FACE REPLACEMENT SYSTEM

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INTRODUCTION

Face Replacement System is a system which replaces human faces in still images.

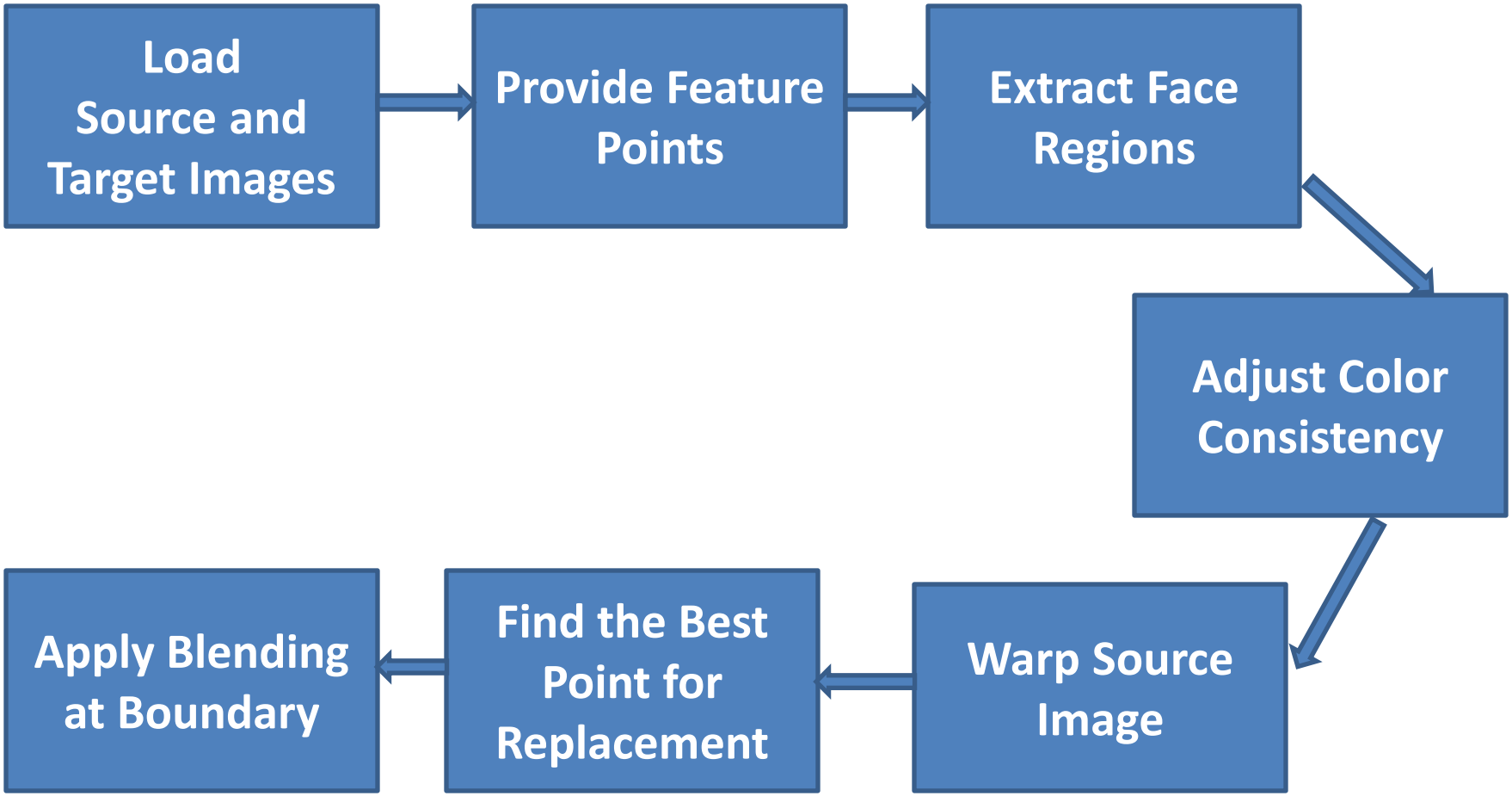
OBJECTIVES

- To implement skin color thresholding, snake algorithm and edge detection for face extraction
- To implement warping, region growing, shifting, color consistency and blending for face replacement
- To develop a face replacement application based on above algorithms

APPLICATIONS

- Entertainment Industries
- Facebook and iPhone apps
- Photo Montage
- Face Deidentification

SYSTEM BLOCK DIAGRAM



FACE EXTRACTION

FACE EXTRACTION

- Two major steps
  - Rough face region extraction
  - Post processing to enhance the region

FACE REGION EXTRACTION

There are 3 alternatives:

1. Skin Color Thresholding

2. Snake Algorithm

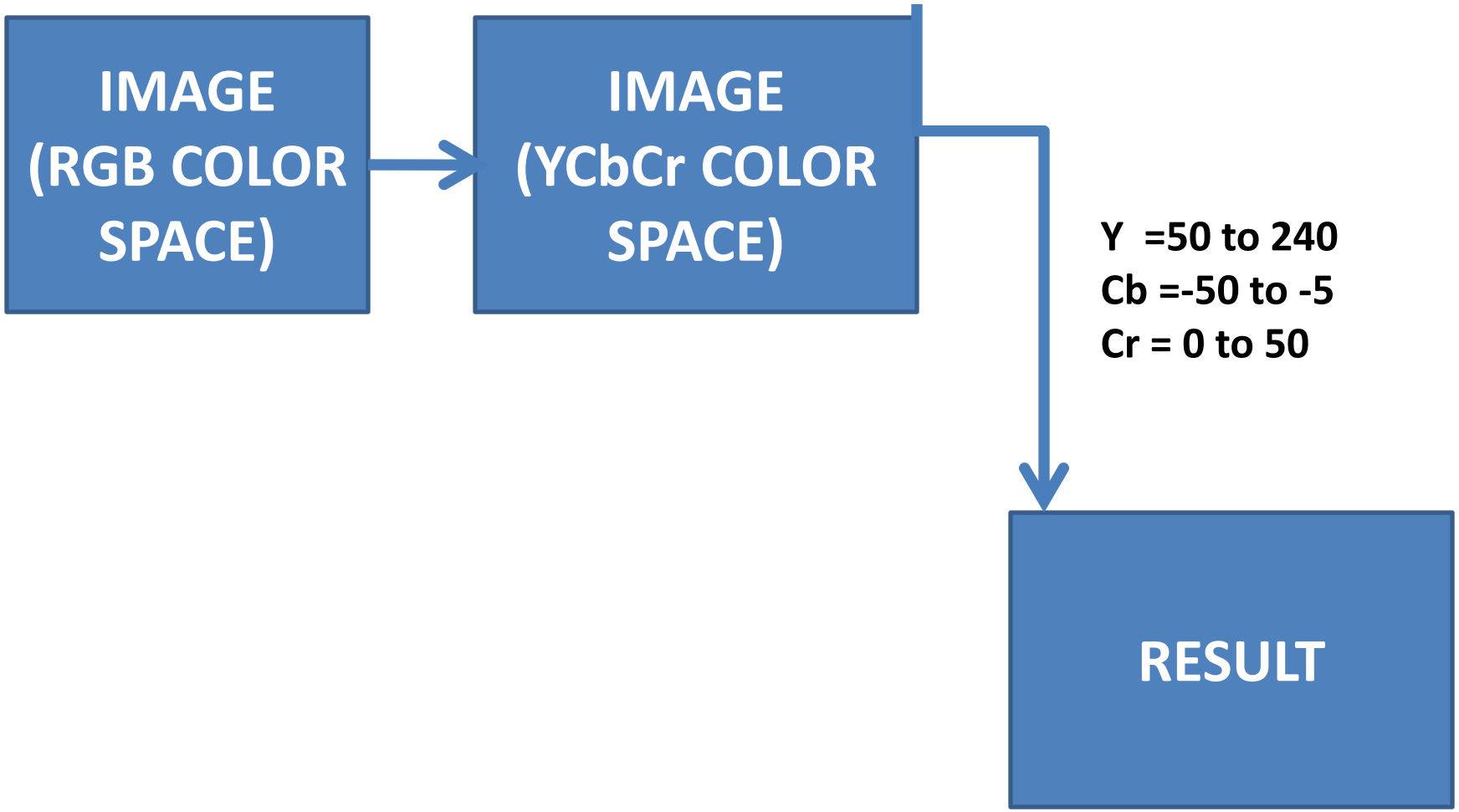
3. Edge Detection

1. SKIN COLOR THRESHOLDING

Face region is extracted by selecting only skin colored pixels in the image.

Thresholding is applied in Y-Cb-Cr color space.

