Disaster Management Using Image Processing

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DECLARATION

We, hereby declare that this thesis is based on the results found by Myself. Materials That I used for work purpose are mentioned by reference. This Thesis, neither in whole or in part, has been previously submitted for any degree.

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Abstract

Many hazards that threaten the country have the ability to cause loss of lives or injury and all of them have the ability to cause severe damage to homes, businesses and infrastructure. These includes earthquakes, meteorological hazards, accidental hazards and flooding. Disasters have become a severe issue of growing concern throughout the world, whether it is natural hazards or by human factors. Our country is vulnerable to a number of natural hazards. It is highly imperative to develop effective methods for disaster management. I propose and demonstrate an image processing technique to identify shortest possible route to affected area after disaster like earthquake, flood, Fire & volcano hazards. The proposed model composed of pre- processing, decision making and result. In my thesis I used speeded up robust features to segment roads based on pre and post disastrous moment. I also used color based segmentation to detect fire and volcano on roads and it also can detect floods on road. Moreover, I used a method called 'K' means clustering which detect the presence and absence of an object by comparing both pre & post disaster images. Finally, I used a shortest path estimation algorithm to find the best possible route to affected area so that the immediate relief can reach the site as soon as possible.

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Chapter 1: Introduction

1.1. Motivation

Natural hazard is divided into two parts: geophysical and biological. Geophysical hazards such as earthquakes, volcanic eruptions, wildfires, cyclonic storms, floods, droughts, and landslides. Biological hazards can refer to a diverse array of disease, infection, and infestation.

Analysis of natural hazard with present technology are quite time and cost consuming. It becomes hard for humans to reach the affected people and analysis the destruction occurred by the natural disaster. If it is possible to measure the destruction, then decision for distribution of reliefs can be easier and efficient.

As Bangladesh is one of countries which are in risk of natural disaster frequently, so the analysis of road destruction and finding the shortest route, measuring the fire affected area and analysis of increase and decrease of river bank with detecting the overflowed area can be helpful for our nation.

1.2. Literature Review

Kusakabe T. and et al. represented that when there is an unusual situation like flood, hurricane, earthquake etc. occurs there is a need of taking immediate steps to reach emergency relief to the victims as soon as possible. For that we need to observe the road disaster with satellite and will detect the damage so that we can select our easiest route to deliver relief. We can't control any natural climates. But we can reduce the damages. Main purpose of our project is to reduce those damages within a short time. After a sudden disaster our device will automatically download two images with the help of the satellite which needs an algorithm to find out the damage road. One is right after the disaster and the other is just before the disaster happened. The device may not be able to detect the proper time but we can manually input the time. The device will then compare the two image and find out the difference to find out the damaged area with an image processing algorithm. After getting all the information about the damaged area we will run a route find algorithm to find out the shortest way to reach to the affected area within a very less time. At a serious disaster, it takes longer time to grasp damage by facility inspection patrol, even if you ignore small damage and focus on serious damage. In such a situation, this technology can play crucial roles. In this report, after presenting consideration matters of using image processing technologies, methods to get damage information from images are discussed. To put it concretely, first, applicability of image processing in order to detect damage from images is presented. Next, information extraction by detecting a suitable route for sending relieves as soon as possible [1].

Mnih V. and et. All represented that extracting image information from aerial image is a difficult problem with many practical applications. One specific case of this problem is the task of automatically detecting roads. Regardless of 30 years of labor on automated street detection, no automated or semi-automated street detection device is currently on the market and no posted technique has been proven to paintings reliably on massive datasets of city imagery. We recommend detecting roads using a neural network with thousands and thousands of trainable weights which looks at a far larger context than was utilized in previous attempts at getting to know the undertaking. The network is trained on massive amounts of facts using a patron GPU. We display that predictive performance may be considerably stepped forward by using initializing the characteristic detectors using these days advanced unsupervised mastering strategies as well as by taking gain of the nearby spatial coherence of the output labels. We display that our method works reliably on two city datasets which are an order of significance larger than what become used to access previous tactics [2].

1.3. Thesis Orientation

The remaining part of this thesis paper is organized as follows:

- Chapter 1 describes the introduction
- Chapter 2 consists of discussion about the fundamentals of image processing
- Chapter 3 narrates the proposed model of our research.
- Chapter 4 explains the results found in our research.
- Chapter 5 wraps up this thesis with future research possibilities for out thesis.

Chapter 2: Fundamentals of Image Processing and Disaster Management by Image Processing

Image processing could be a strategy to vary over footage into computerized form and play out a number of activities thereon, keeping in mind the top goal to urge an improved image. Image processing contains concerning footage as 2 dimensional signs whereas applying formally set flag getting ready techniques to them.

2.1. Stages of Image Processing

Image processing includes the subsequent 3 steps. Importing the image with optical scanner or by digital photography. Analyzing and manipulating the image which incorporates knowledge compression and image improvement and recognizing patterns that aren't to human eyes like satellite pictures. Output is that the last stage within which result may be altered image or report that's supported image analysis.

2.2. Applications of Image Processing

1. **Intelligent Transportation Systems** – Detection of visual data is incredibly necessary in several industries. Image processing is additionally employed in intelligent transport systems applications. In road traffic, image knowledge will be obtained from the stored image, which can be situated higher than or beside the road. they'll be wont to find vehicles on the roads, the speed of moving vehicles, for frontal automobile detection obstacles, to find lanes on the road, road toll, etc. furthermore this method will be employed in Automatic variety plate recognition [17].

