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Research Article

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Age Estimation from Human Face for Crime Investigation

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Abstract Anthropology describes the scientific study of the origin, the behaviour, and the physical, social, and cultural development of humans. Forensic anthropologists are trained physical anthropologists who apply their knowledge of biology, science, and culture to the legal process. They identify human remains, along with pathologists, homicide detectives and other specialists. Age determination of unknown human bodies is important in the setting of a crime investigation or a mass disaster because the age at death, birth date, and year of death as well as gender can guide investigators to the correct identity among a large number of possible matches. Traditional morphological methods used by anthropologists to determine age are often imprecise.

Keywords Feature extraction; gender classification; SVM classifier; histogram equalization; multiclass SVM

Introduction

A forensic anthropologist's skill is used to give an identity and/or a cause of death to skeletal remains. Facial reconstruction is a method used in forensic anthropology to aid in the identification of skeletal remains. **T**he use of facial recognition in the field of forensic science presents a challenging set of issues. Forensic science is the use of scientific principles and methods to answer questions of interest to a legal system. Forensic science differs from the field of security; in security applications the goal is to prevent incidents from occurring, while in forensic cases typically an incident has already occurred. Bones develop from cells known as osteoblasts, first beginning as soft cartilage before the bone hardens through the introduction of various minerals, a process known as ossification. Bones can be divided into a number of classes; short, long, flat, sesamoid and irregular bones. Short bones, such as the carpal bones within the wrist, tend to be as wide as they are long. Long bones are, as the name suggests, longer in length and also tend to be slightly curved, for example the femur. Flat bones, such as the ribs and breastbone, could be described as being fairly flat and plate-like. Sesamoid bones refer to small bones embedded in a tendon, often found in joints, such as in the knees and wrists. Finally, irregular bones refer to a certain class of bone that do not belong in the other categories, such as the bones composing the spine.

The general shape, size and structure of the bones may be sufficient to determine likely species, and methods for distinguishing between human and non-human remains have also been established based on microscopic differences in bone structure . If the bones are relatively recent they may contain the proteins required to carry out serological tests to establish the species.

Age estimation is usually the primary characteristic for identification. Age estimation can also play an important role in the prosecution of forensic cases. Multi- class SVM have been employed which will generate three classes i.e child, adult and old. The age of the input images are detected and classified into one of the three category. Age Detection can be achieved by performing the following steps diligently.

1. Pre-processing
2. Feature Extraction

3. Gender Classification/ Age Detection

The age of an individual is often a fundamental piece of data in connection with forensic identification of unidentified bodies. The methods most often used are based on visually determining various morphological, age-related changes in the skeleton. A fundamental presupposition of most forensic anthropological methods is that the biological age of an individual more or less follows the chronological age. The chronological age is our calendar age, which we identify in years, while the biological age refers to how aging affects our bodies and how this may be observed.

An attempt has been made to perform age detection of a combined set of images and based on the age the images has been classified into either ‘child’ or ‘adult’ or ‘old’. This classification is performed using Multi-Class SVM.

Literature

Identification of human remains almost always involves assessment of the age at death of the individual. While aging phenomena occur in non-bony tissues, it was for a long time osseous tissue and teeth that were at the core of most methods [1–7]. This was due both to the persistence of these tissues (when most soft tissues would decompose) and the fact that age determination is much-used also in archaeological work, when excavating prehistoric and historic skeletons [3-4]. In forensic cases, determining age at death and year of birth are, in all practicality, two sides of the same issue. However, since many of the most-used methods were developed also for use in archaeological anthropology, they are usually referred to as methods for determining age at death. An archaeologically recovered individual can seldom be set in an absolute chronological framework (unless, for example, by tombstones, inscriptions on coffins, coffin plates, etc). But in forensic cases, determining age at death is often translated into probable year of birth (or a range for this), as this is an item of data that may be registered, and thus lead to identification.

Assessing age may be done somewhat reliably when dealing with subadults, as the biological–chronological relationship is clearly reflected in the growing subadult skeleton. Thus, features associated with bone growth, such as epiphyseal closure[4–7] closure of the sphenobasilar synchondrosis,[5] and, obviously, (diaphyseal) bone length [4,7–9] may be used. As will be seen, many of the forensic anthropological methods for determining age have been around for some time – some more than a hundred years, albeit with modifications – and form part of the basic forensic anthropological toolbox [1–7]. These methods generally rely on identifying certain age-related morphological skeletal traits, then setting these traits in a system of stages or scores, which results in an estimated age interval. There are some basic problems inherent in this methodological approach, one of which is whether a given morphological method is well enough defined or explained, so that it does not entail undue intra- or interobserver error when it is applied (ie, there should be no major ambiguity in the assessment of morphological features). Since the results of a forensic anthropological analysis may be presented in court, it is important, obviously, that the degree of observer variation for a given method is quantified. Therefore, continued assessment of the validity of the method, including intra- and interobserver assessment, is important [1].

Proposed Method

The pre-processing stepinvolve operations like image normalization, histogram equalization, and noise removal. The adequacy of operation is explained below:

Image Normalization is a process of changing the intensity values of pixel range in an image.

Histogram Equalizations improves the contrast in an image, in order to stretch out the intensity range so that the area with lower contrast can achieve higher contrast. In this way the intensities can be better distributed on the histogram [9].

Noise Removal- In an image different type of noise can be incorporated that result in pixel values that do not reflect the true intensities of the image. There are several different ways that noise can be introduced into an image, depending on how the image is created. However noise removal can be achieved by implementing different techniques like Linear Filtering or Median Filtering [10].

