Face Detection and Recognition Using Fusion of Color Space Models

Ahmad al-Qerem

Abstract— A colored based technique for face segmentation is presented throughout this work. Basically, we make use of color spaces to categorize pixels as either face or non-face. This study clearly shows how a novel method for fusion of the existing color spaces practically produces better results than the individual color spaces. More accuracy in dealing with face images of many different conditions has been achieved, and we crop the face after detected it from background and convert the crop face to grayscale and align faces together, then calculate the cosine similarity between faces. Comparing this work with other researchers worked using the same data set; we find that our method, which involves the fusion of different color information that comes from different color models, outperforms other method.

Index Terms— Color fusion, Face detection, Face recognition, Similarity measure.

I. Introduction

The Face detection is one of the systems which used for locate face region in all image, which contain a face regardless of its position, orientation and lightning conditions. Such a condition is challenging because faces are non-rigid. There is a great degree of variance among faces including size, shape, color, and texture. It is basically assumed that the camera is installed inside the vehicle facing the driver. Presence of facial features such as beards, mustaches, and glasses can also make a great deal of difference. The other important factor is the lightning conditions. This is mainly affected by the light in our background that can change depending on the time and weather conditions.

According [2] Face detection can be regarded as fundamental part of face recognition systems according to its ability to focus computational resources on the part of an image containing a face. [3] Many of approaches of face detection are based on knowledge, invariant feature approach, statistical and template matching etc. Some methods which are used earlier namely the Gaussian model [4] Gaussian mixture density model [5] and histogram based model [6]. Detecting of faces in color images has become important for a face detection system. As the color being one of the timely and most useful components to extract skin regions. Numerous color spaces have their luminance component and chromatic component separated, and they hold a higher dissimilarity between skin pixels and non-skin pixels over differing illuminating conditions. Skin color models that employ only on chrominance subspaces [7] likely Cb-Cr and H-S found to be efficient in characterizing varying human skin colors.

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The Face recognition is a biometric which uses computer software to determine the identity of the individual. Face recognition falls into the category of biometrics which is “the automatic recognition of a person using distinguishing traits” [21]. Other types of biometrics include fingerprinting, retina scans, and iris scan. Which can recognize a person through his face and adopted by a lot of applications? In Japan, for example, this technique is used to manage employee data; once that the person standing in front of the camera is recording the date of his attendance to the company and the date of his departure

Face Recognition and its importance in Legislations: Facial recognition is attractive for Legislations enforcement. It can be used in conjunction with existing surveillance camera infrastructure to hunt for known criminals. Face recognition is covert and non-intrusive, opposed to other biometrics such as finger prints, retina scans, and iris scans [21]. This is especially important in conjunction with the Legislation because faces are considered public. Comprehensive photo databases from mug shots or driver’s licenses already exist.

Because of difficulties face recognition has with respect to lighting, angle, and other factors, it is advantageous to attempt to get as high quality images with regard to these factors. Frontal face is a concept where cameras are strategically placed in order to obtain relatively controlled photographs [21]. Examples are placing cameras facing doorways, at airport check-ins, or near objects people are likely to stare at. These traps would aid face recognition software by helping to capture a straight frontal image which allow for higher accuracy of the system.

Face recognition must be improved further before it becomes a useful tool for law enforcement. It remains to be seen what the right balance is, socially speaking, between maximizing public safety and respecting individual rights.

In this paper, we used of color spaces to categorize pixels as either Face or non-Face, and we crop the face after detected it from background and convert the crop face to grayscale and align faces together, then calculate the cosine similarity between faces. Many different color spaces and features have been used in the literature, but this study shows how a novel method for fusion of the existing color spaces actually yields better results than the individual color spaces. The proposed approach shows more accuracy in dealing with face images of many different sizes, colors, expressions, orientations, different backgrounds, illuminations and noise.

II. Procedure for Paper Submission

Many approaches have been taken to solve the problem of Face detection in color images. In [8] Hani and Junita implemented Human skin detection is an essential step in most human detection applications, such as face detection. The performance of any skin detection system depends on assessment of two components: feature extraction and

detection method. Skin color is a robust cue used for human skin detection. However, the performance of color-based detection methods is constrained by the overlapping color spaces of skin and non-skin pixels.

