# A COLOUR FACE IMAGE DATABASE FOR BENCHMARKING OF AUTOMATIC FACE DETECTION ALGORITHMS

Prag Sharma, Richard B. Reilly

Dept. of Electronic & Electrical Engineering,
University College Dublin, Belfield, Dublin 4, Ireland.
prag@ee.ucd.ie, richard.reilly@ucd.ie

**Abstract:** *With increasing research in the area of face segmentation, new methods for detecting human faces automatically are being developed. However, less attention is being paid to the development of a standard face image database to evaluate these new algorithms. This paper recognizes the need for a colour face image database and creates such a database for direct benchmarking of automatic face detection algorithms. The database has two parts. Part one contains colour pictures of faces having a high degree of variability in scale, location, orientation, pose, facial expression and lighting conditions, while part two has manually segmented results for each of the images in part one of the database. This allows direct comparison of algorithms. These images are acquired from a wide variety of sources such as digital cameras, pictures scanned in from a photo-scanner and the World Wide Web. The database is intended for distribution to researchers. Details of the face database such as the development process and file information along with a common criterion for performance evaluation measures is also discussed in this paper.*

**Key Words:** *Face Detection, Colour Face Image Database, Evaluation Performance.*

## 1. INTRODUCTION

Detecting human faces automatically is becoming a very important and challenging task in computer vision research. The significance of the problem can be easily illustrated by its vast applications, as face detection is the first step towards intelligent vision-based human computer interaction. Face recognition, face tracking, pose estimation and expression recognition all require robust face detecting algorithms for successful implementation. Segmenting facial regions in images or video sequences can also lead to more efficient coding schemes [1], content-based representation (MPEG4) [2], three-dimensional human face model fitting, image enhancement and audio-visual speech integration [3]. Although a major area of interest, many problems still need to be solved, as segmenting a human face successfully depends on many parameters such as skin-tones under varying lighting conditions, complexity level of the background in the image to be segmented and application for which the segmentation is required. Inherent differences due to the existence of different ethnic backgrounds, gender and age groups also complicate the face detection paradigm.

With so many new applications, the development of faster and more robust face detection algorithms has become a major area of research over the last few years. Techniques based on knowledge of rules that capture the relationship between facial features, feature invariant approaches that tend to define structural features that exist even when the pose, viewpoint and lighting condition vary, and template matching methods that use several standard templates to describe a face, are all being thoroughly investigated. A comprehensive survey on the methods used to detect faces in images can be found in [4]. However, many of the successful claims reported in the literature either use data sets that are too small or the test images acquired are not standard images and so can show biased results favouring one method over another. The comparison difficulties are due to the fact that much less attention has been paid to the development of a standard face detection database that can be used as a benchmark to test the performance of these new algorithms.

This paper is organised as follows. Section 2 gives details of the existing face detection databases and the need for a new database. Section 3 describes the ***UCD Colour Face Image Database for Face Detection*** in detail and Section 4 goes on to discuss the evaluation measures that can be used compare the performance of one algorithm against another. The concluding remarks are present in Section 5.

## 2. EXISTING FACE IMAGE DATABASES

Although several face image databases exist, most of them are geared towards the evaluation of face recognition algorithms. To this end, the face images in these databases end up being taken with a specific set up in order to maintain a degree of consistency throughout each database. For example, the most notable face image database is the FERET [5] database. In this database, each greyscale image consists of an individual (head and neck visible only) on a uniform and uncluttered background in mostly frontal positions. This is typical of many image databases that are available. For example, the MIT [6] database consists of frontal and near-frontal view images on a cluttered background. These databases are more useful as training sets rather then test sets for face detection purposes. A detailed description of the face recognition databases present can be found at [4].

Since all the face databases mentioned above are designed for the evaluation of face recognition algorithms, they are not ideal candidates for the evaluation of face detection algorithms. These databases do not provide the challenges that face detection algorithms can encounter in real applications: such as poor image quality, presence of multiple faces and faces with different orientations (up-right and rotated). To this end, some researchers have compiled image databases to date. Sung and Poggio created two databases for face detection [6]. The first set consists of frontal and near-frontal mugshots of different people in varying lighting conditions whereas the second set contains high and low quality images with most faces appearing in frontal and upright positions. All images are greyscale. Rowley et al. [7] created a face database with most images containing more than one face on a cluttered background. The face size varies significantly but most faces are upright and frontal and do

not contain colour information. To detect faces that are frontal but have a rotation in the image plane, a separate database was compiled [8]. Schneiderman and Kanade further extended the database to include faces with facial expression and in profile view [9]. While all the above databases contain only greyscale images, Kodak has compiled a colour face image database with a variety of face sizes and backgrounds [10]. Table 1 summarizes the above mentioned face detection databases.

