Computing of the Burnt Forest Regions Area Using Digital Image Processing

Hamidreza Gorgani Firouzjaee[1]✉, Hamid Hassanpour[2], Asadollah Shahbahrami[3]

(1) Department of Information Technology, University Of Guilan, Rasht, Iran
(2) School of Computer Engineering & Information Technology, Shahrood University of Technology, Shahrood, Iran
(3) Department of Computer Engineering, University Of Guilan, Rasht, Iran

gorgani_hamidreza@yahoo.com, h_hassanpour@yahoo.com, shahbahrami@guilan.ac.ir

Abstract

At present, there is no conventional scientific method to evaluate the area of the burnt regions of forests and in this field, the related organizations use different methods and variables. Also, the speed in performing the processes of area computing and damage evaluation, especially in the extensive damaged forest regions is very slow; consequently, the expression of results takes more time. Now, one of the most important parameters to evaluate the forests fire damages is computing the area of the burnt forest regions. In this research, an aerial digital image from a forest region after fire occurrence is used and the primary area of the burnt region is calculated in two methods of; integration and interconnected components extraction, by using image processing techniques. Also, in order to estimate the real area, a coefficient "m" is calculated to obtain real area based an measuring the forest land surface by exerting the imaging scale on the primary area. The methods which are introduced to calculate real area of the burnt regions, are dependent on some secondary tools such as aerial camera and special plane, but in the extensive forest regions damaged by fire, they cause to decrease in the evaluation costs and faster notification of the results.

Keywords: Forest Fire, Image Processing, Real Area, the Burnt Regions

1. Introduction

Due to special geographic situation, Iran is always exposed on different kinds of natural and unnatural dangers and imposed by heavy financial (property) damges and human (life) loss [1]. Fire is one of the oldest disasters which can endanger the property and health of people during a short time. When the fire continues for a few days; especially in forests, it will be caused to destroy several hectares of these pastures [2].

According to the available statistics, during just 10 last years, 13832 fires were reported in natural fields of Iran which caused to deteriorate 142941 hectares of natural regions of the country and resulted in high material damages (loss) [3]. One of cases which is usually calculated after fire occurrence in the forests, is the remaining loss which its appropriate assessment is high dependent on the correct estimation of the burnt regions area [4].

In this research, by exploiting the image processing techniques, it was attempted to measure the area of the burnt regions in aerial image after forest fire occurrence [5].

Also, in section 2 of this paper, a background of similar studies and the present research in field of forest fire are examined [4-10]. In sections 3 and 4, after segmentation and noise cancellation in the sample image, the primary area of the burnt regions is calculated by two methods of, integration and the extraction of interconnected components [11-14]. In section 5, measurement of imaging scale to calculate real area [15] and in section 6, the analysis of results are discussed. In final section, the conclusions of the performed research are presented.

2. The Examination Of Similar Studies And The Present Research

In general state, we encounter with three situations in field of forests fire;
- Before fire occurrence
- During fire occurrence
- After fire occurrence

First and second states introduce a background of similar studies in relation to prevention and detection of fire [6-10], while the third state represents the present research in field of calculation of the burnt regions area after fire occurrence [4,5].

2.1 Before Fire Occurrence

In this situation, most researches are about the ways to prevent the fire in natural pastures and forests using, integration and consolidation image-based data obtained from different satellites sensors in GIS (Geographic Information System) applications programs [6-8]. Figure 1 shows an example of forest before any fire occurrence [5].

Figure 1. An aerial image of a forest

2.2 During Fire Occurrence

During fire occurrence in forests, most researches have been focused on fast detection of smoke and (primary) fire as two important parameters, prediction of its development as well as acceleration in performing fire fighting operations [9,10]. Figure 2 shows an image fire occurrence in a forest [7].