To increase the accuracy of skin detection, texture features can be exploited as additional cues. In this paper, we propose a hybrid skin detection method based on YIQ color space and the statistical features of skin. A Multilayer Perception artificial neural network, which is a universal classifier, is combined with the k-means clustering method to accurately detect skin. The experimental results show that the proposed method can achieve high accuracy with an F_1-measure of 87.82% based on images from the ECU database.

Another improvement upon traditional approaches came in 2011 with Dr. D N Chandrappa in [9]. Applied Robust algorithm use YCbCr space to build a skin color model, also as the chrominance components are almost independent of luminance component in the space. There are non-linear relations between chrominance (Cb Cr) and luminance (Y) of skin color in the high and low luminance region.

Later, in 2012, in [10]. Yogesh & Ruchika implemented, attempted to use HSV space histograms and achieved a satisfactory detection rate. And in 2007, Kit Chong Wei and John See present a novel skin color model RGB-H-CbCr for human face detection. This model utilizes the additional hue and chrominance information of the image on top of standard RGB properties to improve the discrimination between skin pixels and Non-skin pixels. In our approach, skin regions are classified using the RGB boundary rules introduced by Peer Et al. Results using various combination of color model bounding rules:

- Model RGB only: FDR = 43.05%, SDR = 69.00%.
- Model RGB + CbCr: FDR = 36.14%, SDR = 77.17%.
- Model RGB+H: FDR = 33.82%, SDR = 83.50%.
- Model RGB + H + CbCr: FDR = 28.29%, SDR = 90.83%.

*system using a test data set of 100 images, containing a total of 600 unique faces.

In 2014, Vandana S. Bhat & J.D. Pujari in [11]. Used the hybrid model a combination of the bounding rules from all the 3 skin color models. The segmentation process is a precise and accurate. Segmentation technique uses all 3 color space to boost up face detection rate. Skin color detection may avoid extensive search of face regions in a given entire image. Initially the process of rejecting non-skin regions, so that only the skin like areas of given image i.e.

The skin color segmented image for further processing. From all 3 color models, the RGB color model is lighting sensitive, in YCbCr color model the distribution of skin areas is consistent in Cb and Cr components across different races and lastly the HSV color model hue is not reliable when saturation is low. Hence combination of these color models overcomes the illumination conditions and yields better result than individual color model. Results of face detected on hybrid model (RGB, YCbCr, HSV color spaces)

No. of images (20), RGB + YCbCr +HSV: False Detection Rate (FDR) = 31.26%, success Detection Rate (SDR) = 79.14%, has detection 18 Face.

III. Detection Approach

Our research methodology consists of several stages, the first of which is data collection. In this stage, we began with data collection of different pictures from the aforementioned databases. After opening each individual image, 10 points were selected on the Face region of each image, and 10 points were selected from the non-Face region of each image. For each point, the program stored the central pixel and 8 adjacent pixels (mask 3x3), one time each for the colors red, green, and blue, resulting in 27 values, Thus, for each image, there were 270 pixels (27 values x 10 points) in the Face region and 270 pixels (27 values x 10 points) in the non-Face region. We then extracted the ratio of red, green, and blue from each image.

We converted the ratios of red, green, and blue to various color spaces, which will be clarified below. The features we used were R / (R + G + B), B/ (R + G + B), G/(R + G + B), YCBCR, HSV, among others. We trained the neural networks on the above features to classify all features that we got from Face points as Class 1 and to classify all features that we got from non-Face points as Class 0. More than one type of standard neural network wizard was used, of which we chose the best 6 types and showed their respective results on a dataset of 2,000 images. For testing new images (those that had not yet been trained on the neural network), all pixels in the new images were examined after applying the Laplacian Pyramid on images; it is a very effective way of representing images. Each pyramid is constructed using several image copies. Successive levels are ¼ the size of the levels previous. Highest resolution is in the lowest level of the pyramid, and lowest resolution in the highest level. There are two parameters for the image pyramid: “reduce” and “expand”. The “reduce” parameter is used to interact with large images in order to reduce complexity time, the "expand” parameter is used to increase with small images like Utrecht database. These pixels that match the features of the Face regions were classified as 1 and colored black, and those pixels that do not were classified as 0 and colored white. This process is called banarization as shown in Fig 1,2,3,4.

