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Feature Extraction using Marker Based Watershed Segmentation on the Human Face

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Abstract - **In this paper, we propose to segment the human face using marker based watershed segmentation, an improved version of watershed segmentation. This algorithm uses the concept of markers as a pre requisite to determine the segments. The proposed method extracts facial features, most importantly the eyes and the lips. The successful feature extraction of the human face can contribute in a significant way to a face recognition algorithm based on the extracted features. The algorithm has been tested on colored face images of various races, obtained from standard databases and produced positive results.**

Keywords - Marker Based Watershed Segmentation, Chrominance, Skin Detection and Luminous Intensity.

I.INTRODUCTION

Face recognition remains a domain where higher accuracy is still much sought after. One aspect of the entire process of face recognition is the segmentation of the image. Its primary application is to segment an image into regions of interest, which are used for further investigation and analysis. The result of image segmentation is a set of segments that collectively cover the entire image.

Pixels in a region could be similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s). Various methods of segmentation exist. The most prominent being partial differential equation based methods, graph partitioning methods, model based segmentation, multi scale segmentation and morphological methods like watershed transformation.

The watershed transform considers the gradient magnitude, the first derivative of an image along a preferred direction, of an image as a topographic surface. The gradient magnitude is computed using a Sobel filter. Pixels having the highest gradient magnitude intensities (GMIs) correspond to watershed lines, which represent the region boundaries. The concept of watershed segmentation is based on a grey level image seen as a topographic relief, where the grey level of a pixel is interpreted as the altitude in the relief. A drop of water falling on a topographic relief flows along a path to finally reach a local minimum. This Low Intensity Minimum (LIM) forms the catch basin which represents a segment.

The Watershed Segmentation algorithm has been applied to images of faces, as in [1] and [2], aimed at face detection over recognition and hence the algorithm helped segment out larger areas of the face (typically the entire face). However, in this paper we have applied the marker based watershed segmentation algorithm to extract features of the face like the eyes and lips, which when extracted could be used for face recognition by subsequent comparison of these extracted features.

In this paper, a variant of watershed segmentation, based on markers has been applied to the human face; this method is called marker based watershed segmentation. This technique is applied specifically to a frontal view of images of the human face. This variation requires markers to identify starting points before the algorithm is implemented. The markers were generated using a skin detection algorithm. The use of such a marker based method improves the accuracy of the algorithm.

However marker based segmentation suffers to a small extent, the problem of over segmentation. Hence before the application of the transform, the image is first preprocessed and smoothened out to improve the efficacy of the algorithm itself. The resulting images have the eyes, lips and hair segmented, while in some cases even the nostrils and earlobes are segmented.
The focus of the paper lies in segmenting the key features of the face including the eyes, the lips and the nostrils to the maximum possible extent. These segments are fairly accurately found in the images used.

II. RELATED WORK

Image segmentation has generally been seen as a precursor to recognition in the domain of face recognition. The aim lies in indentifying areas of interest which are to be extracted by a computer and then taken forward in the domain of face recognition. Among the various prospective segments which can be generated in a face, the eyes are generally considered to be the most useful

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feature for recognition, while the lips and nose tend to be looked at as secondary features. A variety of methods have been used for segmentation, including various variants of watershed segmentation itself.

Anthony et al [3] implements a variation of the traditional watershed segmentation, by applying a multiresolution implementation of the watershed segmentation algorithm. This method uses a morphological pyramid or a watershed pyramid to form a scale space representation to reduce the computational cost and avoid the over segmentation problem present in traditional watershed algorithms. These pyramids are used to produce high accuracy edge maps. The aim of this method is edge detection in an image, not necessarily a face and is used to obtain all the edges present in the image.

In Sobottka et al [4], the conventional watershed algorithm is applied to a human face with pre processing. This application of watershed algorithm is proposed as one of the solutions to segmentation of a human face. First the pixels of the interior of the candidate face are sorted according to their graylevels. Following this step, beginning with the initial regions which are determined by using a threshold, the regions are flooded by applying an iterative method. This allows regions to grow and if the difference between two adjacent regions is below a threshold, they are merged. This procedure continues until the various basins are obtained. The result segments part of the hair and eyes.

