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Research Article

MORPHOLOGICAL IMAGE SEGMENTATION BY MORPHOLOGICAL WATERSHEDS

Suvarna D.Kamble[1]., Pawar D.D[2] and Sharadkumar Jagtap[3]

[1]Shivaji Mahavidyalaya, Udgir
[2]School of Mathematical Sciences, Swami Ramanand Teerth Marathwada University, Vishnupuri Nanded, India
[3]Shivaji Mahavidyalaya, Udgir, Latur, India

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ABSTRACT

A morphological image segmentation technique based on the Morphological watershed is proposed. This segmentation is useful in many applications. Morphology is a technique of image processing based on shape and form of objects. In this we define our some tools of watershed segmentation. We show that this segmentation can be built by implementing a flooding process on a image. Use of this segmentation for image segmentation purposes is discussed. The application of watershed segmentation on remote sensing imageries is relatively recent than other models. We described segmentation approach of watershed segmentation, Watershed-flooding analogy, watershed drop of water analogy, marker based segmentation and its examples.

INTRODUCTION

Morphological Image processing and analysis is an important area in the field of medical imaging. It has the elements of an image analysis system. Image analysis usually starts with a pre-processing stage, which includes operations such a noise reduction and enhancement [1]. For the recognition of any image, segmentation process is to be done to extract some useful intended information. Image segmentation is an essential pre-processing work for the most subsequent image analysis tasks and its main objective is to decompose an image domain into a number of disjoint regions so that the features within each region have visual similarity, strong mathematical morphology and reasonably good homogeneity [2]. In morphological image processing we have to apply one technique that's watershed segmentation. Watershed model is a mathematical morphological approach and derives its analogy from a real life flood situation Watershed Transformation belongs to the category of the region based similarities. [3].It transforms image into a gradient image. Then image is seen as a topographical surface where grey values are deemed as elevation of the surface at that location. Then flooding process starts in which water effuses out of the minimum grey value. When flooding across two minimum converges then a dam is built to identify the boundary across them. This method is essentially an edge based technique. The original watershed algorithm was susceptible to over segmentation so a modified marker-controlled based watershed algorithm was proposed by Beucher(1992). [4]

Watershed produces over-segmentation because of noise or textured patterns. Several modifications on marker controlled watershed segmentation to reduce over-segmentation. Traditionally watershed was applied with median filter to eliminate noise and preserve contours (Carleer et al., 2005; Sun and He, 2008). Chenet al. (2006) stated that median filter fails to encounter high imagery texture which generally present in high resolution imagery. [5].Carleer et al. and Chenet al. proposed a modified technique to encounter this problem.Carleer et al. used a non-linear filter named Peer group filtering for removal of noise and image smoothing. Then a floating point based rainfall for watershed transformation was applied for initial segmentation. Then a multi-scale region merging algorithm was applied based on spectral, shape and compactness feature for final segmentation. However, it may be good for initial segmentation in a multi-scale resolution as it produces an over-segmentation. The watershed for segmentation is attached with the technological

Corresponding author:* **Suvarna D.Kamble
Shivaji Mahavidyalaya, Udgir

development of the morphological image processing devices. In the mid seventies, computer memory was expensive, and computers slow. we developed the first image analyzers, subsequently commercialized by J.kelin [6]. The result of an image transform maybe stored in a memory and become the source of a second transform. some operators permits new developments such as geodesic transforms, skeletons etc.The first watershed transform emerged from an alchemy mixing skeletons by zone of influence and binary thinning and thickening algorithms for constructing skeletons. Christian Lantuejoul, in order to model a polycrystalline alloy, defined and studied the skeleton by zones of influence of a binary collection of grains in his thesis [7].The first algorithm for the construction of watersheds with Serge Beucher, they applied the watershed transform to the gradient image of gas bubbles, yielding the first watershed application to segmentation [6], [7].This method applied to the more complex image of electrophoreticgels highlighted the major drawback of watershed segmentation Instead of performing successive geodesic thickenings of all regional minima, one performs a thickening of a set of markers, some of them inside the objects to segment and at least one of them in the background [8]. This method produces a coarse approximation of the contours, between the inside and outside markers of the objects, as starting point of the successive geodesic homothetic thinning. For increasing thresholds of the gradient image, the contours narrow down an ultimately produce the correct result. Marker driven watershed became the dominant morphological segmentation for sometime [9]. The construction of the watershed maybe obtained as a shortest path problem on a graph for which many algorithms exist [10]. In order to obtain higher precision on digital grids, G.Borgefors introduced chamfer distances[11]. The same type of neighborhoods, based on particular weights for first and second neighbors on a grid can also be adapted for the construction of chamfer topographic distances [12]. The definition of the watershed line tends to an eikonal equation, expressed as a PDE and may be solved as such. This tends to a continuous watershed algorithm. [13],[14]. J. Roerdink published a remarkable review on the various methods for constructing the watershed [15].