Figure 2. An image of a fire beginning in a forest and dissemination of high smoke

2.3 After Fire Occurrence

The calculation of the burnt regions area in the forest is not possible as far as the fire fighting is not performed, because of the continuation of fire and smoke. Therefore, in this research, an image consisting of the burnt areas after fire completion in a forest region is used according to figure 3 [4,5].

Figure 3. An aerial image of a forest after fire completion

3. Image Processing

In this stage, by designing a machine vision system, the primary area of the burnt regions (in pixel) is obtained through implement some of image processing some of image processing techniques by help of "MATLAB 2009" software.

3.1 Taking Image

The desired aerial image is prepared in order to be used in machine vision system using of a helicopter (or plane) and by an appropriate digital camera from the target point, the burnt region as connected and completed inside one picture, according to figure 4.
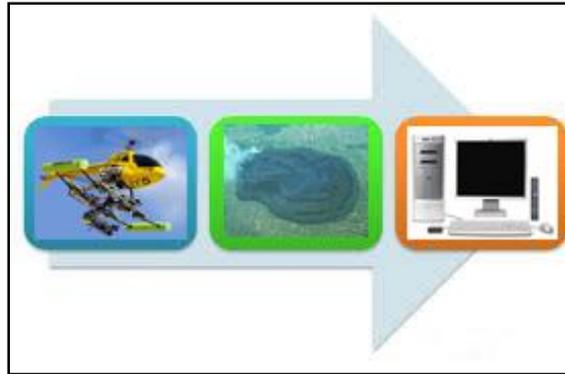
Figure 4. A simple pattern of taking image in a machine vision system

3.2 Image Segmentation

Binarization of the image is one of the effective ways of segmentation in order to draw the burnt regions. The simplest method for this is "Thresholding".

An image with gray degrees (between 0 and 255) can be converted into a binary image (black and white or 0 and 1). To do thresholding technique, we first consider a gray degree like T in the primary image and then, we determine some pixels which have the values less and/or more than T [11]:

$$\begin{cases} \text{Converted into white pixels} \ \rightarrow \ \text{Gray level} \ > \ T \\ \text{Converted into black pixels} \ \rightarrow \ \text{Gray level} \ \leq \ T \end{cases}$$

Now, in the calculation of area becomes easier in the binary image of the burnt region in figure 5.
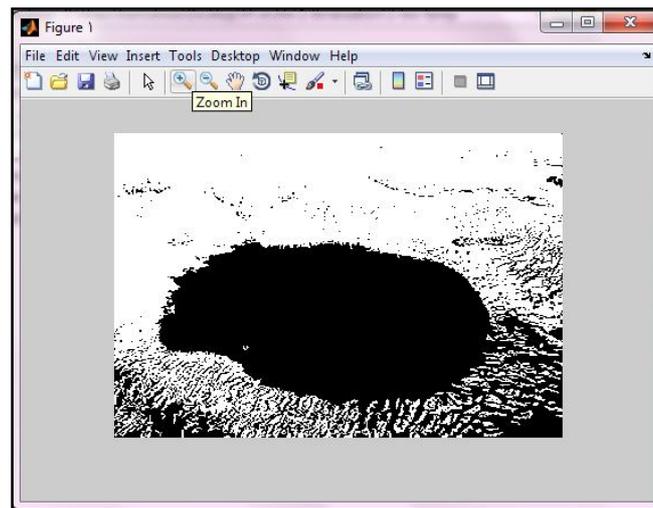

Figure 5. Binary image of the burnt region

3.3 Noise Cancellation

After image segmentation, it is necessary the obtained noise in the image, i.e. some points which are placed outside of the burnt region, shall also be reduced or deleted. To do this technique, two median and average filters can be used. But since it is proved that the median filter is stronger than average filter, we use this filter for implement.