2. **Remote Sensing** – Techniques used to interpret the objects and regions are employed in flood control, urban planning, resource mobilization, agricultural production observation, etc. Numerous information sources are employed in GIS, one in all the most important thing is that provided by remote sensing through the use of satellites, continued program of data acquisition for the entire world with time frames starting from some of weeks to a matter of hours. We've got additional access to remotely detected images in digital form, allowing rapid integration of the results of remote sensing analysis into a GIS [11].

3. **Defense surveillance** – It is important to recognize the distribution of those objects in numerous directions that are east, west, north, south, northeast, northwest, southeast and south west to explain all potential formations of the vessels. We will interpret the whole oceanic situation from the special distribution of those objects. The important duty is to divide the various objects present within the water body part of the image. The different parameters such as length, breadth, area, perimeter, compactness are created to classify each of divided objects [17].

2.3. Image Processing Techniques to Detect Damages By Comparing Pre-Disaster and Post Disaster Images

2.3.1. Median Filter

First the neighboring pixels are sorted out and then the pixel is replaced by the median value of all the sorted pixels and if the neighboring pixels are even in number, then the average value of the middle two-pixel value is used for the replacement. For every pixel in an image, its neighbor pixels are considered. Median filter is also used to reduce the amount of noise in an image. Thus gives us sharper edges than mean filtered image. Secondly, it does not create unrealistic pixel value while filtering. Firstly, is gives more vigorous average of the pixels than mean filter. An illustration of the calculation of median filtering is given below. But it has two major advantages over mean filter. Median filter also follows a simple working procedure.

2.3.2. Gaussian Smoothing Filter

The Gaussian smoothing operator is a 2-D operator which is used to blur images and remove detail and noise. It is similar to the mean filter, but it uses a different kernel that represents the shape of a Gaussian hump. The Gaussian distribution in 1-D has the form:

$$G(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{x^2}{y}} \tag{1}$$

Where σ is the standard deviation of the distribution. We have also assumed that the distribution has a mean of zero (i.e. it is centered on the line x=0) [4]. The distribution is illustrated in **Figure 1**

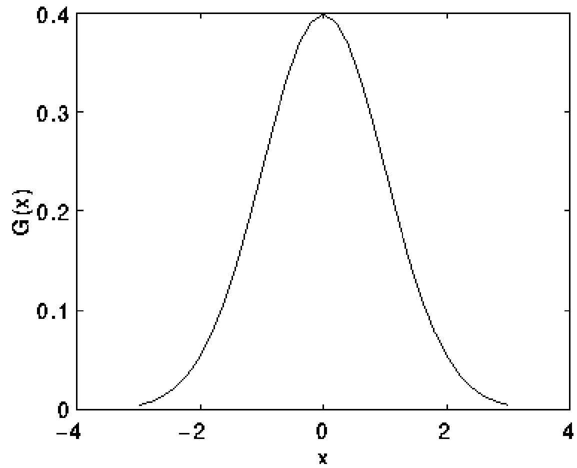

Figure 1: 1-D Gaussian distribution with mean 0 and σ=1 [14].

In 2-D, an isotropic (i.e. circularly symmetric) Gaussian has the form:

$$G(x,y) = \frac{1}{2\pi\sigma} e^{-\frac{x^2+y^2}{2\sigma^2}} \qquad (2)$$

This distribution is shown in **Figure 2**.

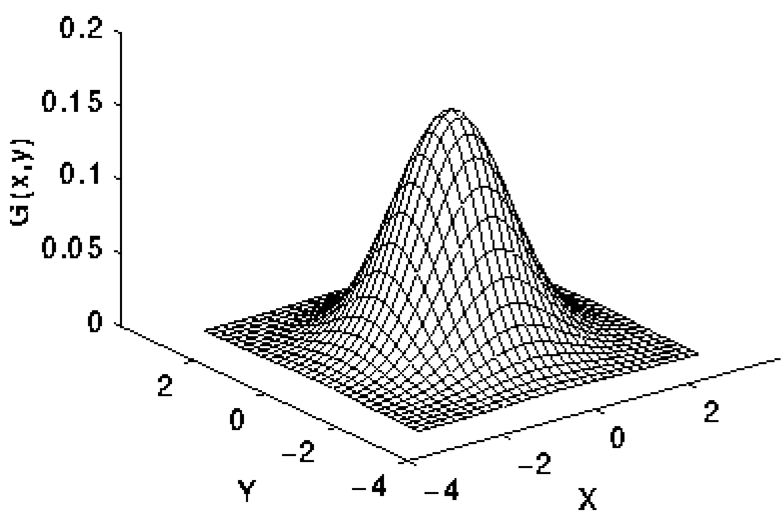

Figure 2: 2-D Gaussian distribution with mean (0,0) and σ=1 [14].