Morphological image Segmentation

Morphological image Segmentation is a process which partitioned image into multiple unique regions, where region is set of pixels. Many techniques have been proposed to deal with the image segmentation problem. It can identify the regions of interest in a scene or annotated the data. We categorize the existing segmentation algorithm into region-based segmentation, data clustering, and edge-base segmentation. Region-based segmentation includes the seeded and unseeded region growing algorithms, the JSEG, and the fast scanning algorithm. All of them expand each region pixel by pixel based on their pixel value or quantized value, so that each cluster has high positional relation. For data clustering, the concept of them is based on the whole image and considers the distance between each data. The characteristic of data clustering is that each pixel of a cluster does not certainly connective. The basis method of data clustering can be divided into hierarchical and partitional clustering. Furthermore, we show the extension of data clustering called mean shift algorithm, although this algorithm much belonging to density estimation. It can be broadly grouped into the following categories.

Thresholding Method

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

1. The segmented region might be smaller or larger than the actual.
2. The edges of the segmented region might not be connected.
3. under-segmentation of the image.

In this Gray-level Thresholding is one of the simplest techniques for partitioning the objects from their background. Tthreshold value may be chosen based on histogram or by analyzing the inter-region homogeneity. In histogram Thresholding, the image is assumed to be composed of a number of constant intensity objects in a well-separated background. The histogram shows number of pixels in the image having each of the 256 possible values of stored brightness. Peaks in the histogram correspond to the most common brightness values which identify particular structures having high intensities that are present in the image. Valleys between the peaks identify the less common brightness values in the image When the image contains an object having homogeneous intensity and background with a different intensity level, Thresholding techniques are applied for segmentation.

$$g(x,y) = f(x) = \begin{cases} 1 & if\ f(x,y) > T \\ 0 & Otherwise \end{cases}$$

In certain applications if the intensity of the object and background are varying, spatially varying Thresholding can be applied.

Edge Based Segmentation

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. In image processing, the edges contain information about object boundaries which is useful for image analysis, object recognition and image filtering. The edges can be defined as the local variation of image intensity. The image gradient will provide useful information about local intensity variations. There are two criteria defined. The first criterion is that it can mark as many real edges as possible. The second is the edges to be marked are as close as possible to the edges in the real image and the last criterion is that the given edge in the image should only be marked once, and where possible, image noise should not create false edges.

Region based Segmentation

Region-based segmentation mainly rely on the assumption that the neighboring pixels within one region have similar value.

The common procedure is to compare one pixel with its neighbors. If a similarity criterion is satisfied, the pixel can be set belong to the cluster as one or more of its neighbors. The selection of the similarity criterion is significant and the results are influenced by noise in all instances. There are four algorithms such as the Seeded region growing, the Unseeded region growing, the Region splitting and merging, and the Fast scanning algorithm.

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 the objects or part of an object partitioning into regions done often by using grey values of image pixels. The advantages of these approaches are that they may always produce continuous, one-pixel-wide contours. Region Splitting and its representations Of Quad Tree are given in Figure 1

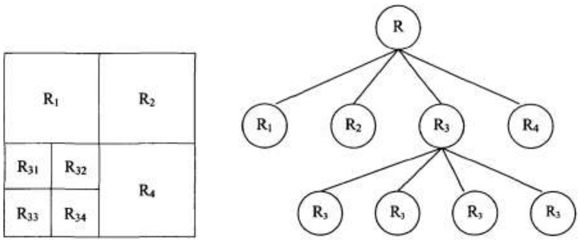

Fig.1. (I) Region Splitting (II) Quad Tree

The seed point initialization is a critical moment in the growing process. Increase in the number of seed points may cause over segmentation. The selection of different number of seed points may lead to different segmentation results. Mutual exclusion is difficult to provide and additional data structure is needed for the storage of edges and seed points.

Some tools for Morphological image segmentation

Morphological image segmentation performs many operation. Image Segmentation is another key tool of image processing applied to a large number of problems. For example, counting blood cells, separation of overlapping grains etc.

