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論　文　内　容　要　旨

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| 学位論文題目 | Automatic Frontal Face Recognition System Based on Wavelet Decomposition and Support Vector Machines<br>ウェーブレット変換とサポートベクターマシンに基づく自動正面顔認識システム | | |

内容要旨

Automatic Face Recognition (AFR) aims at identifying different human beings according to their face images. Such research has both significant theoretic values and wide potential applications. As a scientific issue, AFR is a typical pattern analysis, understanding and classification problem, related to Pattern Recognition, Computer Vision and Cognitive Psychology etc. Its achievements would contribute to the development of these disciplines.

After more than 30 years' development, AFR has made great progress especially in the past ten years. The state-of-the-art AFR system can perform identification successfully under well-controlled environment. However, a great number of challenges are to be solved before one can implement a robust practical AFR application. The following key issues are especially pivotal: (1) the accurate facial feature location problem; (2) efficient face representation and corresponding classifier with high accuracy; (3) how to improve the robustness of AFR to inevitable mis-alignment of the facial feature. In addition, system design is also as important for developing robust and practical AFR systems. In this thesis, the above-mentioned key issues are studied, aiming at practical automatic frontal face recognition (AFFR) system. And the main contribution of this thesis includes:

**1. A novel fast fractal image compression**

A novel fast fractal image coding algorithm based on texture feature is proposed. The most fractal image encoding time is spent on determining the approximate D-block from a large D-blocks library by using the global searching method. Clustering the D-blocks library is an effective method to reduce the encoding time. First, all the D-blocks are clustered into several parts based on the new texture feature alpha derived from variation function; second, for each R-block, the approximate D-blocks are searched for in the same part. In the search process, we import control parameter δ, this step avoids losing the most approximate D-block for each R-block. Finally, the R-blocks whose least errors are larger than the threshold given in advance are coded by the quad tree method. The experimental results show that the proposed algorithm can be over 6 times faster compared to the moment-feature-based fractal image algorithm; in addition, proposed algorithm also improves the quality of the decoded image as well increases the PSNR's average value by 2 dB.

**2. Provided a thorough survey of the AFR history**

The latest AFR survey was published in the year 2000, which in fact surveyed the AFR researches before 1999. This thesis has provided a more recent overview of the AFR research and development. Then, AFR methods are further categorized according to facial feature extraction, face representation, and classification separately. We also survey the main public

face databases and performance evaluations protocols, based on which the state-of-the-arts of AFR are summarized. Finally, the challenges and technical trends in AFR fields are discussed.

**3. Proposed an eye location algorithm based on HSV color space and template matching**

The quality of feature extraction will directly affect recognition results. Eyes are the one of the most important organs of a face including a lot of useful features. Therefore, eye location has become one of the most significant techniques in pattern recognition.

This thesis proposed an eye location method based on the HSV color space model using template matching. At first, we describe an implementation for skin detection which relies on the H channel to characterize the skin colors range, and determine the possible face region. Then we manually extract an average eye template using the human eye's sample images, and finally in the face region, locate the eyes using this average template. As eye template matching, the rectangular region of the eye which confirmed from the skin region is just searched. Compared to other template matching methods that search for the human eye in whole face region, the proposed method saves on the matching time by avoiding the impact of the mouth and nose in the process of positioning. Undoubtedly, this method enhances the accuracy of eye detection.

**4. Investigated the face detection methods, and proposed an improved training AdaBoost algorithm for face detection**

Face detection technology as an important part of face recognition has high research and application value. In 2001 the AdaBoost algorithm was applied to face detection by Paul Viola and Michael Jones. The AdaBoost is an algorithm for constructing a strong classifier as linear combine of weak classifier trained by different training sets. The classifiers can be weak (i.e., display a substantial error rate), but their performance is not random (resulting in an error rate of 0.5 for binary classification), they will improve the final model.

In this section, an improved training algorithm for AdaBoost is proposed to bring down the complexity of human face detection. Two methods are adopted to accelerate the training: (1) A method to solve the parameters of a single weaker classifier is proposed, making the training speed is higher than probability method; (2) a double threshold decision for a single weaker classifier is introduced, and the number of weaker classifiers in the AdaBoost system is reduced. Based on the simplified detector, both the training time and the detecting time could be reduced.

**5. Primarily studied wavelet transform based feature extraction and Support vector machines to face recognition problem; recognition rate is analyzed and evaluated experimentally**

The extracted features from human images by wavelet decomposition are less sensitive to facial expression variation. As a classifier, SVM provides high generation performance without transcendental knowledge. First, we detect the face region using an improved AdaBoost algorithm. Second, we extract the appropriate features of the face by wavelet decomposition, and compose the face feature vectors as input to SVM. Third, we train the SVM model by the face feature vectors, and then use the trained SVM model to classify the human face. In the training process, three different kernel functions are adopted: Radial basis function, Polynomial and Linear kernel function. Finally, we present a face recognition system that can achieve high recognition precision and fast recognition speed in practice. Experimental results indicate that the proposed method can achieve recognition precision of 96.78 percent based on 96 persons in Ren-FEdb database that is higher than other approaches.

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論文審査の結果の要旨

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学位論文題目　Automatic Frontal Face Recognition System Based on Wavelet Decomposition and Support Vector Machines
（ウェーブレット変換とサポートベクターマシンに基づく自動正面顔認識システム）

審査結果の要旨

人の顔をコンピュータによって誰であるかを個人認識する手法は，これまでに多くの研究が行なわれており，すでに，いくつかの認識率の高い手法が開発されている．しかしそれらの手法の多くは，整った環境の下のみで有効な手法であり，照明の変化や背景の変動，顔の向きや表情の変化などの影響を受けやすいものであり，応用分野が限定されるものであった．そのため現在，環境の変化に対してロバストな手法の開発が望まれている．それに対して，本研究では，ウェーブレット変換とサポートベクターマシンに基づく自動正面顔認識手法の開発を行なった．これは，顔画像に対するウェーブレット変換によって得られる周波数ごとの画像から環境の変動の受けにくい個人を表現することのできる特徴量を抽出し，さらにサポートベクターマシンを用いることで，顔の変化に影響されない認識を行なうものである．提案手法について，96名の人の顔の画像データに対して認識処理を行なったところ，約97パーセントと既存の手法よりも高い認識率を得ることができ，高精度な顔の認識が可能になっていることがわかった．

以上本研究は，コンピュータビジョン分野において新しい手法を提案し，様々な実験を通して有効性を確認したもので一定の水準に達するものであり，本論文は博士（工学）の学位授与に値するものと判定する。