Finding Connected Components in a Gray Scale Image

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***Abstract*—**Finding connected components are well defined for binary images. The concept of connected components can be extended for gray level image. But the problem is the criteria based on which a connected component would be defined. A gray level image is an image having 256 different pixel intensity levels. If we consider connected regions having only a particular pixel values, the number of connected components would not be meaningful and the purpose of finding connected components would be lost. So, we define a connected component in a gray scale image based on range of pixel mapping and new method to find connected components in a gray scale image is proposed. Three different types of pixel range mapping are introduced, using connected components in a gray level image can be successfully found. Connected components in a gray level image are the segments of image having the same range of pixel values. Different regions or segments of image can be found easily.

***Keywords*—Connected component, gray scale labelling, pixel range mapping, linear mapping, logarithmic mapping, square root mapping.**

(Article history: Received 1 November 2016 and accepted 30 December 2016)

I. Introduction

Connected component refers to foreground objects in a binary image. A connected component in a binary image is a set of connected foreground pixels. A connected component is a representative of a foreground object. In order to uniquely identify foreground objects, each object is given a label. The algorithm which uniquely labels each connected component is generally known as connected component labeling. It has many applications in medical image analysis, computer vision and pattern recognition. There are many different algorithms for connected component labeling in a binary image [2,3,4,5]. In these algorithms a binary image is generated from a gray scale image and connected component labeling algorithm is applied on the generated binary image. In a slightly different manner, in [1, 6] the connected component labeling is done directly applied on a gray scale image and binarization is done during labeling process based on some chosen threshold. The logic of component labeling however remains the same just to label foreground pixels which are greater than the chosen threshold value. However, it has the flexibility to generate different components based on different threshold values.

In this paper, the concept of connected component labeling in binary image is extended to find connected components in gray scale image. The main objective is to find connected regions having only one particular pixel intensity or a range of pixel intensities. In a gray scale image, there is no clear distinction between background or foreground pixels. So, a connected component in a gray scale would mean a region having only one particular pixel intensity or a particular range of pixel intensity. In other words, a connected component in a gray scale image is a set of connected pixels in a specified range.

The paper is divided into five sections. Section-II describes some of the range mapping methods which can be used to find connected regions having a particular range of pixel intensities. Section-III gives the proposed algorithm to find connected regions in a gray scale image. Experimental result is given in Section-IV in which connected components of an image based on different range mapping methods are given. Also, some of the individual connected components of interests are shown. Conclusion is given in Section-V.

II. Range mapping methods

Gray scale images in 8-bit depth have 256 different pixel intensities. When searching for connected components in gray scale images, we need to redefine connectedness based on pixel intensities rather than the notion of foreground or background pixels. Not a single pixel intensity value can be considered as background or background in a gray scale image. A certain range of pixels may constitute the background region or a different set of pixels may constitute the foreground regions. A certain set of pixels may belong to both background and foreground. In other words, there may not be clear boundary of pixel ranges for foreground and background regions in a gray scale image. There may be several definitions on the 8-connectedness or 4-connectedness of two pixels in gray scale image depending on whether we are considering the regions in individual pixel level or a range of pixel levels. Here, we will be considering connected regions in terms of both individual pixel level as well as in range of pixels. If we are considering individual pixel level, two pixels would be considered connected if they have the same pixel values and they are 4 or 8-connected. If we consider the regions having a certain pixel range, we need to see how the range is specified. We will consider here uniform range, exponential or logarithmic range.

Linear range:

In this case, the whole range of pixel intensity, i.e., 0 to 255 is divided linearly into specified number of intervals. A range of 16 means 0-255 is divided into intervals, 0-15, 16-31, 32-47, and so on. Two pixels in the range of an interval would be considered connected if they are within a specified range and are 4 or 8-neghbours.

Logarithmic range:

The whole range of pixels for a gray scale image i.e., 0 to 255 is divided into logarithmic range, 0, 1, 2-3,4-7, 8-15, 17-31, 32-63, 64-127, 128-255.

The integer parts of logarithms of base 2 of all pixels in the range of an interval have the same value. For example, integer parts of log2 of 8, 9, 10, ...,15 have the value 3 and hence pixels in this in interval can be considered to have a particular level.

Two pixels having the same logarithmic (base-2) value in integer parts are considered to be connected if they are 4 or 8-neighbours.

Square root range:

In this case, the whole range 0 to 255 is divided into 16 different ranges of pixel intervals as

0, 1-3, 4-8, 9-15, 16-24, 25-35, 36-48, 49-63, 64-80, 81-99, 100-120, 121-143, 144-168, 169-195, 196-224, 225-255.

The integer part of square root of pixels in a given interval range has the same value. For example, integer part of square root of each of 25, 26,27, …, 35 is 5 hence pixel values in the 25 to 35 will be considered to have a particular level.

Two pixels having the same square root range is said to be connected if they are 4- or 8 neighbors.

III. Algorithm for Gray Scale Labeling

The algorithm takes three inputs, gray scale image, the method with which the pixel range will be mapped and the connectedness scheme for searching connected pixels in a pixel's neighborhood. The range mapping method may be linear range, logarithmic range or square root range or some other suitable range mapping method. The connectedness may be either of 4-or 8-connectedness. After getting the required input parameters, we perform initialization of the some of the variables which will be used in the labeling process. We create an image matrix for output having the same size as the input image and initialize all its pixel values to zeros. The output image is considered as labeled matrix because each value in it corresponds to the number of connected in the input gray scale image. There is no fixed range of values for a labeled image. Its values may be fewer or in thousands depending on how many components are possible for the range mapping method used. Each connected component in the output image will have the same label. To mark the pixels corresponding to a connected component with the same label or value, we use a variable called label and initialize it to zero. We also use a list called listCord which stores the co-ordinates of connected pixels corresponding to a particular connected component for a specified range of pixels. Initially, the listCord is set to an empty list. As soon as a pixel corresponding to a specified pixel range of a connected component, the row and column index of the pixels, i.e., the co-ordinates of the pixel are added to the list.