Morphological Image enhancement

Image enhancement is a common technique to improve some visual features with respect to different criteria. For Example: contrast enhancement, toggle mapping,de-tected micro aneurysms on eye fundus images, and used a multi-scale top-hat transformation to locally increase contrast of orthopedic X-ray images, which were easier to read.

Morphological Gradient

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.

Morphological gradient image

Any one of the gradient operator 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.

Filters

Filters are low-level vision operators and serve either to eliminate noise and simplify image topology in order to make further processing easier. Morphological filters are commonly used in pre-processing stage of many complex higher-level operators, such as image processing and image segmentation .

Classification

Morphological image segmentation has been mainly used in classification of images (or sections of images) with respect to spatial features.

Watershed segmentation

The concepts of watersheds and catchment basins are well known in topography. Watershed lines divide individual catchment basins The watershed segmentation is a popular segmentation method coming from the field of mathematical morphology. The watershed segmentation has a powerful and fast technique for both contour detection and region-based segmentation. 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

The 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. 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 . There are different ways to find watershed lines. Different approaches may be employed to use the watershed principle for segmentation

- Image data may be interpreted as a topographic surface where the gradient image gray-levels represent altitudes.
- Region edges correspond to high watersheds and low-gradient region interiors correspond to catchment basins.
- Catchment basins of the topographic surface are homogeneous in the sense that all pixels belonging to the same catchment basin are connected with the basin's region of minimum altitude (gray-level) by a simple path of pixels that have monotonically decreasing altitude (gray-level) along the path.
- Such catchment basins then represent the regions of the segmented image.

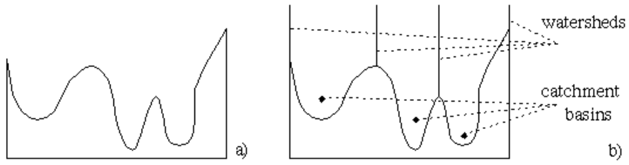

Fig 2 Gray Level profile of image data b)watershed segmentation -Local minima of gray level yield catchment basins, local maxima define the watershed lines.

Two basic approaches to watershed image segmentation. The first one starts with finding a downstream path from each pixel of the image to a local minimum of image surface altitude. A catchment basin is defined as the set of pixels for which their respective downstream paths all end up in the same altitude minimum.

While the downstream paths are easy to determine for continuous altitude surfaces by calculating the local gradients, no rules exist to define the downstream paths uniquely for digital surfaces.

The second approach is essentially dual to the first one; instead of identifying the downstream paths, the catchment basins fill from the bottom. Imagine that there is a hole in each local minimum, and that the topographic surface is immersed in water - water starts filling all catchment basins, minima of which are under the water level. If two catchment basins would merge as a result of further immersion, a dam is built all the way to the highest surface altitude and the dam represents the watershed line.

An efficient algorithm is based on sorting the pixels in increasing order of their gray values, followed by a flooding step consisting of a fast breadth-first scanning of all pixels in the order of their gray-levels.

During the sorting step, a brightness histogram is computed. Simultaneously, a list of pointers to pixels of gray-level h is created and associated with each histogram gray-level to enable direct access to all pixels of any gray-level. Information about the image pixel sorting is used extensively in the flooding step. Suppose the flooding has been completed up to a level (gray-level, altitude) k. Then every pixel having gray-level less than or equal to k has already been assigned a unique catchment basin label.

Next, pixels having gray-level k+1 must be processed A pixel having gray-level k+1 may belong to a catchment basin labeled if at least one of its neighbors already carries this label.

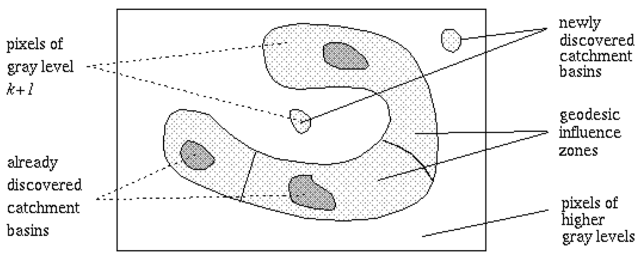

Fig 3 A geodesic influence zone of a catchment basin

All pixels with gray-level k+1 that belong to the influence zone of a catchment basin labeled l thus causing the catchment basin to grow. The pixels from the queue are processed sequentially, and all pixels from the queue that cannot be assigned an existing label represent newly discovered catchment basins and are marked with new and unique labels.

