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Study on Automatic Age Estimation and Restoration for Verification of Human Faces

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Abstract**—**While recognition of most facial variations, like identity, expression, and gender, has been extensively studied, automatic age estimation has seldom been explored. In distinction to alternative facial variations, aging variation presents many unique characteristics that build age estimation a difficult task. This paper proposes associate degree automatic age estimation methodology named AGES (AGing pattern Subspace). The fundamental plan is to model the aging pattern that is outlined because the sequence of a selected individual's face pictures sorted in time order, by constructing a representative topological space. The right aging pattern for a antecedently unseen face image is decided by the projection within the topological space which will reconstruct the face image with minimum reconstruction error, whereas the position of the face image in this aging pattern can then indicate its age.

I. Introduction

Humans can without difficulty extract many varieties of useful know-how from a face image, equivalent to identity, gender, expression, approximate age, and so on. The automated extraction of lots of the understanding has been broadly studied. However, to this point, there's somewhat little work related to automatic age estimation, youngsters that it's on my own an exciting predicament, as good as a challenging sub difficulty in duties like face recognition. Men and women's behavior and preference are different at special ages, indicating mammoth competencies purposes of computerized age estimation. When compared with other facial editions, aging results show three specified characteristics:

1. The aging development is uncontrollable. No person can increase or lengthen getting older at will. The system of getting older is gradual and irreversible.
2. Personalized getting older patterns. Unique individuals age in different approaches. The getting older pattern of every person is dependent upon his/her genes as good as many outside reasons, akin to well-being, subculture, weather stipulations, and many others.
3. The getting older patterns are temporal data. The getting older progress need to obey the order of time. The face fame at a certain age will affect all older faces, but will not impact those younger ones.

Each of these traits contributes to the difficulties of automated age estimation. First, given that men and women cannot freely control aging variation, the collection of sufficient training data for age estimation is incredibly laborious. This obstacle is now partly alleviated as a result of the general public dissemination of the FG-net aging Database. However, every discipline in this database most effective has face pictures at a couple of a while, i.E., the data set is particularly incomplete in the view of aging patterns. Happily, an "entire" aging face database is unnecessary given that human beings also be taught to perceive facial ages from incomplete getting older patterns. Consequently, the learning algorithms utilized to the aging patterns have to be equipped to control tremendously incomplete data. 2nd, the mapping from the occasions (face photos) to the category a label (a long time) isn't precise, but complicatedly depends upon customized causes. Accordingly, the determination of a suitable aging pattern for a precise face becomes a central step in age estimation. 0.33, the set of sophistication labels (ages) is a wholly ordered set. Every age has an exact rank within the time sequence. Once the suitable aging pattern for a specified face photo is chosen, the "function" of the face in that getting older sample uniquely determines its age. Consistent with the final two traits, computerized age estimation must involve at the least two principal steps: Step 1 is to assess the suitable aging sample for a particular face and Step 2 is to find the role of the face in that getting older sample. This paper proposes a subspace process named ages (aging sample Subspace) for computerized age estimation. As an alternative of making use of remote face photographs as knowledge samples, ages regards each aging pattern as a pattern. The elemental concept is to mannequin the getting older patterns by way of a representative subspace. Each and every point in the subspace corresponds to at least one getting older pattern. The appropriate aging pattern for an earlier unseen face photograph depends upon the projection within the subspace that may pleasant reconstruct the face photo. Once the suitable aging sample is determined, the position of the face within the getting older pattern will then point out its age.

II. Techniques Used for Automatic Age Estimation and Restoration for Verification of Human Faces

(A) Comparing Different Classifiers for Automatic Age Estimation

They describe a quantitative evaluation of the performance of different classifiers in the task of automatic age estimation. In this context, they generate a statistical model of facial appearance, which is subsequently used as the basis for obtaining a compact parametric description of face images.

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The aim of their work is to design classifiers that accept the model-based representation of unseen images and produce an estimate of the age of the person in the corresponding face image. For this application, they have tested different classifiers: a classifier based on the use of quadratic functions for modelling the relationship between face model parameters and age, a shortest distance classifier, and artificial neural network based classifiers. They also describe variations to the basic method where they use age-specific and/or appearance specific age estimation methods. In this context, they use age estimation classifiers for each age group and/or classifiers for different clusters of subjects within their training set. They also present comparative results concerning the performance of humans and computers in the task of age estimation. Their results indicate that machines can estimate the age of a person almost as reliably as humans. They presented an experimental evaluation into the problem of automatic age estimation where the performance of a classifier based on quadratic functions, a shortest distance classifier, and neural network based classifiers were evaluated. In order to train age classifiers, it is essential to have available information about the exact age of each subject in the database. In particular, human observers achieved an age estimation error of 3.64 years when tested on a similar, but significantly smaller, database.

