**Bernd Heisele, Tomaso Poggio, Massimiliano Pontil “Face Detection in Still Gray**

**Images” C.B.C.L Paper No. 187, May, 2000.**

In this paper, present and compare two systems: a whole face detection system and a component-based detection system. Both systems are trained from examples and use Support Vector Machines (SVMs) as classifiers. The first system detects the whole face pattern with a single SVM.

The second system performs the detection by means of a two level hierarchy of classifiers.

On the first level, the component classifiers independently detect parts of the face, such as eyes, nose, and mouth.

On the second level, the geometrical configuration classifier combines the results of the component classifiers and performs the final detection step.

**Erik Hjelmas, Boon Kee Low “Face Detection: A Survey”, April 17, 2001**

The algorithms presented in this paper are classified as either feature-based or image-based and are discussed in terms of their technical approach and performance.

They organized into two broad categories distinguished by their different approach to utilizing face knowledge.

The techniques in the first category make explicit use of face knowledge and follow the classical detection methodology in which low level features are derived prior to knowledge-based analysis. in these techniques face detection tasks are accomplished by manipulating distance, angles, and area measurements of the visual features derived from the scene. This approach is called feature based approach.

The techniques in the second group address face detection as a general recognition problem. *Image-based* representations of faces, for example in 2D intensity arrays, are directly classified into a face group using training algorithms without feature derivation and analysis

**Faizan Ahmad, Aaima Najam and Zeeshan Ahmed “Image-based Face Detection and Recognition: ‘State of the Art’ “IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 6, No 1, November 2012**

In this paper AdaBoost classifier is used with Haar and Local Binary Pattern (LBP) features whereas Support Vector Machine (SVM) classifier is used with Histogram of Oriented Gradients (HOG) features for face detection evaluation.

The original LBP operator labels the pixels of an image by thresholding the 3-by-3 neighborhood of each pixel with the center pixel value and considering the result as a binary number. Each face image can be considered as a composition of micro-patterns which can be effectively detected by the LBP operator.

Edge:

Edge features within the head outline are then subjected to feature analysis using shape and position information of the face. The Sobel operator was the most common filter among the techniques of edge detection. In an edge-detection-based approach to face detection, edges need to be labeled and matched to a face model in order to verify correct detections. By labeling edges as the left side, hairline, or right side of a front view face and matches these edges against a face model by using the golden ratio for an ideal face:

Gray-levels:

The gray information within a face can also be used as features. Facial features such as eyebrows, pupils, and lips appear generally darker than their surrounding facial regions. This property can be exploited to differentiate various facial parts. The extraction of dark patches is achieved by low-level gray-scale thresholding. Local maxima, which are defined by a bright pixel surrounded by eight dark neighbors, are used instead to indicate the bright facial spots such as nose tips. When the resolution of a face image is reduced gradually either by subsampling or averaging, macroscopic features of the face will disappear. At low resolution, face region will become uniform.

Color:

One of the most widely used color models is RGB representation in which different colors are defined by combinations of red, green, and blue primary color components. Due to the extra dimensions that color has, two shapes of similar gray information might appear very differently in a color space. It was found that different human skin color gives rise to a tight cluster in color spaces even when faces of difference races are considered.

Motion:

If the use of a video sequence is available, motion information is a convenient means of locating moving objects. A straightforward way to achieve motion segmentation is by frame difference analysis. In, moving frame that include face and body parts are extracted by thresholding accumulated frame difference.

Generalized measures

a generalized symmetry operator that is based on edge pixel operation. Since facial features are symmetrical in nature, the operator which does not rely on higher level a priori knowledge of the face effectively produces a representation that gives high responses to facial feature locations. The symmetry measure assigns a magnitude at every pixel location in an image based on the contribution of surrounding pixels.

Constellation analysis

If given a more general task such as locating the face(s) of various poses in complex backgrounds, many such algorithms will fail because of their rigid nature. The algorithm is able to handle missing features and problems due to translation, rotation, and scale to a certain extent.

Use the concept of snakes a step further by incorporating global information of the eye to improve the reliability of the extraction process. The deformation mechanism involves the steepest gradient descent minimization of a combination of external energy due to valley, edge, peak, and image brightness.

PDM is a compact parameterized description of the shape based upon statistics. The contour of PDM is discretized into a set of labeled points. Variations of these points are first parameterized over a training set that includes objects of different sizes and poses. Using principal component analysis (PCA), variations of the features in a training set are constructed as a linear flexible model. The model comprises the mean of all the features in the sets and the principle modes of variation for each point

**Neural network**

The first component of our system is a filter that receives as input a 20x20 pixel region of the image, and generates an output ranging from 1 to -1, signifying the presence or absence of a face,

respectively. To detect faces anywhere in the input, the filter is applied at every location in the image. To detect faces larger than the window size, the input image is repeatedly reduced in size (by subsampling), and the filter is applied at each size. The window is then passed through a neural network, which decides whether the window contains a face.

To fit a function which varies linearly across the window to the intensity values in an oval region inside the window. Pixels outside the oval may represent the background, so those intensity values are ignored in computing the lighting variation across the face. Then histogram equalization is performed, which non-linearly maps the intensity values to expand the range of intensities in the window. The histogram is computed for pixels inside an oval region in the window.

The preprocessed window is then passed through a neural network. The network has retinal connections to its input layer; There are three types of hidden units: 4 which look at 10x10 pixel subregions, 16 which look at 5x5 pixel subregions, and 6 which look at overlapping 20x5 pixel horizontal stripes of pixels. Each of these types was chosen to allow the hidden units to detect local features that might be important for face detection.

In particular, the horizontal stripes allow the hidden units to detect such features as mouths or pairs of eyes, while the hidden units with square receptive fields might detect features such as individual eyes, the nose, or corners of the mouth. The network has a single, real-valued output, which indicates whether or not the window contains a face.