CONNECTED COMPONENT BASED TECHNIQUE FOR AUTOMATIC EAR DETECTION

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Objective

Development of an efficient technique to detect ear automatically in side face image for ear based biometric system

Technique is required to be invariant to

- Rotation
- Scale
- Ear shape

Input

Output

Proposed Technique

Preprocessing

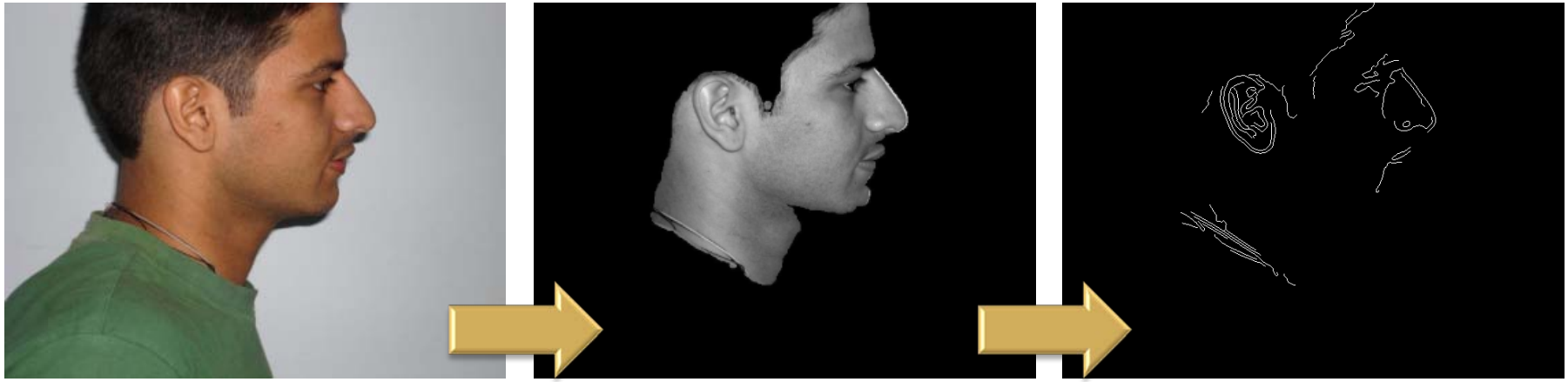
- Skin Segmentation
- Edge Detection
- Approximation of Edges using Line Segments

Ear Detection

- Building Edge Connectivity Graph
- Ear Localization using Connected Components

Preprocessing

Skin Segmentation and Edge Detection



Skin Model

RGB Color Space (R,G,B) → Chromatic Color Space (r,g,b)

$$r = \frac{R}{R+G+B}$$

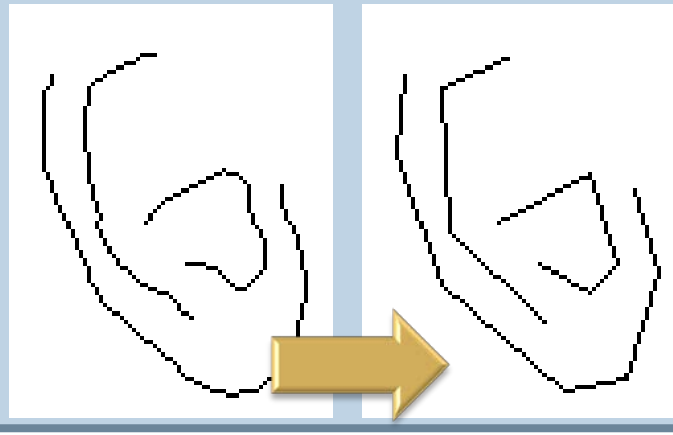
$$b = \frac{B}{R+G+B}$$

$$P(r,b) = \frac{1}{\sqrt{2\pi\,|C|}} \exp\left[-\frac{1}{2}(x-\mu)C^{-1}(x-\mu)^T\right]$$

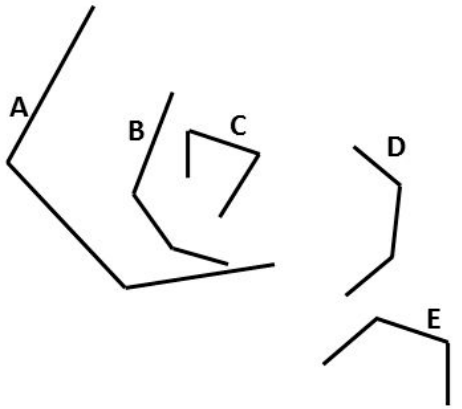
$$x = [r,b]^T$$

Skin if P(r,b) > T

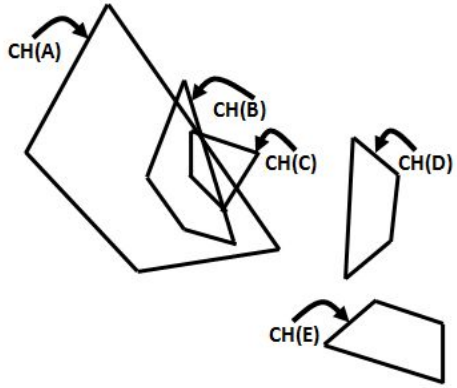
Edge Approximation



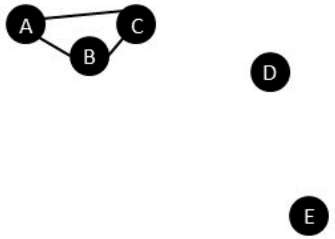
Ear Localization – Building Connectivity Graph