In Alberto et al [5], a similar marker based watershed algorithm is applied on the human face. The image is first divided into skin and non skin pixels. This is followed by construction of a 2D histogram in the Cb-Cr colour space. This is treated as a gray scale image and the algorithm is applied to this histogram. The markers used are set to the local maxima in the histogram. However the histogram is smoothed to avoid over segmentation and then used. The method aims at detecting faces in video frames.

Malik et al [6], proposes use of the conventional watershed tranform, but this procedure is applied only after preprocessing to standardize the contrast of the image and ensure no over segmentation or under segmentation. As a pre processing step, a random walk algorithm is applied on the image which is based on probability. To provide a starting point to the random walk algorithm a seed is generated by using the threshold of the image. The aim of the random walk algorithm is to improve image quality so that watershed algorithm can be applied. The watershed algorithm produces favorable results on standard images; however the implementation on the human face has not been explored.

In Guerfi et al [7], the traditional watershed algorithm is applied to the human face and the catchment basins obtained are merged on the basis of the hue component in the Hue, Saturation and Intensity (HSI) space. The merging of basins based on depth and hue criteria prevents over-segmentation of the image and also eliminates post processing of the image.

III. PROPOSED METHOD

The method begins by marking the foreground and background objects to form the markers which form the basis of marker-based watershed segmentation, this is because the watershed transform works well if you can identify, or "mark," foreground objects and background locations. To begin with a segmentation function to darken the areas of interest is computed. The image is normalized to avoid over-segmentation. This is followed by the computation of the foreground markers, which form continuous and connected pixels and the background objects which are pixels that do not belong to any object. After this the watershed transform is applied to the resulting image. A detailed explanation of each step is given in the following sections.

A. *Compute the Gradient Image*

The first step involves computation of the gradient image. This is done by first reading the coloured image in RGB and then converting the image to gray scale. This is followed by the generation of another image after application of the sobel edge filter. The sobel edge filter is applied to the x and y coordinates of the entire image. The resulting image is the gradient image. It uses intensity values only in a 3×3 region around each image point to approximate the corresponding image gradient, and it uses only integer values for the coefficients which weight the image intensities to produce the gradient approximation.

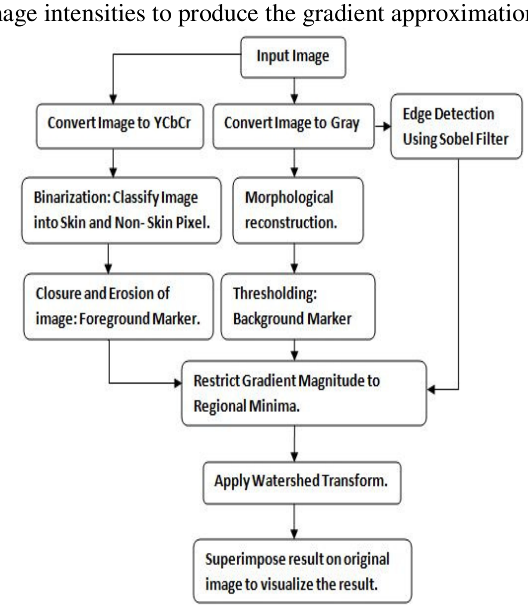

Fig 1: Block Diagram showing various stages.

Fig 2.a: Original RGB Image

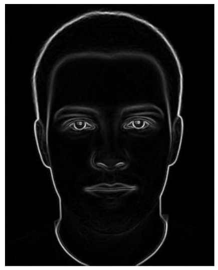

Fig 2.b: Sobel Edge Filter Image

B. Compute the Gradient Image

The marker is computed using a skin detection algorithm. In Shylaja SS et al [6], a range of values to classify pixels of an image into skin and non –skin pixels is specified. The range of values is mentioned in the YCbCr format and is as follows: Cb in the range of 90-130 and Cr in the range of 137-177. This range of values was used to binarize the image into various connected regions of interest by identifying skin pixels. Based on these ranges, the entire image is converted into a binary format. The objects of interest or markers are in white, while the background objects or marker is in black.