Fig.1. Original image

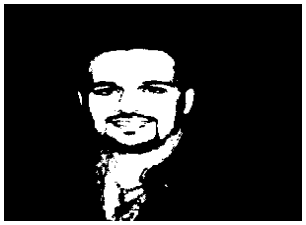

Fig.2. image after banarization

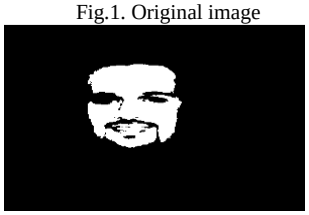

Fig.3. After open morphological operation

Fig.4. Face Detection.

<u>Algorithm 1: Face / non face training</u>

Step 1: Read the image file from training set folder of a specific database.

Step 2: click on different locations on the face’s area

Step 3: on each click, consider each pixel and all of its 8 neighbors to convert their color ratio to features (RGB as the red, green and blue values H, S, V as the hue saturation, value Y, Cb and Cr as the blue-difference and red-difference values respectively for each Image.

Step 4: save to text file and label each row as face or non-face pixel.
Step 5 repeat steps 2-4 10 times
Step 6: repeat step 1 on another image until all images in the training set are trained.
Step 5: Train neural network on the data saved on the previous text file.

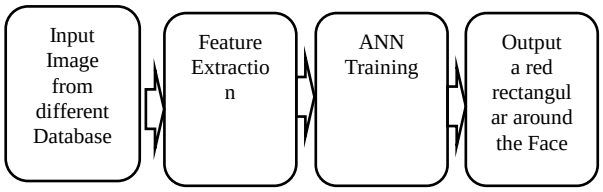

Fig.5. Algorithm face segmentation system

Algorithm 2: face segmentation

Step 1: read an image I from the testing set folder of a specific database.
Step2: detect all faces in each image, using special software.
Step 3 for each pixel in I get the feature vector same as in algorithm 1
Use The Laplacian Pyramid to speed up the algorithm
Use the ANN model to test the new feature vector, if this belongs to class faces set a white 3x3 square in a binary image, else set black pixel.
Step 4: Use Morphological operations.
Assign a red rectangular around the region of the largest rectangle as face area
Step 5: Display the output image, with the Face detection
Step 6: Repeat step 1 until no more images in the test set.
Classification: The classifier decides whether the pixel associated with Face class or Non-Face class based on the information got from the training algorithm 1.

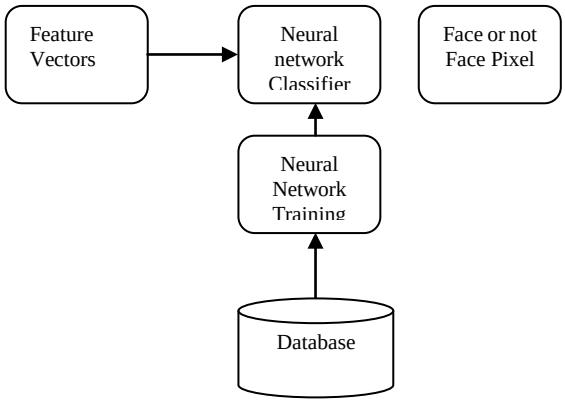

Fig. 6. The Proposed System

The next step of the Face detection system involves the use of morphological operations to refine the Face regions extracted from the segmentation step.

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IV. RECOGNITION APPROACH

There are two ways for face detection. Identification and authentication are two terms that describe the initial phases of the process of allowing access to a system. The terms are often used synonymously, but authentication is typically a more involved process than identification. Identification is what happens when you profess to have a certain identity in the system, while authentication is what happens when the system determines that you are who you claim to be. Both processes are usually used in tandem, with identification taking place before authorization, but they can stand alone, depending on the nuances of the system

Identification is the process of presenting an identity to a system. It is done in the initial stages of gaining access to the system and is what happens when you claim to be a particular system user. The claim can take the form of providing your username during the login process; placing your finger on a scanner; giving your name on a guest list or any other format in which you claim an identity with the aim of gaining access. Identification is not necessary for some systems, such as ATM cards, where anyone with the correct code can gain access to your account without identifying themselves.