Synthetic Edge Map

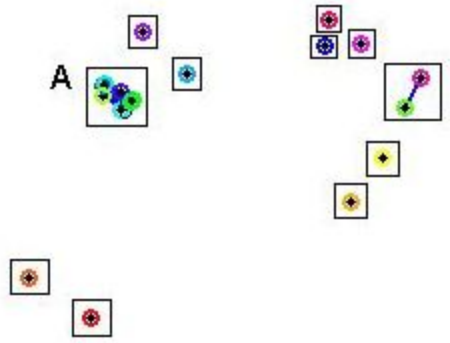


Convex Hulls of Edges

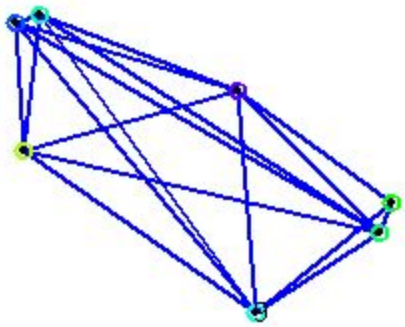


Connectivity Graph

Edge Map



Graph with Connected Components



Magnified View of *A*

Ear Localization – Use of Connected Components

- Graph connected component representing the ear edges shows good connectivity among vertices
- This makes the size of the connected component representing ear larger compared to other components
- Connected component size is defined as the total number of vertices and edges participating in it
- The proposed technique uses size of the connected component for ear localization
- Component having the largest size represents the ear

IIT Kanpur Ear Database – 1

- 490 samples
- 168 subjects

Data Set 1

- 801 samples
- 89 subjects

Data Set 2

- 1070 samples
- 107 subjects

Data Set 3

Data Set 1

- Frontal ear views

Data Set 2

- Rotation with respect to horizontal axis
- Approx. angular rotation: -20 to +20

Date Set 3

- Rotation with respect to vertical axis
- Approx angular rotation: -40 to + 40

IIT Kanpur Ear Database – 2

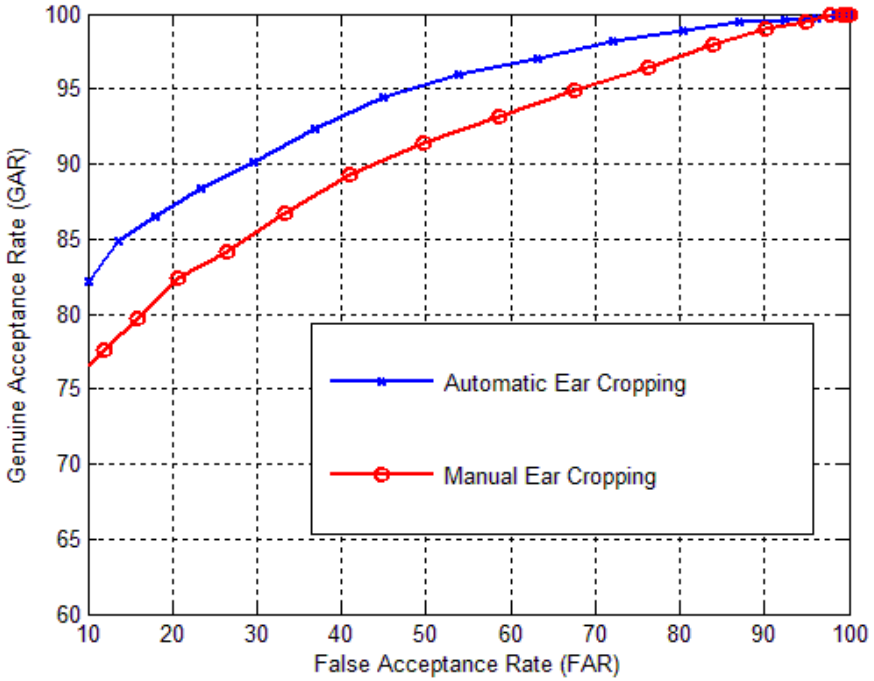
Data Set 1

Data Set 2

Data Set 3

Experimental Result – 1

Data Set	# of Test Images	%age Accuracy	
		Exact Ear Boundary	15% Neighboring Pixels Allowed
Set 1	490	94.01	95.88
Set 2	801	93.20	94.73
Set 3	1070	90.52	91.11



ROC Curves

Experimental Result – 2

Data Set 1

Data Set 2

Data Set 3

Failure Cases

Conclusion – 1

- This paper proposes an efficient technique for automatic ear detection using structural details of the ear
- The technique detects ear in side face image without any user interaction and can be deployed in an automatic ear based biometric system
- It is able to detect ears of different scales, rotations, and shapes efficiently without any user intervention
- The proposed technique is tested on a database containing 2361 side face images collected at IIT Kanpur

Conclusion – 2

- To show the correctness of the detection, detected ears are used for recognition
- It is found that the recognition performance for automatically detected ears is better than the same obtained for manually cropped ears
- This happens due to the fact that manual ear cropping contains some human errors in localizing the ear boundary
- The technique can be easily extended for the detection of multiple ears