Fuzzy Based Semantic Scene Analysis for Flood Detection

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Abstract— **Regional heavy rainfall is usually caused by extreme weather conditions. Consequently, heavy rainfall often results in the flooding of rivers and the neighboring low-lying areas, which is responsible for a large number of casualties and considerable property loss. The existing weather forecast systems focus primarily on the analysis and forecast of large-scale areas and do not provide precise instant automatic monitoring and alert feedback for small areas and sections. In this paper, we propose a method to detect the flood and automatically monitor the probability of flood level of a specific area based on images using image processing methods to provide instant feedback on flooding events.**

I. INTRODUCTION

Images are the most common and convenient means of conveying information. Images concisely convey information about positions, sizes and inter-relationships between objects. They portray spatial information that we can recognize as objects.

A digital remotely sensed image is typically composed of picture elements (pixels) located at the intersection of each row i and column j in each K bands of imagery. A smaller number indicates low average radiance from the area and the high number is an indicator of high radiant properties of the area. Digital image processing (DIP) deals with manipulation of digital images through a digital computer. It is a sub-field of signals and systems but focuses particularly on images. DIP focuses on developing a computer system that is able to perform processing on an image. The input of that system is a digital image and the system process that image using efficient algorithms, and gives an image as an output.

Fig. 1. Digital Image Processing

Most methods for detecting the flood affected area are trained by providing annotated sample images. However, conditions change since training and deployment can be in different locations with widely varying illumination, camera position, apparent object sizes. The proposed method is to detect the flood and estimate the extent of flood from a crowd-sourced mobile images of the disaster affected area using fuzzy based semantic scene analysis.

II. RELATED WORKS

A number of approaches have been used to detect flooded water and classify the objects based on certain properties.

Scene content understanding facilitates a large number of applications, ranging from content based image retrieval to other multimedia applications. Material detection refers to the problem of identifying key semantic material types (such as sky, human beings, buildings, vehicles, water, and trees) in images.[1] This paper states that there are at least two types of spatial contextual relationships are present in natural images. First, relationships exist between co-occurrence of certain materials in natural images. Second, relationships exist between spatial locations of materials in an image. They have developed a spatial context-aware approach to material classification that uses spatial context constraints to increase the accuracy of the initial classification by constraining the beliefs to conform to the spatial context models.

Videos of flood catastrophes in newscast content are undergone certain techniques which utilize the variation in flood and background characteristics. [2] Different flood regions in different images share some common features which are reasonably invariant to lightness, camera angle or background scene. These features are texture, relation among color channels and saturation characteristics. The method analyses the frame-to-frame change in these features and the results are combined according to the Bayes classifier to achieve a decision (i.e. flood happens, flood does not happen).

Another work was relating to classifying images.[3] A priori knowledge about spectral information for certain land cover classes is used in order to classify SPOT image in fuzzy logic classification procedure. Basic idea was to perform the classification procedure first in the supervised and then in fuzzy logic manner

III. IMPLEMENTATION

Our proposed method is to detect the flood scenes and estimate the probability of flood from crowd-sourced mobile images from disaster affected areas. We use the fuzzy logic based on semantic scene analysis to implement this method.

The flood images are fed to the Intelligent Semantic Scene Understanding system. A decision is made by the fuzzy logic system taking the generated rule set into consideration. The probability of flood and the extent of flood is detected.

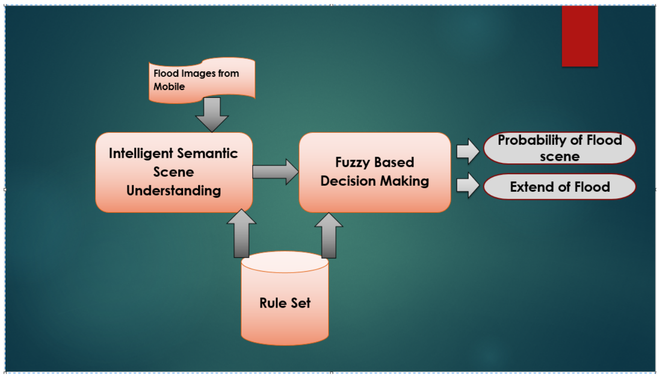

Fig. 2. Solution Approach

A. Intelligent Semantic Scene Analysis

The Semantic Scene analysis consists of various steps like preprocessing, segmentation of objects, extraction of features, segmented scene classification, context aware semantic scene analysis and the generation of rule set.