2.3.3. OTSU's Threshold Algorithm

OTSU's algorithm is an image binarization algorithm named after its inventor Nobuyuki Otsu. It assumes that an image has two types of pixels. Foreground pixels and background pixels. It calculates the optimum threshold separating the two classes. A threshold value is searched that minimizes intra-class variance, defined as a weighted sum of variances of the two classes:

$$\sigma\omega_2\ (t) = \omega_0(t)\ \sigma_0{}^2(t) + \omega_1(t)\ \omega_1{}^2(t) \qquad (3)$$

Weights ω_0 and ω_1 are the probabilities of the two classes separated by a threshold t and σ_0^2 and σ_1^2 are variances of these two classes. The class probability $\omega_{0,1}(t)$ is computed from the L bins of the histogram:

$$\omega_0(t)=i=0t-1p(i) \qquad (4)$$

$$\omega_1(t)=i=tL-1p(i) \qquad (5)$$

Otsu shows minimizing the intra-class variance and maximizing inter-class variance is equivalent.

$$\sigma b_2(t)=\sigma_2-\sigma\omega_2(t)\ = \omega_0(\mu_0-\mu T)_2+ \omega_1(\mu_1-\mu T)_2= \omega_0(t)\omega_1(t)[\ \mu_0(t) - \mu_1(t)]^2 \quad (6)$$

2.3.4. Speeded up robust features (SURF)

SURF goes a little further and approximate log G with Box Filter. **Figure 3** shows a demonstration of such an approximation. The main advantage of this approximation is that, convolution with box filter can be easily calculated with the help of integral images.

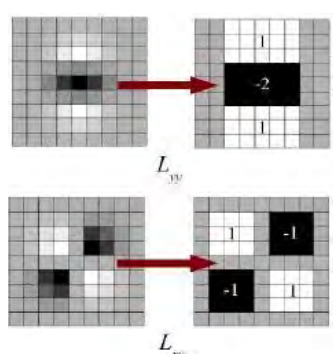

Figure 3: Approximate log G with Box Filter [4].

2.3.5. K Means Clustering Algorithm:

Clustering is converting objects into groups. Basically partitioning the data into subsets. K means clustering is used to represent images. Its main goal is to detect the presence and absence of an object. Represented by attribute value pairs as $10^3 \times 10^3 \times 10^3$ for pixels. It breaks images into set of patches.

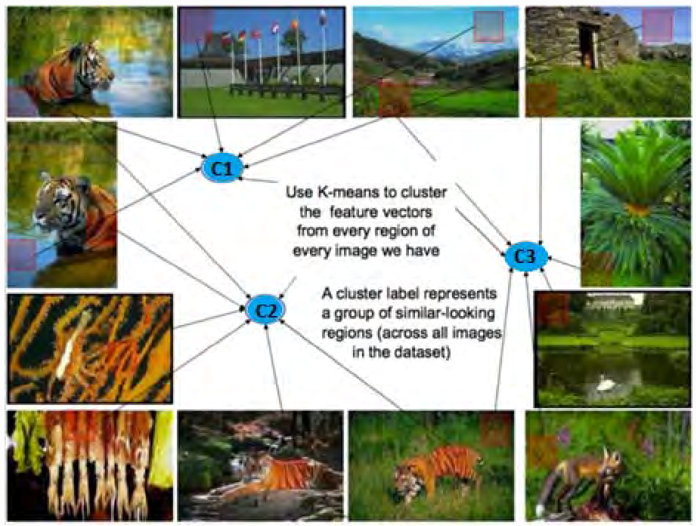

Figure 4: K means Clustering [7].

2.3.6. Color Segmentation:

Many image segmentation techniques are available. Some of them use only the grey level histogram, some use spiral details but most of these techniques are not suitable for noisy environments. Color image segmentation is not that rich as it is for gray tone images [5]. The major segmentation approaches for segmenting monochrome images like histogram thresholding, edge detection, characteristic feature clustering, region-based methods, fuzzy techniques, neural networks, etc. Here is a block diagram of color segmentation illustrated in **Figure 5**.

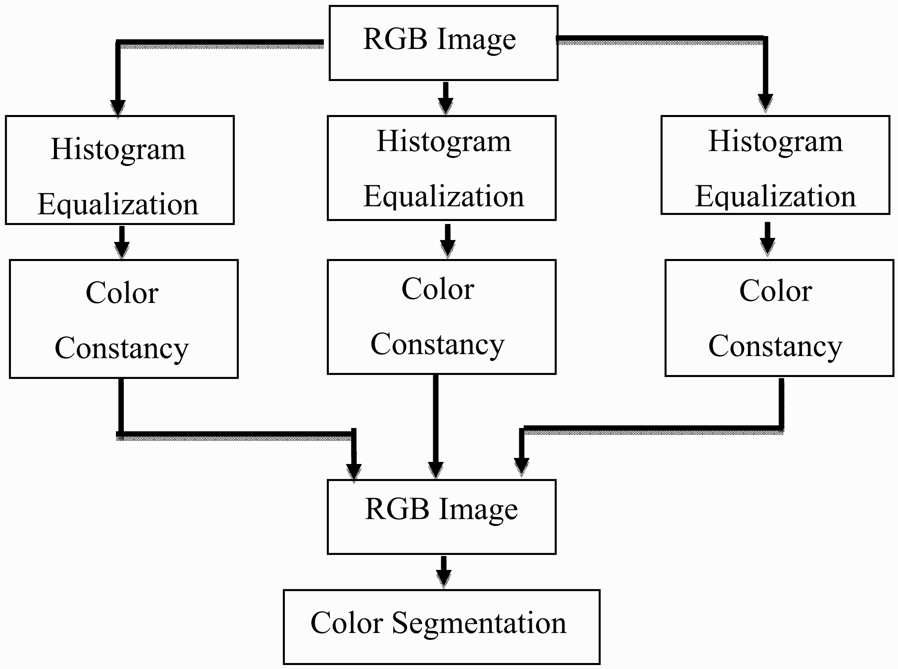

Figure 5: Block Diagram of Color Segmentation.

