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AUTOMATIC EAR LOCALIZATION USING AN EFFECTIVE SKIN SEGMENTATION ALGORITHM AND CORRELATION COEFFICIENT IN 2D IMAGES

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Abstract- Studies have shown that human ear is one of the representative human biometrics with uniqueness and stability. Automatic Localization of 2-D ear from a side face image is one of the challenging problems. This paper presents an efficient technique for automatic ear localization from a side face image. The localization is done using an effective Skin Segmentation algorithm and Template Matching using Correlation Coefficients. The ear is localized automatically through Skin Segmentation followed by automatic ear localization. The proposed technique is tested using an ear database which contains 100 ear images and 95% of the images responded with correct automatic ear localization.
Key words - *Ear localization, Skin Segmentation, Correlation* Matching,

Introduction

Ear biometrics is a physiological passive biometric. Human ear is a perfect data for passive person identification, which can be applied to provide security in the public places [9]**.** There are many approved human traits that can be used as a biometric like fingerprint, face, voice and iris. Despite extensive research, many problems in these methods remain largely unsolved. A wide variety of imaging problems (e.g., lighting, shadows, scale, and translation) remains in these biometric methods. An alternative to this is ear biometrics. Ear images can be easily taken with or without the knowledge of examined person. The ear has desirable properties of a biometric such as universality, uniqueness and permanence [6].

It has been studied that finding two ears which are wholly identical is almost unfeasible and ear does not change much with time. In addition, ear satisfies all the properties that should be possessed by a biometric [6]. Ear have certain advantages over the more established biometrics: they have a rich and firm structure that changes little with age. The ear does not suffer from changes in facial expression and is firmly fixed in the middle side of the head so that the immediate background is predictable. The ear is large compared with the iris, retina and finger print and therefore is more easily captured at distance and thus unlikely to cause anxiety as that may happen with the iris and retina measurements.

As in every biometric method, the steps involved in ear biometrics are Image acquisition (side face image), Image preprocessing, Shape Segmentation / Localization (cropping the ear images either manually or automatic), Ear detection, Feature extraction, Testing with the stored features, Decision (successful hit).

Most of the existing system concentrates on the feature extraction by capturing the image of the ear itself or manually cropping the ear from the side face. The manual method is not so much applicable in the current scenario as the system needs a human interaction on time. This paper proposes a simple, user-friendly and accurate method for automatic ear localization

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A Review on Existing Ear Localization Techniques

In the last two decades, several algorithms have been proposed for ear localization. A concise review of selected works of prominence is presented below.

Bhanu et al. [4] have presented a method for human ear detection from side face image which can be used in 3D ear biometrics. The model has two stages to detect the ear: offline model template building and on-line detection. The model template is represented by an averaged histogram of shape index. The on-line detection is a four-step process: step edge detection and thresholding, image dilation, connect component labeling and template matching. The technique was tested on 30 subjects in the database and every subject has two side face range images taken at different viewpoints. The data need to be split into training and test sets. The system reported 91.5% true detections. The method required manual extraction of ear from the images for training the model which makes it quite disadvantageous.

Another automatic localization method presented by S.Ansari et.al [7] is the localization of ear using outer helix curve of the ear. This was an efficient approach for localization from an arbitrary 2-D side face image with varying background. Outer helix curves of ears moving parallel to each other are used as feature for localizing ear in an image. Decisions were made on a constructed curve whether it belongs to outer helix of ear or not. This technique was implemented on IITK, India database containing 700 samples. Accuracy of localization reported was more than 93%. The method does not need any template but is based on relative values of angles. The result depends on the threshold values selected. This method does not give a satisfactory result if taken in slightly changed orientation in side face.

Surya Prakash, et.al [8][1] have performed ear localization method using Distance Transform and Template Matching. The technique first segments skin and non-skin regions in the face and then uses template based approach to find the ear location within the skin regions. An ear template is created considering the ears of various shapes (triangular, round, oval and rectangular) and is resized to make it suitable for detection. The technique was tested on an ear database which contains around 150 ear images and reported 95.2% correct localization. The system requires additional process and time for template creation and resizing the template based on a reference side face image.

A work on ear localization and extraction using image ray transform were presented by Alastair H. Cummings and team. This is a novel approach for extracting tubular and circular structures [11]. The technique concentrates on image ray transform for enhancing enrolment and relies only upon simple thresholding and template matching.