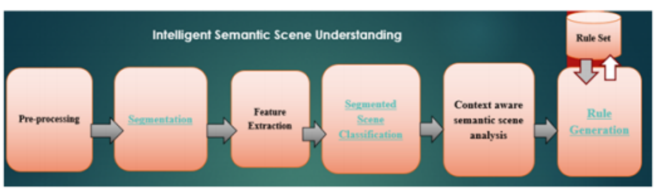

Fig. 3. Gamma Correction

1) Preprocessing: The first step is the preprocessing step wherein illumination of water is corrected using HSV(Hue, Saturation, Value) color space conversion. Performing this removes uneven illumination of the image caused by sensor defaults, non-uniform illumination of the scene or orientation of the objects. Gamma correction is applied to the images. This helps us in encoding or decoding the luminance in the image.

Fig. 4. Gamma Correction

2) Segmentation: In this step objects in the scene are segmented out using color based segmentation. All the objects for the flooded water is segmented out by masking the objects. Masking is nothing but filtering which convolves the mask with the image. We move the mask from point to point on the image to segment out the objects.

Fig. 5. Segmentation of water bodies

3) Feature extraction and segmented scene classification: The extraction of features in the scene are based on color, boundary and texture. the water is segmented considering the color-segmentation technique. By thresholding the histogram equalized images, the flooded water is segmented out.

Fig. 6. Segmentation of flood water

4) Scene analysis: The largest contour covering the flood water is detected and segmented out. Along with this value and the average brown color of th largest contour will be the input to the fuzzy inference system.

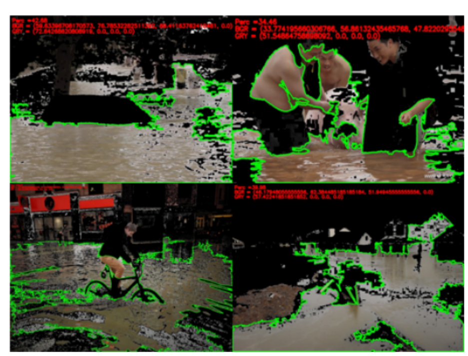

Fig. 7. Largest contour of flooded water

B. Fuzzy Inference System

In our system, the fuzzy logic gives the probability of the flood. Dealing with simple black and white answers is no longer satisfactory enough. It solves problems using the degree of membership.

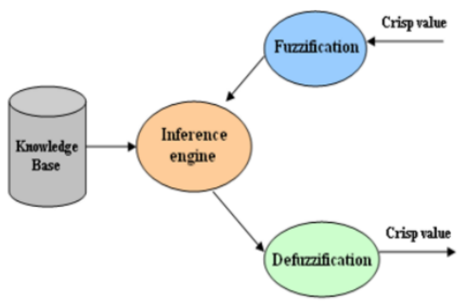

Fig. 8. Structure of fuzzy logic

A fuzzy set is a set whose elements have degrees of membership. An element of a fuzzy set can be full member (100 percentile membership) or a partial member (between 0 percentile and 100 percentile membership).

Mathematical function which defines the degree of an elements membership in a fuzzy set is called membership function. It is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1.

From Feature Extraction, the contour with largest area is calculated and the average color of the same contour is retrieved. These are the input to fuzzy system, which will be converted into fuzzy universe variables namely, color and area respectively and the output being the degree of flood. The universe variables are split into three parts representing the corresponding low, medium and high states of the respective universe:
color : light, medium, dark
area : small, medium, large
flood : low, medium, high

	Light Color	Medium Color	Dark Color
Small	Low flood	Medium flood	Medium flood
Medium	Medium flood	Medium flood	Medium flood
large	Medium flood	High flood	High flood

Fig. 9. Fuzzy Rules

IV. Experimental Results

The Gamma correction is carried out for the original input image and the flooded water is segmented. The largest contour for the flooded water is found out.Thus, the probability of flood is detected using fuzzy inference system which takes color and area as input, which make use of trapezoidal function as membership function and the rule set or knowledge base. Thus, the probability of flood is detected using fuzzy based semantic scene analysis. The current algorithm has been tested on a sample set of 200 images with 25 images that does not contain flood. Out of the 175 flood images the system gave positive result for 130 images and 7 out of 25 non-flooded images were also detected as flood.

Image No.	Contour Area (%)	Average Color (30 - 120)	Flood (%)
1	42.19	44.52	16.90
6	15.20	35.00	81.14
7	42.00	60.00	48.00
10	28.70	85.70	16.90
18	10.00	34.00	16.66
14	25.00	51.00	14.50
20	8.00	31.00	81.14
26	8.00	35.00	80.40
28	2.00	15.00	81.08
33	16.00	56.00	16.66

Fig. 10. Output of flood with crisp value

V. Conclusion

In this project, we have tried to detect flood water using digital image processing and fuzzy logic. Extraction of features such as area and color are done using scene analysis. The probability of is found out using rule-based fuzzy inference system which uses area and color as the inputs. In future, the work can be improved by incorporating various objects in the flood scene such as humans, trees, vehicles and building. The fuzzy inference system can also be enhanced adding rules.

Acknowledgment

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