ALGORITHM FOR FACIAL IMAGE NORMALIZATION AND ANTHROPOMETRIC POINT DETECTION

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Abstract

Facial image normalization and anthropometric point analysis algorithms are widely used in fields such as biometric security, medical diagnostics, digital animation, and face recognition. This article reviews the main steps of facial image normalization, including illumination stabilization, geometric transformation, and image scaling techniques. It also discusses the principles and applications of advanced facial anthropometric point detection algorithms, such as the DLib 68-point model, MediaPipe Face Mesh, Active Shape Models (ASM), and MTCNN. The article is devoted to the study of modern facial analysis methods, their advantages and limitations, and provides theoretical and practical foundations for face identification and face geometry analysis. This study indicates the directions for identifying and solving current problems in the field.

Facial image normalization and anthropometric point analysis are important steps in modern computer vision and biometric systems. This article aims to study modern facial analysis techniques and covers the main stages of image normalization, including important processes such as illumination stabilization, geometric transformation, image rotation and skew correction. The theoretical foundations, operating methods and advantages of algorithms used to determine important anthropometric points on the face - for example, the DLib 68-point model, MediaPipe Face Mesh and MTCNN - are analyzed.

Also, their practical applications in face identification, facial shape anomaly detection, emotion analysis and medical diagnostics are discussed in detail. The article shows Active Shape Models (ASM), Principal Component Analysis (PCA), histogram equalization and other advanced techniques as important tools for more accurate and efficient implementation of the facial analysis process.

The study proposes innovative approaches aimed at identifying and solving current problems in the field of facial analysis. This article serves to create a scientific and practical basis for further improving facial recognition and analysis technologies.

Keywords: Facial image, facial image normalization, anthropometric points, facial recognition algorithms, landmark detection, geometric transformation, biometric systems, facial analysis, facial recognition.

Introduction

With the development of modern technologies, the issues of face recognition and analysis are gaining importance in biometric security, medicine, digital animation and many other fields. Algorithms for normalizing facial images and analyzing anthropometric points are the main tools for increasing the efficiency of these processes. By determining the geometric and structural features of the face, it is possible to solve complex problems such as not only identifying a person, but also analyzing facial changes, analyzing emotions, and assessing health status.

Facial image normalization is aimed at unifying the illumination, position, and geometric changes in the images, which ensures the accuracy of the subsequent analysis process. Anthropometric point detection is based on finding important anatomical points of the face and studying their mutual ratios and distances. These processes are necessary to increase the accuracy and speed of face analysis.

This article studies modern algorithms for normalizing facial images and analyzing anthropometric points, their principles of operation, and areas of practical application. At the same time, the advantages and limitations of these algorithms are discussed. This study provides a theoretical framework and practical directions for further improving facial analysis technologies.

Problem statement. Suppose we are given n facial images. The goal is to develop an algorithm and program to smooth the given facial images and determine their anthropometric points.

I. Facial image normalization algorithm

Facial image normalization algorithm is one of the initial steps used in biometric systems and facial recognition technologies. Its main task is to bring facial images taken under different conditions into a uniform format and provide an optimal state for further analysis. Normalization algorithms adapt the image to a common standard by stabilizing illumination, rotation, scale, and geometric changes.

Main stages of normalization.

1. Face detection and localization:

✓ In the initial stage, the area where the face is located in the image is determined. For this, face detection algorithms such as Haar cascades, DLib or MTCNN are used.

✓ The face image is extracted in a limited part.

2. Landmark (main point) detection:

✓ Using landmark detection algorithms, the main anthropometric points of the face (eyes, nose, corners of the lips) are determined.

✓ For example, the DLib 68-point model or MediaPipe Face Mesh technology are widely used to detect important points on the face.

3. Geometric transformations:

✓ Geometric transformations are performed to correct facial rotation, skew or perspective deformations:

✓ Affine Transformation: Face correction based on the location of the eyes and nose.

✓ Procrustes Analysis: Face alignment by matching landmark points.

4. Illumination normalization:

✓ Illumination differences in the facial image are eliminated:

✓ Histogram Equalization: Uniformization of the brightness level.

