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Natural Disaster Management Study by Review of Topographical Features Using Satellite Imagery

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ABSTRACT

Natural Disasters are the events occurred within the earth system that leads to death or injury to humans and damage of valuable goods like buildings, communication systems, agricultural land, forest, natural environment. Natural disasters can be easily identified and the cause and effect of it can be minimized by the satellite image analysis. Satellite image analysis plays an essential role for environment and climate monitoring. Image classification is an essential process for performing the digital image examination in an efficient way. In satellite image classification process the grouping of image pixel values into pre-defined classes is done. Many satellite image classification methods were introduced for performing efficient disaster management. The analysis of two different problems is carried out in this paper to improvise the efficiency of determining the disaster management using satellite imagery.

Keywords : Satellite image analysis, disaster, disaster management, image classification, Topographical features, Social Media.

I. INTRODUCTION

Natural disasters occurs suddenly causing economic damage and ecological disruption and loss of human life. The natural disasters are captured via satellite images. Satellite image is the representation of earth part collected with artificial satellites. Satellite image has rich content for providing the environmental evidence. Satellite and remote sensing image provides the quantifiable and qualitative evidence to reduce the effort and complexity. The sensing equipment integrates data and images at regular intervals. The classification has significant role in removal of essential information from satellite images. The classification is defined as a procedure of integrating the pixels with the significant classes. The classification is considered as the robust technique for important information extraction. Satellite image classification plays vital role for the extraction and analysis of the useful satellite image information.

This paper is arranged as follows: Section 2 reviews the natural image classification with satellite images. Section 3 explains the existing natural image classification techniques. Section 4 discusses the experimental settings with possible comparison between them. Section 5 explains the limitation of existing natural image classification methods. Section 6 concludes the paper.

II. LITERATURE SURVEY

A bitemporal image classification approach was introduced in [1] to evaluate the pre and post disaster scenes and find whether regions were impacted or not. A ground truth satellite image from DigitalGlobe with labeled regions identified the issues of Hurricane Harvey to attain higher accuracy and F1-Score. But, the segmentation accuracy was not improved by bitemporal image classification approach.

A hybrid machine learning pipeline was employed in [2] with all relevant tweets to uncover disaster events across the different locations. The pipeline combined the Named Entity Recognition for identifying the location in posts to extract coordinate and to remove the noise information. A fine-tuned BERT model was used for categorizing the posts with humanitarian categories and graph-based clustering to find the information. However, the time complexity was not reduced by hybrid machine learning pipeline.

A machine learning-based approach was introduced in [3]with satellite radar images and geographical data to classify the damage status of individual buildings after wildfire event. The damage estimation methodology and application have high potential to enhance the social resilience. However, the pre-processing was not carried out in efficient manner by machine learning-based approach.

A new framework was designed in [4] for uncertainty reduction in damage assessment. An information-theoretic model was designed with maximum a posteriori probability estimation for probabilistic description. But, the image denoising was not performed in efficient manner.

A Satellite Precipitation-based Extreme Event Detection (SPEED) model was designed in [5]to support the parametric insurance instruments for minimizing the flood risk. But, the computational complexity was not minimized by SPEED model.

A new multi-hazard disaster methodology was designed in [6] with experiment–simulation–field data. The designed methodology carried out multi-hazard field investigation and scenario analysis. But, the image pre-processing was not carried out in efficient manner by multi-hazard disaster methodology.

An integrated methodology was introduced in [7] for mapping flood extent and depths depending on Synthetic Aperture Radar (SAR) images and digital elevation model (DEM). But, the segmentation was not carried out in efficient manner by integrated methodology.

A hybrid deep learning (ConvLSTM) algorithm was introduced in [8] for combining the predictive merits. ConvLSTM algorithm employed flood forecasting model to predict flood event occurrence. But, the peak signal-to noise ratio was not improved by ConvLSTM algorithm.

A segmentation neural network framework was designed in [9] to find the areas and accessible roads in post-disaster circumstances. ImageNet was used for aerial image segmentation. But, the segmentation accuracy was not increased through segmentation neural network framework.

The drought trend analysis was performed in [10] based on duration, mean spatial extent and frequency. A blockchain-based framework improved current drought risk management system. But, the computational cost was not reduced through drought trend analysis.

