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Study of Face Detection Algorithms

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Abstract-

With innovation in network technologies, industrial dependency on network technology is increasing day by day. Due to which network information security issues are increasing. With development of industrialization, the use of sensors has become extensive. Sensors perceive some signals and convert those signals into an electrical signal and records it. With use of conversion circuit, it transfers electrical signal into a digital form or other display form that is conducive to observation. Based on original function, which is combined with computer technology, it now integrates to store data, communicate data, process data and display better information. In early days finger and palm lines used to scan to recognise person. But this method has certain limitations. This research paper proposes new computer-based algorithms from face detection technology. Face detection technology is mainly introduced from the OpenCV method. By using contrast experiment, the detection rates under the three different requirements of side face detection, occlusion detection and facial exaggerated expression are compared. It is found that accuracy of each method is improved. The advantages and disadvantages of the algorithm verifies the effectiveness of the method.

Artificial neural networks are the most popular method in image recognition. The algorithms perform three main tasks. It detects faces in real-time through camera, video or through images. It then calculates mathematical model of a face and compares models with database or training sets.

Keywords

Face detection, Principal Component Analysis (PCA), Fisherfaces, Support vector machine (SVM), Convolutional Neural Network, Skin Texture Analysis

Introduction

In present days face detection is applied in many fields such as mobile phone unlocking, security access, attendance system in offices, schools and colleges. With gradual diversification of the technology, face detection has become very close to our lives. It makes easier and faster and also adds

a touch of technology fun. Through the series of operations such as phone unlocking, security access it became a vital part of our lives. Sensors used for face detection can be combined with many other technologies to form smart sensors.

The research on face detection has important research value due to the variability of skin color, face expression, and illumination. Study the face detection based on skin color features done by Yong and Yanru [1]. They found that the difference in skin color is observable under different illumination levels. To overcome this problem, they uses HIS and YCbCr two-skin color space lighting as the technical basis. The skin color area can be distinguished using skin color model which reduces the impact of care on skin color. This is more convenient for the face detection and positioning through the SNoW classifier. For the enhancement of face detection accuracy and speed, Chengji et al. [2] designed experimental differences caused by the complexity of the face in the real picture and background frame.

The face detection technology is analyzed by the many methods. The effect of face detection under different conditions is compared with the accuracy of face detection in different situations according to the three methods.

Literature Review

Face detection has recently received significant attention, especially during Covid-19 pandemic. Successful image analysis of the application helped to boost its popularity. There are main two reasons for this trend. First is the extensive range of commercial applications and the second is the availability of technologies. Old face detection systems have reached a certain level of maturity. Success of those applications is limited by the conditions forced by many current real applications. Face images acquired in open environment with changes in illumination or pose remains a mostly unsolved problem.

Problem Definition

Face detection has many challenges due to pose variation, different dimensions, skin colour, illumination variations, uncontrolled environments and aging. Currently Face detection is getting remarkable improvement and accuracy to resolve these challenges. Li et al [3] proposed Near Infrared (NIR) imaging system that gives satisfactory results for face detection in illumination variance conditions but it does not give good results when matching NIR image to visible images.

Objective

The objective of face detection is to find a series of data of the same face in a database. Face detection process is carried out in real-time. Sometime this data is not available to all biometric facial recognition software providers.

The facial recognition process can perform two variants:

1. A face is registered and associate it with an identity, in such a way that it is recorded in the system.

2. The incoming data from the camera is cross checked with the existing data in the database. If the face matches with already registered identity, the user will get access to the system.

Research Methodology

This is a method of biometric identification that uses body measures like eye, face and head which verifies the identity of a person through its facial biometric pattern and data. The collection of unique biometric data of each person helps to identify, verify and authenticate a person.

The face detection procedure requires devices that has digital photographic technology to obtain the images and necessary data to create biometric facial pattern to identify a person.

Biometric facial detection uses unique mathematical and dynamic patterns which make this system safest and most effective than the current use of email, passwords, images, fingerprint and selfies.

Face detection systems captures images from a camera in a two-dimensional or three-dimensional way depending on the characteristics of the device.

These compares relevant information of image signal in real-time photos or videos in a database, which is more reliable and secure than the information obtained in a static image. This biometric facial recognition procedure requires an internet connection to capture data from the servers.

Algorithms

The face detection algorithms are methods which constructs biometric face models for further analysis and the face detection process.

- **Principal Component Analysis (PCA) :**

For dimensionality reduction method PCA is commonly used. It computes the principal components and performs a change of basis. It stores the data in the direction of maximum alteration. The reduced features are uncorrelated with each other. These uncorrelated features are used for unsupervised clustering and classification. Autoencoder is also used for dimensionality reduction. But, the latent space is not necessarily uncorrelated of autoencoder. PCA promises that all features are uncorrelated with each other.

- **Fisherfaces :**

Fisherfaces is one of the most popular facial detection algorithms. It is considered greater to many of its alternatives. As an enhancement to the Eigenfaces algorithm, it is often compared to Eigenfaces and considered more successful in class difference in the training process. The main advantage of this algorithm is its capability to interpolate and extrapolate over lighting and facial expression variation. It has 93% accuracy of the Fisherfaces algorithm when combined with the PCA method at the pre-processing stage.

- **Support vector machine (SVM) :**

Support vector machine is a machine learning algorithm that uses a two-group classification principle for distinguishing faces from not-faces. SVM model receives a labelled training data set to categorize new test data for each category. Investigators apply linear and nonlinear SVM training models for face detection. The current results show that the nonlinear training machine has a better recognition and classification results and larger margin.