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2.3.7. The shortest path estimation algorithm:

Shortest path algorithm is considered as one of the suitable method for searching best path. [6]. I used a discrete directed graph as G (V, E). The set of vertex V= $\{v_i|i=i,\ldots,n\}$ is defined as the set of intersections and ending points of a road. The set of edges E= $\{e_i|i=i,\ldots, n\}$ is defined as the set of road segments between a pair of adjacent intersections or ending points. There is a source position s and destination position d. The main purpose of this algorithm is to find the shortest road from source to destination assuming that there is no obstacle on the road. Along with Dijkstra with heuristic based on the greedy best first search (BFS) is used to estimate the shortest path on the huge area of the map. As there are some complexities in using heuristic searching technique

Chapter 3: Proposed Method

When a disaster takes place first we detect all the possible roads that direct to affected area. To do this we need to apply an algorithm which will detect the possible roads to find the route. When the detection process will finish it will apply another algorithm which will find the shortest Route.

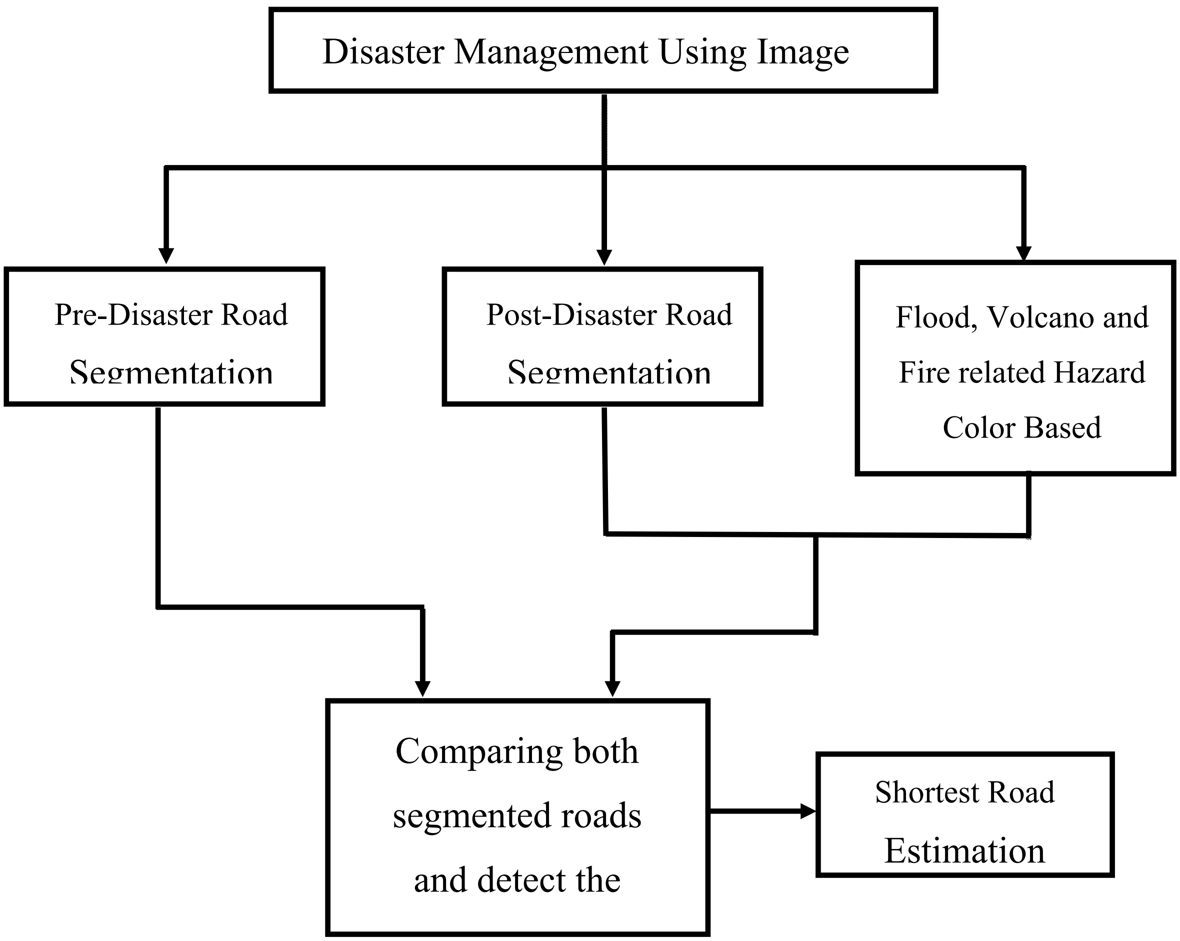


Figure 6: Flowchart of Proposed method.

3.1. Pre-Disaster Road Segmentation:

To do the analysis, we input two images, one is affected and another one is unaffected. To reduce the color complexity, we applied gray scaling and Gaussian blurring in this image, as a result low pass noise will be reduce. It also helps to reduce the complexness not to detect

Figure 7: Original image [16].

The destroyed parts, roof of the house or region beside road. After applying adaptive thresholding, we convert the images binary image into and perform flood fill method to fill gaps. Now, by the method of connected components, we measure the longest connected neighbor. The longest connected components will mark as road. Further change the pixel values and color the paths.

Figure 8: Converted Binary Image.

