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Flood Inundation Mapping – A Comparison of Different Satellite Image Processing Methods Using Sentinel 2 Images: A Review Paper.

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ABSTRACT

This study is about the comparison of 5 five satellite image processing techniques for flood inundation mapping using Sentinel 2 multispectral imagery. Flood water extent can be found out using five water classification techniques (i.e., supervised classification, unsupervised classification, Normalized Difference Water Index [NDWI], delta-cue change detection and modified NDWI [MNDWI]). Manual digitization is a time taking process and it will hinder the disaster management procedures. Image processing is the perfect way to do the process faster and effectively. Every processing algorithms are different and result accuracy also varies, so to know the best image processing technique is important. Five image processing techniques will be compared with manual digitized sample. For multispectral satellite images, during flood times, cloud coverage will hinder the synoptic view, which we will overcome using DEM based method.

Keywords: NDWI, Image classification, MNDWI, Remote Sensing, and GIS

INTRODUCTION

Floods are very destructive force which shatter the livelihood, devastate property and agriculture lands, destroys businesses and impacts national GDP (Lakshmi, 2016). It is sure that global climate change and its effects will boost the flood intensities and frequency, which will threaten the humanity (Khan, 2011), (Pandey and Singh 2015). So, we need the information of current trend and future predictions of flood, which require accurate spatial and temporal information. Accurate

spatial extent of flood inundated areas is essential during the flood times and for post flood studies, recovery measures, relief efforts and to find out reason for flood events, which is important for deciding the future mitigation planning. General public and first responders need to know the flooded area and its risk, then only they can evaluate the situation and respond to the threat. Real time flood extent map can boost the mitigation strategies by forwarding immediate data to scientists and authorities. There is an alternative of for flood mapping based on direct ground survey and aerial mapping using aeroplanes and UAV's, such methods involves huge cost and its time consuming, also slow down the pace of the studying the impact of flood. (Dinuke Munasinghe, 2018), (Kanga and Singh. 2017) Perfect method is to use satellite image with good synoptic view. Remote sensing have lots of advantages i.e.; near real time surveillance, good spatial coverage and low cost of mapping large extent. (Schultz, 1998). Many pioneer works was done of remote sensing in flood was done using multi spectral scanner sensor on ERTS-1(Landsar-1), MSS imagery was used for flood mapping of lowa (Rango, 1974), (Kanga and Singh. 2017), (G. Peters Guarín, 2004) performed the basic flood risk assessment by using field survey using questionnaires and aerial photo interpretation, further analysis was done using GIS. The cadastral base map with attribute was the key inputs for flood hazard assessment. For estimating loss the vulnerability map was combined with cost information. (Philip A.Townsend, 1998) have done works modelling flood areas using GIS and remote sensing. Inundated surfaces where created using regression models from known flood elevations.ERS-I and JERS- I images where used to findout flood inundated areas during different flood levels. For mapping actual inundated area, timing and intensity, then important thing is to understand Land use/Land cover of floodplain. Even if the resolution of NOAA (AVHRR) is coarser, it is widely used for flood mapping and time series analysis of an area. NOAA data can be used for mapping of large area, but cloud cover is hinderance for NOAA optical sensor. An algorithm has been used to clear the cloud cover from pixel for flood study ((M. M. Islam, 2000), (Nathawat et al. 2010). SAR sensors were also used in flood mapping, they are capable to penetrate the clouded regions, which enable it for clear mapping of flooded area. But the processing of SAR data is difficult and it includes geometric and radiometric distortions. (Schumann, 2007),

The Sentinel 2 is relatively new satellite of European space agency launched in 2015, having high resolution of 10M, 20M and 60M. Revisit time is 5 days and 13 bands are present. They are following a free and open source data policy, which enable researchers to work on the possibilities. There is limited researches have been done using sentinel 2 datasets, compared to the Landsat datasets.

This study targets the (1) generation of flood inundated area (2) and comparison of five different image classification methods. (3) Then evaluate the effectiveness of DEM based approach of finding out cloud-pixels and (4) to check the accuracy of flood extent with respect to manually digitized flood extent.

CLOUD COVER REMOVAL

Cloud coverage is the main problem while mapping the flood, because rain clouds will block the view during bad weather conditions (Sanyal, 2004)

The "DEM- based approach" for cloud removal involves following steps

1. Bands 8, 4 and 3 are used to make infrared based false colour composite for manually digitize flood extent (see "Reference Flood Polygon"). This flood extent polygon is used to clip the flooded area from SRTM-DEM, 30M resolution.
2. Flood extent boundary passes through the highest elevation pixels in clipped DEM, this pixels are taken as thresholds
3. Clouds are also digitized from the false colour composite. Using raster calculator tool, pixels are extracted from DEM were clouds polygon are present. And if elevations are lower than highest elevation pixels, that area were classified as flood and added to the digitized flood extent layer. These pixels will also be added with the all five image classifications outputs.

Reference Flood Polygon

As said earlier false colour composite was used to digitize the flooded area. Visual image interpretation was used for the purpose. False colour composite was used because, water feature will show in dark tones.The result of the "DEM- based approach" also merged with the digitized polygon to include the cloud covered flood effected area.

FLOOD IMAGE CLASSIFICATION METHOD

Following image classifications methods

are used to map the flooded area and compared the quality of results. Satellite image during the flood peak hours are used for image classification. Exception is delta-cue change detection technique, were pre and post flood images are used.

Supervised Classification Based on the Maximum Likelihood Classifier:

Supervised classification is proved to be very effective in classify images at point of interest for matching ground reality (Shalaby, 2007). Supervised classification is a method which user can select a known pixel in the study area with specific spectral signature and with respect to that whole area can be classified, so that the result will be more likely same as that of the user defined classes.

Unsupervised Classification Based on the K-Means Classification Algorithm:

Unsupervised classification is where the result is automatically classified by the s algorithms of the image analysis software. In this method user don't provide any sample sites. User only provides the number of classes to be analysed. However user should have idea about the site conditions that where is the features like road, built-up, barren land, vegetation etc. are coming. The K-mean classification we are using is based on partitioning n number of observation in to clusters of k numbers. (Jensen, 2015), (Roy et al. 2017).

Delta-Cue Change Detection:

In this method, changes between two images of same area are analysed. Images of flood and post flood are used assess the change in pixels, especially water inundated area.

Normalized Difference Water Index (NDWI):

NDWI is a water index that uses green and near-infrared (NIR) bands for delineation of water logged area (McFeeters, 2013). It uses the higher reflectance of green band and higher absorption of NIR band in water.

$$NDWI = \frac{Green-NIR}{Green+NIR}$$

Modified NDWI:

NDWI of thick built-up areas shows matching with water pixels giving error output. (Xu, 2006) Suggested the use of MNDWI, where water features are boosted and eliminates the built-up noise and also suppress the vegetation and soil noise. The MNDWI use SWIR, shortwave infrared instead of NIR.

$$MNDWI = \frac{Green-SWIR}{Green+SWIR}$$

A threshold value of the resultant index

should be found out using trial and error method. This threshold value indicates the distinguishing between water and other features.

CONCLUSION

Image classification is an effective method for flood mapping, which is fast and cost effective. Near real time flood mapping can be done using this technology, which will enable the responders and decision makers to respond to the disaster effectively.

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