**Table 1** Test Sets for Face Detection

| Data Set | Description |
|---|---|
| MIT Test Set (Sung and Poggio) [6] | First set contains 301 frontal and near-frontal mugshots of 71 different people and the second set contains 23 images with 149 faces in complex backgrounds. Most faces are frontal and upright. All images are greyscale. |
| CMU Test Set (Rowley et al.) [7], [8] | 130 images with a total of 507 frontal faces. Face sizes vary. All images are greyscale. Also contains 50 images with a total of 223 faces with 95% of the rotated at an angle of more than 10 degrees. All images are greyscale. |
| CMU Profile Test Set (Schneiderman and Kanade) [9] | 208 images with varying facial expressions and in profile view. The images are greyscale. |
| Kodak Data Set [10] | 80 images with 90% of the faces in frontal view. Wide variety of resolutions and face sizes. The images are in colour. |

### 2.1. Need for a New Database

As more face detection algorithms are being developed, new approaches that use multiple features such as skin colour, size, shape and presence of facial features are being developed. A typical approach starts with skin-colour based region detection [11], [12]. This is primarily due to the processing of colour information has proven to be much faster than the processing of other facial characteristics. Moreover, if an effective colour model can be created that adapts to varying lighting conditions, colour can be found to be invariant to changes in size, orientation and partial occlusion of the face. Because of these advantages, more and more algorithms are now using colour as a segmentation tool, [4]. However, most experimental results reported using new algorithms often use very different test sets [11], [12]. These test sets are not standard and often use personal images that are not available to the research community and often not in colour. The MIT and CMU databases contain greyscale images only whereas the Kodak dataset has most of the faces in frontal view only. In order to compare results fairly, a face database of colour images that can challenge face detection algorithms is needed.

## 3. THE UCD COLOUR FACE IMAGE DATABASE FOR FACE DETECTION

The details of the UCD face detection database are described in this section. The database has two parts. The first part contains a 100 colour images of faces with variations in background

(indoors, outdoors, complex, simple) facial structural components (beards, moustaches, and glasses), poses (frontal, near-frontal, profile), orientation (upright and upside down), facial expressions, imaging conditions (poor quality, good quality) occluded areas, age, gender, race and size. The images have been captured from the following sources: 1) Digital Cameras 2) Pictures scanned in using a scanner 3) Images from the World Wide Web 4) Images from existing face recognition and detection databases. It should be noted that all the pictures in the database are original pictures from the source without performing any processing such as colour correction, sharpening, noise removal, etc. This ensures that the images in the database reflect actual images that might be encountered by face detection algorithms. No restrictions are imposed on the face size or image resolution (See Figure 2). Details of the database are shown in Table 2 in terms of 3D pose, orientation, structural components and occlusion. While no standard terms exist to define face pose and orientation, researchers often use their own terminology such as frontal, near-frontal, half-profile, profile, semi-frontal, tilted etc [11], [12]. This paper defines the terminology used to describe faces in the *UCD Colour Face Image Database* as follows:

**3D Pose of the Face:**

*Frontal:* A frontal view is a mugshot–type view where the sagittal plane of the body divides the face in half.

*Profile:* A side-view of the face where the plane of the image divides the face in half.

*Intermediate:* A face pose that is neither frontal nor profile.

The definitions above are subjective as accurate pose estimation is an entirely different area of research. Our definitions only serve the purpose of comparing the performance of face detection algorithms for different poses.

**Orientation of the Face:**

*Upright:* A face is considered upright if the major axis of the best-fit ellipse makes an angle of less than $\pm 15^0$ with the vertical axis.

*Rotated:* Faces outside the above range are defined as rotated.

**Occluded Face:** A face is occluded if the entire face region is not clearly visible. Other faces or objects in the image can occlude faces.

**Structural Components:** Structural components such as glasses, sunglasses, beards and moustaches present a real challenge in face detection and are also noted for each face in the image.