The binary we got will be used to detect roads using K means clustering algorithm. Which will detect all the Euclidean points. Basically K means clustering method will find the presence and absence of any object on that path and detect the road that are connected.

Figure 9: Marked Road by Thresholding.

After implementing K means Clustering we found the available roads. Figure 10 shows the available roads on map.

3.2. Post-disaster Road Segmentation:

Now we will test affected area after disaster with the same process. We will apply median filter, Gaussian Smoothing Filter and we will find the clear RGB image of road map

Figure 10: After disaster blocked areas.

This image will be converted into binary image to find the roads

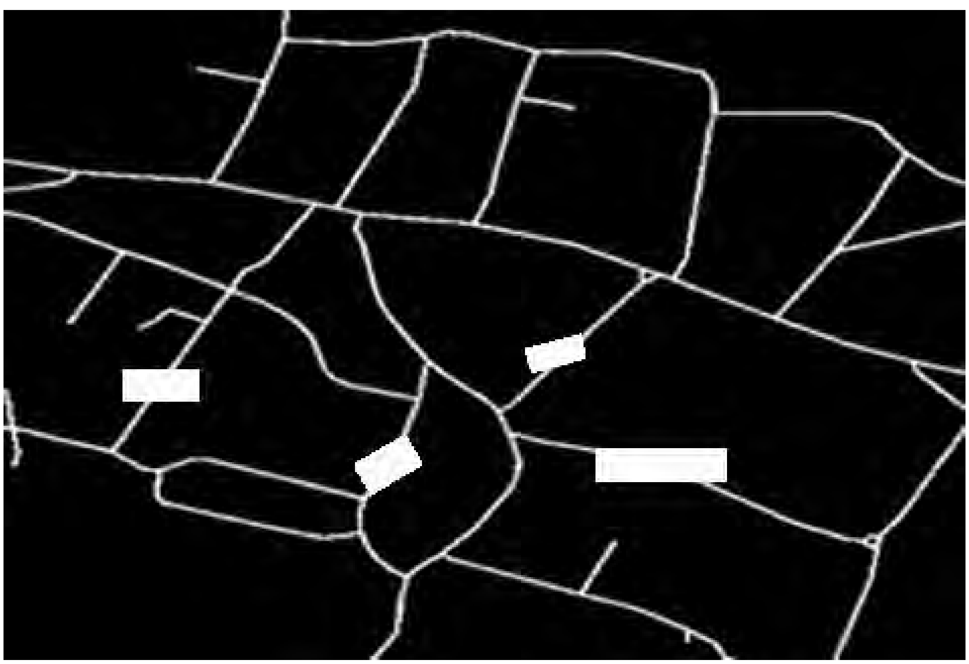


Figure 11: Converted into binary image (post disaster).

K means clustering will be applied to this image to detect the availableroutes. K means will try to find the presence and absence of an object and it finds an object on that path it will not count that.

Figure 12: Available Roads.

3.3. Volcano and Fire related Hazard Color Based Segmentation:

This algorithm is the transforming from RGB to CIE L*a*b* color space. The transformation from any color space representation to CIE L*a*b* color space is straightforward. Given RGB data, the conversion to CIE L*a*b* color space is formulated as follows:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.412453 & 0.357580 & 0.180423 \\ 0.212671 & 0.715160 & 0.072169 \\ 0.019334 & 0.119793 & 0.950227 \end{bmatrix} \quad (9)$$

$$L^{*} = \{116 \times (Y/Y_n)^{1/3} - 16, if (Y/Y_n) > 0.008856 \quad (10)$$

here X_n, Y_n, and Z_n are the tri-stimulus values of the reference color white. The data range of RGB color channels is between 0 and 255 for 8-bit data representation. Meanwhile, the data ranges of L*, a*, and b* components are [0, 100], [–110, 110], and [–110, 110], respectively.

The numeric color responses L*, a*, and b* are normalized to [0, 1]. It is assumed that the fire in an image has the brightest image region and is near to the color red. Thus, the following rules can be used to define a fire pixel:

$$\mathrm{R1}(x,y) = \begin{cases} 1, if\ L^*(x,y) \geq L_m \\ 0, \quad otherwise \end{cases} \tag{11}$$

$$\mathrm{R2}(x,y) = \begin{cases} 1, & if\ a^*(x,y) \geq a_m^*, \\ 0, & otherwise \end{cases} \tag{12}$$

$$\mathrm{R3}(x,y) = \begin{cases} 1, & if\ b^*(x,y) \geq b_m^* \\ 0, & otherwise \end{cases} \tag{13}$$

$$\mathrm{R4}(x,y) = \begin{cases} 1, & if\ b^*(x,y) \geq a^*(x,y), \\ 0, & otherwise \end{cases} \tag{14}$$

Where L*, a*, and b* channels are quantized into 24 levels, and 6,223,467 pixels are used to create each histogram. The number of quantization levels can be changed, but through experimentation, 24 levels were found to give satisfactory results. A look-up table is created for each pair of 24 quantized levels to keep track of the likelihood that any pair of L*, a*, and b* belongs to a fire. It is clear from Figs. 4(a), 4(b), and 4(c) that a fire can be defined by the combination of three histograms. Given the L*, a*, and b* color values at spatial location (x, y), the likelihood that L*, a*, and b* belong to a fire P(L*, a*, b*) is defined as where P(L*, a*),

In figure 13 we choose a RGB image of fire. We use graythresh and convert it to binary image. From that binary image we calculated the color constancy and covert it to RGB image again with detected fire.

