Development of Real-time Multi-object Recognition System

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1. Research Target

Image recognition is a very difficult task for a computer because of complexity of a natural scene. In order to recognize various kinds of object from a natural scene, robust image processing techniques are required under variation in size, orientation, lighting condition and so on. Moreover, it is also necessary to combine several image processing. The high-level information processing technologies realizing natural scene recognition is not developed at present.

On the other hand, a human brain can easily recognize complex images unconsciously. It seems that highly complex processing can be achieved by massively parallel behavior of a large number of neurons and hierarchical information processing architecture that integrates low-level image features extracted from an input into meaningful high-level image features over several stages.

The objective of our research is realization of highly intelligent information processing system that can recognize the variety and the various objects in a natural scene in an instant.

2. Research Results

2.1 A Concept of Multi-object Recognition System

For the purpose of developing a real-time/high-level recognition technology, we have been introduced a concept of multi-object recognition system composed of 3D custom stack of multi-functional chips [1]. The hierarchical and massively-parallel processing of human brain are achieved using multi-functional chips and local/global wireless interconnects among LSIs based on pixel-parallel circuit architecture. Furthermore, we apply the eigenfaces method which is one of the major pattern recognition methods using principal component analysis (PCA) [2] to the algorithm of our proposed system. The multi-object recognition system can composed of image sensor, image normalizer, objects detector, objects recognizer and multi-object database (DB) chips.

2.2 Eigenfaces Method with Principal Component Analysis

The eigenfaces method is based on the principal component analysis [3]. First, the face images in a dataset is decomposed into a small set of characteristic feature images, called eigenfaces, which are the orthogonal eigenvectors calculated from the face images. The eigenfaces are considered as the principal components of the original images. Next, a weight vector to represent face images as a linear combination of eigenvectors is calculated. Finally, by comparing the weight vectors of an unknown new face to those of dataset's images, an unknown face can be identified as a person.

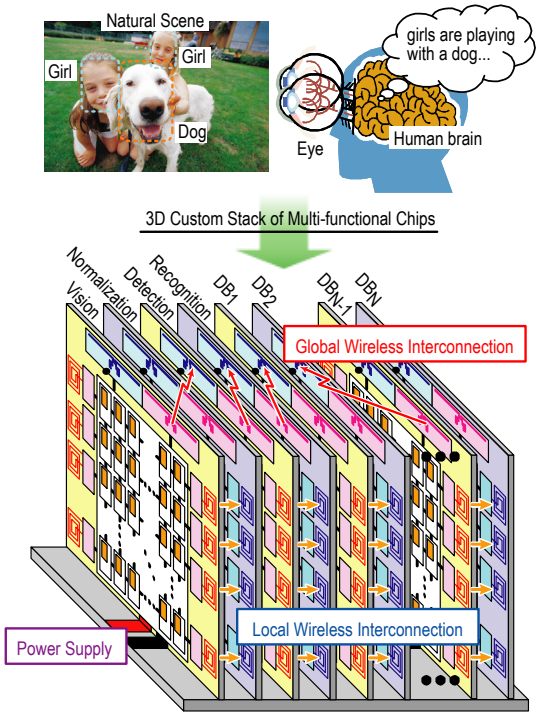

Figure 1: A concept of multi-object recognition system.

One can reconstruct an input image by using its weight vector and the eigenvectors of a dataset. If the Euclidian distance between input and reconstructed images is lower than a threshold, an input image should be identified with same class as a dataset.

2.3 Numerical Simulation of Human Face Recognition

We performed a numerical simulation of human face recognition by using the eigenfaces method. The face dataset composed of 10 persons is shown in Fig. 2(a). First, we calculated 9 eigenfaces and 10 weight vectors from these faces, and then searched each minimum distance between weight vectors for 4 input images as shown in Fig. 2(b). As a result, input images were recognized as output images, respectively, as shown in Fig. 2(c), even though there were some variations in face orientation.

Human face detection from a natural scene is shown in Fig. 3, where the eigenfaces of Fig. 2(a) were used for creating reconstructed face images. As a result of finding the image regions whose distances were lower than a threshold, only three human faces were detected exactly as shown in Fig. 3(a) and (b).