Authentication is the process of validating an identity provided to a system. This entails checking the validity of the identity prior to the authorization phase. The process of checking the validity of the evidence provided to support the claimed identity must be sufficiently robust to detect impostors. Authentication usually occurs after identification is complete, such as when you supply a password to support a username during the login process. It can happen, however, at the same time as the identification process.

V. SIMILARITY MEASURES

There are many of metrics used to solve problems of natural language processing [1, 2], such as Euclidean distance, Cosine distance, Jaccard, Dice. Similarity or distance measure any one of these two concepts can be used to express degree of closeness between letters, words, strings or documents.

There is no measure gives the best results for all kinds of problems related to the word processing. This is due to the nature of the problem and the type of problem. Therefore, the choice of an appropriate measure of similarity and comprehension its effects is essential.

For the purposes of comparison vectors together and measuring the proportion of similarities between them. We used Cosine distances.

It is a metric used to compute amount of similarity between two vectors, according following formula:

$$\text{similarity}(Dki, Tk) = \frac{\sum_{k=1}^{n} Dki * Tk}{\sqrt{\sum_{k=1}^{n} D_{ki}^{2}} * \sqrt{\sum_{i=1}^{n} T_{k}^{2}}}$$

Where:
Dki Is image k in the individual i.
Tk Is image k in the new individual test.
$\text{similarity}(Dki, Tk)$ Is the cosine similarity of Dki and Tk, we can also say that it the cosine of the angle between Dki and Tk. The figure below shows the similarity between test vector Colored in blue with D1 and D2, Where observed that the test vector is similar to document 2(D2).

VI. EXPERIMENTAL RESULTS

All feature extraction techniques were applied on the following databases:

- **The Frontal Face Database [26].** This database was collected at California Institute of Technology. It contains 450 face images. Each image is 896 x 592

pixels. Moreover, it includes 27 or so unique people under different lighting, expressions, and backgrounds. (vasc.ri.cmu.edu/idb/html/face/)

- **Iranian woman Database [27].** This database was collected at Iran. It contains 369 face image, 34 women, mostly with smile and neutral in each of five orientations. Each image is 1200x900.(http://pics.stir.ac.uk/2D_face_sets.htm)
- **Aberdeen Database [28].** This database was collected at Aberdeen. It contains 687 face images, with between 1 and 18 images of 90 individuals. Each image is between 336x480 and 624x544 pixels. There are some variations in lighting, and 8 images have varied viewpoint. (http://pics.psych.stir.ac.uk/2D_face_sets.htm)
- **Utrecht ECVP Database [29].** This database was collected at the European Conference on Visual Perception in Utrecht in 2008. It contains 131 face images, with 49 men and 20 women. Each image is 900x1200 pixels. There is a neutral and smiling image for almost all participants. (http://pics.psych.stir.ac.uk/2D_face_sets.htm)

In order to find the most effective way to segment the faces from a background image, we trained our neural networks "TRAINBR" to work with several databases based on several different features: f1f2f3, HSV, H, YCbCr, CbCr, and different fusion.

In testing our system, we used more than 1500 images. The testing images were not used in training set and we took in our consideration luminance on the images and those images taken from different environments the image were input to neural network gives the highest accuracy.

To see all the results from the training test, for more than one method, and the success detection rate, you can find it in the tables bellow:

TABLE I
COMPARING THE RESULTS OF DIFFERENT METHODS ON FRONTAL FACE DATABASES BY USING TRAINBR NEURAL NETWORK, AND SHOWING THE RESULT OF FACE DETECTION RATE (SDR).

Methods	TRAINBR	Success detection
f1f2f3	92.1%	77.5%
f1f2	92.1%	55.3%
RGB	95.3%	87.7%
RG	92.6%	84.0%
YCbCr	95.2%	89.7%
CbCr	92.8%	79.1%
HSV	95.3%	89.3
H	90.1%	65.7%
f1f2f3+HSV+YCbCr	95.4%	95.7%
f1f2f3+H+YCbCr	95.0%	93.3%
f1f2+H+CbCr	92.8%	89.1%
RGB+HSV+YCbCr	95.1%	89.5%
RGB+H+YCbCr	95.4%	90%
RG+H+CbCr	92.7%	85.5%

TABLE II
COMPARING THE RESULTS OF DIFFERENT METHODS ON UTRECHT DATABASE, BY USING TRAINBR NEURAL NETWORK, AND SHOWING THE RESULT OF FACE DETECTION RATE (SDR).