C. Opening and Closing Image

The resulting image requires further processing. We clean the edges of the marker by shrinking them slightly and then perform erosion. We then remove any stray pixels left along with blobs which contain very few pixels. After this, the image is opened and closed to finally remove any dark spots. To thin the background objects we use the distance transform which is based on Euclidean distance to compute the distance between each pixel and it's nearest non zero pixel.

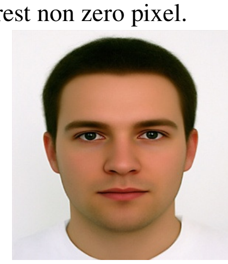

Fig 3.a: Original RGB Image

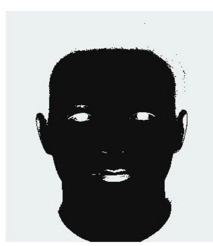

Fig 3.b: Skin Detected Image

Fig 4. Opening and Closing Image

D. Application of Watershed Transform

We restrict the regional minima to the markers obtained and apply the watershed transform to the resulting image. The features extracted are the lips and the eyes. The resulting image is then dilated to make the object boundaries more visible. Finally the result is superimposed over the original image to mark out clearly the specific segments extracted.

Fig 5. Result of the Watershed transform

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

This algorithm has been applied on a database consisting of a variety of still color images of single faces with frontal view. The images have been taken under different lighting conditions. The algorithm was implemented using Matlab R2009a on an Intel i5-540M dual core 4GB ram windows 7 workstation. The average run time is approximately 4 seconds. After testing on a variety of images it can be concluded that the algorithm segments the eyes and lips and also in certain cases the nostrils and earlobes too. However in images where the light intensity is non uniform, the algorithm fails to generate any meaningful segments. Also the segments formed as a result of the algorithm are not smooth; the edges are sharp and geometric. On a macro scale however, the segments are clearly distinguishable.