III. NATURAL DISASTER IMAGE CLASSIFICATION

Satellite remote sensing is an essential one for rapid mapping of damage after the natural disasters. Satellite imagery has been used to inspect natural disasters and the other adverse events and to analyse its impact on the environment. The satellite image extraction is valuable information source because of their vast ground coverage and rising availability. Segmentation is the method of dividing the digital image into many segments. The segmentation is to reduce and/or vary the image representation into more meaningful one. Image segmentation is employed to find the objects and boundaries in images. Image classification is an essential one for remote sensing, image analysis and pattern recognition.

3.1 Disaster Assessment from Satellite Imagery by Analysing Topographical Features using Deep Learning

A bitemporal image classification approach was designed to determine the pre and post disaster scenes for identifying whether regions were impacted or not. Through testing the ground truth satellite image from DigitalGlobe with labelled regions, impacts of Hurricane Harvey were depicted. The main aim of designed approach was to recognize region impacted by water related disasters such as floods and hurricanes and map them on available satellite imagery. The impacted region mapping issue was formulated in an urban landscape with densely packed road networks. The impacted region mapping issue was formulated in rural landscape with sparsely distributed road networks. A road segmentation neural network was employed to forecast the binary segmentation mask of pre and post disaster satellite images. Every pixel gets classified as belonging to road or not. The segmentation masks were fed into change detection system for post processing. The change was computed to find the impacted regions highlighted over the satellite image. A bitemporal image classification scheme was employed to find the flooded regions. Pre and post disaster satellite images were fed into CNN network. The impacted regions were highlighted over satellite image for manual inspection.

Algorithm 1 for Disaster Assessment from Satellite Imagery using Topographical Features

Step 1: Get the Input image

Step 2: Resize the image to reduce the size of the image to a constant format.

Step 3: Improve the quality of the image by denoising it

Step 4: Topographical Feature Extraction is done on the Image.

Step 5: Perform Semantic segmentation on the image

Step 6: Perform Deep Learning Classification on the image.

3.2 A Hybrid Machine Learning Pipeline for Automated Mapping of Events and Locations from Social Media in Disasters

A hybrid machine learning pipeline was introduced to employ all significant tweets to reveal disaster event evolution across diverse locations. The pipeline combined the Named Entity Recognition for identifying the locations in the posts. The location fusion approach was employed to collect the location coordinates and to remove the noise information for categorizing the posts with humanitarian class and graph-based clustering to recognize the credible situational information. A hybrid machine learning pipeline was employed to identify the evolution and geographical distribution of disaster events with help of the social media data. The pipeline included three modules, namely input, learning, and output. The input module was introduced to prepare the data for learning purposes. Users send new tweets to assign the experience and observation in the disasters. Users tweet post again from additional users to transmit the situational information. The post classification removed the off-topic posts that harm the unfolding event accuracy and geographic distribution. The posts with similar topic for location were assembled for clustering to enable the credible situational information.

Algorithm 2 for Hybrid Machine Learning Pipeline for Automated Mapping of Events and Locations

Step 1: Get the Input image
Step 2: Resize the image to reduce the size of the image to a constant format.
Step 3: Improve the quality of the image by denoising it
Step 4: Topographical Feature Extraction is done on the Image.
Step 5: Perform Semantic segmentation on the image
Step 6: Perform Deep Learning Classification on the image.

IV. METHODOLOGY

In order to compare the natural disaster classification techniques, number of satellite images is taken and to explain the case scenario, the algorithm is experimented and the output for a single image is shown here. The experimental evaluation of 2 methods namely bitemporal image classification approach and hybrid Hybrid Machine Learning Pipeline for Automated Mapping of Events and Locations are implemented using Matlab. The natural disaster images sample are taken from Kaggle disaster image dataset.
https://www.kaggle.com/mikolajbabula/disaster-images-dataset-cnn-model

4.1 Bitemporal Image Classification Approach

The bitemporal classification approach is applied for an Input image and the following step by step evaluation is carried out based on the Algorithmic steps given in format of the Algorithm 1 is produced