✓ Gamma Correction: Adjusts contrast and brightness.

✓ Difference of Gaussian (DoG): Smooths the image and reduces excessive noise.

5. Zoom and orientation stability:

✓ The face image is scaled to a certain standard size (for example, 128x128 or 224x224 pixels).

✓ The eyes are aligned and the position of the face image is centered.

6. Cropping:

II. Only the part containing the face area is cropped, so that background elements are kept to a minimum.

Algorithms for analyzing anthropometric points of a face image

Anthropometric points on the face are anatomically important points on the face that determine mutual geometric proportions, through which it is possible to analyze the face, make measurements and recognize the face. These points usually represent specific anatomical locations such as the corners of the eyes, the tip of the nose, the corners of the lips, the edges of the eyebrows. Algorithms for analyzing anthropometric points of the face are widely used in many fields, including biometric systems, face recognition, emotion recognition and medical diagnostics.

The main tasks of anthropometric point analysis algorithms.

1. Landmark detection:

Identify important anthropometric points in the image and find their coordinates.

2. Calculate geometric dimensions and proportions:

Determine distances between points, angles, and overall proportions of the face.

3. Study facial shape and features:

Analyze individual facial features based on geometric proportions.

4. Study facial dynamics:

Observe facial movements (facial expressions, emotions, expressions).

Anthropometric point analysis algorithms.

1. DLib 68-point model:

✓ The DLib library's facial landmark detection model identifies 68 important anthropometric points on the face.

✓ Using these points, the face shape, eyebrows, eyes, nose, and lips are accurately positioned.

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✓ The model is adapted to work in different lighting and orientations.

2. MediaPipe Face Mesh:

✓ A real-time face detection and 468 high-precision landmark detection technology developed by Google.

✓ It is used to analyze emotions, study facial expressions, and create a face model in 3D format.

3. Active Shape Models (ASM):

✓ The ASM algorithm identifies important points on the face by matching a predefined face shape (template) and points in the image.

✓ It aligns the face and performs measurements, taking into account geometric transformations.

4. Active Appearance Models (AAM):

✓ An algorithm that analyzes the geometric shape and texture of the face together.

✓ It includes anthropometric points to determine the face shape in the image.

5. MTCNN (Multi-task Cascaded Convolutional Networks):

✓ A model based on deep learning that detects the main landmarks (eyes, nose, lips) along with face recognition.

✓ High-precision and fast algorithm.

6. Facial Action Coding System (FACS):

✓ A system for analyzing facial expressions based on the movement of facial muscles.

✓ Accurate anatomical analysis of facial movements is performed based on anthropometric points.

7. Procrustes Analysis:

✓ Used to align anthropometric points of the face.

✓ Allows face analysis by comparing the positions of landmarks with a standard shape.

8. Deep Learning algorithms (FaceNet, OpenFace):

✓ Deep neural networks are used to detect landmarks and analyze facial expressions.

✓ Allows face shape to be determined in 2D or 3D format.

Conclusion

Facial image normalization and anthropometric point analysis algorithms are crucial in facial recognition, biometric security, emotion analysis, and many other fields. This paper analyzes in detail the main steps of facial image normalization, including illumination stabilization, application of geometric transformations, and image scaling techniques. At the same time, the principles and advantages of modern algorithms for anthropometric point detection, including the DLib 68-point model, MediaPipe Face Mesh, Active Shape Models (ASM), and MTCNN, are reviewed.

The study shows that facial normalization and analysis technologies have high accuracy, speed, and flexibility, which can significantly improve the accuracy of biometric systems. However, these technologies have limitations, such as sensitivity to illumination, facial rotation, or skewed positions, as well as high computing power requirements.

In the future, further improvement of face normalization and anthropometric point detection algorithms will play an important role in making face recognition systems universal and stable. Also, expanding deep learning-based algorithms in this area and creating optimized datasets for them can be one of the main directions of future research. This article will highlight the theoretical and practical foundations of face analysis technologies and serve as an important source for new scientific developments in this area.

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