SKIN COLOR THRESHOLDING



RESULT

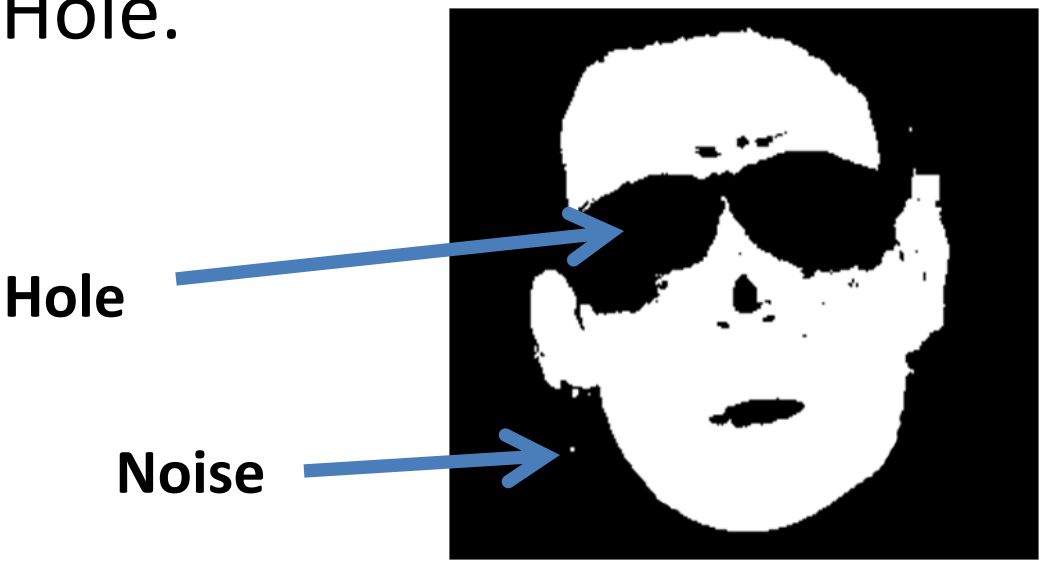
Original Image

Result of Skin Region Detection

SKIN COLOR THRESHOLDING

Problem:

The output of the skin color detection contains Noise and Hole.



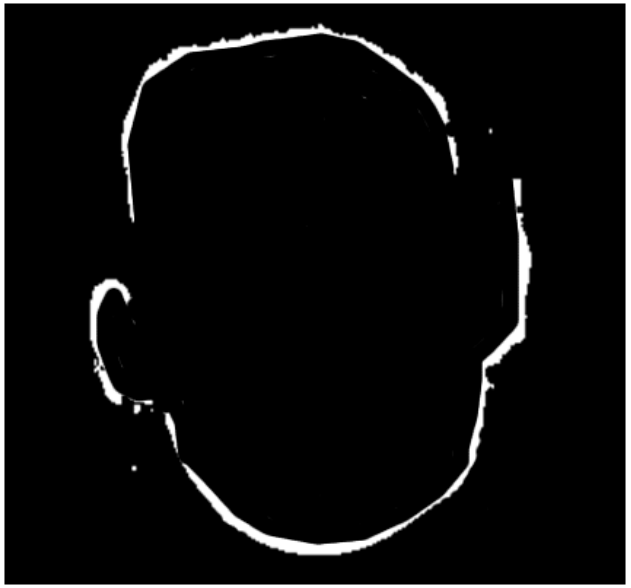
Result obtained after applying Skin Color Thresholding

Solution For Holes:

HOLE FILLING ALGORITHM

HOLE FILLING ALGORITHM

FACE MASK



BOUNDARY

FILLING IN X-DIRECTION

HOLE FILLING ALGORITHM

X-direction filled mask

Y-direction filled mask

Area contributed by Noise

HOLE FILLING ISSUES

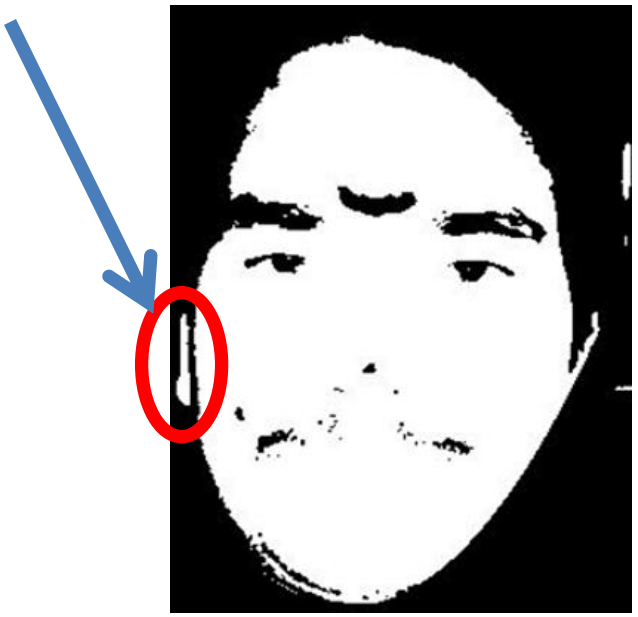
- Noises present in the mask may produce bad result.
- Noise reduction should be done first.

Solution For Noise:

PIXEL SHRINKING AND GROWING

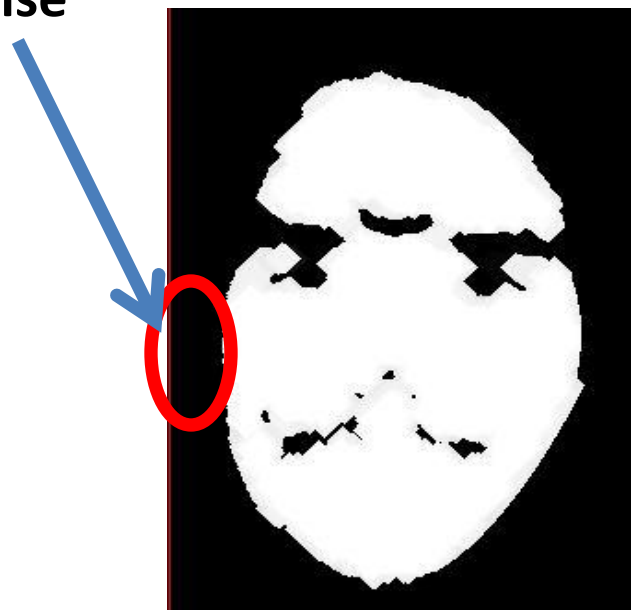
SHRINKING AND GROWING

Presence of Noise



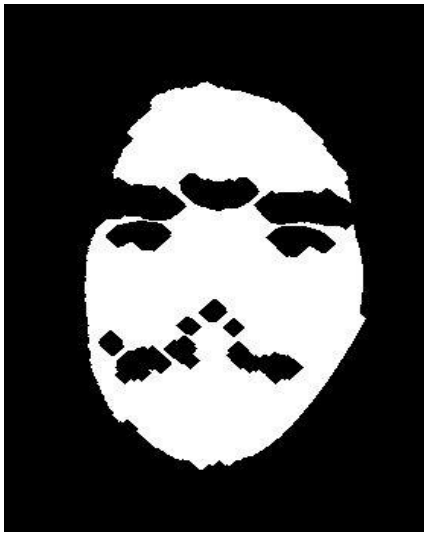
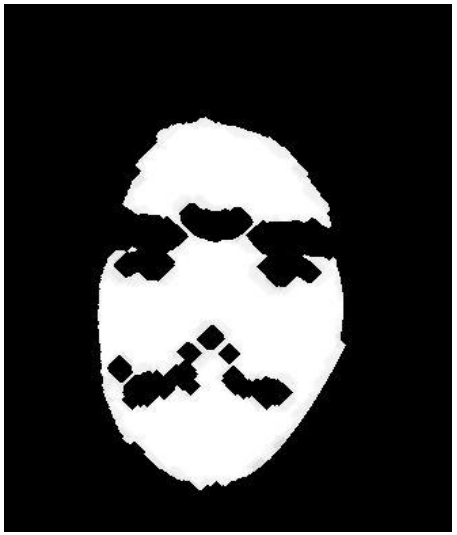
Before Shrinking and Growing

Removal of Noise



After Shrinking and Growing

EXAMPLE OF SHRINKING

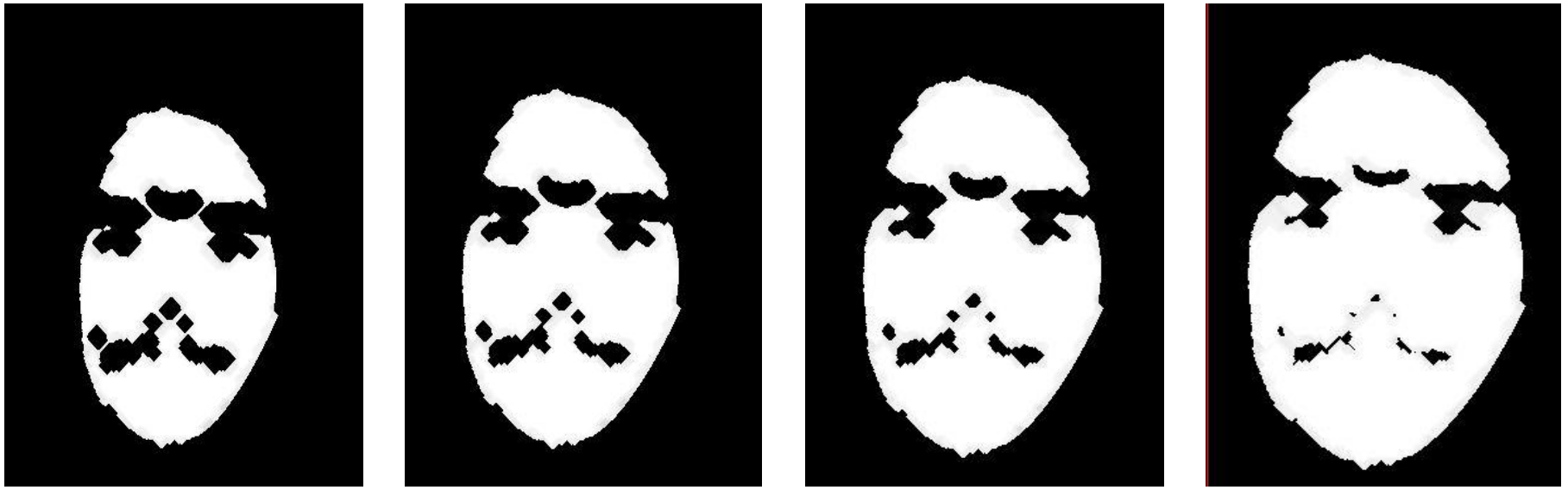




The figures show the results of the “shrinking” algorithm

GROWING

“Growing” algorithm restores the original shape and size of the image.

