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Watershed: An Image Segmentation Approach

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***Abstract*— A grey-level image may be visualized as a topographic relief, where the grey-level of a pixel is thought as its height in the relief. Supposing that a drop of water falls on a topographic relief, it flows along a path to finally reach a local minimum. The watershed of a relief corresponds to the limits of the adjacent catchment areas of the drops of water. In image processing, different types of watershed lines can be computed. In graphs - watershed lines can be defined on the nodes, on the edges, or hybrid lines on both nodes and edges. Watersheds can also be defined in the continuous domain. There are also many different algorithms to compute watersheds. Watershed algorithm is used in image processing primarily for segmentation purposes. Watersheds use many of the concepts of edge-detection, thresholding & region growing and often produce stable segmentation results.**

***Keywords*— Image-Segmentation, Watershed, Distance Transform**

I. Introduction

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.

Fig 1: From top to bottom (Initial Image, Topographic Surface, and Final Watersheds)

II. Methods Of Watershed Implementation

A. Distance Transform Approach

A tool used often in conjunction with the watershed transform for segmentation is the distance transform. It is the distance from every pixel to the nearest non-zero valued pixel.

B. *Gradient Method:*

The gradient magnitude is used to pre-process a gray-scale image before using the watershed transform for segmentation. The gradient magnitude image has higher pixel values along object edges and lower pixel values otherwise. Watershed transform results in watershed ridge lines along object edges.

C. *Marker Controlled Methods:*

Direct application of watershed transform to a gradient image results in over-segmentation due to noise. Over-segmentation means a large number of segmented regions. An approach used to control over segmentation is based on the concept of markers. A marker is a connected component belonging to an image. Markers modify the gradient image. Markers are of two types internal and external, internal for object and external for boundary. The marker-controlled watershed segmentation has been shown to be a robust and flexible method for segmentation of objects with closed contours, where the boundaries are expressed as ridges. Markers are placed inside an object of interest; internal markers associate with objects of interest, and external markers associate with the background. After segmentation, the boundaries of the watershed regions are arranged on the desired ridges, thus separating each object from its neighbors.

III. Our Proposed Method

1) Turning the colour image into a grayscale image.
2) In the image keep only the pixels which are less than an intensity value of 195 .Transforms the image into a matrix of 0's and 1's . Every pixel which had an intensity value greater than or equal to 195 will be converted to 0 and pixel values which were less than 195 to 1. This transforms the image matrix into a binary matrix.
3) Remove from the binary image all connected components that have fewer than 20 pixels.
4) Perform the flood-fill operation by filling the 'holes' in the background image. A hole is a set of background pixels that cannot be reached by filling in the background from the edge of the image.
5) Suppress structures that are lighter than their surroundings that are connected to the image border.
6) Invert the image matrix, i.e., change 0's into 1's and vice-versa. Compute the Euclidean distance transform of the binary image, i.e., for each pixel, the distance transform assigns a number that is the distance between that pixel and the nearest nonzero pixel. Negate the pixels of the entire matrix, i.e., pixels with 0 as a value will remain unchanged but pixels with 1 change into -1.
7) Force non-object pixels to be –Infinity.
8) Eliminate regional maxima. Use it by specifying certain threshold values say 2, 4, 8 etc. which means that eliminate regional maxima but keep 2 or 4 or 8 significant maxima intact.
9) Now compute the label matrix identifying the watershed regions. The elements labelled 0 do not belong to a unique watershed region. These are called "watershed pixels". The elements labelled 1 belong to the first watershed region, the elements labelled 2 belong to the second watershed region and so on.

IV. Results

Fig 2: The MATLAB interface

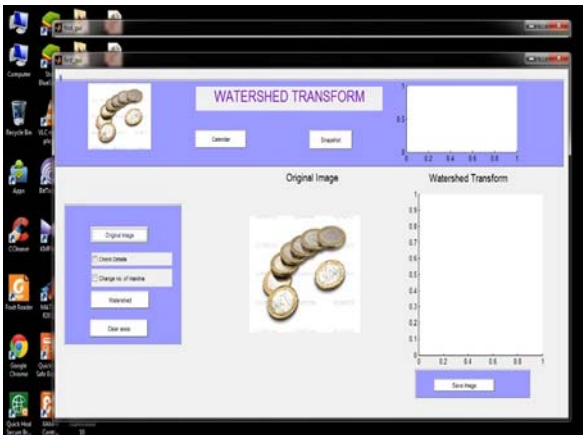

Fig 3: Select the original image

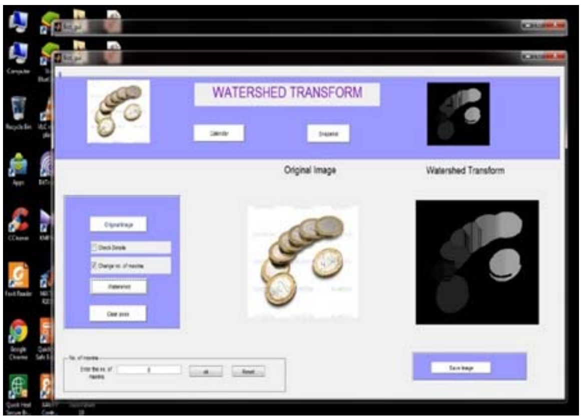

Fig 4: The Watershed of the image taking 8 no. of significant maxima intact

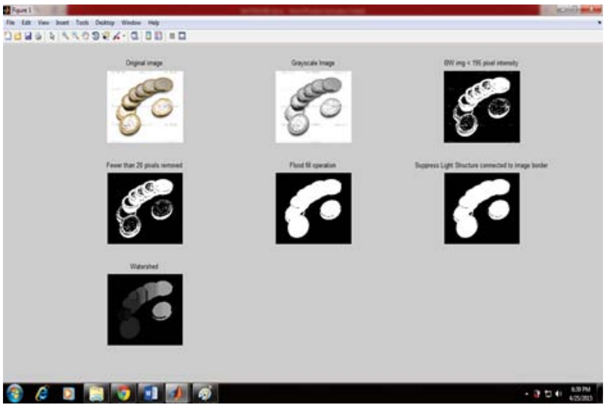

Fig 5: The steps involved in this approach

V. Conclusions

In our approach we have tried to improvise on the watershed segmentation procedure. We have implemented it in a different way. We have used the distance transform method of watershed. Watershed transform is a powerful tool for the purpose of image segmentation. However, the purpose of watershed transform is not limited in image segmentation. Here we have used variable values for the threshold of regional maxima. We see that the resultant image changes according to the value of the threshold. Like if we present a value of 4, 4 significant maxima in the image are kept intact and the rest are changed.

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