For designing the median filter, it is necessary to move a filter with determined dimensions, for example 3*3 and with 9 pixels on the image according to figure 6. Then, for each pixel which is placed in the center of this filter, we arrange the data surrounding it and select its median and replace it by the main pixel [12].
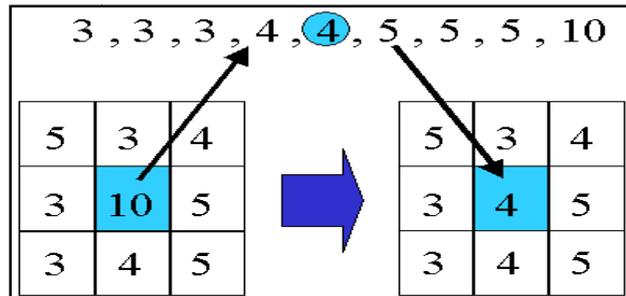

*Figure 6. The arrangement of pixels in tentative 3*3 median filter*

To implement this noise cancellation filter in the burnt region of figure 5, we first use a median filter with 3*3 dimensions. Then, to delete more noise, we increase the dimensions of filters. As it is obvious in figure 7, moving the median filter with small dimensions of 3*3 on the pixels of binary image, it is clear, the new picture becomes blurrier.
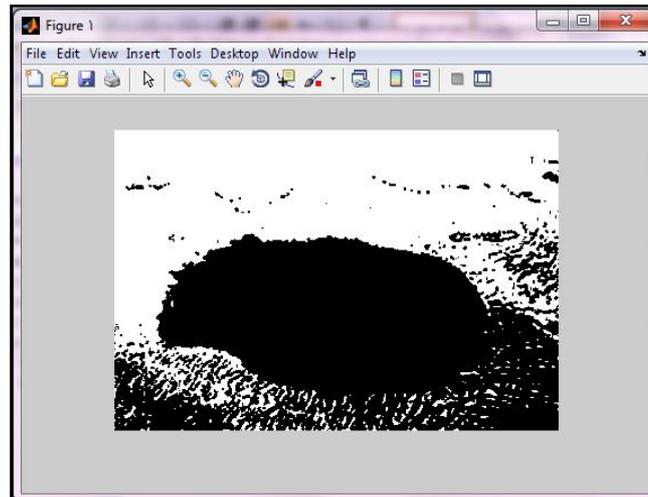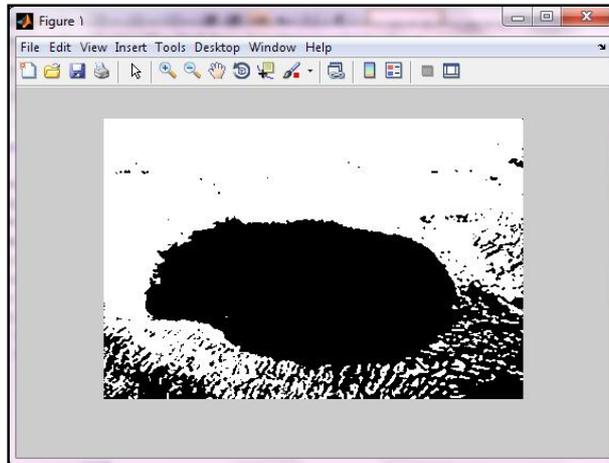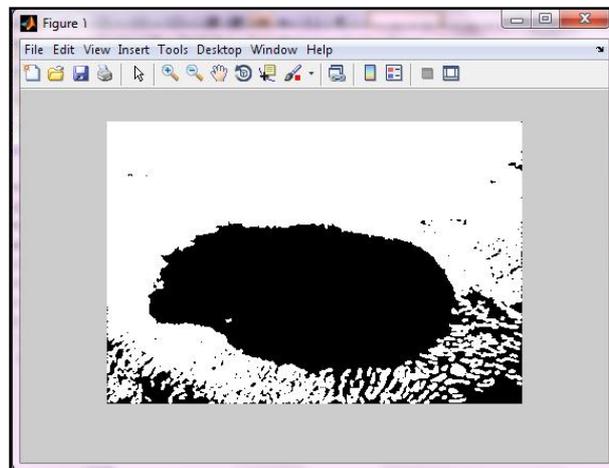