EXAMPLE OF GROWING



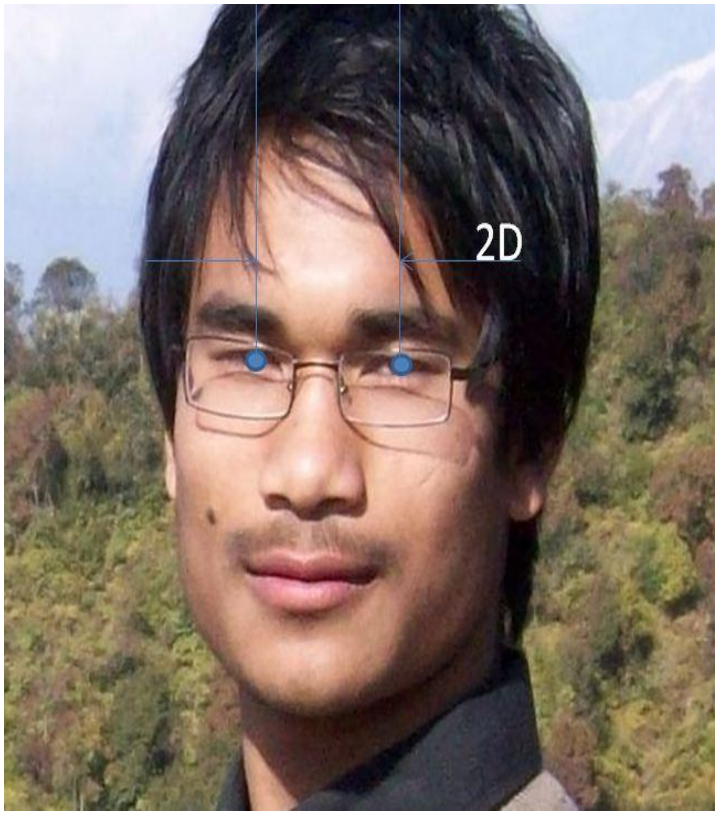
The figures show the results of the “growing” algorithm