Methods	TRAINBR	Success
f1f2f3	92.1%	77.5%
f1f2	92.1%	55.3%
RGB	95.3%	87.7%
RG	92.6%	84.0%
YCbCr	95.2%	89.7%
CbCr	92.8%	79.1%
HSV	95.3%	89.3
H	90.1%	65.7%
f1f2f3+HSV+YCbCr	95.4%	95.7%
f1f2f3+H+YCbCr	95.0%	93.3%
f1f2+H+CbCr	92.8%	89.1%
RGB+HSV+YCbCr	95.1%	89.5%
RGB+H+YCbCr	95.4%	90%
RG+H+CbCr	92.7%	85.5%

Here, in this section we displayed some of random figures that illustrated the output of testing from different database. Figure shows figures of Iranian woman. The results were satisfied for Iranian woman database. And our algorithm achieved a good result with white background and orientation. The Frontal Face and Utrecht ECVP database give an accurate detection and ability to determine the face in images that contain mustaches this give our algorithm more powerful as shown in figure 9 and figure 10 respectively.

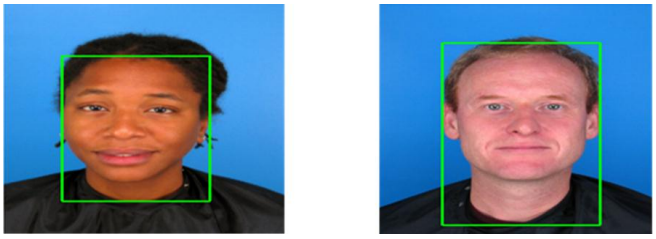

Fig.9. Utrecht dataset

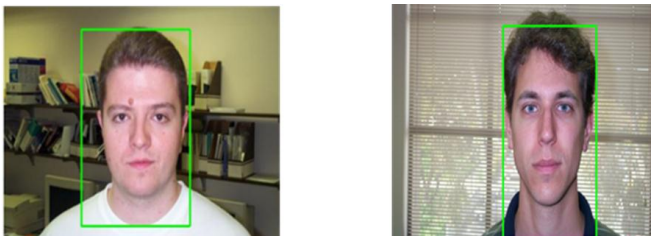

Fig.9. Frontal face dataset

VII. Conclusion

Several methods for image segmentation using color information have been proposed and investigated in this study, the methods involve training a feature vector of each face pixel with its 8 neighbors using color information gained from different color models, the experiments show the power of the color information when employed to segment the face. Comparing to related work on the same subject and using the same databases, we find that our method particularly the last one, which involves the fusion of different color information that come from different color models, outperform other methods in the literature significantly. Our future work will involve the use of color information for segmenting different objects, in addition to use the proposed face segmentation to be used as a preliminary stage for a biometric system use the face recognition.

References

[1] Ankita Shah1, Sonaka Kukreja2, Pooja Shinde3, Ankita Kumari4," Yawning Detection of Driver Drowsiness", International Journal of Recent Development in Engineering and Technology Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 2, Issue 3, March 2014)

[2] Turk M & Pentland A (1991) "Eigenfaces for recognition", Journal of Cognitive Neuroscience, Vol.3, Pp71–86.

[3] Jilin and China, "Research of Face Detection System Based on Skin-Tone Feature 2011 International Conference on Mechatronic Science, Electric Engineering and Computer August 19-22, 2011.

[4] P.Peer,J.Kovac, F.Solina, "Human Skin Color Clustering for Face Detection", EUROCON, Ljubljana, Slovenia, pp. 144-148, September 2003

[5] S.J. McKenna, S. Gong, and Y. Raja, "Modeling Facial Color and Identity with Gaussian Mixtures," Pattern Recognition, 31(12), pp.1883-1892, 1998.

[6] D. Chai and K.N. Ngan, "Face segmentation using skin-color map in videophone applications", IEEE Transactions on Circuits and Systems for Video Technology, Vol.9 N°4, pp.551-564, 1999.

[7] Sayantan Thakur, Sayantanu Paul, Ankur Mondal , " Face Detection Using Skin Tone Segmentation" 2011 IEEE.

