ABSTRACT

- Unstable slope conditions can lead to slump slides, which weaken the levees and increase the likelihood of failure during floods.
- On-site inspection of levees is expensive and time-consuming, so there is a need to develop efficient automated techniques based on remote sensing technologies to identify levees that are more vulnerable to failure under flood loading.
- The main focus of this research is to detect vulnerabilities on the Mississippi river levees using remotely sensed Synthetic Aperture Radar (SAR) imagery.
- Synthetic Aperture Radar technology, due to its high spatial resolution and potential soil penetration capability, is a good choice to identify problem areas along the levee so that they can be treated to avoid possible catastrophic failure.
- This research analyzes the ability of detecting the slump slides on the levee with NASA JPL's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) data using supervised and unsupervised classification techniques.
- The main contribution of this research is the development of a machine learning framework to:
  - detect anomalies on the levee sections
  - provide early warning of impending levee failures
  - develop efficient tools for levee health assessment

STUDY AREA AND DATA USED

Slump slides are slope failures along a levee, which leave areas of the levee vulnerable to seepage and failure during high water events. The clay soil on the levees shrinks during dry weather periods and gains moisture during wet periods resulting a loss in shear strength which can lead to failure. NASA JPL’s UAVSAR data acquired on June 16, 2009 was used in this study as there were active slides during the time of image acquisition.

CLASSIFICATION APPROACH

RX ANOMALY DETECTOR – UNSUPERVISED CLASSIFICATION RESULTS

The RX Detector (RXD) unsupervised classification algorithm was implemented on the extracted features of the SAR data. The output generated by RXD is a grayscale image; the larger the value of the pixels, the more anomalous the pixels would be. For visualization purposes, the range of values of the output are color-coded. A threshold is used to identify the true positives, which are the slide pixels.

SUPPORT VECTOR MACHINE – SUPERVISED CLASSIFICATION RESULTS

Wavelet features were extracted with different window (block) sizes: 4, 8, and 16 and the SVM algorithm was implemented on the extracted texture features of the SAR dataset using a Gaussian radial basis function (RBF) kernel and the performance of the classification was tested with different values of the kernel parameter $\sigma$. The results showed that the SVM classifier performed well in detecting the slump slides with the highest accuracies of 94.5% for the slump slide class and 95.6% for the healthy levee class.

AUTOMATED LEVEE TARGET RECOGNITION SYSTEM

- Surface roughness is an important property that can be used to distinguish slump slides as the radar backscatter is strongly influenced by the surface roughness.
- Therefore, textural features derived from Synthetic Aperture Radar imagery using the discrete wavelet transform (DWT) technique have been used in the classification tasks.
- Supervised and unsupervised classification algorithms have been applied to SAR data for efficient land cover classification.
- The RX Detector (RXD) unsupervised classification algorithm was implemented on the extracted features of the SAR data.
- The support vector machine (SVM) supervised classification algorithm was implemented on the DWT features with the ground truth data and the performance has been evaluated by the classification accuracies.

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