2.EDGE BASED FACE EXTRACTION

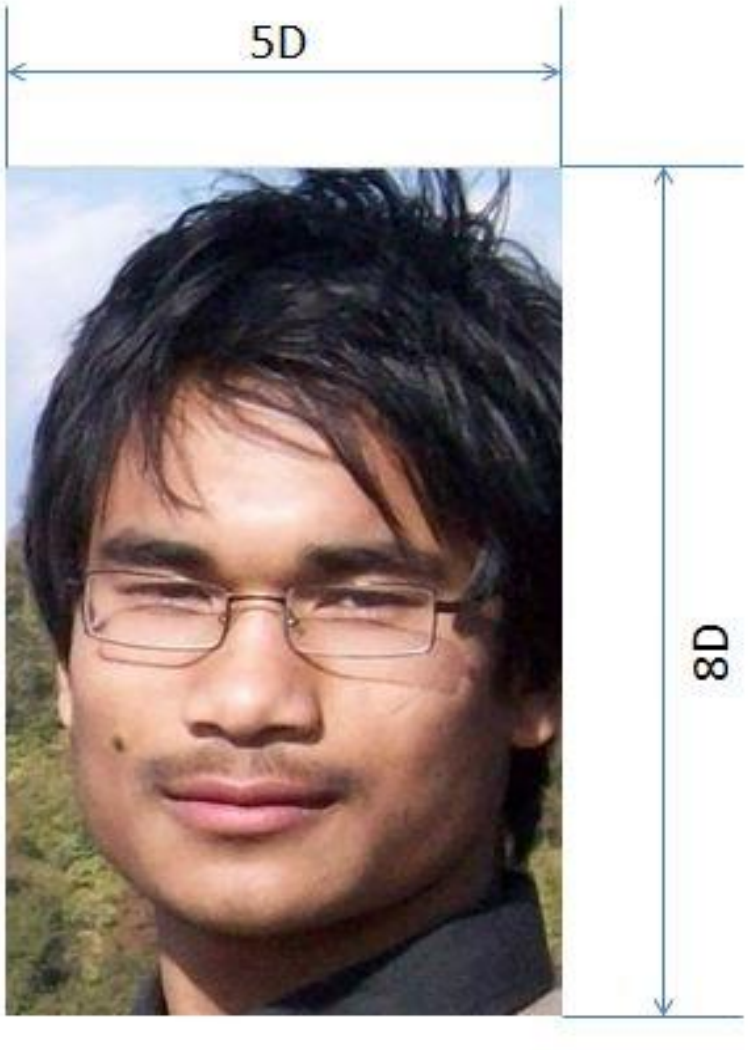
CANNY EDGE DETECTION

CANNY EDGE DETECTION

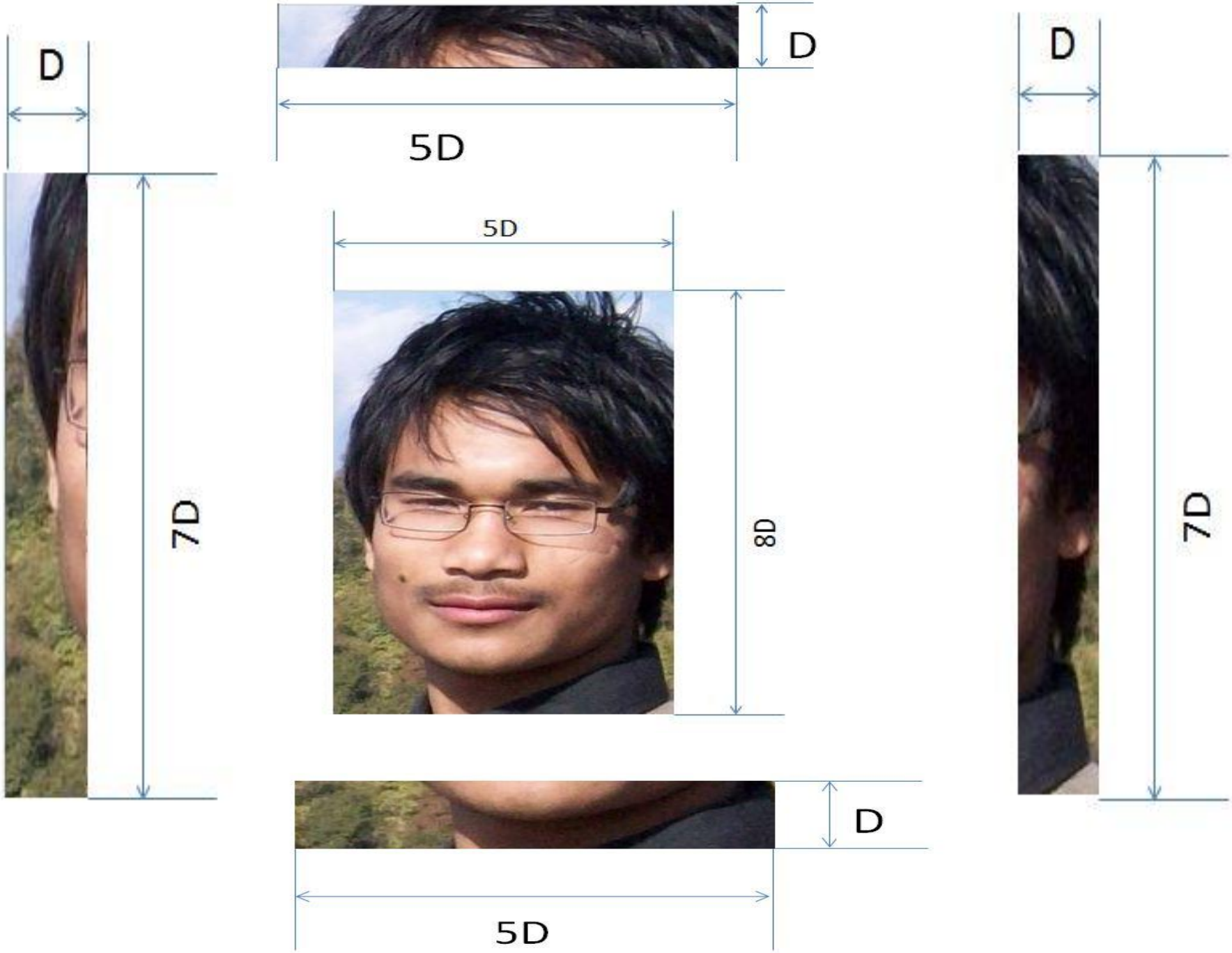
	
Input Image	**Output Image (Low threshold = 1 High threshold = 4)**



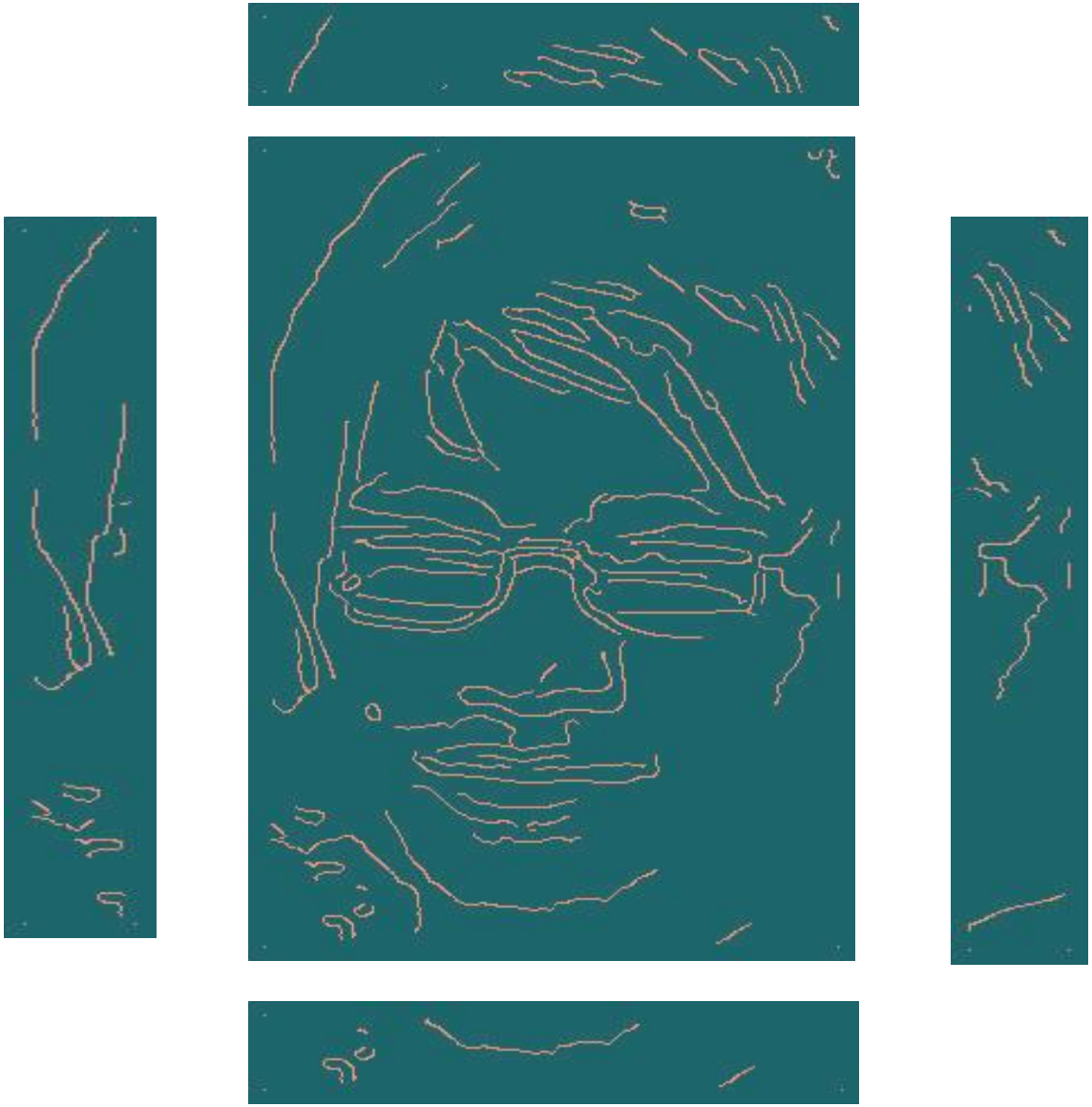
Separation between eyes



Rectangle around the face


D
D
5D
D
7D
5D
8D
7D
D
5D

OUTPUT OF CANNY EDGE DETECTION



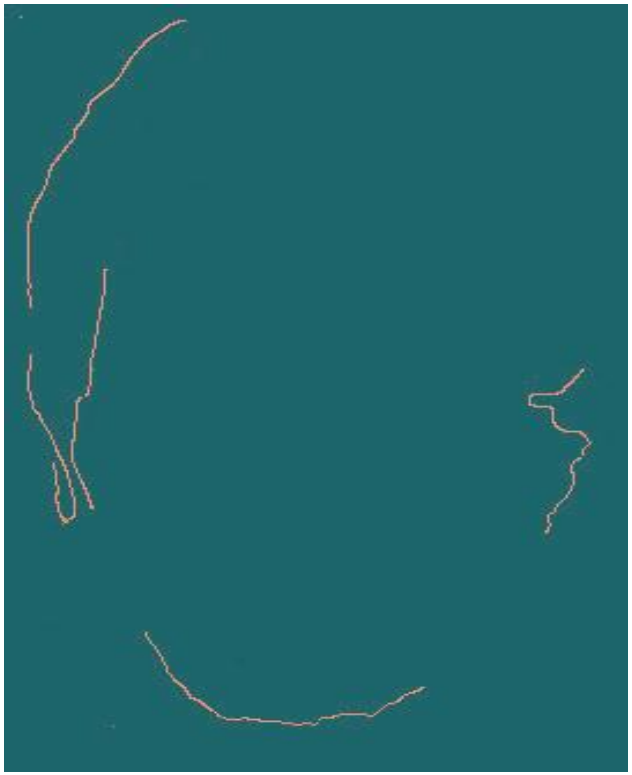
LONGEST EDGE DETECTION

Longest edges are considered to be parts of the face boundary.

Output after Canny Edge Detection

Longest edge

LONGEST EDGES



Edge map of longest edges of four region of face.

Genetic Algorithm

- It was used to find the thresholds for Canny Edge Detection that give the longest edges.

Active Contour Model

- The output of the edge map of the longest edges were supposed to be treated with the active contour model or Hough transform in order to find the continuity in the edges.

Problems

- All the thresholds in the Canny Edge Detection provide the longest edges with the similar length.
- This process consumes too much time

Solution

- Adaptive active contour algorithm(Snake algorithm)
- The result that was supposed to be obtained from above all methods of Canny Edge Detection, Genetic algorithm and active contour model was easily obtained by applying only Snake Algorithm

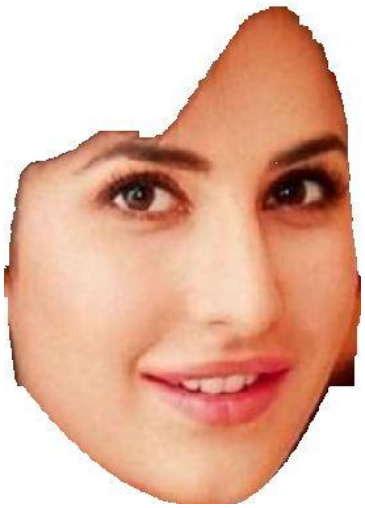
3. Adaptive Active Contour Model

(Snake Algorithm)

- Skin color thresholding doesn’t give fine output for the faces with shadows.

Original Image

Result of skin color thresholding



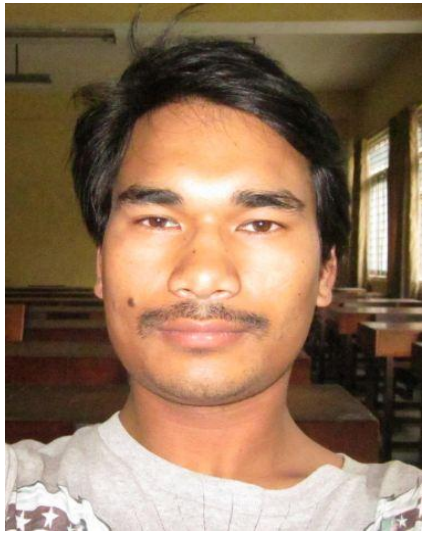
Result of snake algorithm

- The processing time of Snake Algorithm is lesser than the combined processing time of Canny Edge Detection, Active Contour Model and Genetic Algorithm.
- Also the expected result from combined Canny Edge Detection, Genetic Algorithm and Active Contour Model was single obtained using Snake algorithm and even better.

Outputs (Snake Algorithm)

T = 3 and I = 10

After applying Snake



T = 2 and I = 11

After applying Snake

Input Image

Output Image

Conclusion For Face Extraction

- Use skin color thresholding when there is no shadow in face and face color can be separated from background.
- Use snake algorithm when the face edges are clear

CHIN CURVE ESTIMATION

- Chin curve can be estimated using feature points
- It is used for separating face and neck region

CHIN CURVE ESTIMATION

Original Image

Image with Chin curve

CHIN CURVE ESTIMATION

Before curve estimation

After curve estimation

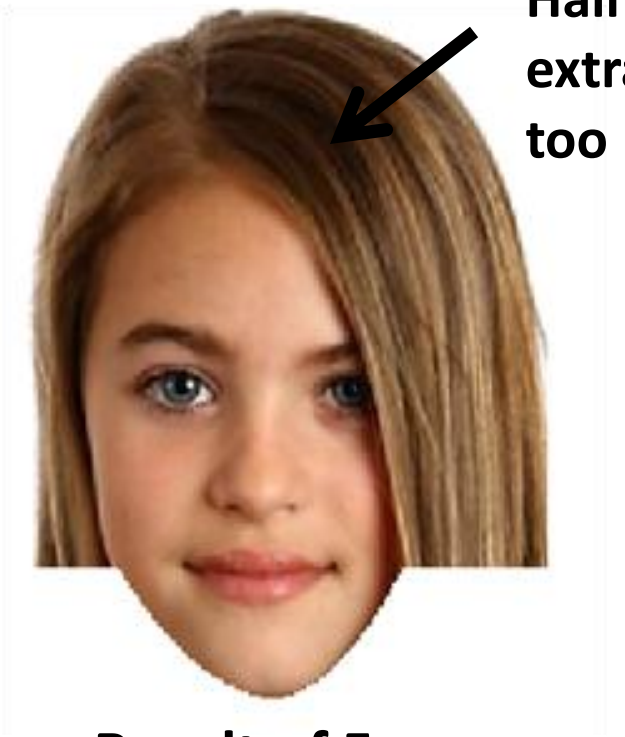
3. HAIR AND BACKGROUND REMOVAL

Problem:

Hair and Background may have colors similar to that of the face.