[8] Hani K. Al-Mohair, Junita Mohamad Saleh, Shahrel Azmin Suandi ,"Hybrid Human Skin Detection Using Neural Network and K-Means Clustering Technique," Applied Soft Computing, Volume 33, August 2015, Pages 337-347 .

[9] Dr. D N Chandrappa, "Face Detection in Color Images using Skin Color Model Algorithm based on Skin Color Information," DOI: 10.1109/ICECTECH.2011.5941600 Conference: 3rd International Conference on Electronics Computer Technology (ICECT 2011), Volume: 1.

[10] Yogesh Tayal, Ruchika Lamba, Subhransu Padhee ," Automatic Face Detection Using Color Based Segmentation ,"International Journal of Scientific and Research Publications, Volume 2, Issue 6, June 2012 1 ISSN 2250-3153.

[11] Nusirwan Anwar bin Abdul Rahman, Kit Chong Wei and John See†, "RGB-H-CbCr Skin Colour Model for Human Face Detection" Faculty of Information Technology, Multimedia University johnsee@mmu.edu.my†2007.

[12] Prashanth Kumar G., Shashidhara M. "Real Time Detection and Tracking of Human Face using Skin Color Segmentation and Region Properties", I.J. Image, Graphics and Signal Processing, 2014, 8, 40-46 Published Online July 2014 in MECS, DOI: 10.5815/ijigsp.2014.08.06.

[13] Vladimir Vezhnevets, Vassili Sazonov, Alla Andreeva." A Survey on Pixel-Based Skin Color Detection Techniques" Graphics and Media Laboratory Faculty of Computational Mathematics and Cybernetics Moscow State University, Published in 2005.

[14] Crowley, James L., et al," Perceptual components for context aware computing" .UbiComp 2002: Ubiquitous Computing. Springer Berlin Heidelberg, 2002. 117-134.

[15] POYNTON, C. A," Frequently asked questions about color", In ftp://www.inforamp.net/pub/users/poynton/doc/colour/ColorFAQ.ps.gz. , 1995.

[16] ZARIT, B. D., SUPER, B. J, AND QUEK, F. K. H," Comparison of five color models in skin pixel classification". In ICCV'99 Int'l Workshop on recognition, analysis and tracking of faces and gestures in Real-Time systems, 58–63, 1999.

[17] MCKENNA, S., GONG, S., AND RAJA, Y. "Modelling facial color and identity with Gaussian mixtures". Pattern Recognition Volume 31, Issue 12, December 1998, Pages 1883–1892

[18] SIGAL, L., SCLAROFF, S., AND ATHITSOS, V. ," Estimation and prediction of evolving color distributions for skin segmentation under varying illumination. In Proc. IEEE Conf. on Computer Vision and Pattern Recognition, vol. 2, 152–159, 2000.

[19] BIRCHFIELD, S. "Elliptical head tracking using intensity gradients and color histograms". In Proceedings of CVPR '98, Pages 232–237.

[20] JORDAO, L., PERRONE, M., COSTEIRA, J., AND SANTOS-VICTOR, J. "Active face and feature tracking". In Proceedings of the 10th International Conference on Image Analysis and Processing, Pages 572–577, 1999.

[21] John D. Woodward, Jr., Christopher Horn, Julius Gatune, Aryn Thomas, "Biometrics, A Look at Facial Recognition," RAND, 2003.

[22] Pawan Sinha, Benjamin Balas, Yuri Ostrovsky, and Richard Russell, "Face Recognition by Humans: Nineteen Results All Computer Vision Researchers Should Know About," Proceedings of the IEEE, Volume: 94, Issue: 11, 2006.

[23] Michael Kraus, "Face the facts: facial recognition technology's troubled past--and troubling future," The Free Library, 2002.

[24] Ryan Johnson, Kevin Bonsor, "How Facial Recognition Systems Work," How Stuff Works, 2007.

[25] "New: Google Image Search Categories," Google Blogoscoped, May 28, 2007.

[26] (http://vasc.ri.cmu.edu/idb/html/face)

[27] (http://pics.psych.stir.ac.uk/2D_face_sets.htm)

[28] (http://pics.psych.stir.ac.uk/2D_face_sets.htm)

[29] (http://pics.psych.stir.ac.uk/2D_face_sets.htm)