After initialization, we start labeling process by scanning each pixel in the input image. The scanning of the image is done in left to right and top to bottom order. We assume that all pixels to be labeled have non-negative values i.e., 0 and positive values. After a pixel is given a label in the output image, we mark the corresponding pixel value with a negative value to avoid the pixel for labeling in the subsequent search for connected pixels. Starting from the leftmost top corner pixel, we test whether a pixel value is greater than or equal to 0, if so, we increase the label by 1 and add the co-ordinates of the pixel to the listCord.

Then we find the connected pixels in the neighbourhood of the pixels corresponding to the co-ordinates in the listCord. This is done in a loop, which test whether listCord is non-empty. As long as the listCord is non-empty, we get the pixel from the input image corresponding to co-ordinates at the top index of the list. The neighboring pixels are then found for the current pixel being processed. The neighbors may be 4-neighbors or 8-neighbors, depending on the specified connectedness. Suppose (I,J) is the current pixel being processed, then the 4-neighbours are pixels at the coordinates (I-1, J), (I, J-1), (I, J+1) and (I+1, J) and the 8-neighbours are pixels at the co-ordinates (I-1, J-1), (I-1, J), (I-1, J+1), (I, J-1), (I, J+1), (I+1, J-1), (I+1, J), (I+1,J+1). We map the neighbor pixels according to the specified range mapping method and then find whether there is any pixel which have the same value as the mapped value of the current pixel. If so, the co-ordinates of the matching neighbors are added to the listCord. The value of the output matrix corresponding to the co-ordinates of the pixel value is given the current label, i.e., Output(I,J)=label and current pixel in the input image is set to a negative value such as -1, i.e., Input(I,J)=-1. We then remove the top-index in the ListCord which is having the co-ordinate of current pixel. This will continue until the listCord is empty. When a list cord is empty, a connected component would have been given a particular label. Then the algorithm will find another pixel in the image which has yet not been processed for labeling, the label value will be incremented by 1 and the same labeling process continues until all the pixels in the image are properly labeled according the range mapping method and the connectedness scheme specified.

Algorithm: Connected components in gray

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Input: Gray scale image of size M by N
       : Range mapping method
       : Connectedness for 4 or 8-connectedness
Output: Labeled image of size M by N
Initialization:
Output[M,N]=0;
Label=0;
listCord={};
foreach pixel in input image
if pixel is non-negative
Increase the label by 1
Get the range of the pixel
 Put the pixel coordinate to listCord
whilelistCord is not empty
            Get the pixel corresponding to the top index of listCord
            Get the 4 or 8 neighbourhood
            Map the pixel range in the neighbourhood
            Add to listCord the coordinates of the neighbourhood pixels which have the
            same pixel range
            Mark the current pixel in input image with a negative value
            Mark the current pixel in output image with current label
            Remove the top index from ListCord
 End while
End if
End foreach
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IV. Experimental results

We consider the popular Lena image of size 512-by-512 for experimentation purpose. The image is converted into gray and various range mapping techniques are applied to find the connected components in the image. We then select connected components having size larger than certain specified value, which generally correspond to foreground objects. Smaller connected components are largely contributed to noise. Most of the range mapping techniques gives different results for the same image. So, judicious choice of the range mapping techniques is important for different applications. We show here only the gray level components obtained using the base-2 logarithmic range mapping technique. The original image is shown in figure-1 and five of connected components in gray scale image separated from the image based on logarithmic range are shown in Figures 2-6. These components could not be separated properly if we first convert the image in binary find connected components in the binary image.

V. Conclusions

A new method of finding connected components in gray scale images is proposed. The different schemes of defining 4 and 8-connectedness have also been suggested. Several pixel range mapping schemes for finding connected components in a gray scale image have been suggested. Each of these mapping schemes would be effective for different images and applications. An algorithm to find the connected components in a gray scale image is also provided. Finding connected regions enables us to get different regions of interest in the gray scale image which may give significant information for medical image analysis point of view. Once we get connected components, we can eliminate the noisy parts from the image or see only the desired components or regions.

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Yumnam Kirani Singh, has completed Master's Degree in Electronics Science from Guwahati University in 1997 and got Ph. D. degree from Indian Statistical Institute, Kolkata in 2006. Served as a lecturer in Electronics in Shri Shankaracharaya College of Engineering & Technology from Jan, 2005 to May, 2006. Joined CDAC Kolkata in May 2006 and worked there before coming to CDAC Silchar, in March 2014. Developed Bino's Model of Multiplication, ISITRA, YKSK Transforms and several other image binarization and edge detection techniques. Interested to work in the application and research areas of Signal Processing, Image Processing, Pattern recognition and Information Security. Published several papers in national and international journals and conferences

Figure-2: Connected Component-1

Figure-1: Original Image

Figure-3: Connected Component-2.

Figure-4: Connected Component-3

Figure-5: Connected Component-4

Figure-6: Connected Component-5