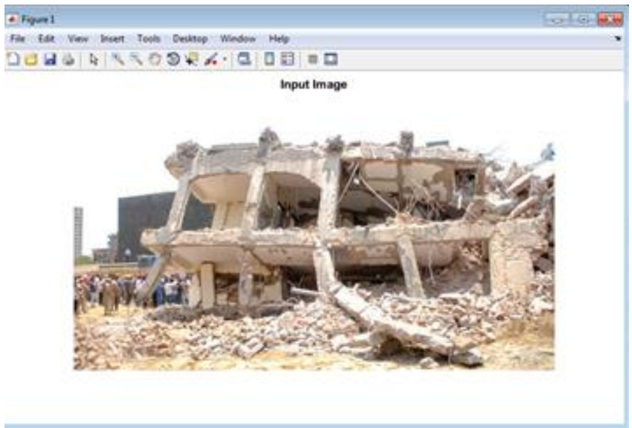


Figure 1 Input Image1

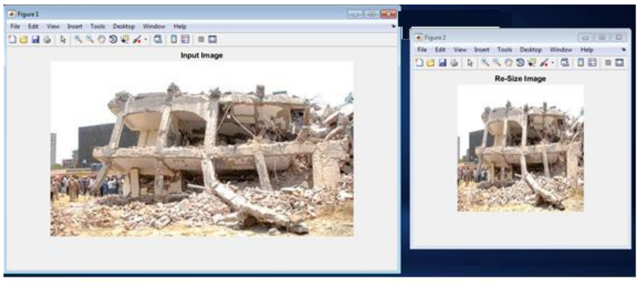


Figure 2 Input Image & Resized Image

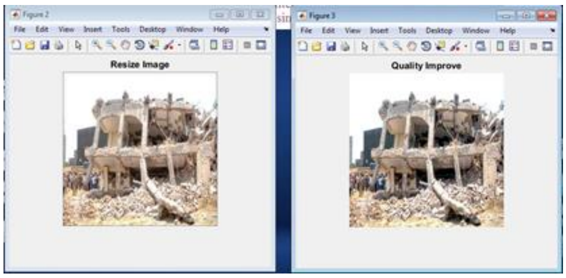


Figure 3 Resized Image and Quality Improved Image

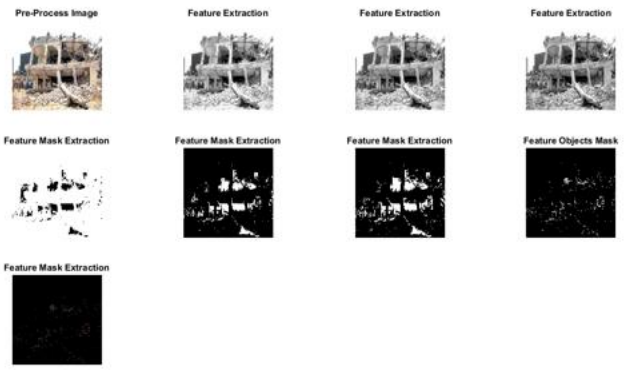


Figure 4 Topographical Feature Extraction

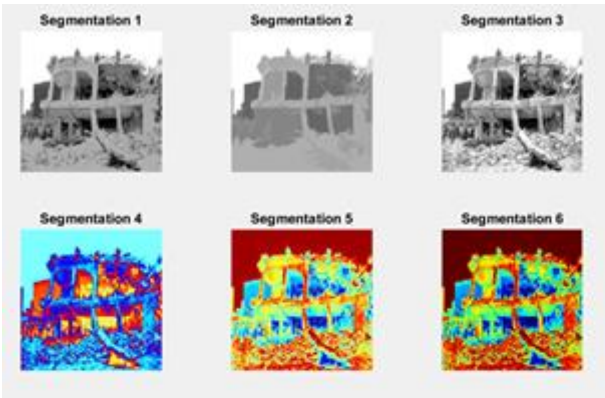


Figure 5 Semantic Segmentation

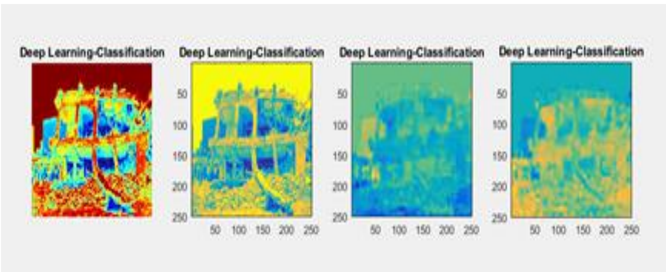


Figure 6 Deep Learning Classification

The Input image is obtained as in Figure 1 and the size of the image is reduced to a constant format as Figure 2 and the quality of the resized image is done by denoising it as in Figure 3 and the Topographical Feature Extraction is done on the image and the output is Figure 4and perform semantic segmentation on the image as Figure 5 and deep learning classification process is done on the image as Figure 6

4.2 Hybrid Pipeline Approach

The Hybrid pipeline approach is applied for an Input image and the following step by step evaluation is carried out based on the Algorithmic steps given in format of the Algorithm 2 is produced.

