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LUNG SCANS SEGMENTATION USING MARKER-CONTROLLED WATERSHED TRANSFORMATION

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***Abstract*— Image segmentation is the process of partitioning a digital image into multiple segments knows as set of pixels. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. It is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The Watershed Transform consists of an image partitioning into its constitutive regions. This transform is easily adapted to be used in different types of images and it allows distinguishing complex objects. The marker watershed transformation is an improvement one on the basis of the watershed transform, which is set a tag in the image. The tag can be a point, a line or an area, the importance is its location instead of the marked shape. Each tag represents the image of a final partition and selecting a tag is a key factor in the decision segmentation.**

***Keywords*— Image Segmentation, lung slices, marker controlled watershed, markers, gradient magnitude, black top-hat morphology.**

I. INTRODUCTION

Image processing is a way to convert an image to a digital aspect and perform certain functions on it, in order to get an enhanced image or extract other useful information from it. It is a type of signal time when the input is an image, such as a video frame or image and output can be an image or features associated with that image. Usually, the Image Processing system includes treating images as two equal symbols while using the set methods used.

It is one of the fastest growing technologies today, with its use in various business sectors. Graphic Design forms the core of the research space within the engineering and computer science industry as well. Image processing is a way by which an individual can enhance the quality of an image or gather alerting insights from an image and feed it to an algorithm to predict the later things.

Image segmentation is the process of partitioning a digital image into multiple segments knows as set of pixels. The goal of segmentation is to simplify change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. It is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region are similar with respect to some characteristic or computed property such as color, intensity, or texture.

A. Watershed Algorithm

The concept of watersheds literally means that the image is visualized in three dimensions – two spatial coordinates and one intensity. There are three kinds of points a) points belonging to a regional minimum; b) points at which a drop of water if placed at that point would fall with surety at a local minimum; c) points at which the water is equally likely to fall to more than one such minimum. The set of points satisfying condition (b) is called the catchment basin or watershed of that minimum. The points satisfying condition (c) are termed as divide lines or watershed lines.

The principle objective of segmentation algorithms based on watershed is to find the watershed lines. The basic idea is relatively simple. Suppose that a hole is punched in each regional minimum and that the entire topography is flooded from below by letting water rise through the holes at a uniform rate. When the rising water in distinct catchment basins is about to merge, a dam is built to prevent the merging. The flooding will eventually reach a stage when only the tops of the dams are visible above the water line. These dam boundaries correspond to the divide lines of the watersheds. Therefore they are the connected boundaries extracted by watershed segmentation algorithms.

B. Over-Segmentation

For some images it is not possible to set segmentation process parameters, such as a threshold value, so that all the objects of interest are extracted from the background or each other without over-segmenting the data. Over-segmentation is the process by which the objects being segmented from the background are themselves segmented or fractured into subcomponents.

Whereas over-segmentation increases the chances that boundaries of importance have been extracted, it does so at the cost of creating many insignificant boundaries. In this case, pre-filtering techniques should be used in an attempt to eliminate noise, improve inter-object definition, or smooth image textures, all of which might cause segmentation difficulties. If these techniques are not sufficient, over-segmentation can be used as a preliminary processing step, followed by grouping processes that attempt to reassemble the objects into singular image events (one object). Each segment derived from the image is referred to as an object, and the properties of the segments are designated as attributes or features.

II. LITERATURE SURVEY

Boren Li, Mao Pan and Zixing Wu (2012) [1] has presented an approach to reduce over segmentation using both pre- and post-processing for watershed segmentation. They have used more prior knowledge in pre processing and merge the redundant minimal regions in post processing. In the initial stage of the watershed transform produces a gradient image from the original image, but also introduces the texture gradient. The texture gradient can be extracted using a gray -level cooccurrence matrix. Then, both gradient images are fused to give the final gradient image. After the initial results of segmentation, we use the merging region technique to remove small regions.

