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UNIVERSITY PROJECT REPORT

FACIAL RECOGNITION

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INTRODUCTION:

Face recognition is the task of identifying an already detected object as a known or unknown face.Often the problem of face recognition is confused with the problem of face detection. Face Recognition on the other hand is to decide if the "face" is someone known, or unknown, using for this purpose a database of faces in order to validate this input face.

In recent years, face recognition has attracted much attention and its research has rapidly expanded by not only engineers but also neuroscientists, since it has many potential applications in computer vision communication and automatic access control systems. Face detection is especially an important part of face recognition as the first step of automatic face recognition. However, face detection is not straightforward because it has lots of variations of image appearance, such as pose variation (front, non-front), occlusion, image orientation, illuminating condition and facial expression.

There are two predominant approaches to the face recognition problem: Geometric (feature based) and photometric (view based).

OBJECTIVES:

The project's objectives were:

1. To create a facial detection system
2. Build upon the same facial detection system to create facial recognition using geometric feature based approach

METHODOLOGY

Recognition algorithms can be divided into two main approaches:

1. Geometric: Is based on the geometrical relationship between facial landmarks, or in other words the spatial configuration of facial features. That means that the main geometrical features of the face such as the eyes, nose and mouth are first located and then faces are classified on the basis of various geometrical distances and angles between features.

2. Photometric stereo: Used to recover the shape of an object from a number of images taken under different lighting conditions. The shape of the recovered object is defined by a gradient map, which is made up of an array of surface normals.

Furthermore, facial recognition models can be broken down into 4 phases.

PHASE	PROCESS	DESCRIPTION
Phase 1	Detection	Initial Recognition
Phase 2	Analysis	Measurement of the curves of the face on a sub-millimeter scale
Phase 3	Extraction	The mean of the computed feature and the feature of the first principal component are selected.
Phase 4	Retrieval	Retrieval of stored data that is a match from database.

Phase 1 - Detection

In order to work, face detection applications use machine learning and formulas known as algorithms to detect human faces within larger images. These larger images might contain numerous objects that aren't faces such as landscapes, buildings and other parts of humans.

While the process is somewhat complex, the algorithms often begin by searching for human eyes. Eyes constitute what is known as a valley region and are one of the easiest features to detect. Once the algorithm surmises that it has detected a facial region, it can then apply additional tests to validate whether it has, in fact, detected a face.

The face detection system can be divided into the following steps:-

Phase 1.1 - Pre-Processing: To reduce the variability in the faces, the images are processed before they are fed into the network. All positive examples, that is the face images, are obtained by cropping Department of ECE Page 3 images with frontal faces to include only the front view. All the cropped images are then corrected for lighting through standard algorithms.

Phase 1.2 - Classification: Neural networks are implemented to classify the images as faces or non faced by training on these examples. We use both our implementation of the neural network and the Matlab neural network toolbox for this task. Different network configurations are experimented with to optimize the results.

detection

```
from PIL import Image, ImageDraw
from IPython.display import display

# The program we will be finding faces on the example below
pil_im = Image.open('two_people3.jpg')
display(pil_im)
```

Phase 1.3 - Localization: The trained neural network is then used to search for faces in an image and if present localize them in a bounding box. Various Feature of Face on which the work has done on:- Position Scale Orientation Illumination

Phase 2 - Analysis

Only the necessary high contributing descriptors are collected out of the massive data dump and the redundant data clusters are weeded out. The primary goal of principal component analysis for facial recognition is the transformation of higher dimensional data into a lower feature subspace known as the eigenface.

This eigenspace represents the locus of the covariance matrix of the feature landmarks. Dimensionality reduction in matrix principal component analysis is obtained by truncation of the singular value decomposition.

Phase 2.1 - Colour Segmentation: Detection of skin color in color images is a very popular and useful technique for face detection. Many techniques have been reported for locating skin color regions in the input image. While the input color image is typically in the RGB format, these techniques usually use color components in the color space, such as the HSV or YIQ formats. That is because RGB components are subject to the lighting conditions thus the face detection may fail if the lighting condition changes. Among many Page 2 color spaces, this project used YCbCr components since it is one of existing Matlab functions thus saving computation time. In the YCbCr color space, the luminance information is contained in the Y component; and, the chrominance information is in Cb and Cr. Therefore, the luminance information can be easily de-embedded. The RGB components were converted to the YCbCr components using the following formula.

In the skin color detection process, each pixel was classified as skin or non-skin based on its color components. The next step is to separate the image blobs in the color filtered binary image into individual regions. The process consists of three steps. The first step is to fill up black isolated holes and to remove white isolated regions which are smaller than the minimum face area in the training image. The filtered image followed by initial erosion only leaves the white regions with reasonable areas

Gray information within a face can also be treated as important features. Facial features such as eyebrows, pupils, and lips appear generally darker than their surrounding facial regions. Various recent feature extraction algorithms search for local gray minima within segmented facial regions. In these algorithms, the input images are first enhanced by contrast-stretching and gray-scale morphological routines to improve the quality of local dark patches and thereby make detection easier. The extraction of dark patches is achieved by low-level gray-scale thresholding. Based method and consist of three levels.

