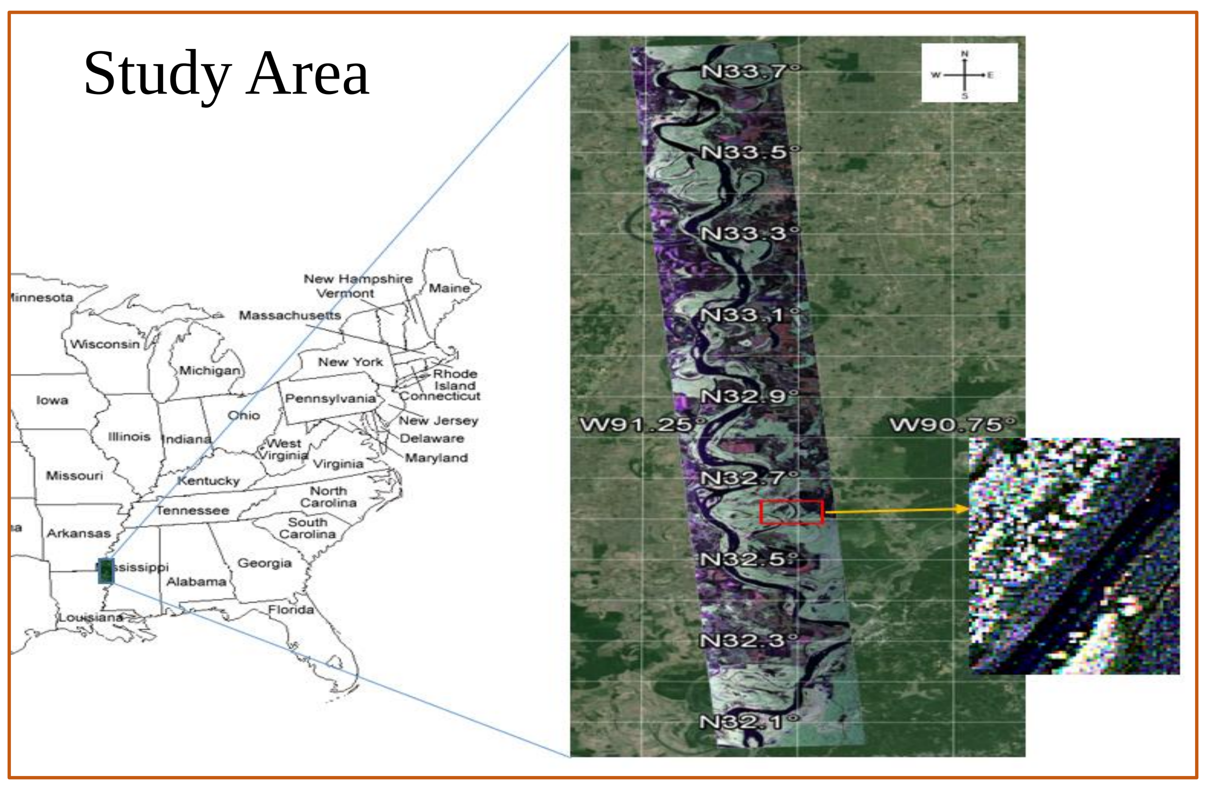


Figure 1. (a) Image segment (river side of the levee), (b) Regions of interest (slide and nonslide area, training areas), and (c) Image segment overlaid with the slide and nonslide classes.

Data and Study Area

The fully quad-polarimetric L-band (λ = 23.98 cm) SAR imagery from the NASA Jet Propulsion Laboratory's (JPL's) Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) with a range bandwidth of 80 MHz was used. The study area, as shown in Figure to the right, is a section of the lower the Mississippi River valley in the southern USA.