The experiments described in this paper rely on the compact parameterization of face images provided by applying principal component analysis. Since face parameters derived from principal components have been used successfully for age estimation, they can conclude that the age of a person could be defined based on the holistic structure of a face. However, they believe that in order to improve even more the performance of automatic age estimation algorithms, information about the fine details of a face (i.e., wrinkles) must be incorporated in the age estimation procedure. The results obtained so far prove that it is feasible to develop in the short-term systems that incorporate automatic age estimation in their functionality, resulting in more efficient human machine interaction systems.

(B) Face Verification Across Age Progression

In this paper, they develop a Bayesian age difference classifier that classifies face images of individuals based on age differences and performs face verification across age progression. Further, they study the similarity of faces across age progression. Since age separated face images invariably differ in illumination and pose, they propose preprocessing methods for minimizing such variations. Experimental results using a database comprising of pairs of face images that were retrieved from the passports of 465 individuals are presented. The verification system for faces separated by as many as nine years, attains an equal error rate of 8.5%. From a face recognition perspective, understanding the process of age progression in human faces is crucial towards the development of face recognition systems that are robust to aging effects and in the successful deployment of such systems. Some of the limitations one faces while addressing age progression in human faces as discussed as follows.

Modelling the complex shape variations human faces undergo during one's younger years or the textural variations that are observed during the later years is a very challenging task. Apart from biological factors, since factors as diverse as ethnicity, climatic conditions, food intake, mental stress, etc., also contribute towards aging effects, it is natural to expect different individuals to age differently. Manifestations of aging effects in human faces such as shape and textural variations can be best understood using 3-D scans of human heads. With 3-D head scans becoming increasingly available, Lack of databases of age progressed face images of individuals is another reason for lesser research on this topic.
They presented a Bayesian age-difference classifier that identifies the age separation between a pair of face images of an individual. In their formulation, the difference images obtained from a pair of intrapersonal age separated face images formed the primary basis for classification. While the method presented in this paper is suitable to handle age progression in adult face images, since it does not account for shape variations in faces, it may not be effective for handling age progression in face images of children. They also studied facial similarity across age progression and highlighted the role of age progression in affecting similarity scores. The methods presented to address age progression in human faces have direct relevance to passport image renewal applications.

(C) Automatic Age Estimation Based on Facial Aging Patterns

This paper proposes an automatic age estimation method named AGES (AGing pattErn Subspace). The basic idea is to model the aging pattern, which is defined as the sequence of a particular individual's face images sorted in time order, by constructing a representative subspace. The proper aging pattern for a previously unseen face image is determined by the projection in the subspace that can reconstruct the face image with minimum reconstruction error, while the position of the face image in that aging pattern will then indicate its age. In the experiments, AGES and its variants are compared with the limited existing age estimation methods (WAS and AAS) and some well-established classification methods (kNN, BP, C4.5, and SVM). Moreover, a comparison with human perception ability on age is conducted. It is interesting to note that the performance of AGES is not only significantly better than that of all the other algorithms, but also comparable to that of the human observers.

This paper proposes an automatic age estimation method named AGES, which improves their earlier work. It is interesting to note that, at least under the experimental configuration in this paper, the performance of AGES is not only significantly better than that of the state-of-the-art algorithms, but also comparable to that of the human observers. The current pre-processing method in AGES relies on many landmark points in the face images, eventually these landmarks should be determined by applying automatic land marking algorithms like. Moreover, the current pre-process does not retain the information about the outer contour size of the face. However, face size varies across ages, especially during formative years. Hence, as future work, taking the size and shape of the face contour into consideration might significantly improve the accuracy of AGES, especially for age estimation on children's faces.

Besides age estimation, AGES can be utilized in other computer vision tasks. For example, with the ability to simulate facial aging effects, AGES can be used for face recognition across ages, which have been tested in the experiment. More generally, pose and illumination variations are always troublesome in computer vision systems. Similar to AGES dealing with images at different ages, images under different pose and illumination conditions can be treated as a whole (analogous to an aging pattern). This idea has been explored in face recognition, known as the "Eigen Light-field". In order to model the light-field, a "generic training data set" is required in such works, which contains face images under all possible pose and illumination conditions. But, this is not always available in reality.

(D) A Compositional and Dynamic Model for Face Aging

In this paper, they present a compositional and dynamic model for face aging. The compositional model represents faces in each age group by a hierarchical And-Or graph, in which And nodes decompose a face into parts to describe details (e.g., hair, wrinkles, etc.) crucial for age perception and Or nodes represent large diversity of faces by alternative selections. Then a face instance is a transverse of the And-Or graph—parse graph. Face aging is modeled as a Markov process on the parse graph representation. Based on this model, they propose a face aging simulation and prediction algorithm. Inversely, an automatic age estimation algorithm is also developed under this representation. They study two criteria to evaluate the aging results using human perception experiments: 1) the accuracy of simulation: whether the aged faces are perceived of the intended age group, and 2) preservation of identity: whether the aged faces are perceived as the same person. Quantitative statistical analysis validates the performance of their aging model and age estimation algorithm.