PROBLEM: HAIR IS EXTRACTED TOO

Original Image



Result of Face Extraction

SOLUTION

Solution:

Extract Hair/ Background too.

Remove those regions from the result.

HAIR AND BACKGROUND REMOVAL

Before removing hair

After removing hair

BUT HOW?

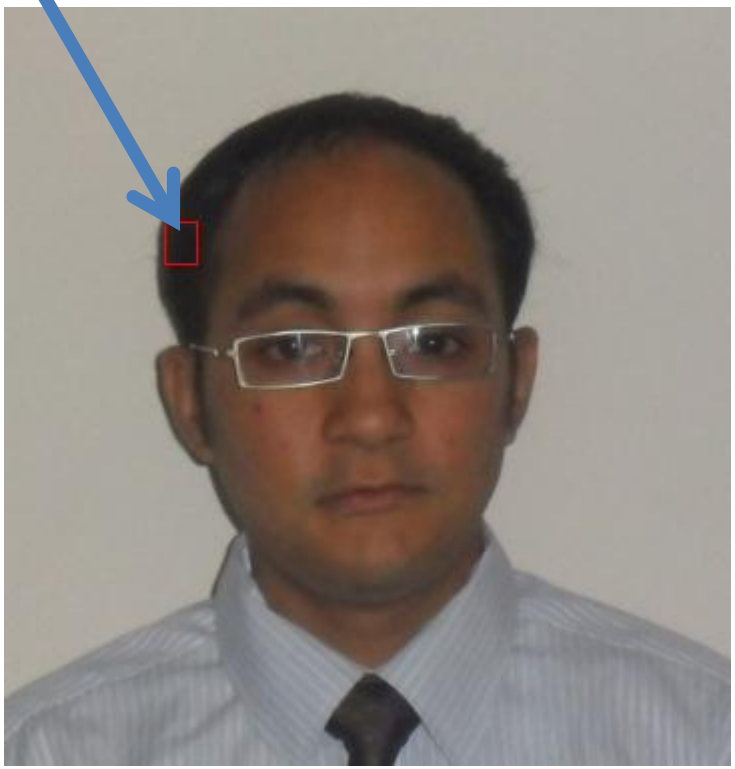
Background and hair regions can be extracted using:

SEED REGION GROWING ALGORITHM

It places similar (connected) pixels into same region.

SEED REGION GROWING

Seeds

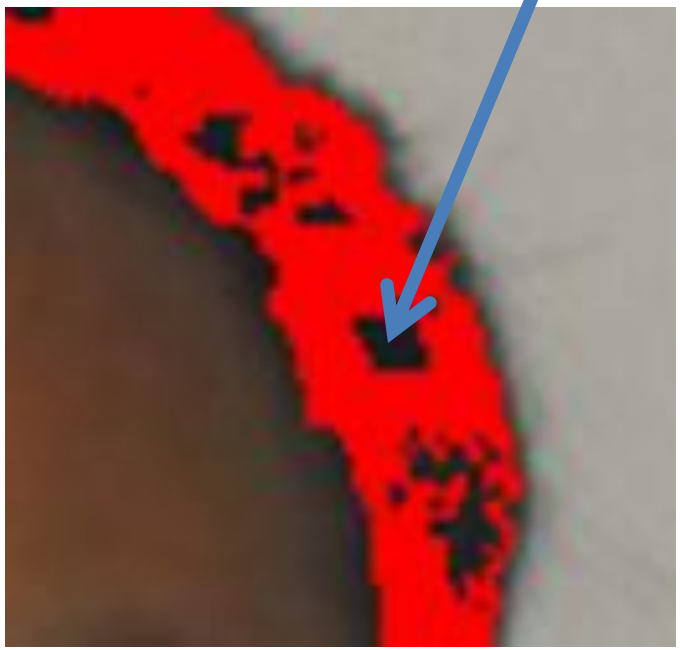


Specifying seed pixels

After applying “Seed Region Growing”

SEED REGION GROWING

Problem: The result contains “holes” inside the region.



The image shows that the hair region has not been extracted properly.

Solution: Fill up the holes

Before filling the holes

After filling the holes

IMAGE WARPING

Source and Target faces might have different **sizes** and **pose angles**.

Source Image

Target Image with different size and pose

IMAGE WARPING

Therefore, the source image needs to be:

1. Shifted
2. Scaled
3. Rotated

This is image warping.

EXAMPLE

Source

Target

After Warping

Here, the source face has been **ROTATED ANTI-CLOCKWISE**.

It has also been **SCALED** to a different size.

INTERPOLATION

The image thus obtained contains fuzziness. So the intensity levels should be interpolated.

Before Interpolation

After Interpolation

APPROPRIATE POSITION TO PASTE

The source face is pasted in such a way that region of overlap of the source and target face regions is the largest. The source face is shifted in search for such a position.

OVERLAP

LESS OVERLAP

MORE OVERLAP

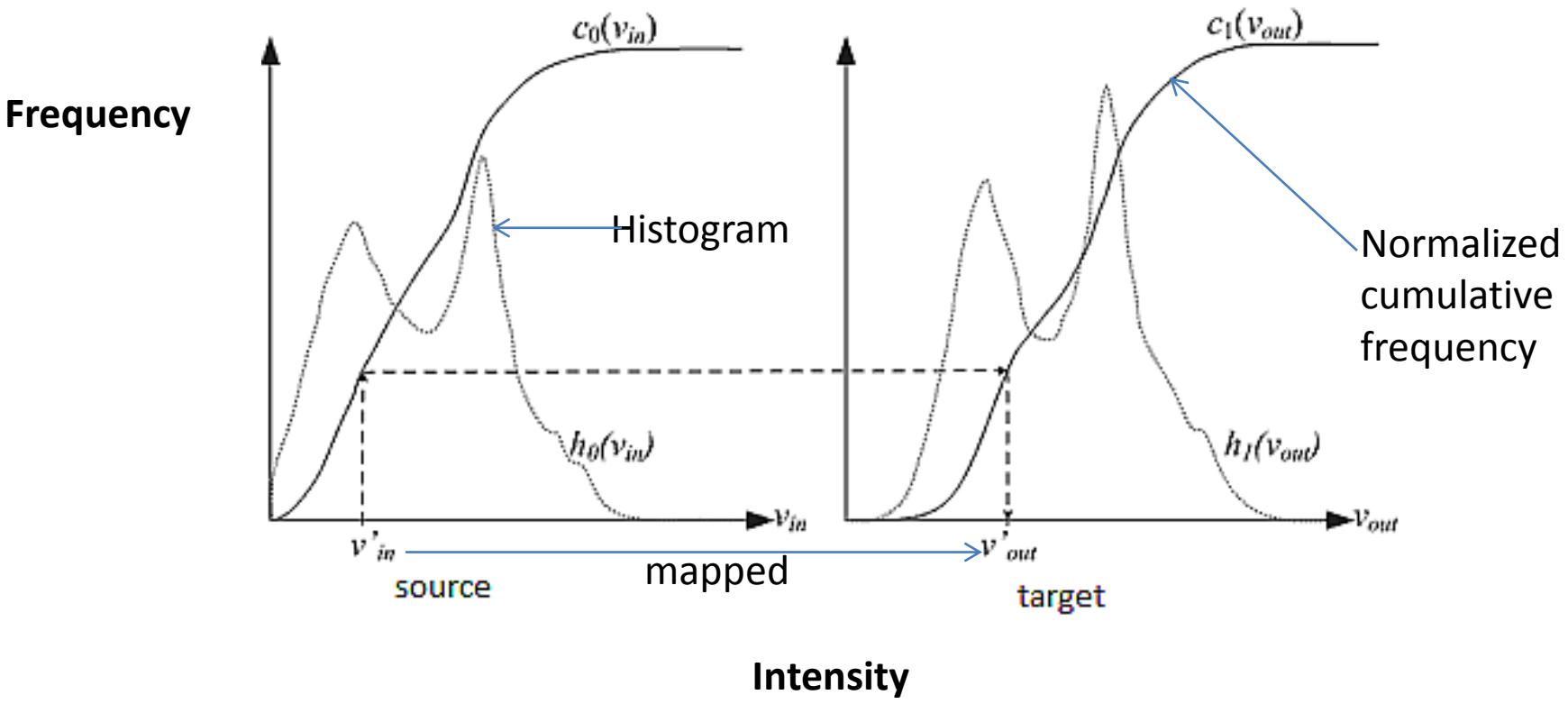
NOT SO GOOD

MUCH BETTER

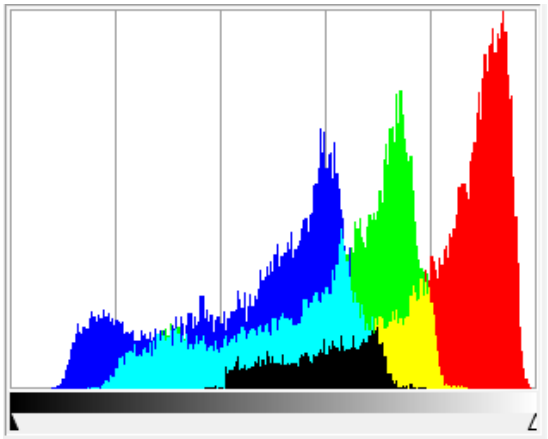
COLOR CONSISTENCY

HISTOGRAM MATCHING

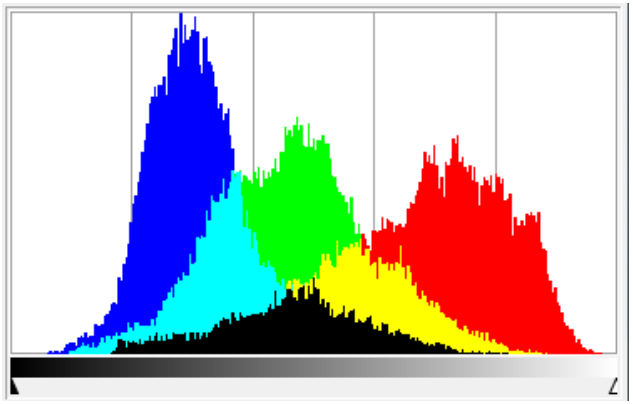
- It is a method of generating image that has a specified histogram
- The specification of the histogram is given by the histogram of target image