Xiaoyan Zhang, Lichao Chen, Lihu Pan and Lizhi Xiong (2012) [2] has presented an image segmentation approach based on independent component analysis(ICA) and watershed algorithm is proposed. ICA is a method of image filtering for its characteristics.ICA can effectively remove the noises and maintain a clear image texture. Using independent component analysis algorithm can eliminate wavebands redundancy and extract the image signal components from source signal for image segmentation. Results showed that this method can process image segmentation effectively and identify features accurately.

Zhonglin Xia ,Danfeng Hu and Xueyan Hu (2011) [3] has presented watershed algorithm is introduced based on image processing technology for the contamination of insulator. This algorithm can be used to obtain the size of contamination area of the insulator, and follow the following steps. Firstly segment the insulator image with watershed algorithm, and then the region growing algorithm is used to process the segmented image, which can guarantee the segmentation effectiveness and reduce the number of segmented regions so as to enhance the segmentation results of the insulator image.

Li Cheng, Li Yan and Fan Shangchun (2011) [4] has presented a watershed algorithm as a primary tool of mathematical morphology for image segmentation is used. Based on the mathematical morphology, this paper develops a general purpose watershed segmentation algorithm used for the automatic segmentation in regions of pedestrians of infrared image. Then the experimental system is established by using the infrared CCD device for pedestrian image detection. The image segmentation results that the watershed method can implement the automatic detection and segmentation for the characteristic information in regions of interest of image.

Quan Longzhe and Jiang Enchen (2011) [5] has presented the improvement to the watershed algorithm and resolve the problems of „over-segmentation" and „leakage", and realized automatic segmentation of touching corn kernels. Firstly to get the pretreatment image, Wiener filter and mathematical morphology were adopted to reduce noises and clarify background of the image. Secondly, by combining with edge detection operators, the boundary of touching corn kernels was determined in the image, which can serve as watershed of the algorithm. Thirdly, erode transform was used to construct basin of the algorithm. At last, the algorithm of purifying image background was proposed, solving the problem of leakage.

III. SYSTEM METHODOLOGY

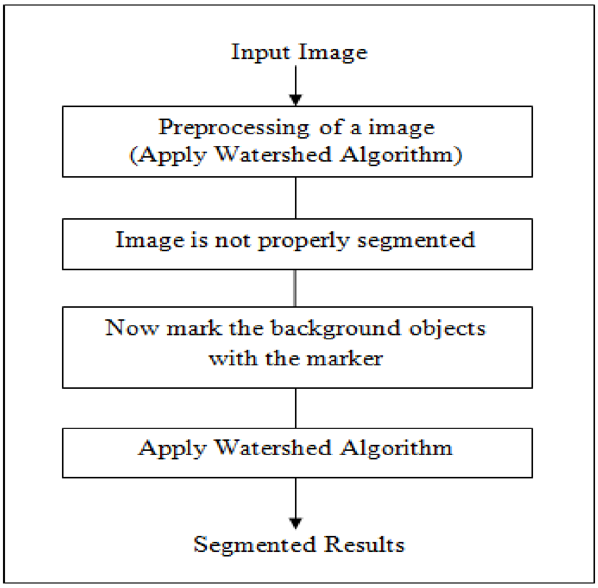


Fig: Flowchart

Applying watershed algorithm directly to the preprocessed image does not give a proper segmentation of the image. Due to the low contrast and the high level of noise there may be no proper segmentation and it may also lead to over-segmentation. Initial filtering of the original image cannot solve this problem. To get rid of over-segmentation, at least two alternatives are available:

- Either removes the irrelevant arcs of the watersheds (post-processing).
- Modify the gradient function in such a way that its watersheds coincide with the contours of the desired objects (pre-processing).

After the preprocessing of the image the distance between the pixels is calculated using distance-transform method. Then the markers are used to mark the background objects with the marker. And then we can apply a watershed algorithm to get an accurate segmented output of the image.

A. Visualizing and Analyzing DICOM Images

The first step is to install the necessary packages. Pydicom is used for reading dicom files. The second step is to load the dicom images. The dicom pixels have been extracted for each slice location.