Figure 7 Input Image2

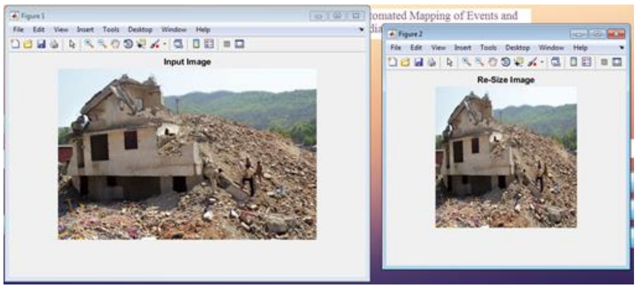


Figure 8 Input Image & Resized Image 2

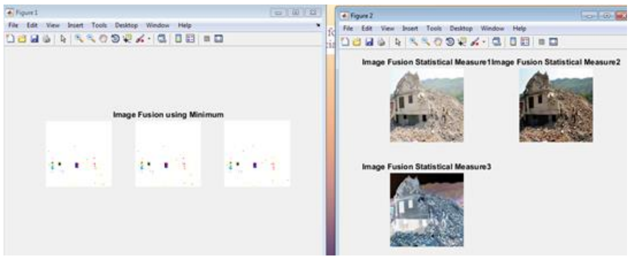


Figure 9 Location Fusion Recognition

Figure 10 Image Fusion

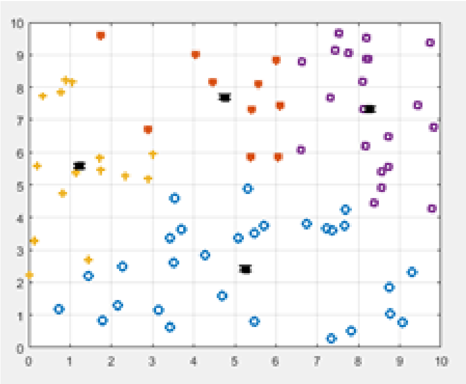


Figure 11 Graph Based Clustering

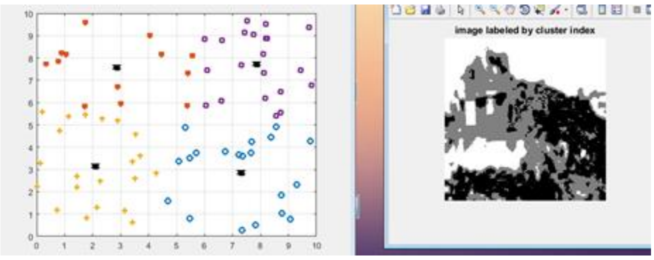


Figure 12 Image Labelled by Cluster Index

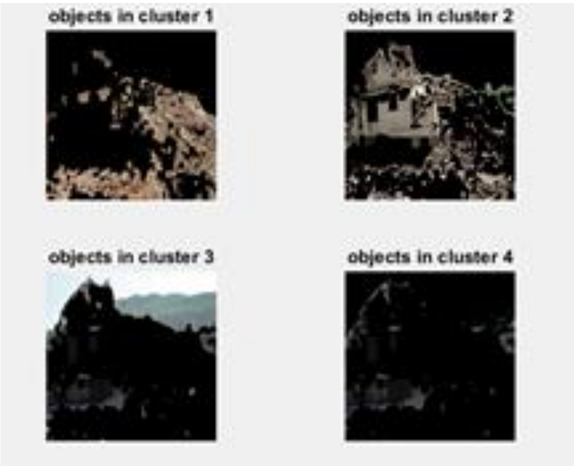


Figure 13 Objects in Clusters

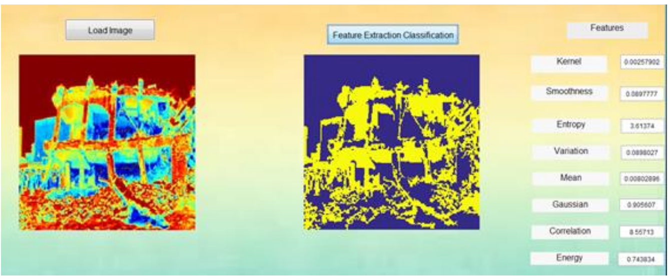


Figure 14 Feature Extraction

V. PERFORMANCE ANALYSIS OF NATURAL DISASTER IMAGE CLASSIFICATION TECHNIQUES

The performance measurement is calculated using 3 parameters

- PSNR Rate
- Segmentation Time
- Classification Accuracy

5.1 The PSNR Rate

Peak Signal-to-noise ratio is the ratio between the maximum possible power of an image and the power of corrupting noise that affects the quality of its representation. The higher the PSNR, better the quality of the reconstructed image.

The calculated PSNR Ratio is 38.0597

5.2 Segmentation Time

In digital image processing, image segmentation is the process of partitioning digital image into multiple image segments. The objective of segmentation is to simplify and / or change the representation of an image into something that is more meaningful and easier to analyse. It is used to locate objects and boundaries in images. The time taken to perform this process is called as Segmentation time.

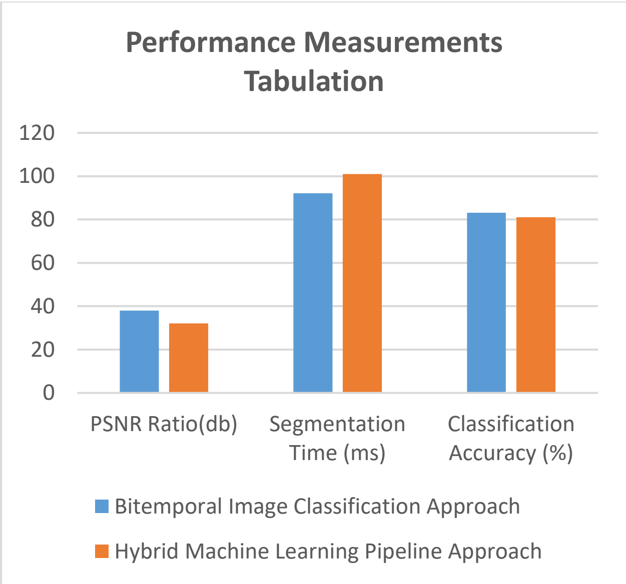
5.3 Classification Accuracy

Classification accuracy, which measure the number of correct predictions made divided by the total number of predictions made, multiplied by 100 to turn into percentage.

Table 1 Performance Measurements Tabulation

Performance Parameters	Bitemporal Image Classification Approach	Hybrid Machine Learning Pipeline Approach

PSNR Ratio(db)	38.0597	32.025
Segmentation Time (ms)	92.1193	101.05
Classification Accuracy (%)	83.1193	81.05



VI.DISCUSSION AND LIMITATION ON EXISTING NATURAL DISASTER IMAGE CLASSIFICATION METHODS