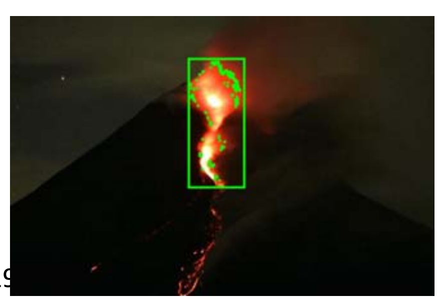


Figure 13:(i) RGB image, (ii) gray Scaled, (iii) Binary Masking, (iii) Noise Reduced in binary image, (iv) detected Volcano part.

3.4. Flood Detection Using Color Based Segmentation:

In our research we have some sample images different types of flood water dataset. When flood occurs our system will compare flood affected area with our sample flood water dataset.

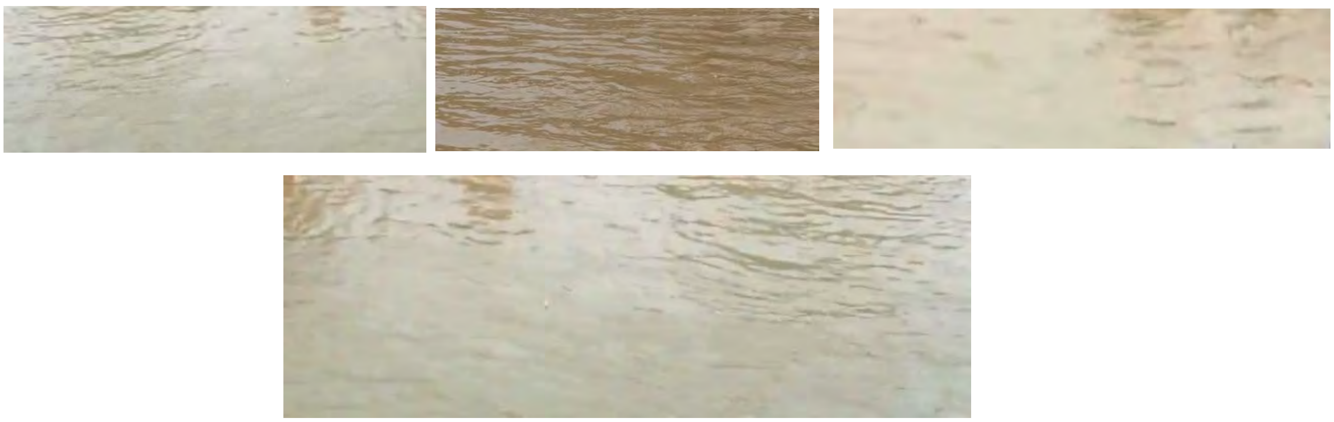


Figure 14: Flood water dataset.

Flood affected road images collected from satellite view are compared with the flood water dataset. If the water color of affected area matches with flood water dataset it will mark it with a particular color.

Figure 15: Flood Detection.

Chapter 4: Result

4.1. Simulation Methodologies

By using our proposed method, we got post disaster road map satellite images from different areas and also fire or volcano affected areas. Finally, we run a shortest path algorithm to find the shortest route to the affected area. So basically this process happens in 3 stages

1. By using Image processing techniques, we detect the normal roads of that area. This area map is previously stored in database(figure)
2. Using the same technique comparing after disaster image and stored image we got newly detected roads on post disaster image.
3. Finally, we implemented the shortest path estimation algorithm to find the shortest road so that the relief team can reach the destination as soon as possible.

4.2. Comparing Pre-Disaster & Post-Disaster Image Result:

The main motivation is to detect the road and marked theme on the basis of before after disaster, segmenting the vocation's part, finding the shortest routes and analyzing before after disaster images.

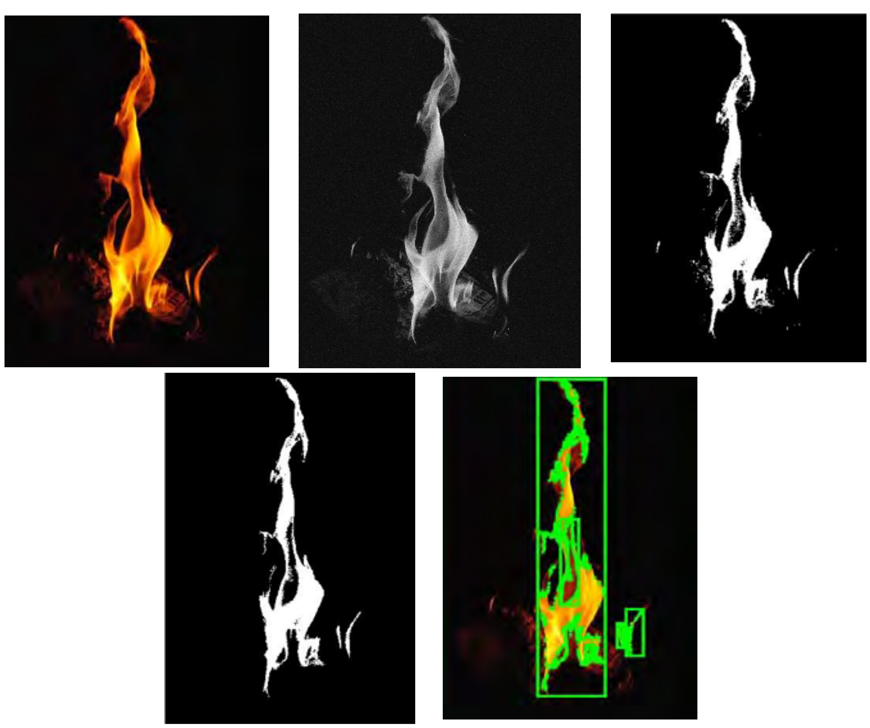
(a) (b) (c)