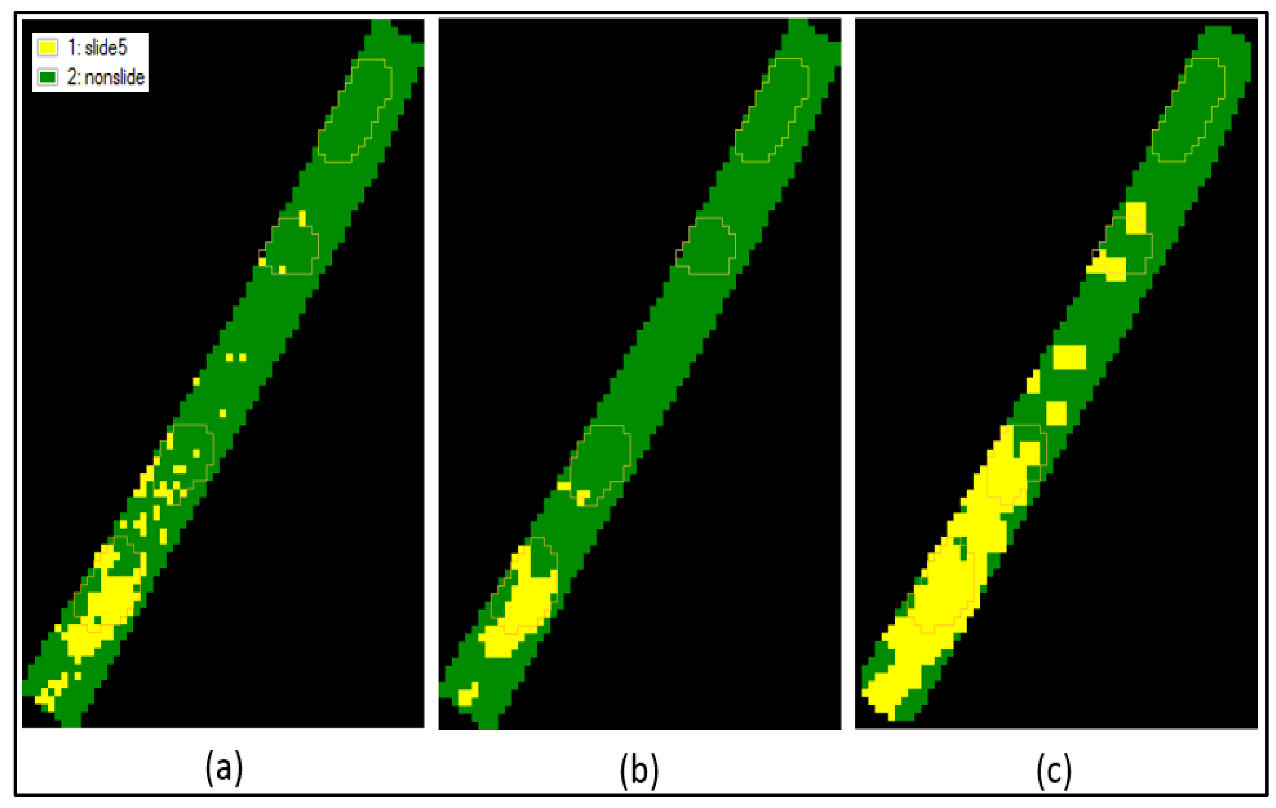


Figure 2. (a) Minimum distance classification, (b) with majority filter, and (c) with morphology filter (erode), overlaid with shapes for training areas and anomalous areas.

Minimum distance

Minimum distance classification uses the mean vectors for each class and calculates the Euclidean distance from each unknown pixel to the mean vector for each class. The pixels are classified to the nearest class. Minimum distance classification calculates the Euclidean distance for each pixel in the image to each class:

$$D_i(x) = \sqrt{(x - m_i)^T (x - m_i)}$$

where,

- D - Euclidean distance
- i - The i^{th} class
- x - n-dimensional data (where n is the number of features)
- m_i - mean vector of a class