The Digital Imaging and Communications in Medicine (DICOM) Standard specifies a non-proprietary data interchange protocol, digital image format, and file structure for biomedical images and image-related information. The fundamental concepts of the DICOM message protocol, services, and information objects are reviewed as background for a detailed discussion of the functionality of DICOM; the innovations and limitations of the Standard; and the impact of various DICOM features on information system users.

B. Hounsfield Units

The unit of measurement in CT scans is the Hounsfield Unit (HU), which is a measure of radiodensity. **Hounsfield units (HU)** are a dimensionless unit universally used in computed tomography (CT) scanning to express CT numbers in a standardized and convenient form. Hounsfield units are obtained from a linear transformation of the measured attenuation coefficients.

C. Marker Generation

For using marker-controlled watershed segmentation, we'll need to identify markers. Internal marker, which is our region of interest, i.e lung tissue and an external marker, which is the region outside of our region of interest. The external marker is created by morphological dilation of the internal marker, by iterating twice and subtracting the results. The watershed marker is created by superimposing both the markers.

The external markers represent the background around each object and are obtained by applying the distance transform to the internal markers. These external markers help to constrain the watershed method in specific zones.

D. Sobel Gradient

The Sobel operator performs a 2D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges.

It consists of a pair of 3×3 convolution kernels.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

These kernels can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient.

The gradient magnitude is given

by: G=sqrt(Gx2+Gy2)G=sqrt(Gx2+Gy2)

Sobel gradient can be calculated by scipy.ndimage.

The sobel operator is very similar to Prewitt operator. It is also a derivate mask and is used for edge detection. Like Prewitt operator sobel operator is also used to detect two kinds of edges in an image:

- Vertical direction
- Horizontal direction

E. Black top-hat morphology

The black top hat of an image is defined as its morphological closing minus the original image. This operation returns the dark spots of the image that are smaller than the structuring element. The dark spots in the original image are bright spots after the black top hat.

The top-hat filter is used to enhance bright objects of interest in a dark background. The black-hat operation is used to do the opposite, enhance dark objects of interest in a bright background. the very small details are enhanced and taken out using the Top-Hat operation. Hence, it is useful in observing the minor details of the inputs when are present as light pixels on a dark background.

All the objects which are white on a dark background are highlighted due to the Black Hat transformation applied to the input image.

IV. IMPLEMENTATION

Watershed Transform is a really powerful segmentation algorithm, but has a drawback:

- **Over Segmentation:** Over segmentation occurs because every regional minimum forms its own catchment basin. Here is an example where steel grains are over-segmented by watershed transformation:

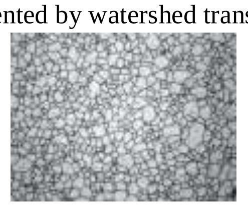


Fig (a): Steel Grains **Fig (b):** Oversegmented image

To overcome this drawback, we use a marker-controlled watershed transformation, where we manually create markers where we start the flooding process.

Marker-controlled watershed segmentation follows this basic procedure:

1. Compute a segmentation function. This is an image whose dark regions are the objects you are trying to segment.
2. Compute foreground markers. These are connected blobs of pixels within each of the objects.
3. Compute background markers. These are pixels that are not part of any object.
4. Modify the segmentation function so that it only has minima at the foreground and background marker locations.
5. Compute the watershed transform of the modified segmentation function.

V RESULTS

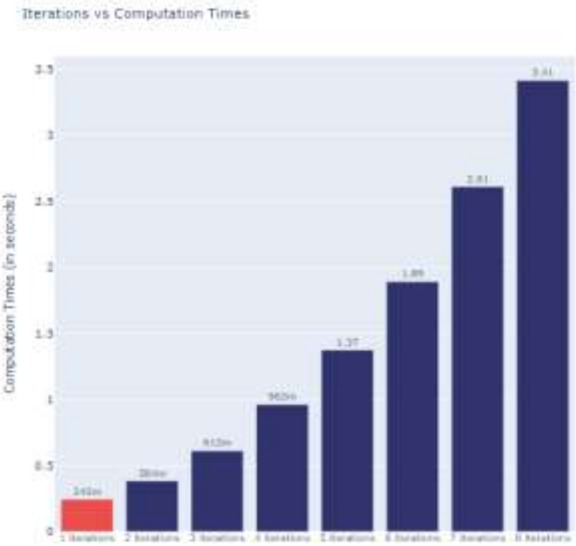
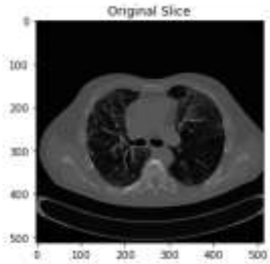


