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Research Article

Performance Analysis of Image Segmentation based on Watershed Transforms

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Abstract

Segmentation of images is a key step in the field of image processing. Watershed segmentation is very important tool for segmentation of images in the field of mathematical morphology. Watershed transform is basically marker controlled segmentation technique. Segmentation of images by watershed generally results in the over segmentation. In this paper we proposed a novel approach to watershed segmentation using laplacian filter for noise removal and enhancement of images. Result of proposed algorithm is compared and analyzed with the result of existing methods. Result of proposed method shows it could effectively reduce the over segmentation and achieve more accurate segmentation results than existing methods.

Keywords: *segmentation, watershed, marker, gradient, mathematical morphology, reconstruction*.

1. Introduction

In different fields segmentation of images is a challenging task in image analysis, In this an image is portioned in to different region, accord to its characteristic such as, intensity, objects and color present in the images. Generally, corresponding to meaningful easier to analyze and understand objects in a scene (maplica *et al*, 2002).
Image segmentation is a basic problem in different fields, in image processing for example image analysis, scene analysis and pattern recognition. Good segmented result is very useful for the predication, diagnoses and analysis. With the advancement of technology much progress has been made in the image segmentation field so far. As a result of the progress, computer vision is able to segment increasingly more complex images. Image segmentation is based on two basic properties, first intensity values involving discontinuity that refers to sudden or abrupt changes in intensity as edges and second similarity that refers to partitioning a digital image into regions according to some pre-defined likeness criterion. Segmentation is a process which partitioned image into multiple unique regions, where region is set of pixels (Zhang *et al*, 2009). Many techniques have been proposed to deal with the image segmentation problem. It can be broadly grouped into the following categories.

1.1 Thresholding Method

Image segmentation based on thresholding partitioned an input image through comparison of pixel values in to two or more pixel values with the predefined threshold value T individually. There is no suitable algorithm which can determine the threshold values. Therefore it leads to the result which might be might be one or all of the following;

(a) The segmented region might be smaller or larger than the actual
(b) The edges of the segmented region might not be connected
(c) Over or under-segmentation of the image

1.2 Edge Based Methods

Edge based segmentation is the location of pixels in the image that correspond to the boundaries of the objects seen in the image. It is then assumed that since it is a boundary of a region or an object then it is closed and that the number of objects of interest is equal to the number of boundaries in an image. For precision of the segmentation, the perimeter of the boundaries detected must be approximately equal to that of the object in the input image.

1.3 Region based

It is a group of connected pixels with similar properties region is an important concept in interpreting an image because regions may correspond to objects in a scene consequently for a correct interpretation of an image we need to partition an image into regions that correspond to objects or part of an object partitioning into regions done often by using grey values of image pixels.

2. Watershed segmentation

The watershed segmentation is a popular segmentation method coming from the field of mathematical morphology.

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The watershed segmentation has proven to be a powerful and fast technique for both contour detection and region-based segmentation (Schar *et al*, 2005). In principal, watershed segmentation depends on ridges to perform a proper segmentation, a property which is often fulfilled in contour detection where the boundaries of the objects are expressed as ridges. For region-based segmentation it is possible to convert the edges of the objects into ridges by calculating an edge map of the image. Watershed is normally implemented by region growing based on a set of markers to avoid severe over-segmentation. Different watershed methods use slightly different distance measures, but they all share the property that the watershed lines appear as the points of equidistance between two adjacent minima (Salman, 2006). The success of watershed segmentation relies on a situation where the desired boundaries are ridges. Unfortunately, the standard watershed framework has a very limited flexibility on optimization parameters. The intuitive description of this transform is quite simple if we consider the image as a topographic relief, where the height of each point is directly related to its gray level, and consider rain gradually falling on the terrain, then the watersheds are the lines that separate the "lakes" actually called catchments basins that form. Generally, the watershed segmentation is computed on the gradient of the original image, so that the catchments basin boundaries are located at high gradient points (Hamarneh *et al,* 2009). Due to the number of advantages watershed segmentation has been widely used in many fields of image processing, including medical image segmentation, it is fast and can be parallelized and it produces a complete division of the image in separated regions even if the contrast is poor, thus avoiding the need for any kind of contour joining. Several researchers have proposed techniques to embed the watershed segmentation in a multi scale framework, thus providing the advantages of these representations.

3. Watershed transform

The concept of Watersheds is well known in topography. It was first proposed as a potential method for image segmentation. It is a morphological based method of image segmentation. The gradient magnitude of an image is considered as a topographic surface for the watershed transformation. Watershed lines can be found by different ways (Kaur *et al,* 2011). The complete division of the image through watershed transformation relies mostly on a good estimation of image gradients. The result of the watershed transform is degraded by the background noise and produces the over segmentation. Also, under segmentation is produced by low-contrast edges generate small magnitude gradients, causing distinct regions to be erroneously merged (Fnaiech *et al,* 2013). There are different ways to find watershed lines. Different approaches may be employed to use the watershed principle for segmentation. Local minima of the gradient of the image may be chosen as markers, in this case an over-segmentation is produced and a second step involves region merging. Marker based watershed transformation make use of specific marker positions which have been either explicitly defined by the user or determined automatically with morphological operators or other ways. The basic concept of watershed is based on visualizing an image in three dimensions i.e. two spatial coordinates versus gray levels. In such a topographic interpretation, three types of points are considered, such as,

(a) Points belonging to a regional minimum,

(b) points at which a drop of water, if placed at the location of any of those points, would fall with certainty to a single minimum; and

(c) Points at which water would be equally likely to fall to more than one such minimum. For a particular regional minimum, the set of points satisfying condition are called catchment basin or watershed of that minimum. The points satisfying condition form crest line on the topographic surface and are termed as watershed lines or divide lines.

