Face Detection

MaryJane B. Miceli

Computer Vision

December 19th, 2005

Face Detection

- Face detection deals with the problem of identifying a face, and if one exists in the image.
- It is a much harder problem then recognition.
- Generally, in recognition systems, the model at least knows the input image is a face.

A few different approaches

The three approaches we will look at today are:

- Color-based approach
- Feature-based approach
- Model-based approach

Color-based approach

The color-based approach labels each pixel in a image according to its similarity to skin color and the region whether or not it’s in a region of similar skin colors.

Color-based approach

The HSV color space gives the best performance model for skin color detection for each pixel. What does HSV mean?

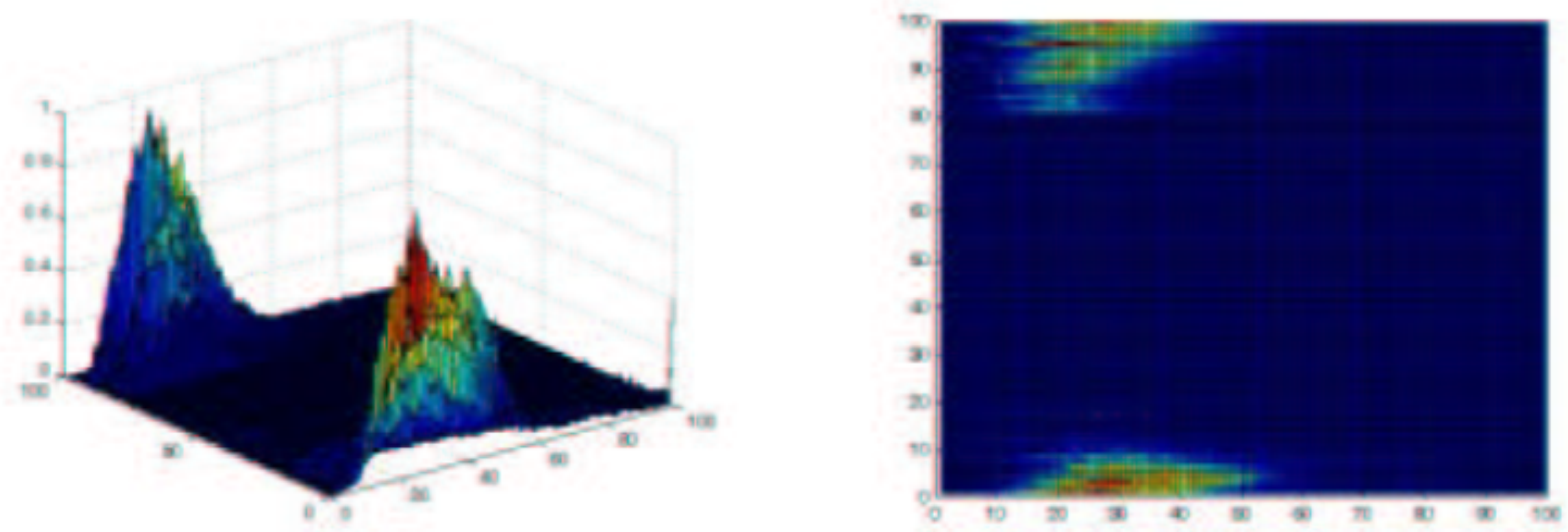
- The H stands for hue and describes the shade of color.
- The S stands for saturation component and tells how pure the hue is.
- The V stands for the value component and tells how bright the hue is.

Color-based approach

If we remove the V value for brightness, we can use this model without the worry of varying brightness in different images.

We find that skin color is within a small region of the HS color space.