In above simulations, we treated only gray-scale images, but a real world is different. Therefore, we modified the algorithm to recognize a color image and executed numerical simulations again. As shown in Fig. 4(b), a candi-

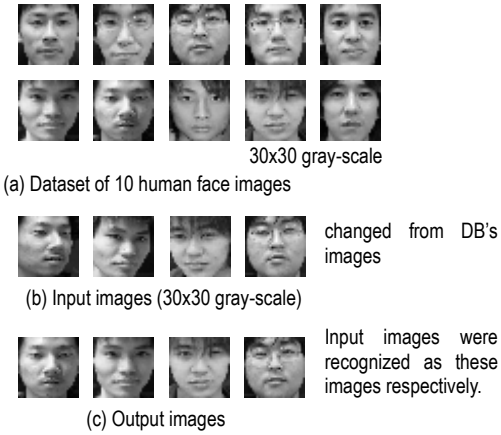

Figure 2: Numerical simulation results of human face recognition.

Figure 3: Numerical simulation results of human face detection.

date for human face was extracted using skin color information (HQ color space), and face detection and recognition were achieved successfully.

Moreover, we developed a prototype real-time human face recognition system composed of personal USB camera and software based on Win32API as shown in Fig. 5. This system can operate about 10 frame/s and recognize one or more human faces between each frame.

3. Conclusion

We proposed a concept of the multi-object recognition system composed of 3D custom stack. We also confirmed human face detection in a natural scene and recognition under some variations using the eigenfaces method by numerical simulation. Moreover, we developed a prototype real-time human face recognition software system.

We are scheduled to extend the eigenfaces method to multi-object recognition and realize their VLSI implementation.

References

[1] H. Ando, *et al*., Proc. 2nd International Workshop, 2004.
[2] M. Yang, *et al*., IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 24, pp. 34-58, 2002.
[3] M. A. Turk, *et al*., CVPR'91, pp.5860591, 1991.

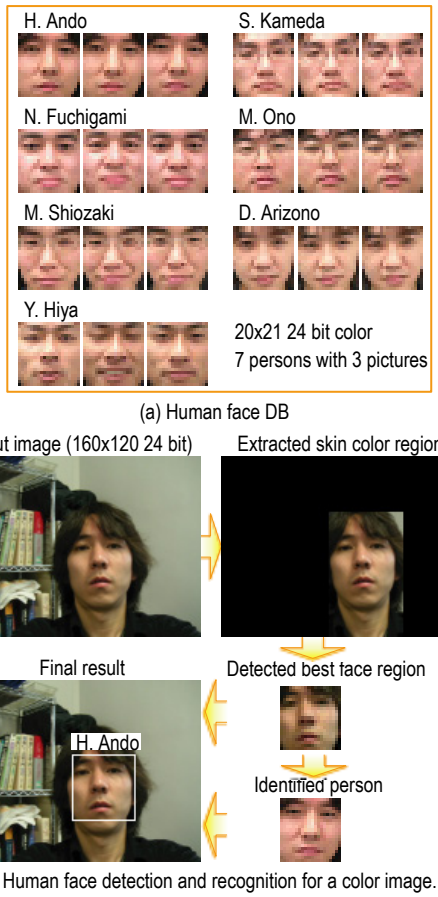

Figure 4: Numerical simulation results using color information for natural scene recognition.

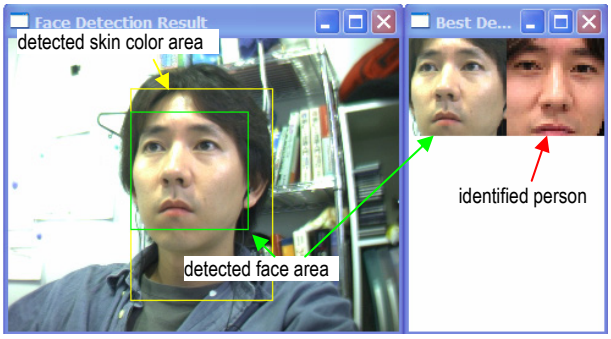

Figure 5: A prototype of real-time multi-object recognition system (now only human face).

Published Papers and Patents

① Published Papers

1. H. Ando, T. Morie, M. Miyake, M. Nagata and A. Iwata "Image Segmentation/Extraction Using Nonlinear Cellular Networks and their VLSI Implementation Using Pulse-Modulation Techniques", IEICE Trans. Fundamentals, Vol. E85-A, No. 2, pp. 381-388, 2002.

② Proceedings

1. H. Ando, T. Morie, M. Nagata and A. Iwata, "An Image Region Extraction LSI Based on a Merged/Mixed-Signal Nonlinear Oscillator Network Circuit", 28th European Solid-State Circuits Conference (ESSCIRC 2002), September 2002, Florence, Italy