Frequency
$c_0(v_{in})$
Histogram
$h_0(v_{in})$
v_{in}
v'_{in}
source
mapped
$c_1(v_{out})$
Normalized
cumulative
frequency
$h_1(v_{out})$
v_{out}
v'_{out}
target
Intensity

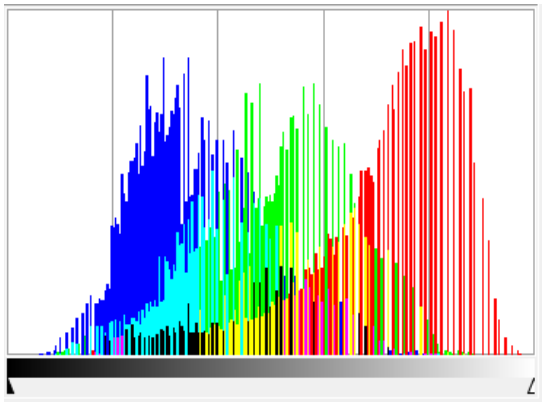
Result



Source image and
its histogram



Target image and
its histogram



Result image and
its histogram

BLENDING

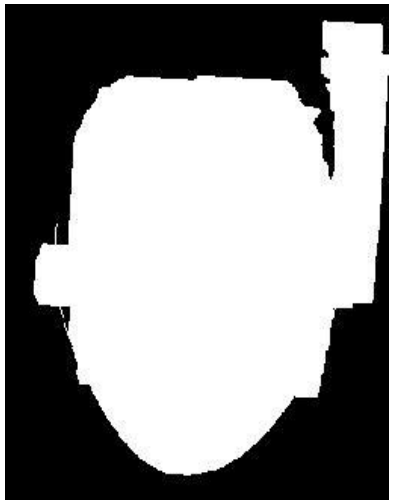
- Two major steps
  - Alpha Blending
  - Intensity Interpolation

Alpha Blending

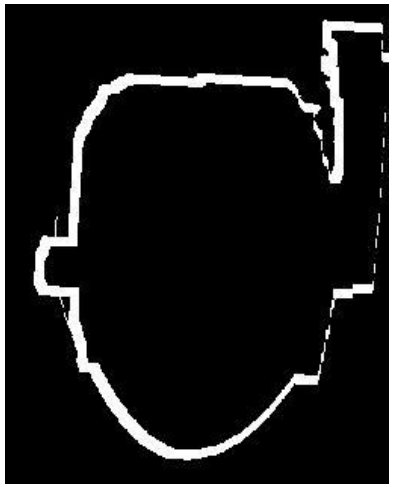
- Used to smooth the sharp transition of regions in the boundary
- Use iterative transparency variation

Process of alpha blending

- Create a transparency gradient in the face boundary



Face Region



Face Boundary

ALPHA BLENDING

Before alpha blending

After alpha blending

Intensity Interpolation

- To reduce the region transition effect
- Increase realistic look in the edge
- Weighted Interpolation of Intensity through the boundary

Change in result

Alpha blended image

Intensity gradient Image

RESULTS OF FACE REPLACEMENT

SOURCE

TARGET

RESULT

RESULT

RESULT OF FACE REPLACEMENT

Source image

Target image

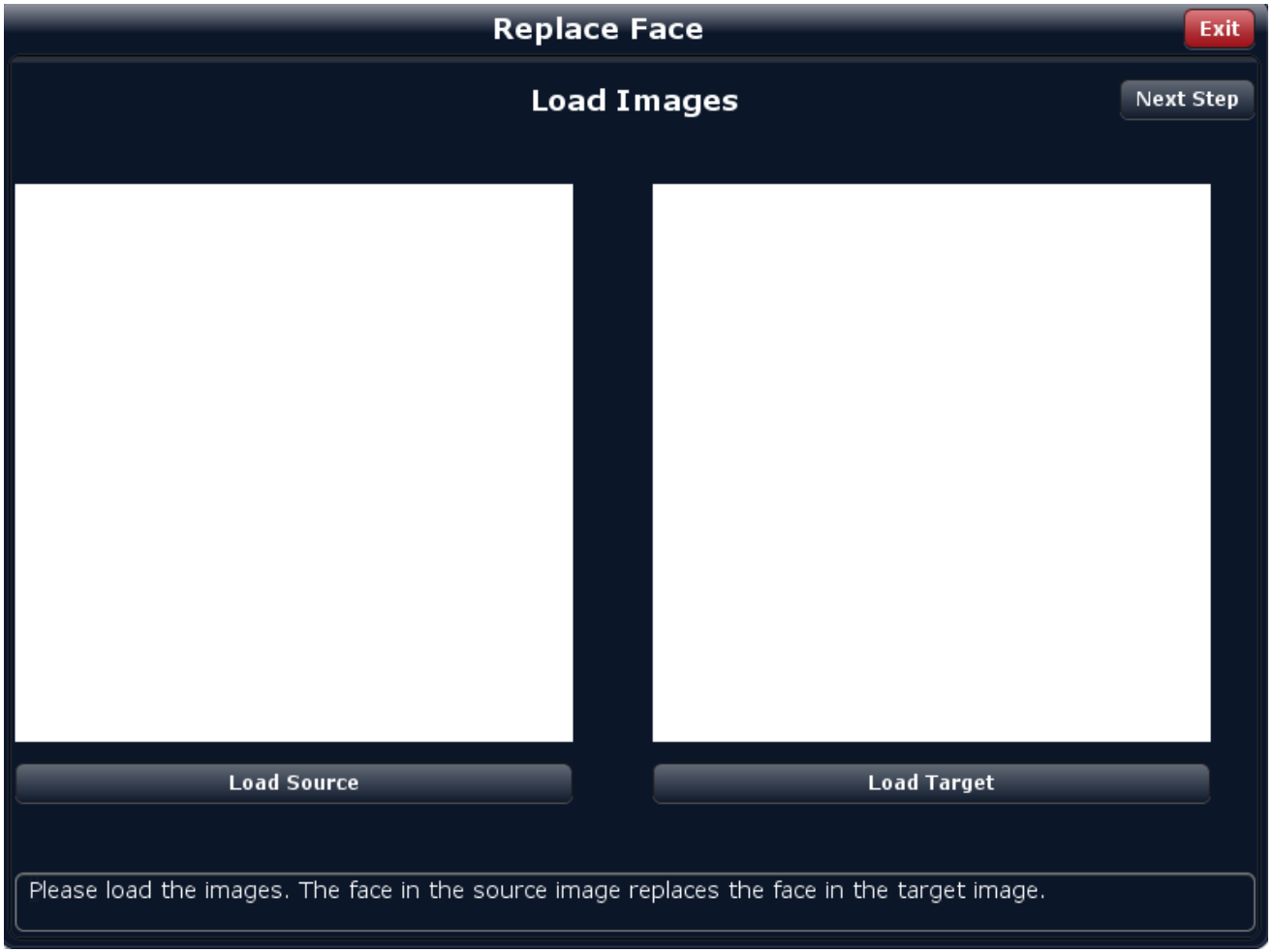
Result

FUTURE WORKS

The system can be extended for

1. profile (side) view.
2. transferring facial expressions.
3. notifying the users if the faces cannot be replaced accurately.
4. automatic feature points allocation