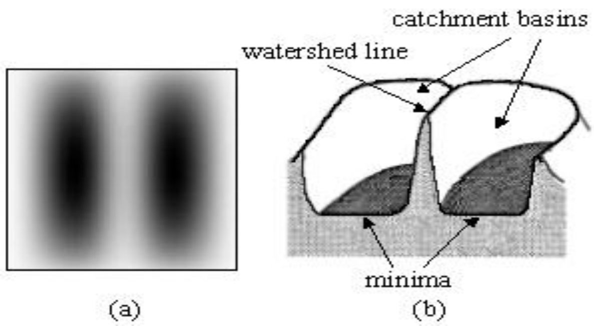

Fig.1 (a) gray level image (b) topological surface

The principal objective of segmentation algorithms based on these concepts is to find the watershed lines. The punching holes at each regional minimum and entire topography is flooded from below by letting water rise through the hole uniformly when rising water in distinct catchment basin is about to merge a dam is built to prevent the merging. The flooding will eventually reach a stage when only the tops of dams are visible above the water line. The dam boundaries correspond to the divide lines of the watersheds. Therefore, they are continuous boundaries extracted by a watershed segmentation algorithm. Watershed segmentation algorithm is applied to the gradient of an image rather than to the image itself. This is based on the concept that regions characterized by small variations in gray levels have small gradient values. In the formulation of watershed segmentation, the regional minima of catchment basins correlate nicely with the small value of the gradient corresponding to the objects of interest.

4. Implementation steps of watershed segmentation

Watershed transform has been used here to take care of the over segmentation. The systematic block diagram of the proposed method is shown in fig. the detailed description is given in fig.2.

4.1 Filtered and gradient image

A pre-processed weld image is used in watershed transformation. During pre-processing filtering is used to reduce the noise level, The pre-processed smoothed image is used for gradient calculation. Any one of the gradient operators like Sobel, Prewitt or laplacian is used in this segmentation. Since the noise level is efficiently reduced by filtering, these operators perform well on filtered images. Gradient magnitude is high at borders of the object and low inside the objects. Main drawbacks of gradient magnitude watershed over segmentation and it became difficult to determine which basin is actually associated with the objects.

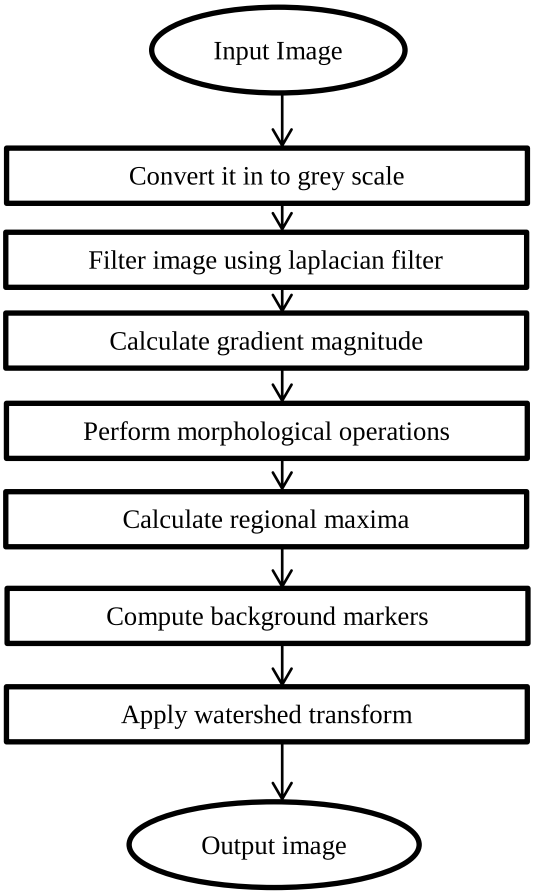

Fig.2 Overview of proposed algorithm

4.2 Gradient watershed transform

A gradient watershed transform can be classified as an edge detector as it locates regions of high gradient strengths given in a high gradient image as input. Main drawbacks of it are over segmentation, which is basically due to an inaccurate determination of markers.