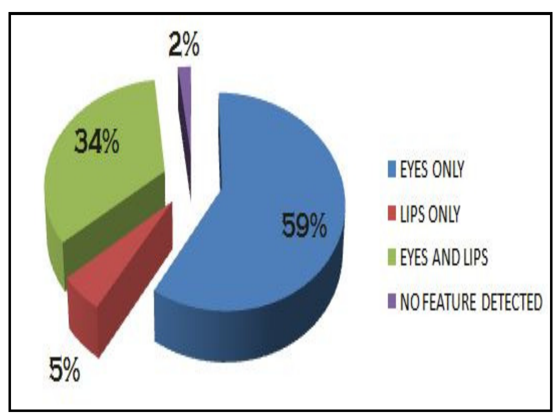

Fig 6. Percentage of Extracted Features

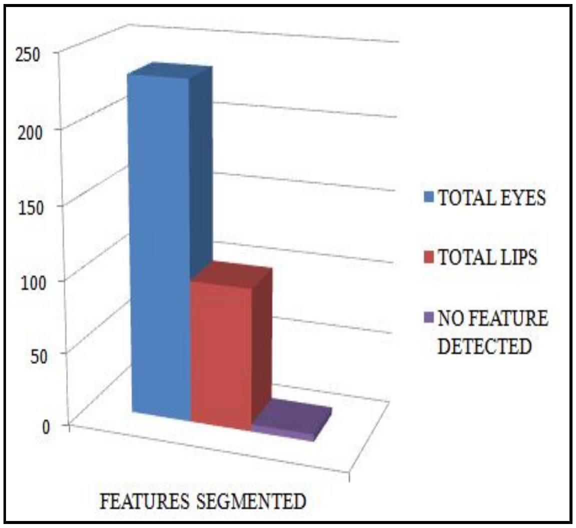

Fig 7. Quantitative Feature Extraction Results

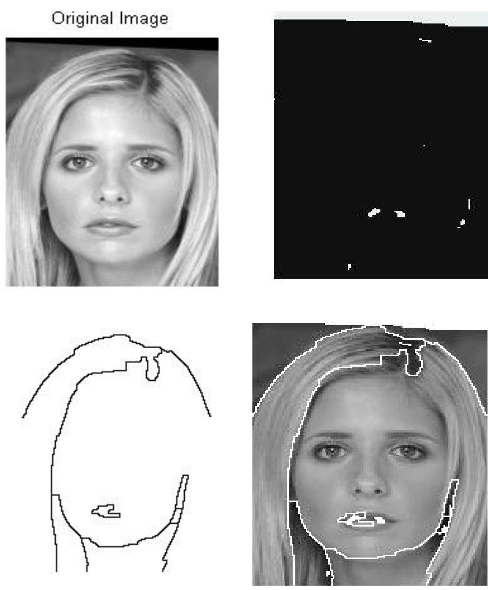

Fig. 8 Stages of an Undersegmented Image

In Fig. 8 the 4 images represent the Original Image, the Skin Detected Image, the Segmented region and the result after superimposition of the segmented image on the original face. As can be seen clearly from the original image, the image has non uniform luminosity. Due to high brightness, the skin detection algorithm fails and subsequently the marker is distorted. The resulting segmentation leads to lesser number than required catchment basins, each of a larger size, leading to under segmentation.

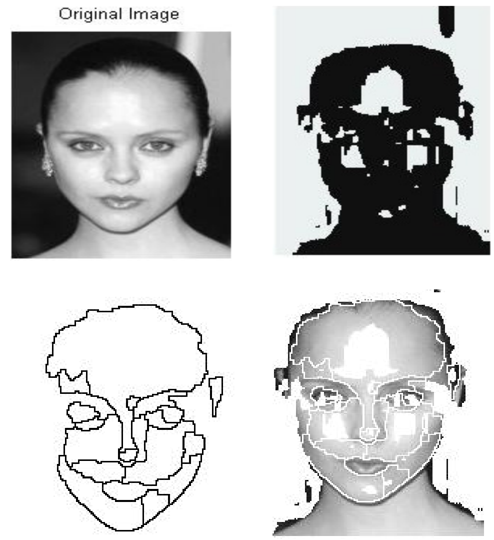

Fig. 9 Stages of an Oversegmented Image

In Fig. 9 the 4 images represent the Original Image, the Skin Detected Image, the Segmented region and the result after superimposition of the segmented image on the original face. Here, the image suffers from excessive exposure to light in some areas. This excessive brightness leads to a large reduction in accuracy of the skin detection algorithm and subsequently the marker is distorted. This results in a larger number of catchment basins than required and thus results in oversegmentation.

Fig. 10 Stages of an Image Segmented As Required

In Fig. 10 the 4 images represent the Original Image, the Skin Detected Image, the Segmented region and the result after superimposition of the segmented image on the original face. The original image in fairly clear and has minimal noise. The skin detection algorithm produces a near perfect result and provides an accurate marker. The watershed algorithm builds on this marker to form the catchment basins, and manages to successfully segment the eyes and lips and separate the face and hair as independent segments.

Fig 11. Snapshots of Segmented Images

V. CONCLUSIONS AND FUTURE WORK

This paper aims at demonstrating the application of the watershed transform on the human face to extract useful features of the face. These generated segments could then be considered for use for face recognition. This paper presents the application of the marker based watershed segmentation which works better than the watershed segmentation on its own. The entire experimental set was limited to frontal views of the face in colour and with varying backgrounds and luminous intensities. The algorithm requires pre processing and post processing to be effective. The approach taken here uses pre processing to standardize the given image before applying the algorithm. After this pre processing, the algorithm produced encouraging results when the illumination was fairly uniform. However, it failed to produce meaningful segments when large differences in luminous intensity existed. Post processing to make the edges of the segments smooth using curve fitting could be addressed. Further challenges which remain to be addressed include large differences in luminous intensity and faces with non frontal views.

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