Proposed Technique

The proposed technique is the automatic ear localization using efficient skin segmentation algorithm [1] and correlation of the template. The technique begins with the acquisition of the side face image of a human. This is followed by skin segmentation procedure to separate the skin pixels from the non skin pixels of the face. This helps to reduce the area of exploration for the ear localization, as the possibility of finding ear is in the skin region of the face [4].The area can again be reduced by performing image processing functions like removing unconnected components, identifying the topmost, bottom, leftmost and rightmost end skin pixels from the obtained skin segmented area and further cropping the determined area. The reduction of the search space improves the efficiency of the final output.

The Region of Interest (ROI-skin segmented region) undergoes a template matching where correlation coefficient is considered to find the area of matching. The technique used is a simple template matching which does not need a reference image for resizing the template before ear comparison, as used in previous works[1][8][4]. The steps used to reduce the search space and non-usage of reference image will make the localization procedure easier and reduce the processing time and gives better results.

Skin Detection and Segmentation

Skin detection [1] is the process of finding skin-colored pixels and regions in an image or a video. This process is typically used as a preprocessing step to find regions that potentially have human ear. Such regions detected are segmented and separated so that the possible area to find the ear can be reduced.

The skin segmentation is done on the acquired color image of the side face. The output of the skin segmentation algorithm will be the skin segmented portion of the input image which acts as the input to the correlation matching.

The most popular algorithm for skin detection is based on color skin information. Different color space information are required for the conversion of image in RGB to appropriate color to get a better result.[12][13][14] The color space conversions like YCbCr, HSV were studied and compared. In this paper we convert the image from RGB to YCbCr, as RGB is sensitive to the variation of intensity. YCbCr space segments the image into a luminosity component and chrominance components. The main advantage is that influence of luminosity can be removed during processing a image when using YCbCr segmentation method[1].

Experimenting with various thresholds, the best result for segmenting the skin was found to be in the range: Cb in [77, 127] and Cr in [139, 210]. The obtained skin segmented portion then undergoes image processing steps to avoid unwanted pixels .Fig(**1**) shows the skin segmentation result of a side face.

Segmentation of the ROI

The process following skin segmentation is grouping or merging the parts to form candidate face region. The unconnected components and noise in the obtained output is removed.

A second step performed to reduce the search area and at the same time increase the possibility to find ear is to identify the leftmost, rightmost, top and bottom skin pixels and automatically crop the image with the estimated pixels. This helps to omit the uninterested region of search. This method of reducing area of search gives positive signs to the computational time of localization thereby increasing the efficiency of the algorithm. .Fig(**2**) illustrates the segmentation of ROI from the skin segmented face.

Ear localization

The skin segmented portion of the image will contain the side face region with the hair erased. The side face image may hold the right ear or left ear depending on direction to which the person faces. The ear localization using template matching is performed.

Out of the two template matching methods i.e. feature based and template based approaches, this paper explains the work on template based matching algorithm using correlation coefficient. The template-based approach uses the entire template, with generally a sum-comparing metric (e.g. cross correlation) that determines the best location by testing all or a sample of the viable test locations within the search image that the template image may match.

The proposed template matching has two inputs: a skin segmented side faces image as the search image and a proper ear template image of a standard size for comparison.

The template is sequentially positioned throughout the window, and at each position a linear cross correlation is performed. For each position a correlation coefficient is computed and the corresponding coordinates are saved. The maximum coefficient obtained is assumed to be the best representation for a true match.

The existing template matching method [1][8][4][14]needs a reference image to resize the template before template matching process. This requires additional input, i.e. the reference image. The proposed method doesn't need the reference image for template resizing.

Experiment and Results

The side face images of 100 individuals are used in the study. The skin segmentation and image processing steps are performed to avoid the unwanted pixels. The template matching using correlation coefficient is performed to find the location of the ear in the face image. 95% images showed proper localization. *Fig (**3**)*shows the result of ear localization of different images.

The proposed technique is found to be advantageous over other existing methods [1][4][7][8]. The proposed method localizes the ear of the human even if there is variation in his or her pose. Also it requires lesser computation time :

Variations in Pose: The advantage of the proposed technique is that images in any pose with the ears visible can locate the ear in minimal time. Fig (**4**) illustrates this.

Comparison on Time: The graph shown (Fig (**5**)) gives the performance of the proposed technique compared to two existing ear localization methods. The figure (Fig 5) proves that the computation time required is much lower in the proposed technique when compared to other methods [8][4]. This adds up to the efficiency of the proposed technique.

