Portraits of Automated Facial Recognition

1. “The uniqueness of body parts, such as finger prints, an iris or a person’s face, allow these technologies to ascertain an individual’s identity. ” (Pg. 22)
2. “The practice of using the body as a sign of identity has a long history that dates back to the mid-1800s” (Pg. 22)
3. “The eigenface approach, now considered a dated method, was open source from its inception. Because of its simplicity, it is often still used as a training tool by computer science students, so examples of its use are widely available on the internet. There are two primary reasons for my interest in this method. Firstly, the eigenface approach is considered a holistic method: that is, it takes into account the entire face, rather than isolated features of the face, and is, as such, designed to emulate human facilities of facial recognition. Secondly, as a part of its algorithmic processes of recognition, the eigenface approach was designed to produce an image, a visual artifact through which it is possible to enter into a visual analysis of its processes of recognition. The success of the eigenface approach to recognition made it a benchmark for the AFR methods that developed subsequently” (Pg. 26)
4. “This image appears as a phantom-like blur of multiple overlapped faces, which, to human eyes, lingers on the threshold of recognition. While the eigenface image remains blurry to human vision, it contains a wealth of information that, for the processes of perception by the machine, equates to a form of clarity. “ (Pg. 29)
5. “In 1987, Sirovich and Kirby published a paper on the use of a statistical method of pattern recognition called Principal Component Analysis (PCA), which they applied to facial images in order to produce what they called “eigenpictures.”13 In their paper, Sirovich and Kirby speculate about how humans perform the function of recognizing faces and note how adept humans are at this complex task: humans can recognize an almost infinite number of different faces. They propose that humans are able to recognize so many faces because we engage in a process of deduction in relation to facial characteristics; that is, we recognize the characteristics of a face that depart from a kind of characteristic mean. They additionally propose a mathematical translation of this process, applied to multiple facial images, as a possible model for how humans recognize faces.”

These three aspects of the eigenface process are Principal Component Analysis, the eigenvector and the face space.

1. Principal Component Analysis is a statistical procedure that has primarily been used as a classification tool and as way of producing predictive models based on a statistical method of mean centering. In mathematical terms, PCA treats each facial image as a point or a vector on a grid with a high-dimensional space allowing for high degrees of variation. This high-dimensional coordinate space can be understood as Cartesian space gone digital. Each collected facial image in the training set is translated into a unit of measurement, or a weight, within this virtual space. Averages are calculated from the different weights of facial images. Each average takes into account all the possible variations of each weight. The averaged or mean face is described as “the center of gravity for all the faces combined.”23 This averaged face delimits the highest degrees of variation, that is, the farthest directions of deviation from the average that exist between the collected facial images.
2. “The application of PCA to training set images creates “eigenvectors,” that is, mathematical objects that display the degree of variability or deviation between facial characteristics and an average. Each eigenvector represents the greatest degree by which the facial images may vary – i.e., the highest eigenvalues. Multiple eigenvectors result from applying PCA to training sets, creating a mechanism to classify unknown faces based on their deviation from these eigenvectors. The eigenvector is a virtual model of “known” faces and serves as a reference point for the classification of unknown faces. Like a map, an eigenvector stands as a kind of idealized model; it acts as a primary referent on the basis of which the algorithm is able to measure the distance or variation between it and an unknown face. As a virtual model, the eigenvector is a form of representation that transforms the pictorial, individual representations of known faces into a geometrical space defined by facial measurements. In this way the eigenvector comes to represent faces based solely on their relationships to other faces. The eigenvector is a representation of the differences and similarities between faces and in this way functions as a unit of facial measurement. ”
3. “The collection of eigenvectors create a subspace referred to as the “face space.” Eigenface developers have described the face space as a virtual subspace that is defined and framed by the measured distances between a collection of eigenvectors. The concept of a face space derived from the field of psychology in interpreting how faces are processed by human recognition. The face space is originally defined as a, “multidimensional psychological space, in which faces can be represented according to their perceived properties” and with the, “assumption…that faces (or concepts) could be represented as a collection of interchangeable parts.”36 The face space in the eigenface algorithm is defined by the range of variability of these “interchangeable parts.” Conceptually, the face space spans all possible variations of faces.”
4. “The actual recognition process in eigenface involves projecting the captured image of the individual who needs to be identified on to the face space. The image is compared with the face space by calculating the Euclidian distances between the eigenvectors and the captured image. If there is a small distance between the capture and the eigenface, there may be a match. The distances between them are then expressed in numerical values and a data set is created. This data set then represents a person’s identity and is entered into a database.”
5. “The greater the variation of an eigenvector, the more blurred it appears.”

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1. “While two-dimensional face images are commonly used in most applications, certain applications requiring higher levels of security demand the use of three-dimensional (depth or range) images or optical images beyond the visual spectrum.”
2. “A face recognition system generally consists of four modules:
3. “Face detection segments the face area from the background. In the case of video, the detected faces may need to be tracked across multiple frames using a face tracking component. While face detection provides a coarse estimate of the location and scale of the face, face landmarking localizes facial landmarks (e.g., eyes, nose, mouth, and facial outline). This may be accomplished by a landmarking module or face alignment module. Face normalization is performed to normalize the face geometrically and photometrically. This is necessary because state-of-the-art recognition methods are expected to recognize face images with varying pose and illumination. The geometrical normalization process transforms the face into a standard frame by face cropping. Warping or morphing may be used for more elaborate geometric normalization. The photometric normalization process normalizes the face based on properties such as illumination and gray scale. Face feature extraction is performed on the normalized face to extract salient information that is useful for distinguishing faces of different persons and is robust with respect to the geometric and photometric variations. The extracted face features are used for face matching. In face matching the extracted features from the input face are matched against one or many of the enrolled faces in the database. The matcher outputs ‘yes’ or ‘no’ for 1:1 verification; for 1:N identification, the output is the identity of the input face when the top match is found with sufficient confidence or unknown when the tip match score is below a threshold. The main challenge in this stage of face recognition is to find a suitable similarity metric for comparing facial features.”
4. “Subspace analysis techniques for face recognition are based on the fact that a class of patterns of interest, such as the face, resides in a subspace of the input image space. For example, a 64 × 64 8-bit image with 4096 pixels can express a large number of pattern classes, such as trees, houses, and faces. However, among the 2564096 > 109864 possible “configurations,” only a tiny fraction correspond to faces.”
5. “It is common to model the face subspace as a (possibly disconnected) principal manifold embedded in the high-dimensional image space. Its intrinsic dimensionality is determined by the number of degrees of freedom within the face subspace; the goal of subspace analysis is to determine this number and to extract the principal modes of the manifold. The principal modes are computed as functions of the pixel values and referred to as basis functions of the principal manifold.”

Diagram, schematic

Description automatically generated

7.

Text

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8.Text, letter

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(Pg 32 and on)

9.

Diagram, schematic

Description automatically generated

1. Pg 88 Face description

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1. Pg 13 – 15
2. Chapter 4 different FR methods

3D FACE MODELING, ANALYSIS AND RECOGNITION

1. the 3D face needs more than one scan to be fully acquired. Especially when the pose is not frontal as illustrated in Figure 5.8b, the resulting scan is said to be 2.5D and not full 3D. However, this 2.5D scan is roughly approximated by 3D scan by 3D face recognition community researchers. Additionally, variations in face data due to facial expressions cause deformations in the 3D mesh. Figure 5.8a illustrates expressive faces at the bottom row (as 3D textured mesh). The top row illustrates the resulting 3D mesh with deformations
2. Page 164 (SIFT)

Practical

1. Page 110