Color-based approach



(a) (b)

Figure 1: HS histogram for skin pixels (a) 3D view (b) 2D view

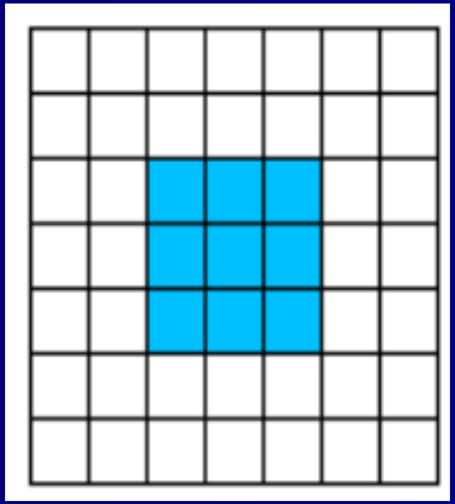
Color-based approach

The proposed algorithm [5]:

- Convert RGB (rgb(i,j)) image to HSV (hsv(i,j)) image.
- Get the edge map image (edge(i,j)) from the RGB image using Sobel operator.
- For each pixel, get the corresponding H and S values.
- If (colorhistogram(H,S) > Skinthreshold) and (edge (i,j) < edgethresold) then skin(i,j)= 1 e.g. is a skin pixel else skin(i,j) = 0 e.g. a non-skin pixel.
- Find the different regions in the image by implementing connectivity analysis using 8-connected neighborhood.
- Find height, width and centroid for each region and percentage of skin in each region.
- For each region, if (height/width) or (width/height) is within the range (Goldenratio + tolerance) and percentage of skin > percentagethreshold) then the region is a face, else it is not a face.

Color-based approach

An 8-connected neighborhood means the surrounding pixels are in its neighborhood.



Color-based approach

- A threshold is used to determine what level a bin in the histogram needs to be at to be included as a face pixel.
- Those thresholds that are set to low, could have a lot of false positives face areas.
- Those thresholds that are too high, may lead to false negative face areas.

Color-based approach

(a) (b)

Figure 2: Classification of pixels as skin or non-skin (a) Original Image (b) Skin detected Image

Color-based approach

- Advantages to this approach allow a model to quickly identify areas with possible faces quickly.

- Disadvantages to this approach is that it doesn’t work on black and white photos, sepia tones, or negatives. This algorithm also doesn’t discriminate between a face and a hand.

Feature-based approach

The bottom-up feature-based approach model searches and entire image for a set of face features and groups them as candidates based on geometric relationships.

Feature-based approach

This following example of an algorithm uses a colored-based approach to find areas of a possible face, then tries to find faces by looking for a feature. This is a simple example of one feature: the eyes. This approach is proposed by Peer and Solina.

Feature-based approach

The original image

Feature-based approach

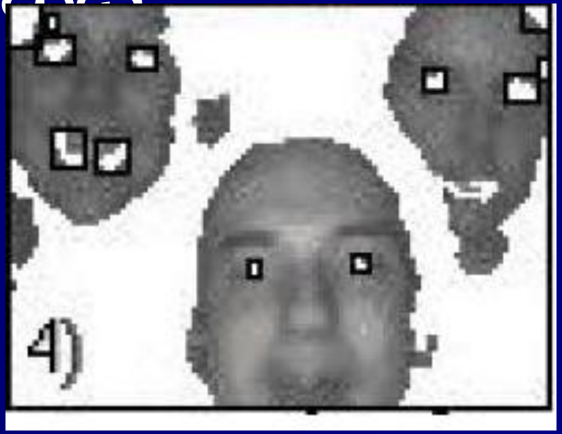
All non-skin colors are removed from the images and replaced with white color. Image is then converted to a grey scale image.

Feature-based approach

The image is filtered with a median filter, which blurs unimportant white regions

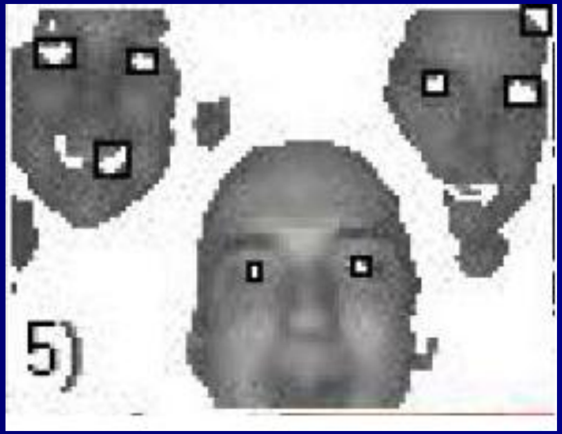
Feature-based approach

A “Region growth” algorithm is used to segment white regions. Areas that cannot contain a pair of eyes are eliminated. Image areas are traced with significant grays.