*Figure 7. Implementation of median filter with 3*3 dimensions*

Figure 8 shows that by implementation of larger filter with 5*5 dimensions, the noise of the obtained image has been reduced compared to that of the previous image.
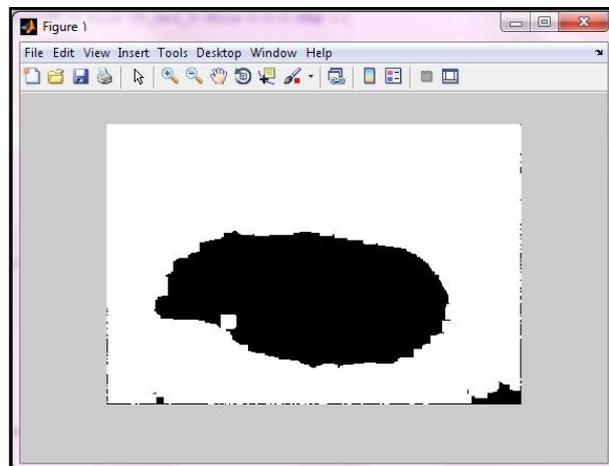
Figure 8. Implementation of median filter with 5*5 dimensions

Also, figure 9 shows the result of implementing median filter with 7*7 dimensions as well as figure 10 shows the result of implementing the median filter with 9*9 dimensions.

Figure 9. Implementation of median filter with 7*7 dimensions

Figure 10. Implementation of median filter with 9*9 dimensions

Therefore, increasing the dimensions of filters in order to noise cancellation, has results better than other smaller filters.

4. Computing The Primary Area

In this research, the primary area of the desired image (burnt region, in figure 3) is calculated after binarization and noise cancellation in two methods;

4.1 Computing of area in integration method

The availble burnt region in figure 10 is a binary image array consisting of values of 0s and 1s. In fact, this image has two colors of black (the burnt region) and white (background). It is enough to count the number of black pixels, i.e. the number of 1 available in the image to obtain the primary area by integration method (i.e. the sum of the pixels 1 which represents the approximate value of the area) [13].

4.2 Computing of area using of interconnected components extraction method

In this method, first using of some instructions in MATLAB language, we first select the desired binary object, then we extract the pixels connected to it from the remaining image to calculate the area of that object ultimately [14].

5. Applying Of Imaging Scale

After computing of the primary area of the burnt region, a coefficient, such as "m", should be calculated according to equations (1) and (2). By applying the imaging scale on it, real area is obtained according to equation (3) based on the measurement of forest land surface area [15];

Imaging Scale = Camera Focal (f) / Flight height (h)   (1)

m = 1 / Imaging Scale   (2)

Real Area = Primary area * m   (3)

In the sample image, if we have the values of "f" in millimeter and "h" in meter; therefore, real area obtained in hectare.

6. Analysis Of Resultes

In this research, the image of forest region after fire occurrence is used. First, the burnt region is extracted by binarization and then, the noises inside the burnt region and surrounding it are reduced as much as possible by several median filters which had various dimensions. Also, for better assessment and evaluation of the primary area of the burnt region in the forest (in the selected image) in a machine vision system, two method are implemented which the values of areas (in pixel) are presented in table 1;

Table 1. The comparison between the primary areas

NO.	Method	Primary area (in pixels)
1	Integration	77689
2	Interconnected components extraction	77922

As it is obvious, table 1 shows the difference between two obtained areas as equal to 233 pixels which is almost negligible.

7. Conclusions

In this paper, the methods which are introduced to calculate real area of the burnt regions, are dependent on some secondary tools such as an aerial camera and special plane, but in the extensive forest regions damaged by fire, they cause to decrease in the evaluation costs and faster notification of the results.

8. Acknowledgment

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