4.3 Maxima and minima selection

Several algorithms have been proposed for minima selection. The simplest way is interactive selection by the user. A second approach is the automatic selection of minima using a priori knowledge of the image another approach is to hierarchically order all minima and to select only those above a threshold used dynamics as the criterion for minima reduction, as it provides an intuitive selection scheme controlled by a single parameter. The concept is easily visualized using the immersion simulation. The deepness of a basin would be the level the water would reach, coming in through the minimum of the basin, before the water would overflow into a neighbor basin. That is, the height from the minimum to the lowest point in the watershed line of the basin. The dynamics of a basin is a similar concept, but referring to a neighbor basin with a lower minimum than the actual one.

$$f^{k+1} = max\big(g(p), f^k(p)\big)\, \theta B \quad (1)$$

Where f and g are two grey sale imageθ denotes the grey-level erosion of the function using a structuring element B. The dynamics algorithm is applied to the gradient of the image. We can expect the regions that are due to noise to be surrounded by a smaller gradient, and therefore, to have a smaller dynamics than regions formed by objects in the image. The value of the dynamics is automatically selected depending on the dynamic range of the image.

4.4 *Morphological reconstruction*

Morphological reconstruction is little-known but very useful method for the extraction meaningful information from an image. It involves two images one is original image and other is marker, which is the starting point of transformation. Dilation and erosion process is used during this transformation. Original image must be in limit of second image known as mask. Size of mask is immaterial. Let F is marker and G is mask then calculation of mask from the marker is given by following procedure:

1. Initialize h_1 to be the marker image, F.
2. Create the structuring element: B = ones(3).
3. Repeat: $h^{k+1} = (h^k \oplus B)G$ until $hk^{+1} = h^{k.}$
4. RG(F) = hk^{+1}..)

Morphological reconstruction is used for the detection of holes, clearing objects commented by borders, to improve opening procedure and to restore the original shape of the image.

4.5 Marker Based Watershed Segmentation

In image processing operations it is one of the difficult process to separate touching objects marker based segmentation provides an ideal solution to this problem,. A marker is connected component belonging to an image. Generally there are two methods for the selection of marker. First, when image is preprocessed to select a marker a set of creation must be defined. Other is selection of marker from morphological threshold operator. A marker is a connected component belonging to an image. Markers are of two types; internal marker and external marker. Internal markers associate with objects of interest, and external markers associate with the background. The criteria for an internal marker can for example be that it has to be surrounded by pixels with higher altitude. The watershed lines created here are defined as external markers. The external markers efficiently partition the image into regions containing one single internal marker and some background. The problem is then reduced to partitioning each of these regions into two, which can be done by some simpler segmentation algorithm.

5. Result and discussion

Watershed segmentation is a technique used for all types of images. It provides better segmentation for images to connect with it's different portions like edges regions etc. there are different process involved to obtain the experimental results which are as follows;

Fig.3 input image

Fig.4 grey scale image

Fig.5 Reconstruction by opening and closing (a) sobel (b) prewitt (c) laplacian

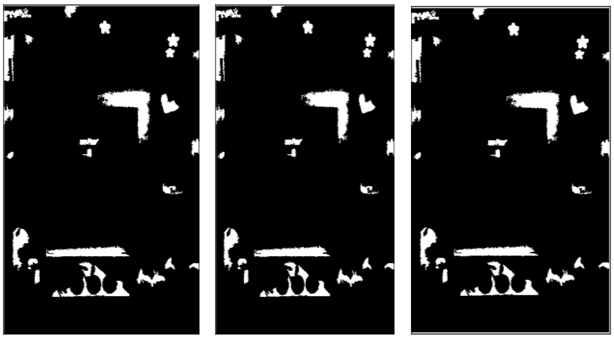

Fig.6 Regional maxima of reconstructed image (a) sobel (b) prewitt (c) laplacian

To compute gradient magnitude make use of different edge operators, edge mask imfilter and some simple arthematic is needed.

Fig.7 Watershed ridge lines (a) sobel (b) prewitt (c) laplacian

Fig.8 final segmented result (a) sobel (b) prewitt (c) laplacian

The gradient is low inside the objects and at the borders of the object while segmenting the gradient magnitude image directly using watershed segmentation it results in over segmentation. To find the foreground markers different procedures are used here which must have each pixel connected inside object. To clean up the images reconstruction by opening and closing is used it creates maxima inside each object. Reconstruction based opening and closing are more important than normal opening and closing as it removes small blemishes without affecting the overall shape of the objects. As seen in fig. 6 some shadowed objects are not marked to segment these images background markers must be computed and also edge of the markers needed to be cleaned. Watershed ridge lines are calculated because markers are so close to the edge of the objects; and to give desired locations to the regional maxima it can be calculated by applying distance transform. In final result problem of over segmentation is eliminated. To get final segmented result in this process partially occluded darker objects are merged with their brighter objects at some locations as the occluded objects did not have foreground markers.

Conclusion

It has been concluded that watershed segmentation is an important technique in digital image processing. Although, there are so many techniques available for the segmentation of images but the problem related to that of over segmentation is reduced or overcome by the better selection of marker.

In our proposed algorithm by applying watershed segmentation is directly on gradient magnitude results shows there problem of over segmentation. Then, reconstructing the image by opening and closing and selecting markers from foreground and background objects overlapping objects are separated and well defined boundaries is achieved.

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