Fig 6.1: Computation of iterations with time

We'll be checking for iterations in the range of 1-8. iterations = 1 is the default for the seperate_lungs function. Repeating identical or similar tasks without making errors is something that computers do well. Repeated execution of a set of statements is called iteration. Python provides several language features to make it easier.
Iterations with respect to time can be seen in the above image. This shows that for each iterations the execution time increases.
The below images shows the outputs which we have got for the certain operations performed. Fig (a) is the original input given for segmentation. Fig (b) is the image obtained using the internal marker. Fig (c) is the image obtained by using the ecternal marker. Fig (d) is the image obtained by using watershed marker. Fig (e) is the image obtained by using sobel gradient. Fig (f) is the image of watershed. Fig (g) is the image of lung outline. Fig (h) is the image of lung filter. Fig (i) is the final segmented output of the lungs.



Fig(a): Original Slice

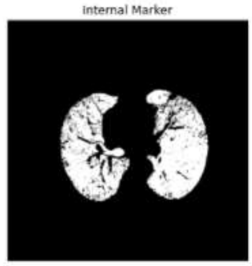


Fig (b): Internal marker

Fig (c): External marker

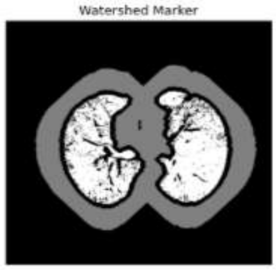


Fig (d): Watershed marker

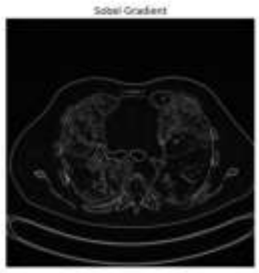


Fig (e): Sobel gradient

Fig (f): Watershed

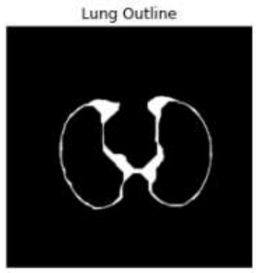


Fig (g): Lung Outline

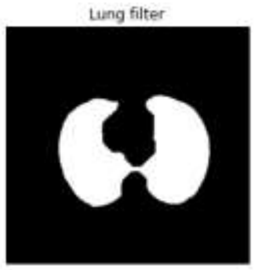


Fig (h): Lung filter

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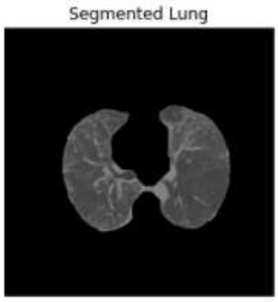

Fig (i): Segmented Lung

VI. CONCLUSION

In this, we have discussed about the watershed transformation. The scans are load using pydicom and HU values have been obtained from pixel data. The drawback of watershed transformation is over-segmentation. To overcome the drawback, we moved to marker-controlled watershed algorithm. Watershed transformation is comparatively better than algorithms. We use a marker-based approach which reduces the chances of over-segmentation and preserves the original lung border very accurately. The internal, external and watershed markers have been created by generating the markers. Sobel-gradient filter is used for the edge detection. Black top-hat transform morphology is an operation which is used to extract small elements and details from given images. Thus we get the segmented lung image.

VII. FUTURE ENHANCEMENTS

The lung segmentation is an initial step in many CAD systems for detection of lung disease. A fast and simple lung segmentation algorithm thus would be a considerable advantage for the development and application of the subsequent CAD systems. These segmented lung images can be used for determination of lung volume or for any other purpose.

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