Watershed -flooding analogy

Assume gray level image as a landscape. Let water rise from the bottom of each valley i.e. the water from the valley it given its own label. As soon as the water from two valleys meet, build a dam, or a watershed. These watersheds will define the borders between different regions in the image. The watershed can be used directly on the image, on an edge enhanced image or on a distance transformed image.

Watershed -drop of water analogy

In this the gray level image as a landscape. A drop of water landing at any point in the landscape will flow down to a local minimum in the landscape. For any local minimum in the landscape, there is a set of points, called the *catchment basin,* from which a drop of water will flow to that given minimum. The boundaries between adjacent catchment basins form the watershed. Some examples of watershed directly applied on gray level image is follows.

Example I

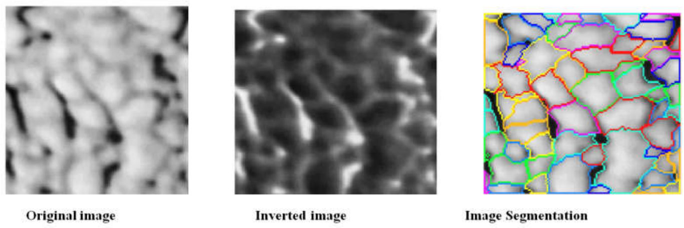

Fig 5 watershed directly applied on gray level image

Example II

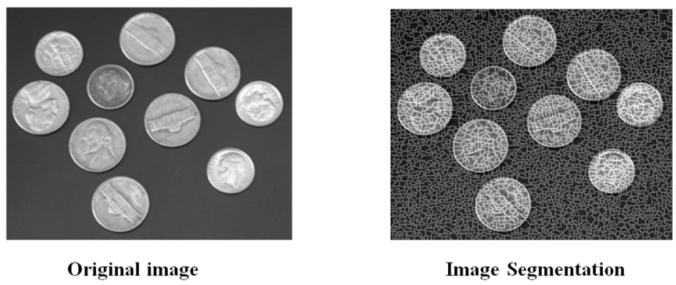

Fig 6

Example for seeded watershed

Every cell has a cell nucleus, which can be detected by Thresholding and watershed segmentation. Using these nuclei as seeds, the cytoplasm are easy to find.

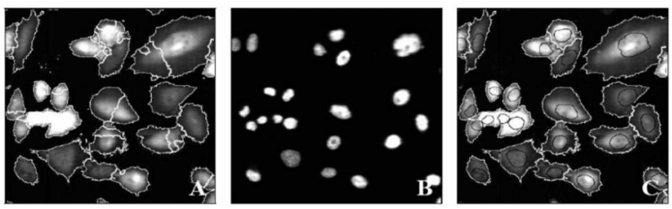

Fig.6 Over segmentation Seeds (nuclei) Seeded watershed Image

Marker Based Watershed Segmentation

There are two markers first is internal marker and second one external marker. In this internal markers are used to limit the number of regions by specifying the objects of interest Like seeds in region growing method can be assigned manually or automatically Regions without markers are allowed to be merged (no dam is to be built)External markers those pixels we are confident to belong to the background Watershed lines are typical external markers and they belong the same region. Use internal markers to obtain watershed lines of the gradient of the image to be segmented. Use the obtained watershed lines as external markers

Each region defined by the external markers contains a single internal marker and part of the background. The problem is reduced to partitioning each region into two parts: object (containing internal markers) and a single background (containing external markers).Following figure containing marker based watershed segmentation

Example

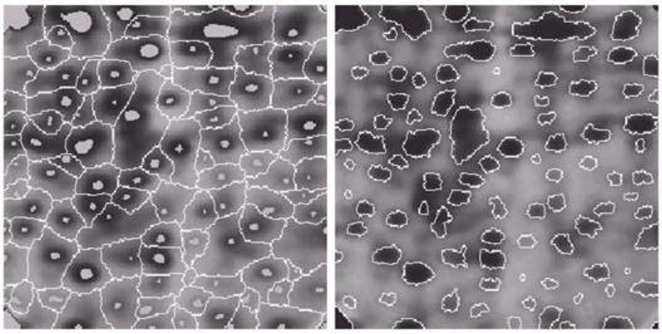

Fig 7 Watershed Lines Result of segmentation

CONCLUSION

We concluded that watershed segmentation is an important technique in Morphological image processing. Although, there are so many techniques available for the segmentation of images but the problem related to that segmentation is reduced or overcome by the better selection of marker controlled. In our examples 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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