- **Convolutional Neural Network :**

Convolutional neural network (CNN) is one of the advances of artificial neural networks (ANN) and AI development. It is the most popular algorithms

in deep learning. It is a type of machine learning in which a model learns itself to perform classification tasks directly on text, an image, video, or sound. The model shows remarkable results in many fields such as natural language processing (NLP), computer vision and the largest image classification data set. CNN is a neural network with new layers convolutional and pooling. CNN can have many layers and each learns to detect different imaging features.

- **Skin Texture Analysis**

Skin recognition technology has many applications — hand gesture analysis, face detection algorithms, objectionable image filtering etc. It uses high-resolution images. Actual cases of skin texture analysis use different distinctive parameters like moles, skin tones, skin colour and many others. Current research based on a mixture of texture features and skin colour showed exciting results. The investigators used a neural network to develop and test a skin recognition system.

Analysis & Findings

Face detection applications uses algorithms and Machine Learning to find human faces in larger images/pictures. This often incorporate other non-face objects such as other human body parts like feet or hands, landscapes and buildings. Generally face detection algorithm start by searching for human eyes which is one of the easiest features to detect. The algorithm then detect, nose, nostrils, eyebrows, mouth and the iris. Once the algorithm finds a facial region, it applies other tests to confirm that it has detected a face.

To ensure accuracy, the algorithms need to be trained on large data sets with lakhs of positive and negative images. The training improves the algorithm's ability to determine whether there are faces in an image and where they are.

The methods which are being used in face detection should be feature-based, knowledge-based, template matching or appearance-based. Each has advantages and disadvantages:

Some of the more precise techniques used in face detection are:

- Removing the background. For example, if an image has a plain, mono-colour background or a pre-defined, static background, then removing the background can help reveal the face boundaries.
- In colour images, sometimes skin colour can be used to find faces; however, this may not work with all complexions.
- Using motion to find faces is another option. In real-time video, a face is always in motion, so this method must calculate the moving area. If other object is moving in background, this method confuses.
- A combination of the strategies listed above can provide a comprehensive face detection method.

Identifying faces in images can be complicated due to the various factors such as expression, pose, position and orientation, skin colour and pixel values, the presence of glasses or facial hair and differences in lighting conditions, camera picture and image resolution. With use of deep learning, face detection brings advances in recent years. This represents the advantage of considerably outperforming traditional computer vision methods.

Computer vision researchers Paul Viola and Michael Jones proposed a framework to detect

faces in real time with high accuracy brings Major improvements to face detection methodology. Viola-Jones framework trains a model to understand what a face is and not-face. The model extracts detailed features, which are stored in a file. This features can be compared with new images with the previously stored features at several stages. When the captured image passes through each stage of the feature comparison, then it can be concluded that a face has been detected and operations on it can be proceed.

Viola-Jones framework is still popular for detect faces in real-time applications, it also has limitations. For example, this framework may not work if a face is covered with a scarf of mask or if a face is not oriented properly then this algorithm fails to find it.

Advantages of face detection

In facial imaging applications, such as facial detection and face analysis it various advantages for users, such as:

- Improved security.
- Easy to integrate.
- Automated identification

Disadvantages of face detection

Various disadvantages of face detection are:

- Massive data storage burden.
- Detection is vulnerable.
- A potential breach of privacy

Uses of face detection

- Access Control
- Attendance Tracking
- Banking : For reliable authorization
- Public Security
- Law Enforcement

Face Detection problem during Covid-19

During coronavirus (COVID-19) pandemic, wearing face masks have become an important part of daily routine life. Use of face mask was protective and preventive essential of everyday life to fight with the coronavirus. Worldwide many organizations were using fingerprint or card-based attendance system. They switched to face-based attendance system to avoid direct contact. But adaption of face mask by everyone brought a new challenge to existing commercial biometric facial recognition techniques. In this paper, we have elaborated few methodologies that will enhance existing face detection technology capabilities. A dataset of faces wearing mask was collected to train the Support Vector Machine (SVM) classifier on Face Detection Feature vector. This methodology gives face detection accuracy up to 97% with masked faces.

Limitations

1. Poor Image Quality Limits Facial Recognition's Effectiveness
2. Small Image Sizes Make Facial Recognition More Difficult
3. Different Face Angles Can Throw Off Facial Recognition's Reliability
4. Data Processing and Storage Can Limit Facial Recognition Tech

Future Scope

As technology improves, higher-definition cameras will become available. As computer's speed and networks are growing faster, it will help to move more data and processors will work faster. Data available in database will help to better Facial-recognition from an image. The mechanisms that defeat today's algorithms, such as confusing parts of the face with masks and sunglasses or changing one's hairstyle, will be easily overcome.
Pattern of capturing images is an immediate way to overcome these limitations. Using checkpoints which requires subjects to line up and funnel through a single point. Sophisticated cameras can be used to focus on each person closely which yield far more useful frontal, higher-resolution probe images. Wide-scale implementation of this technology increases with number of cameras required.

Conclusion

The most essential part of the human body is face and its unique features make it more critical to identify. Many different types of algorithms and technologies are being used worldwide to make the face recognition process more reliable and accurate. The applications of face detection technology is also growing in defence, security, healthcare, forensic and transportation which requires more accuracy. However, some challenges are still there while developing face recognition technology such as occlusion, pose, ageing, expressions, etc. which have been discussed above in the article.

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