Figure 16: (a) Before disaster Road detection, (b) After disaster, (c) contacting two outputs

Here, in fig 16.a and 16.b shows before after road segmentation and 16.c denotes the concatenation after overlapping both images. The yellow part is the commonly segmented or structured common roads after disaster and red refers the missing or destroyed road. More segmentations of roads are given.

Figure 17: Segmented roads

The volcano and fire detect is marked based on the L*a*b color space, and binary masking and it refers and marks the brightest part which is the creating point of volcano or fire. From this results, the perimeter of volcano's creating point can be measured.



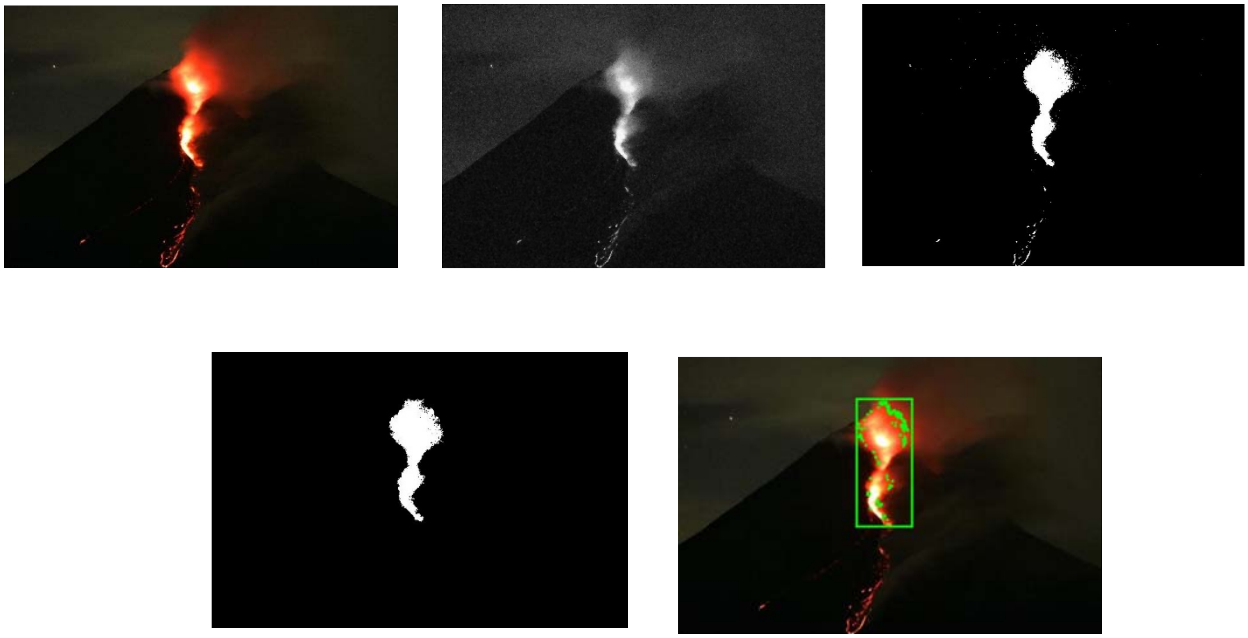


Figure 18: RGB image, gray Scaled, Binary Masking, Noise Reduced in binary image, detected Volcano/Fire part.