A bitemporal image classification approach evaluated the disaster scenes and identified whether the regions were impacted or not. The designed approach found region as belong to urban or rural landscape increasing the autonomy level in the system. However, the classification accuracy was not increased by bitemporal image classification approach. A hybrid machine learning pipeline was used in all relevant tweets to find out the disaster events across various locations. Named Entity Recognition was carried out for finding the location in posts to extract coordinate and to eliminate the noise. Hybrid machine learning pipeline attained better awareness for disaster-affected areas. But, the time complexity was not reduced by hybrid machine learning pipeline. A machine learning-based approach was performed with the satellite radar images and geographical data to categorize the damage status of individual buildings after wildfire event. The damage estimation methodology has high potential to improve the social resilience. But, pre-processing was not carried out in efficient manner by machine learning-based approach.

VII. CONCLUSION

A comparison of different existing natural disaster image classification methods was described. From survival study, it is clear that the classification accuracy was not increased by bitemporal image classification approach. The survival review shows that the pre-processing was not performed by machine learning-based approach. In addition, the time complexity was not reduced by hybrid machine learning pipeline. The wide range of experiments on many existing natural disaster image classification method computes the performance with its limitations. Finally, the research work can be carried out using machine learning and deep learning methods for increasing the performance of natural disaster image classification.

VIII. FUTURE DIRECTION

The future direction of work can be carried out using deep learning techniques for increasing natural disaster image classification with higher accuracy and lesser time consumption.

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