The second phase involves Feature Detection and its appropriate extraction which can be achieved by adapting the following approaches:
Geometry-based Approach uses geometric information such as features relative positions and sizes of the face components as a features measure.
Template-based Approach in which previously designed standard face pattern template is used to match with the located face components. This uses appropriate energy function. The best match of a template in the facial image will yield the minimum energy. Genetic algorithms can be used for more efficient searching times and achieving more optimization in template matching.
Colour segmentation techniques makes use of skin colour to isolate the face. Any non-skin colour region within the face is viewed as a candidate for eyes and/or mouth localization. This method gives limited performance on facial image databases, due to the diversity of ethnical backgrounds.
Lastly in Appearance-based approaches the concept of "feature" varies from simple facial features such as eyes and mouth. Any extracted characteristic from the image is referred to as a feature. Traditional statistical techniques such as principal component analysis (PCA), independent component analysis, and Gabor wavelets are used to extract the facial feature vector. It projects the data images into Eigen-space that encodes the variation among known face images. This gives eigenvectors of the set of faces, which they do not necessarily correspond to isolated features such as eyes, ears, and nose. These approaches are commonly used for face recognition rather than person identification.
Finally, in the last phase the Support Vector Machine Classifier can be used for solving binary classification problem where the final result is to be classified into two classes.
A Support Vector Machine can therefore be defined as a learning algorithm for pattern classification and regression. The basic training principle behind SVMs is finding the optimal linear hyper plane such that the expected classification error for unseen test samples is minimized — i.e., good generalization performance [11]. However if the two classes are not linearly separable, the SVM makes an attempt to find the hyper plane that maximises the margin at the same time, minimising a quantity proportional to the number of misclassification errors. Thus to solve multi-class problems like Age Detection problem where the age is supposed to be categorized into three groups / classes i.e. 'child', 'adult' and 'old', a suitable multi- class classification technique is needed to be suitably designed and implemented. The approach to solve multi-class SVM problem has variables proportional to the number of classes. Thus for multi – class SVM problem, either several binary classifiers are to be constructed or a larger optimization problem is needed [12].
The strategies being adapted to solve a multi-class problem can be stated as (1) The "One against All" Strategy: This strategy aims at constructing one SVM per class, which is trained to distinguish the samples of one class from the samples of all remaining classes. Therefore, M binary SVM classifiers may be created where each classifier is trained to distinguish one class from the remaining M-1 classes. [13] This method is also known as winner-take-all classification. (2) One against One strategy involves "pairwise coupling", "all pairs" or "round robin". It involves the construction of one SVM for each pair of classes. Thus, for a problem with c classes, c(c-1)/2 SVMs are trained to distinguish the data points of one class from another class. Finally the classification of an unknown pattern is done according to the maximum voting, where each SVM votes for one class. [14].
This section illustrates the technique which has been adapted to perform age detection and classification of the same from an image set into three classes i.e 'child', 'adult', 'old'. The classifier used for the implementation and the evaluation of the proposed algorithm is the Multi- Class SVM. Unlike binary classifiers, this type of SVM can effectively classify the input data set into multiple classes.
The design and implementation of the proposed methodology is discussed in the following sub-section.

Algorithm

Step 1: Read Input Image Set.
Step 2: Convert individual input image to grey scale.
Step 3: Perform Histogram Equalization of the grey scale image.
Step 4: Use ROI principle perform feature extraction from the individual image. Step 4.1: for each image perform the following steps

Step 4.1.1: Extract the 'lip' from individual image

Step 4.1.2: Reshape the extracted image from 2 D to 1 D.

Step 4.1.3: Associate with each image a class ` label. Assign +1 to child image, +2 to adult images and +3 to old image.

Step 4.1.4: Form a Feature Vector consisting of the extracted images and the class label.

Step 5: Shuffle the Feature Vector matrix.

Step 6: Cross- Validate the matrix and generate the train data set and the test data set.

Step 7: Perform training on the train data set using SVM classifier.

Step 8: Perform testing on the test data set along with the train vector. Step 9: Obtain the resultant classified data. A set of 119 Jpeg images have been considered for the input image set of which ‘child image’ and ‘adult image’ are of equal ratio of 40 images each. The remaining 39 images are the images of old people. Each image has been resized to the dimension of 128*115.

Figure 1: Image with original contrast

Figure 2: Resultant Image with enhanced contrast

(a) Processing of Child Image

Figure 3: Original grayscale image

Figure 4: Detected region

Figure 5: Extracted Feature of interest

(b) Processing of Adult Image

Figure 6: Original grayscale image

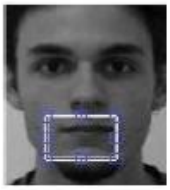

Figure 7: Detected region of interest

Figure 8: Extracted feature

(c) Processing of Old Image

Figure 9: Original grayscale image

Figure 10: Detected region of interest

Figure 11: Extracted

On these image set, histogram equalization is performed which improves the contrast of the input image set. Methods have been employed to perform Feature Extraction and Age Detection from the input data points. Finally the output class labels of the tested data points are obtained and it determines the accuracy of the SVM classifier.

Conclusions

The proposed method studied age detection using Support Vector Machine Classifier. Although the stated methodologies have been implemented on facial image data set and results are obtained with a level of accuracy, yet there are areas which are yet to be cultivated and where further enhancement can be achieved.

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