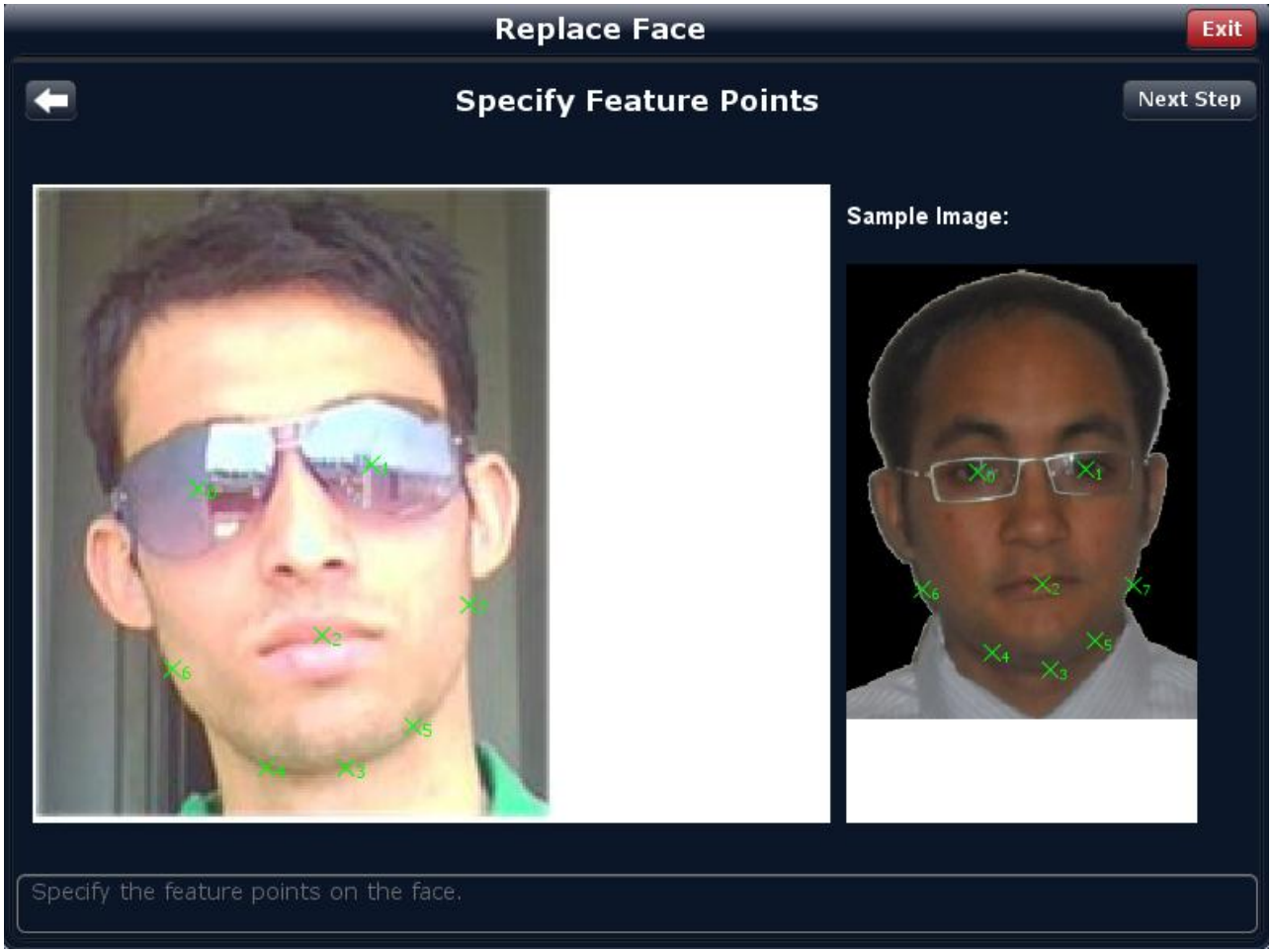
SCREENSHOTS OF APPLICATION



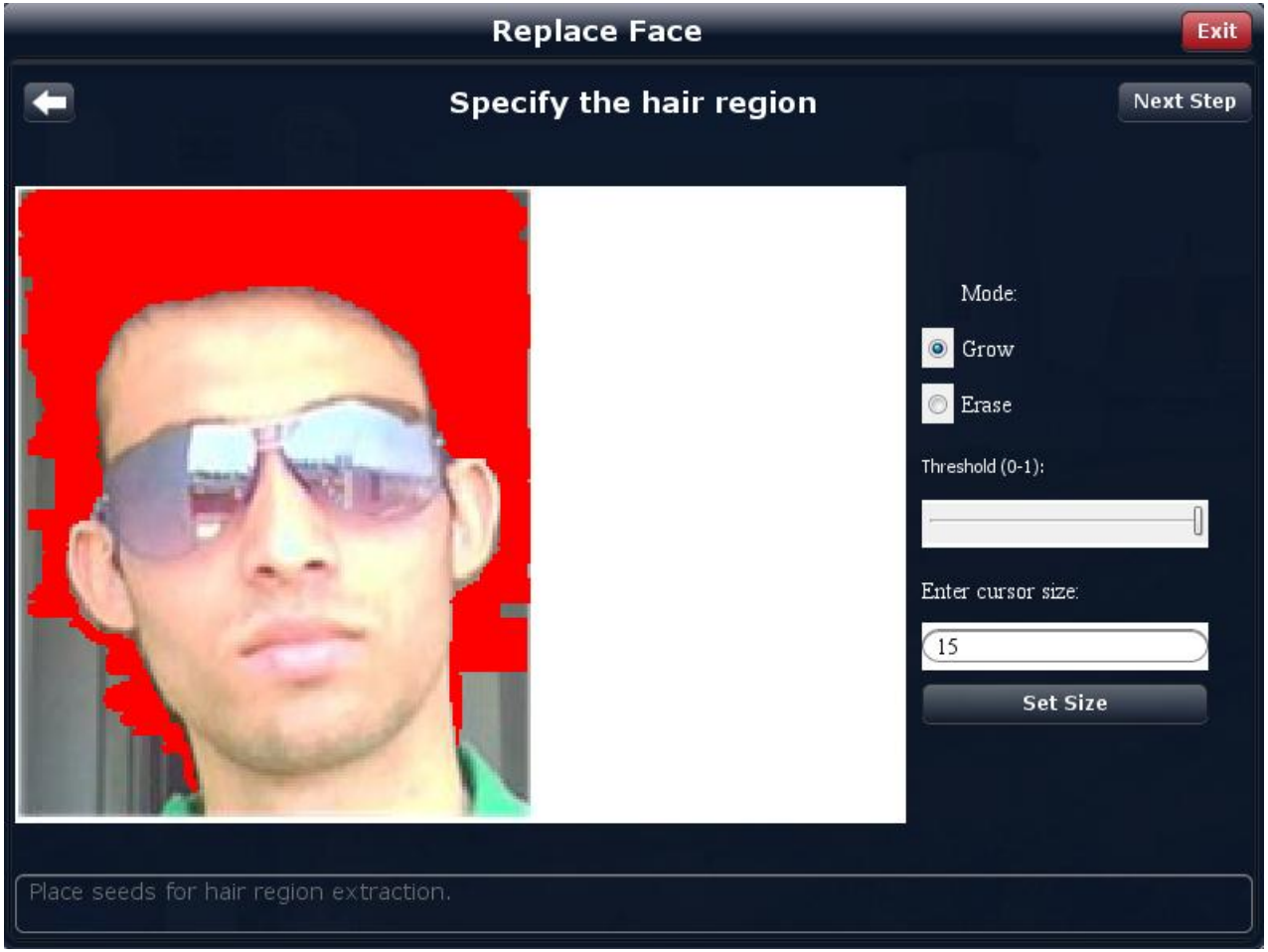
LOAD IMAGES


Replace Face
Exit
Load Images
Next Step
Load Source
Load Target
Please load the images. The face in the source image replaces the face in the target image.