Feature-based approach

Using a Hough Transform the remaining regions searches for circles – possible eyes.



Feature-based approach

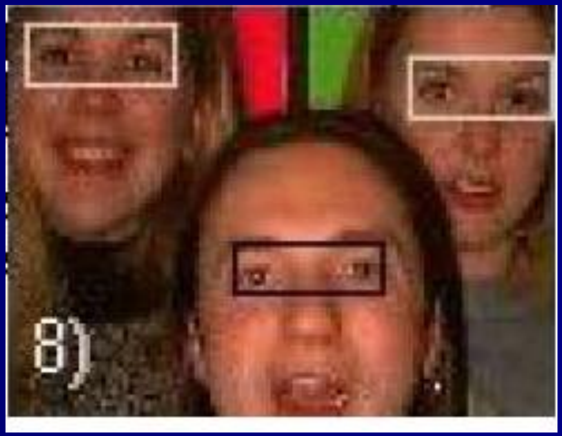
Within each region, a best possible circle is found.

Feature-based approach

The algorithm uses geometry to find the other circle - the other eye.

Feature-based approach

Color information is used to help predict the probability of a face. Finally, using heuristics, the algorithm tries to remove falsely classified eyes.



Feature-based approach

The advantage to this model is that it does distinguish between a hand and a face more easily.

This disadvantage, is that lots of circles could be falsely identified.

Model-based approach

The Top-down model-based approach makes the assumption that a different face model at different course-to-fine scales is needed. The model searches the image at the coarsest scale first and moves to a finer scale until a match is found.

Model-based approach

This model-based approach can utilize eigenfaces, which we went over last week in class.

Eigenfaces go by many terms:

PCA (Principal Component Analysis)

Eigenspace

Model-based approach

What are eigenfaces?

"In layperson's terms, **eigenfaces** are a set of "standardized face ingredients", derived from statistical analysis of many pictures of faces. Any human face can be considered to be a combination of these standard faces. One person's face might be made up of 10% from face 1, 24% from face 2 and so on. This means that if you want to record someone's face for use by face recognition software you can use far less space than would be taken up by a digitised photograph." [12]

Model-based approach

- To generate a **set of eigenfaces**, a large set of digitized images of human faces, taken under the same lighting conditions, are normalized to line up the eyes and mouths. They are then all resampled at the same pixel resolution (say $m \times n$), and then treated as mn-dimensional vectors whose components are the values of their pixels. The eigenvectors of the covariance matrix of the statistical distribution of face image vectors are then extracted.
- Since the eigenvectors belong to the same vector space as face images, they can be viewed as if they were $m \times n$ pixel face images: hence the name

Model-based approach

- When properly weighted, eigenfaces can be summed together to create an approximate gray-scale rendering of a human face. Remarkably few eigenvector terms are needed to give a fair likeness of most people's faces, so eigenfaces provide a means of applying data compression to faces for identification purposes. [12]