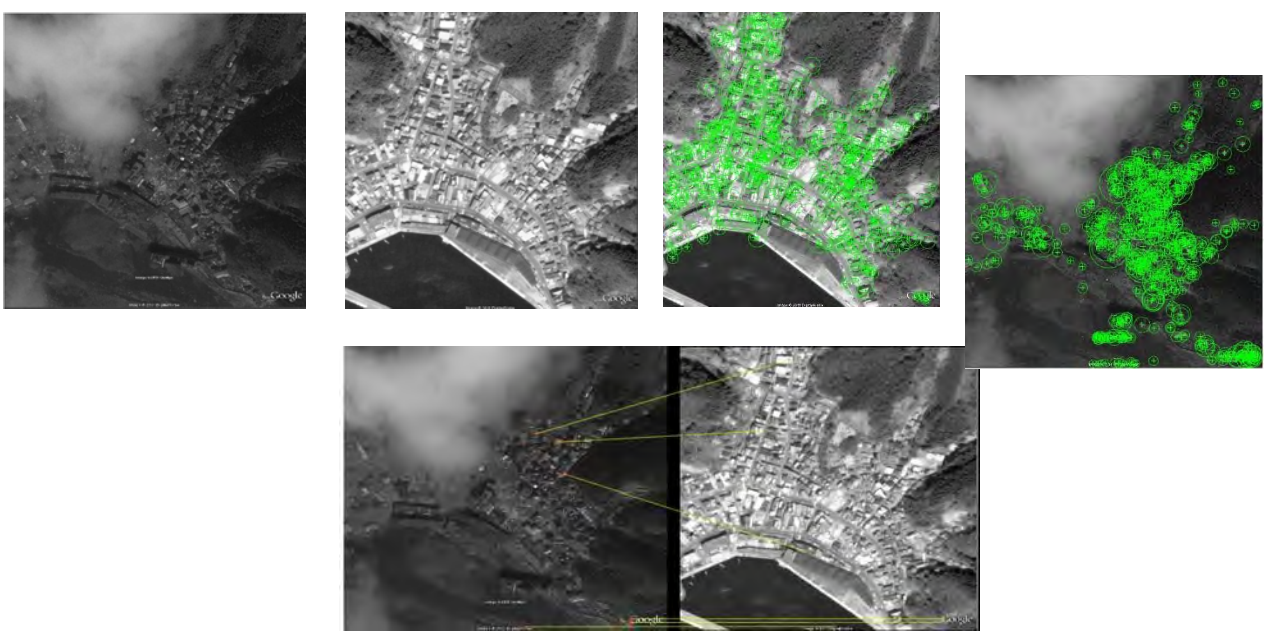


Figure 19: Speed Up Robust Feature based destruction denoting.

Figure 18 shows the important 100 key points in each image for feature extraction. and using SURF algorithm the matching feature is connected. The less it matches , it defines more destruction .

First pre disaster road segmentation result showed all the available roads on that map but second post disaster road segmentation result showed only showed only those roads which are not blocked by obstacles or fire hazards. From this we got a clear visual route from source to destination area.

Figure 20: Processed images.

4.3. Shortest Road Estimation:

The shortest path estimation algorithm will be implemented on the recent output from post disaster situation. [**Figure 12**] It will extract the shortest path for sending relieves. The post disaster road images are manually collected from the road segmentation process. In this process we will combine both images for road detection using both kind of images, road map and satellite images. The image dataset for experiment was automatically retrieved from Road segmentation process. The intersection and the ending points of roads are orderly numbered. In this process, the intersection of roads at a position is separated into a set of intersection points, which depends on the number of road branches and they connect to other by small road segments.

Chapter 5: Conclusion & Future Works

5.1. Conclusion:

In this research I used different methods to identify all the available roads. I used K means algorithm to compare the pre and post disaster road images. I used color based segmentation method to detect fire and volcano hazards which can also detect flood affected area. I also use shortest path estimation algorithm to find out the shortest road which is not blocked by any object. It will help us to reach the affected area as soon as possible.

5.2. Future Works:

This research has come up with a novel approach to detect the shortest roads in disastrous moment so that our relief team easily find out a way to reach the affected area as soon as possible but there are still some complexities in our project. In future we will try to find out that complexities and find a solution for that. Moreover, we will make a graphical user interface (GUI) for this where all the methods will be merged and will be stored huge datasets. This Interface will help us to detect shortest route automatically.

References:

[1] Kusakabe, T., Sanada, A.: Application of Image Processing to Detect Infrastructure Damage Caused by Earthquakes

[2] Mnih, V., Hinton, E.: Learning to Detect Roads in High-Resolution Aerial Images. University of Toronto.

[3] Celik. T.: Fire and Smoke Detection without Sensors: Image Processing.

[4] Bay, H.(2006),Tuytelaars, T. and Van Gool, L.: SURF: Speeded Up Robust Features

[5] Nikhil R, Sankar K.:A review on image segmentation techniques (1993)

[6] Hoang, V.-D., Jo K.: Path planning for autonomous vehicle based on heuristic searching using online images (2015).

[7] Akhbardeh, Farhad. (2014): K-means clustering based angiographic image analysis to measure coronary stenosis, Eastern Mediterranean University.

[8] LaValle, S.M.: Planning Algorithms. Cambridge University Press, Cambridge (2006)

[9] Sun,W., Messinger, D.W.: An automated approach for constructing road network graph from multispectral images. In: Proceedings of SPIE Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral Imagery, pp. 83901W-1–83901W-13 (2012)

[10] Bielski, C., Gentilini, S.,Pappalardo, M.: Post-Disaster Image Processing for Damage Analysis Using GENESI-DR, WPS and Grid Computing

[11] Bello, M., O., Aina, A., Y.:Satellite Remote Sensing Tool in Disaster Management and Sustainable Development Towards a Synergistic Approach.

[12] Otsu, N., A Threshold Selection Method from Gray-Level Histograms.

[13] Nosal E.R. (February 2009) Flood-fill algorithms used for passive acoustic detection and tracking.

[14] Gaussian smoothing from: https://homepages.inf.ed.ac.uk/rbf/HIPR2/gsmooth.htm.

[15] RGB to Grayscale Conversion in CUDA and OpenCV (2015). Retrieved from: http://www.coldvision.io/2015/11/17/rgb-grayscale-conversion-cuda-opencv/

[16] Road and Building Detection Datasets from: https://www.cs.toronto.edu/~vmnih/data/ .

[17] Tim Morris(2004). Computer vision and image processing. Palgrave Macmillan.

[18] Mohapatra, B. R., Mishra, A., & Rout, S. K. (2014). A Comprehensive Review on Image Restoration Techniques.

[19] Gonzalez, R.C. & Woods, R.E. (2006). Digital Image Processing. NJ,USA:Prentice-Hall,Inc.Upper Saddle River.
[20] Nosal E.R. (February 2009) Flood-fill algorithms used for passive acoustic detection and tracking, DOI: 10.1109/PASSIVE.2008.4786975,Hyeres, French Riviera, France.