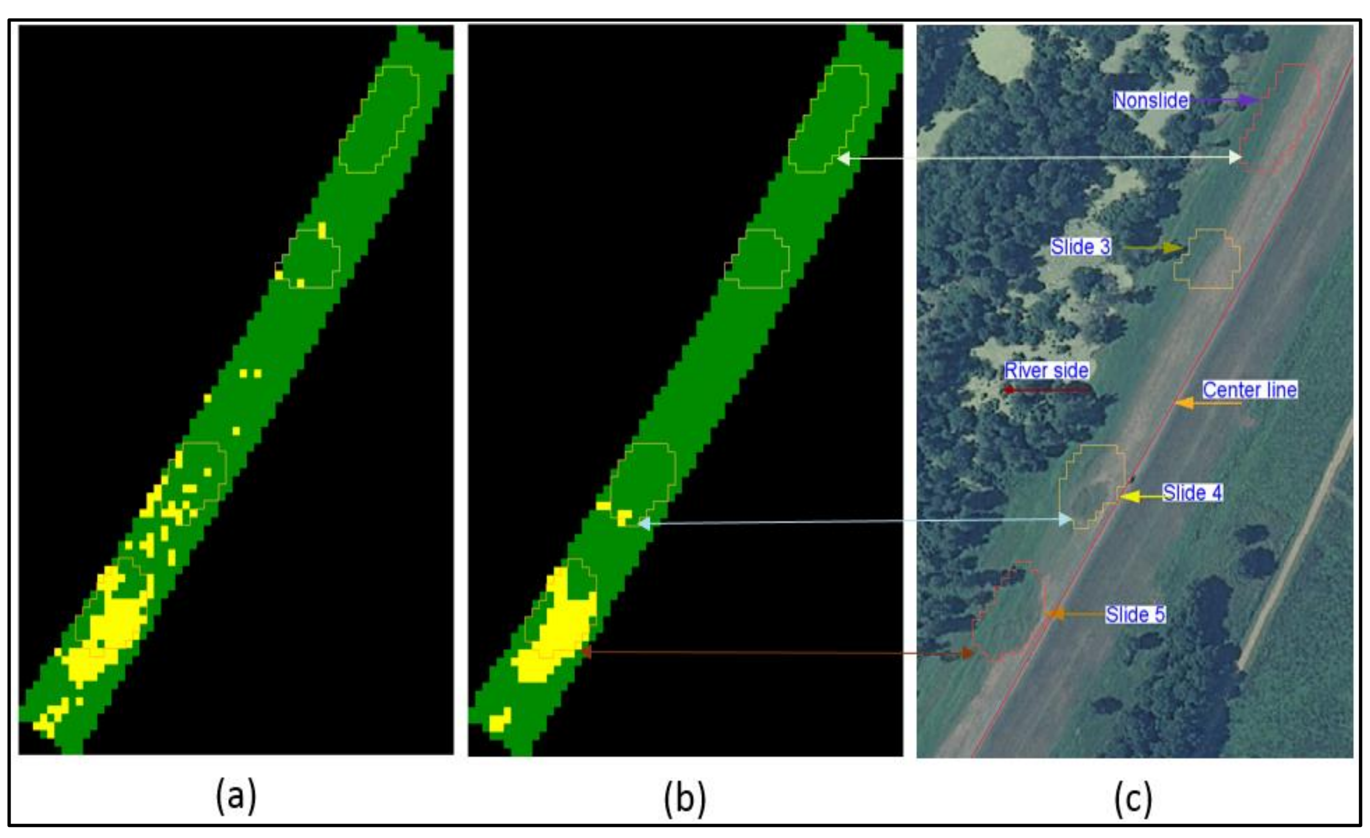
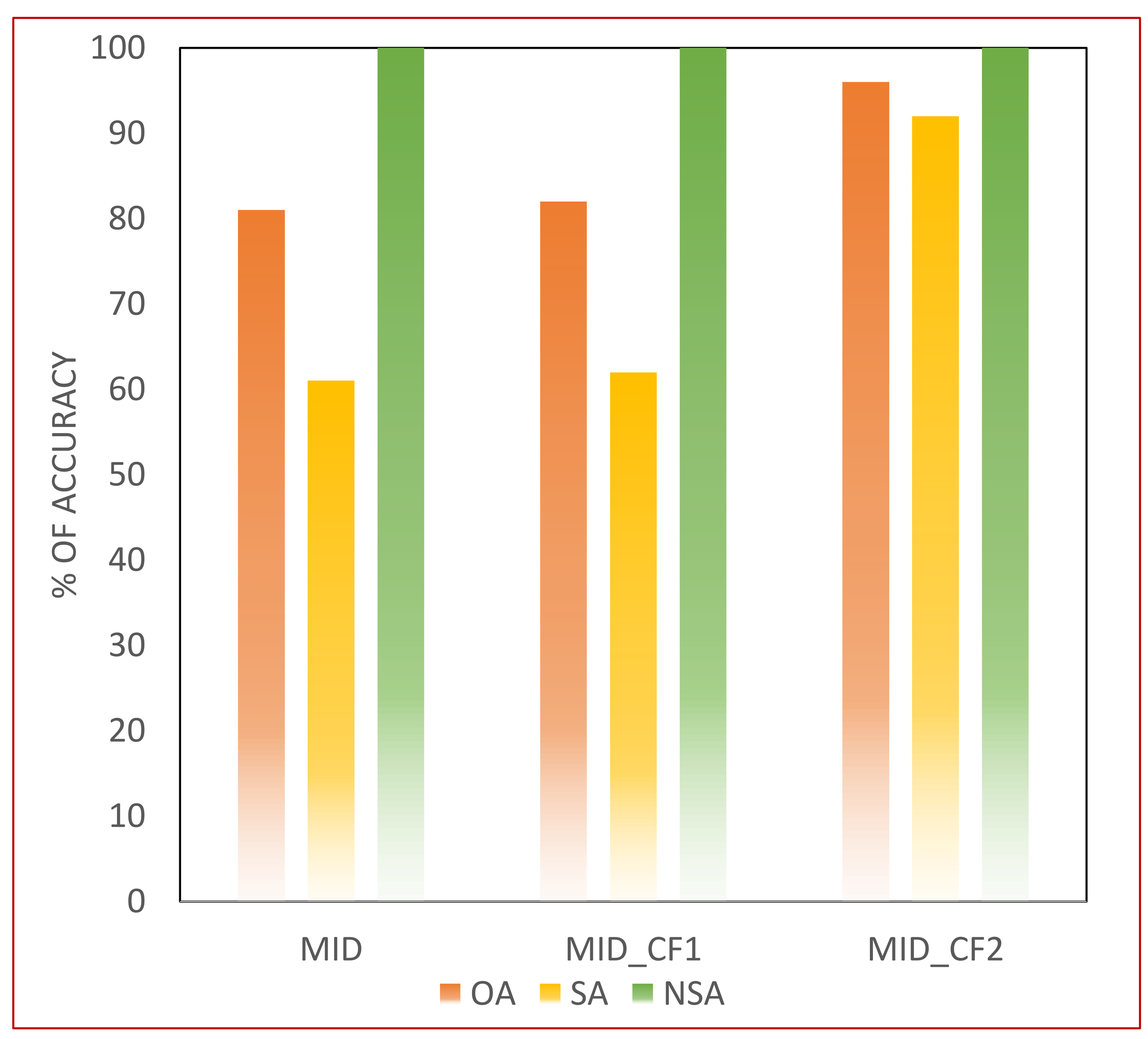