Phase 3 - Extraction

A set of eigenimages would be generated and then the eigenimages would be computed using the test images. In order to get a generalized shape of a face, the largest 10 eigenimages in terms of their energy densities, would be obtained. To save computing time, the information of eigenimages would be compacted into one image.

Phase 3.1 - Building Eigenimage Database : In order to save time to magnify or shrink an eigenimage to meet the size of the test image, a group of eigenimages was stored in the database so that an appropriate eigenimage can be called with ease without going through an image enlarging or shrinking process. The stored eigenimages were normalized by means of dividing the image matrix by its 2nd norm so that the effect of eigenimage size does not affect the face detection algorithm.

Phase 3.2 - Test Image Selection: After the color-based segmentation process, skin-colored areas can be taken apart. Given this binary image, a set of small test images needs to be selected and passed to the image matching algorithm for the further process.

Phase 4 - Retrieval

The test images selected by an appropriate square window can be passed to the image matching algorithm. Before the image matching process, the test image needs to be converted to gray scale, and should be divided by the average brightness of the image in order to eliminate the effect of the brightness of the test image in the process of image matching.

Average brightness was defined as the 2nd norm of the skin-colored area of the test image. Note that it is not the 2nd norm applied to the total area of the test image, since the value that we are looking for is not the average brightness of the test image, but the average brightness of the skin colored parts only.

With the normalized test image, the image matching can be simply accomplished by loading a correspondent file of eigenimage from the database, then performing correlation of the test image with respect to the loaded eigenimage.

Phase 4.1 - Distance Compensation: Since the figure to be tested can potentially be a group picture, faces in the figure are located close to each other in the central area of the figure. However, hands, arms, or legs are relatively located far from the faces in the figure. Therefore, the mean square distance of a test image with respect to other test images can be calculated, and then its reciprocal can be multiplied to the correlation value obtained above, to take the geographical information into account. In other words, a test image which is located close to the other test images will get a larger correlation value, while a test image which is far from the other group will have smaller correlation value.

Some faces are divided into several pieces. This is due to the erosion process which was applied to evade occlusion. To merge these separate areas into one area, a box-merge algorithm was used which simply merges two or more adjacent square boxes into one. Since this phenomenon happens between face and neck part most of times, distance threshold was set small for horizontal direction, while set large for vertical direction.

Results And Analysis

The Statistical Approach

To filter out and find faces as such, several approaches have been taken, but it was not easy to find an absolute threshold value which can be applied to various pictures with different light conditions and composition. Approaches using luminance, average brightness, and etc., have been tried, but they turned out not to be good enough to set an appropriate threshold for filtering out non-facial test images. Lastly, a statistical method was tried. The histogram of the correlation values after geographical consideration shows wide distribution of the output values.

To confirm that this actually works to a reliable extent, we had tested it in one of our early works by storing the values in an array and printing it. The resultant image and array is shown below along with the relevant graph.

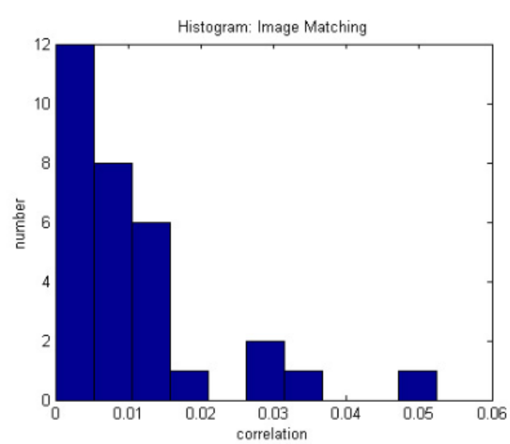

Fig. 15. Histogram: Image Matching.

```
In [37]: import face_recognition
         image = face_recognition.load_image_file("rickroll_4k.jpg")
         image
```

```
Out[37]: array([[[185, 195, 246],
                 [185, 195, 246],
                 [185, 195, 246],
                 ...,
                 [173, 187, 226],
                 [178, 192, 231],
                 [185, 199, 236]],

                [[185, 195, 246],
                 [185, 195, 246],
                 [185, 195, 246],
                 ...,
                 [173, 187, 226],
                 [178, 192, 231],
                 [185, 199, 236]],

                [[185, 195, 246],
                 [185, 195, 246],
                 [185, 195, 246],
```

Conclusion

In color segmentation, a rectangular window was used for the skin color detection while the actual distribution was a cone shape. As a result, some of the actual skin color was excluded and conversely some of the non-skin color was included. More precise skin color detection is expected if the window shape is closer to the actual distribution, such as triangle. Despite this imperfect windowing, the overall results of skin color detection were very encouraging.

A modified version of the approach presented here for face detection and tracking can potentially decrease the computation time producing results with high accuracy. Using this system many security and surveillance systems can be developed and required faces can be traced down easily. In the coming days these algorithms can be used to detect a particular object rather than faces.

The future scope for face detection systems is immense. Future work is to work on the same domain but to track a particular face in a video sequence. That is like avoiding all other faces except the face required. This algorithm is only meant for frontal and upright movement of the faces. It doesn’t work when it comes to any arbitrary movement and hence, doesn’t make sense.

A future attempt could be to try to train classifiers so that it is subtle to all sort of movements while trying to find the displacement of the Eigenvectors using Taylor Series

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