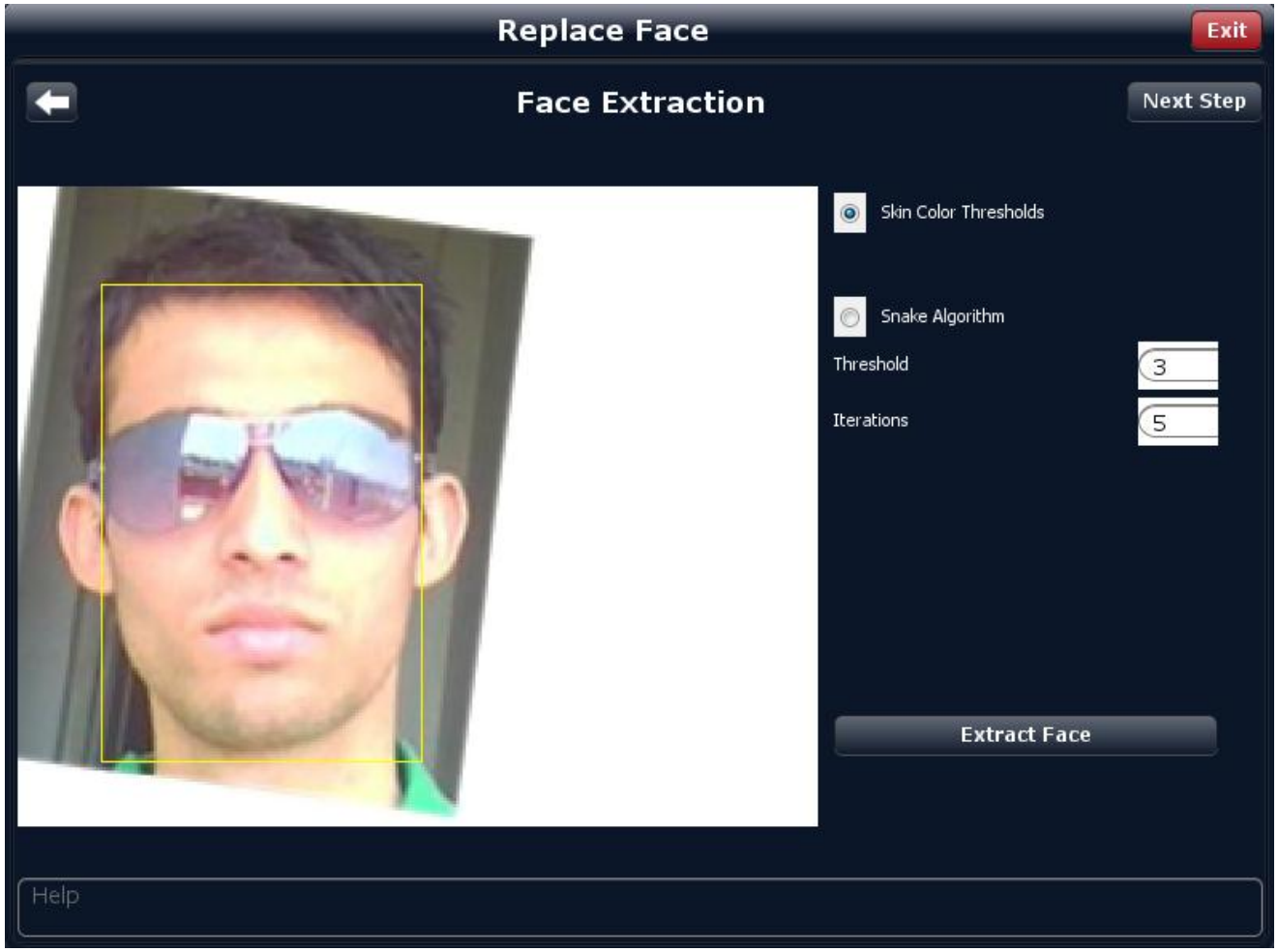
SPECIFY FEATURE POINTS OF SOURCE



SPECIFY SOURCE HAIR



SOURCE FACE EXTRACTION

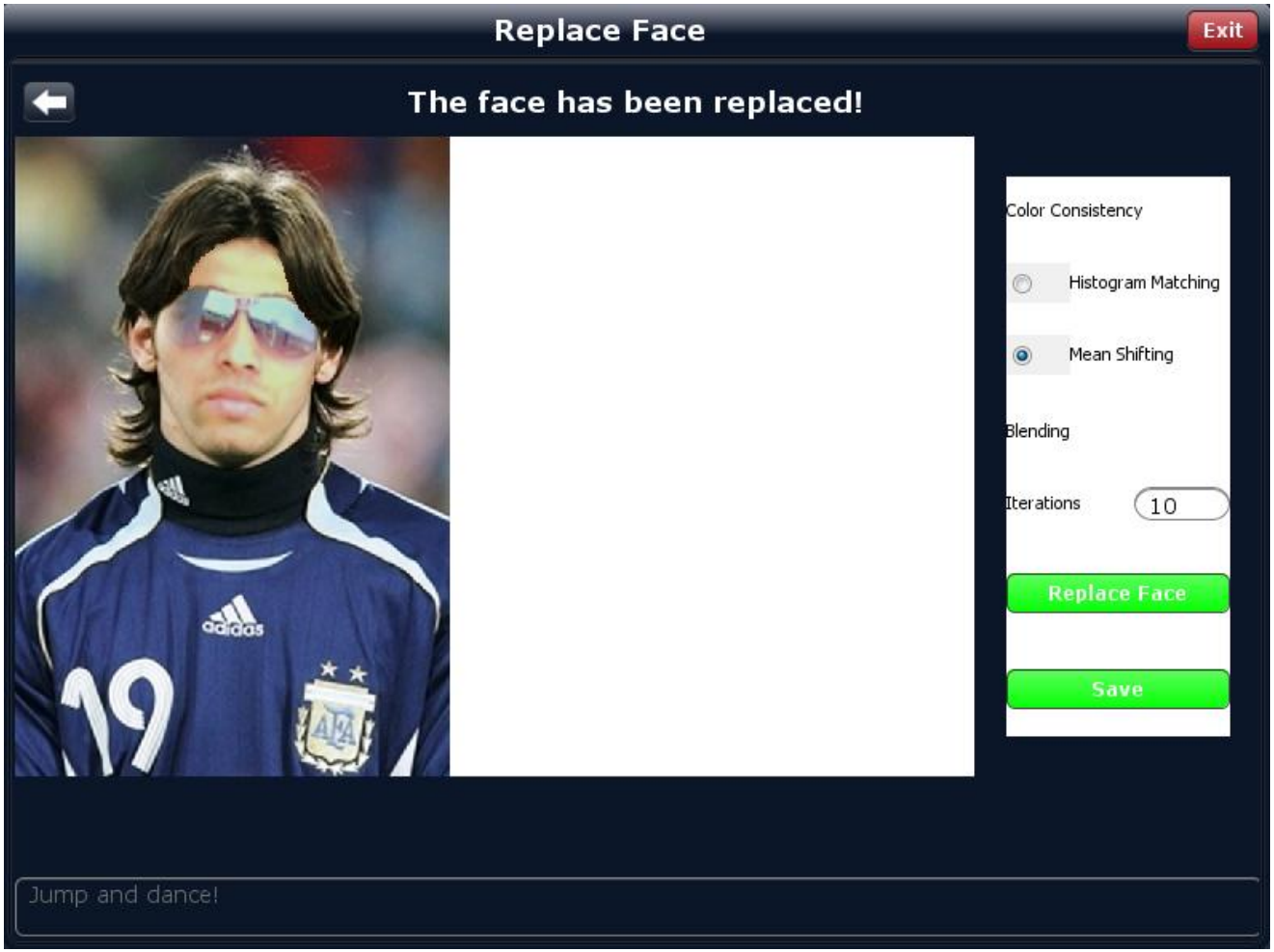


SPECIFY TARGET FEATURE POINTS

SPECIFY TARGET HAIR

TARGET FACE EXTRACTION

FINAL RESULT

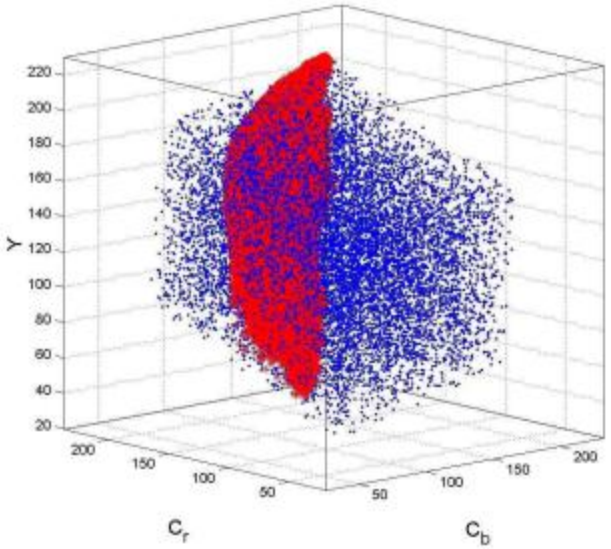


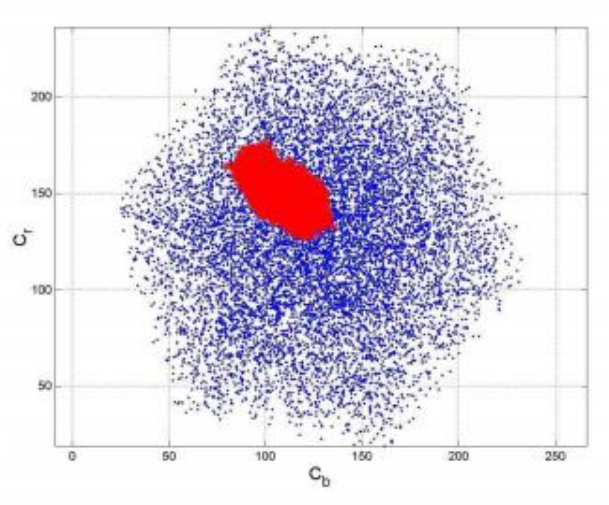
Thank You

Questions ?

BACKUP SLIDES

SKIN COLOR THRESHOLDING





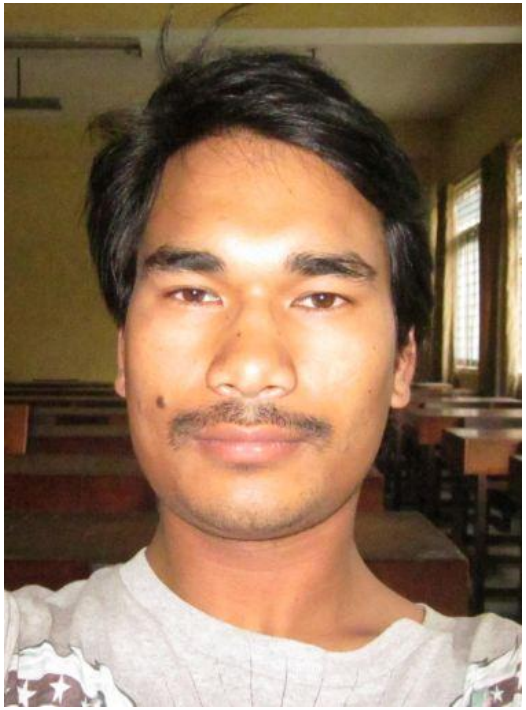
YCbCr Color Space

2D Projection on CbCr

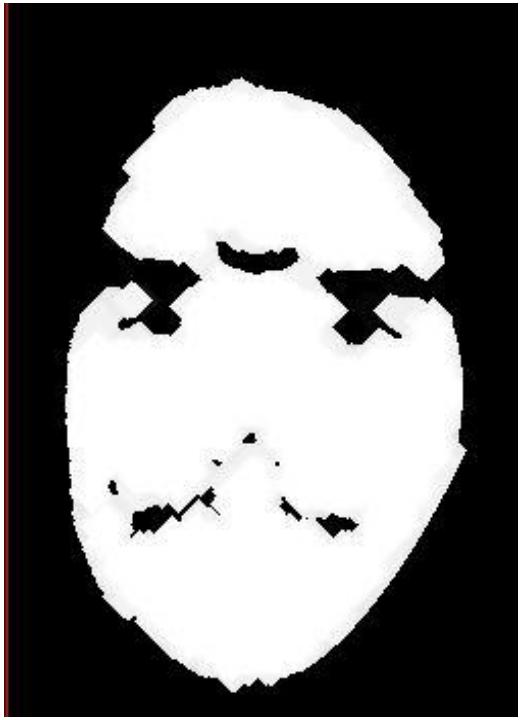
BLUE dots represent the reproducible color on a monitor

RED dots represent the skin color samples

OUTPUT OF SHRINKING AND GROWING



Original Image



Result of "shrinking and growing" algorithm

After hole filling

The face is divided into four regions:

- Forehead
- Left Face
- Right Face
- Bottom Face