Figure 3. (a) Minimum distance classification, (b) with majority filter, and (c) optical image overlaid with slides and nonslide classes shape.



C: classification, CF1: with majority filter, CF2: with morphology filter
OA: overall accuracy; SA: slide accuracy; NSA: nonslide accuracy

Figure 4. Accuracy comparison of the Minimum distance and Mahalanobis distance classification, with majority and morphology filter, of the Sample 3 for the magnitude data.

Discussion

Three sets of real floating point co-polarized MLC data which correspond to the magnitudes of the HHHH, HVHV, and VVVV bands are used as features. Two training areas were chosen as slide 5 (anomalous) and nonslide (healthy) areas. The ground truth pixels used for slide 5 and nonslide area are 78 and 84, respectively. The image segment ground truth pixels has a total of 929. Majority filter is applied to a classification image to change false pixels within a large single class to the own class. The kernel size used here for the majority filter is 3x3. Though some of the slide areas (slide 3 & 4) were repaired by the time of the image acquisition, they still show anomalous and are detected by the classification technique. Because these slide areas (slide 3 & 4) were repaired two months ago, by the time of the image acquisition, they still show anomalous because of the texture roughness and possibly lack of grass on repaired slide area.

Conclusions

Supervised minimum distance classification is applied to polSAR data. This work shows that slough slides on levees exhibit distinctive scattering mechanisms compared with the healthy (i.e., non-slough slide) areas, and that these differences are revealed by classification method. The obtained classification results reveal that the identification of the anomalies are good with the classification results and was improved with the majority filter. The classification accuracy is further improved with morphology filter.

Acknowledgements: National Science Foundation under Award No. OISE-1243539, and by the NASA Applied Sciences Division(Grant# NNX09AV25G). US Army Corps of Engineers, Engineer Research and Development Center and Vicksburg Levee District. NASA Jet Propulsion Laboratory's for providing the UAVSAR image.