**Table 2** UCD Colour Face Image Database

| 3D Pose | | | Orientation | | Occluded Faces | Structural Components | |
|---|---|---|---|---|---|---|---|
| Frontal | Intermediate | Profile | Upright | Rotated | | Beard/ Moustache | Glasses/ Sunglasses |
| 182 | 91 | 26 | 242 | 50 | 39 | 18 | 26 |
| Total Number of Faces: 299 | | | | | | | |

| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | File name (*.jpg) | Total Faces | Frontal | Intermediate | Profile | Upright | Rotated | Occluded | Structural Comp. |
| 2 | 1Person0001.jpg | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 3 | 1Person0002.jpg | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 4 | 1Person0003.jpg | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 5 | 1Person0004.jpg | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 6 | 1Person0005.jpg | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |

**Fig. 1.** Sample of the spreadsheet describing of each image in the database.

## 4. PERFORMANCE EVALUATION MEASURES

In order to evaluate face detection methods fairly, it is essential to use standard and representative datasets. Similarly, in order to compare the performance of several face detection methods some standard metrics need to be defined. Researchers often use detection rates, false positives, false negatives etc. to compare results but this becomes more difficult when different definitions are used for these metrics. Generally speaking, *detection rate* is defined as the number of faces correctly detected to the number of faces determined by a human. A *false positive* is where an image region is declared to be a face but it is not and a *false negative* is where a face is not detected at all. However, in order to evaluate these measures, the number and location of the faces present in the database need to be determined by a human. To this end, part 2 of the UCD face database comes with hand-segmented results for each image in the database as shown in Figure 2. Thus, false positives and negatives can now be automatically evaluated by comparing the location of the detected regions to the hand segmented results, and then using an accuracy measure to confirm a 'correctly detected' face. A spreadsheet with details of the faces present in each image of the database is also provided (See Figure 1).

**Fig. 2.** Sample images from Part 1 and Part 2 of the UCD Colour Face Image Database.

## 5. CONCLUDING REMARKS

In this paper, we describe the development of a colour image database for face detection. The database has been developed with the intention of providing a common benchmark for existing and new algorithms that are being developed. It contains colour images that provide 'real world' challenges to face detection algorithms by including faces with a large variety in size, shape, orientation, expression and images that have varying lighting conditions, resolution and backgrounds. It is available to all researchers working in the field and can be downloaded by contacting the authors or visiting the site http://*dsp.ucd.ie/~prag*. Further work

is being carried out in developing a face detection algorithm using a multiple feature approach.

**REFERENCES:**


[1] D. Chai, K. N. Ngan, Foreground/background Video Coding Scheme, *Proc. IEEE Int. Symp. Circuits Syst*., Hong Kong, June 1997, vol. II, pp. 1448-1451.

[2] F. Pereira, MPEG-4: Why, What, How and When?, *Signal Processing: Image Communication.* Vol. 15, 2000, p271-279.

[3] C. C. Chibeluschi, F. Deravi, A Review of Speech-Based Bimodal Recognition, *IEEE transactions on Multimedia*, Vol. 4, No. 1, March 2001.

[4] M. H. Yang, D. J. Kriegman, Detecting Faces in Images: A Survey, *IEEE Transactions on Pattern Analysis and Machine Intelligence,* Vol. 24, No. 1, January 2002.

[5] P. J. Phillips, P. Rauss, S. Der, FERET (Face Recognition Technology) Recognition Algorithm Development and Test Report, *Technical Report ARL-TR 995*, U.S. Army Research Laboratory.

[6] K-K. Sung, T. Poggio, Example-Based Learning for View-Based Human Face Detection, *IEEE Transactions on Pattern Analysis and Machine Intelligence,* Vol. 20, No. 1,pp. 39-51, January 1998.

[7] H. Rowley, S. Baluja, T. Kanade, Neural Network-Based Face Detection, *IEEE Transactions on Pattern Analysis and Machine Intelligence,* Vol. 20, No. 1, pp. 23-38 January 1998.

[8] H. Rowley, S. Baluja, T. Kanade, Rotation Invariant Neural Network-Based Face Detection, *IEEE Conf. Computer Vision and Pattern Recognition*, pp. 38-44, 1998.

[9] H. Schneiderman, T. Kanade, A Statistical Method for 3D Object Detection Applied to Faces and Cars, *Proc. IEEE Conference on Computer Vision and Pattern Recognition*, Vol. 1, pp.746-751, 2000.

[10] A. C. Loui, C. N. Judice, S. Liu, An Image Database for Benchmarking of Automatic Face Detection and Recognition Algorithms, *Proc. IEEE Conference on Image Processing*, Vol. 1, pp.146-150, 1998.

[11] R-L. Hsu, M. Abdel-Mottaleb, Face Detection in Colour Images, *IEEE Transactions on Pattern Analysis and Machine Intelligence,* Vol. 24, No. 5, May 2002.

[12] C. Garcia, G. Tziritas, Face Detection Using Quantized Skin Colour Regions Merging and Wavelet Packet Analysis, *IEEE Transactions on Multimedia,* Vol. 1, No. 3, September 1999.