The proposed system was tested on 100 images and 95% gave correct results. There was some false detection. The reasons could be any of the following:

- the quality of the camera used for image acquisition,
- the background pixel color (as the segmentation used depended on range of pixel values),
- the mismatch in choice of template (eg: Right ear (target) Vs Left Ear(Template) or vice versa),
- the orientation of the face(images with no ear clear does not give the desired result),
- The result may be poor in the case of ear occlusions i.e. when the ea far being fully of partially covered by hair.

*Fig (**6**) shows the false detection due to the change in orientation of face.*

Conclusion

Many research works have pointed out the importance of correct, precise and automatic ear localization as the fundamental step for the ear recognition. As the localization quality decreases, the results will decay rapidly. The survey of recent ear localization techniques clearly shows that there needs lot of work to reach perfect localization. The Different approaches tend to solve the problem in an analogous way, by decomposing it in a top-down fashion and thus incrementally reducing its toughness. The proposed system also specifies a similar method: first the face is roughly localized, followed by ear localization.

The work describes a novel approach to automatic ear localization. First the segmentation of skin of a face image is carried out in YCbCr domain, which is followed by segmentation of ROI. Ear localization is achieved through template based matching algorithm using correlation coefficient. The proposed method eliminates the need of a reference image for template matching. The results obtained with 100 test images are promising in terms of the success in ear localization. The work is being extended with further refinement so as to achieve near perfection in the automatic ear localization process.

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Fig 1: Skin Segmentation Procedure

Fig 2: Segmentation of the ROI

Fig 3: Ear Localization

Fig 4: Ear localization when the face taken at different orientation

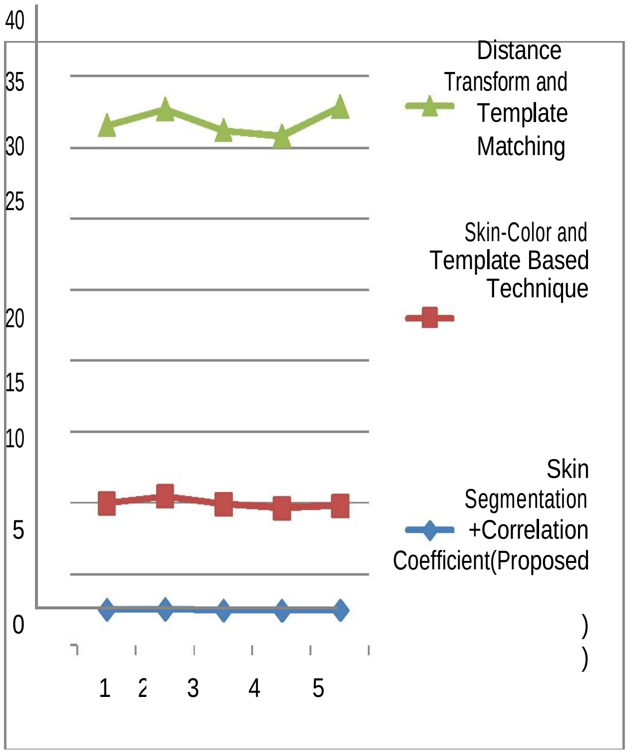

Fig 5: Time Comparison with existing methods

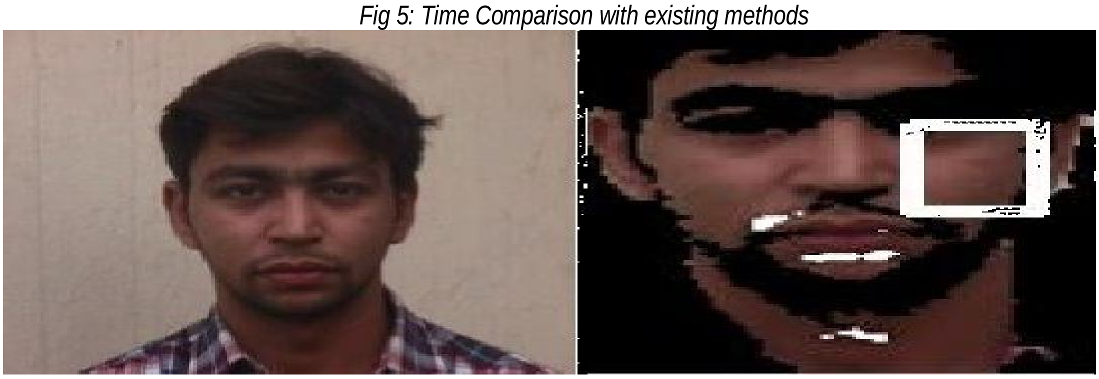

Fig 6: False Detection