They present a compositional and dynamic face aging model, based on which they develop algorithms for aging simulation and age estimation. Results synthesized by their algorithm are evaluated for the accuracy of age simulation and the preservation of identity. Their estimation algorithm obtains performances comparative to the state-of-the-art algorithms. Their results are attributed to two factors: a large training set and the expressive power of the compositional model, including external appearance (e.g., hair color and hair style) and high resolution factors (e.g., wrinkles, skin marks, etc.).

(E) Age-Invariant Face Recognition

Facial aging is a complex process that affects both the 3D shape of the face and its texture (e.g. wrinkles). These shape and texture changes degrade the performance of automatic face recognition systems. However, facial aging has not received substantial attention compared to other facial variations due to pose, lighting, and expression. They propose a 3D aging modeling technique and show how it can be used to compensate for the age variations to improve the face recognition performance. The aging modeling technique adapts view-invariant 3D face models to the given 2D face aging database. The proposed approach is evaluated on three different databases (i.g., FG-NET, MORPH, and BROWNS) using FaceVACS, a state-of-the-art commercial face recognition engine.

They have shown that their method is capable of handling both growth (developmental) and adult face aging effects. Exploring different (nonlinear) methods for building aging pattern space given noisy 2D or 3D shape and texture data with cross validation of the aging pattern space and aging simulation results in terms of face recognition performance can further improve simulated aging. Age estimation is crucial if a fully automatic age-invariant face recognition system is needed.

(F) Age Synthesis and Estimation via Faces: A Survey

Age estimation is defined to label a face image automatically with the exact age (year) or the age group (year range) of the individual face. Because of their particularity and complexity, both problems are attractive yet challenging to computer-based application system designers. Large efforts from both academia and industry have been devoted in the last a few decades. In this paper, they survey the complete state-of-the-art techniques in the face image-based age synthesis and estimation topics. Existing models, popular algorithms, system performances, technical difficulties, popular face aging databases, evaluation protocols, and promising future directions are also provided with systematic discussions.

They have presented a complete survey of the state-of-the-art techniques for age synthesis and estimation via face images, which became fairly particular in recent decades because of their promising real-world applications in several emerging fields. Texture synthesis is more effective for the face aging after adulthood when skin aging dominates and craniofacial growth slows down. Appearance synthesis is applicable to both cases since, usually, a statistical model will be available built on a large face aging database. Aging cues can be learned statistically for all aging stages and implemented to realistic age synthesis. But the most difficult part of appearance synthesis is the database collection and automatic face correspondence.

(G) Improving Automatic Age Estimation Algorithms using an Efficient Ensemble Technique

This work resents a framework for facial age estimation based on ensemble of individual age estimators. Both mathematical and experimental proofs show, if the individual age estimators are diverse in error, then to improve the results, they can make the ensemble age estimator using the best selected individual age estimators. They emphasize that although the experiments presented here are performed by neural networks, the proposed framework is readily applicable to any other regressor.

An ensemble age estimation algorithm which can improve individual age estimation algorithms is proposed. In the first step, several individual age estimators which are diverse in error are created. Different representation of face images using 2D Gabor filters and the Modified Census Transform are used

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to create diversity in error between the component individual age estimators. Among them, the four individual age estimators that have the best performance are selected. The four individual age estimators use a same classification model on different feature representations of same facial images. Averaging of the age estimation results of these best age estimators gives us an ensemble age estimator that has the better performance compared to all the individual estimators. Mathematical proofs ensure further improvement of the ensemble age estimation algorithm when the best individual age estimators are diverse in error.

III. Conclusion

The cutting-edge pre-processing approach in AGES is predicated on many landmark points in the face photographs, finally those landmarks have to be decided with the aid of making use of automated land marking algorithms like [4]. Furthermore, the present day pre-process does no longer keep the information about the outer contour length of the face. However, face length varies across ages, especially during early life. Hence, as future works, taking the dimensions and form of the face contour into consideration would possibly appreciably enhance the accuracy of AGES, in particular for age estimation on youngsters' faces. Besides age estimation, AGES may be applied in different system vision works. As an example, with the capacity to simulate facial ageing consequences, AGES may be used for face popularity throughout ages, which has been tested in the experiments. Generally, pose and illumination variations are constantly troublesome in computer vision systems. Similar to AGES with pictures at various ages, images beneath one-of-a-kind pose and illumination situations can be dealt with as an entire (analogous to an aging sample). This idea has been explored in face recognition, known as the "Eigen light-area". So as to version the light-area, a "regularly occurring education data set" is needed in such works, which contains face images beneath all feasible pose and illumination situations. But, this isn't always available in truth.

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