Model-based approach

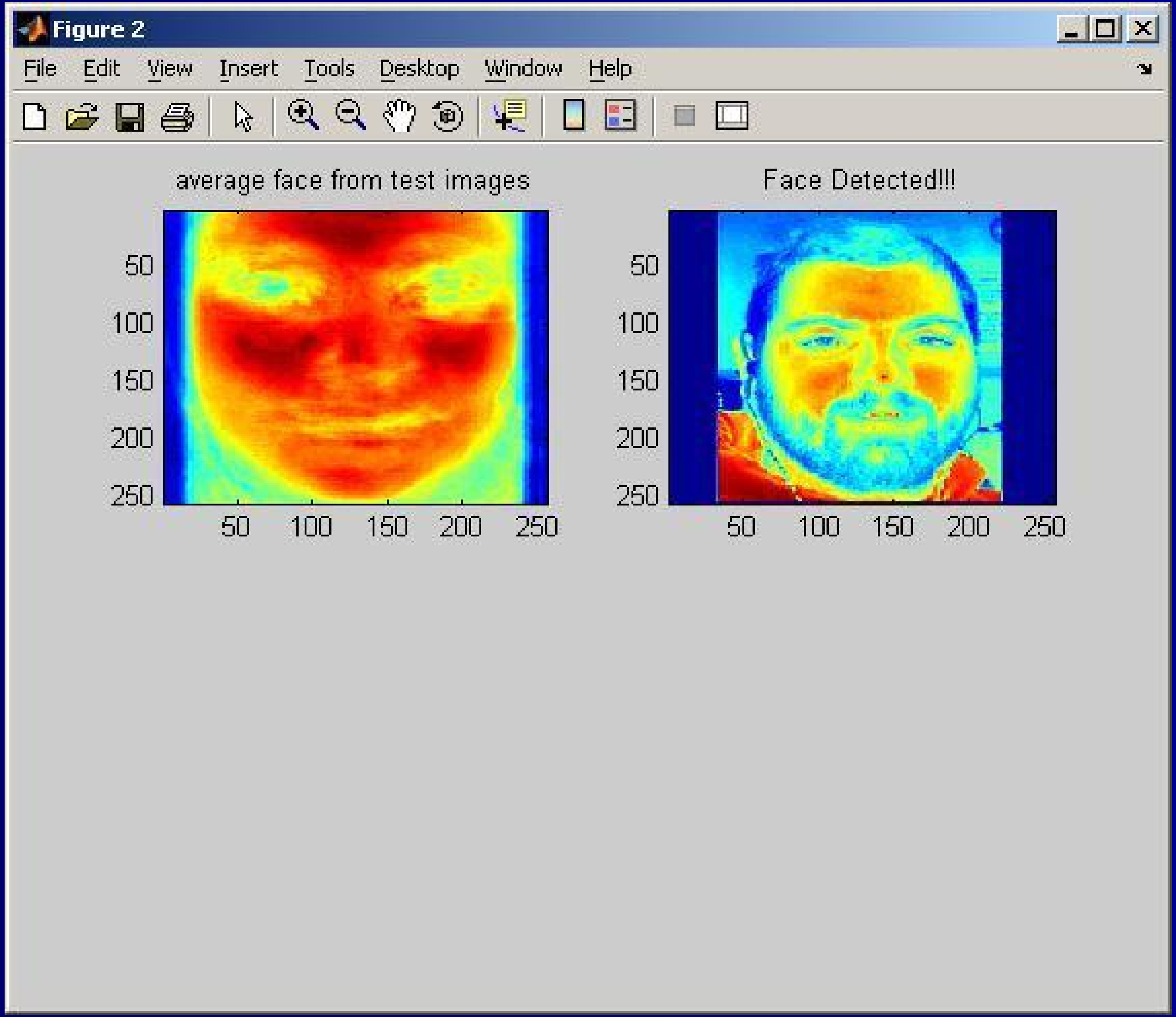
I implemented the algorithm and used 20 pictures that were 256x256 pixels to create the average eigenface. This is a projection in to the face space, or a a point in a 65,536 dimensional vector.

Model-based approach

Model-based approach

The average face

Model-based approach



Model-based approach

The eigenface approach seems to be the most widely used for face recognition. This can be easily utilized for face detection given a wide range of faces. A threshold is need and can be calculated by how different the face is from the average face. Experimentation on a large scale is needed to find out what this threshold should be.

Summary

The three approaches we looked at today were:

- Color-based approach
- Feature-based approach
- Model-based approach

Summary

There are many more approaches including:

The Texture-based approach

The Neural network approach

The rotation invariant approach

Color-based with other color scales

… Just to name a few.

Summary

None of these models presented, or that I've researched, are a complete solution to the problem of face detection. A combination of the models seems to be the best solution to date.

References

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- Questions?