Edge Detection Based on Biomimetic Pattern Recognition

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Abstract
This paper introduced a technique for edge detection by biomimetic pattern recognition (BPR). The images were scanned into a computer. Due to the nature of the acquiring technique, the acquired images have lots of artifacts, resulting in complicated edge detection. According to this, we used Biomimetic pattern recognition, which is based on "matter cognition" instead of "matter classification" and rather closer to the function of the human being. Finally, the experiments showed that the technique is feasible and has some flexibility.

Keywords: *biomimetic pattern recognition, biomimetic edge detection, ART-2, artificial neural network, edge detection*

1. Introduction

Edge Detection is an important concept in image processing, which has been extensively studied by researchers of applied science. There are many edge detection models in the pattern recognition field, which can be used to implement some kinds of image processing task [1]. Examples include Sobel detector, Roberts detector, Prewitt detector and many others. Under practice and theory analysis, Canny proposed three continuous criteria to compare the performance of the different edge detector: good detection, good localization and low-responses. Based on the criteria, an optimal detector for edge detection is obtained: derivative of Gaussian functions. Also, mathematical methods to study edge detection based on convolution were presented in [2] and [3].

These traditional edge detectors take the optimal demarcation of the derivative of samples in feature space as the target**.** Whereas the biomimetic pattern recognition takes the optimal cover of distribution of one kind of samples in feature space as the target**.** This new model is rather closer to the function of the human being, than traditional Statistical Pattern Recognition using "optimal separating" as its main principle.

Adaptive Resonance Theory (ART) [4] is an important method of Artificial neural network (ANN) all along, according to ANN's powerful ability to approximate functions and excellent ability of self-learning, partitioning and robustness, with extensive application such as electrical and mechanical engineering, biology and laser systems and secure communication systems. Therefore, ART using the analysis method of high-dimensional space geometry is a very appropriate method to implement the Biomimetic Pattern Recognition.

In this paper, we consider two-dimensional edge detection based on ART with Biomimetic Pattern Recognition. Then, the features are applied to a network of ANN to solve gray-level image segmentation problems.

This paper is organized as follows. In Section 2, the theoretical results of key techniques are presented. In Section 3, we present the Biomimetic Edge Detection. In Section 4, Experiment Results are shown and Section 5 concludes the paper.

2. Key Techniques
2.1. ART-2

The key technique is the supervised ART-2 shown in Figure 1, upgraded versions of ART. Kamal R. Al-Rawi etc. presented a supervised ART-2 algorithm [5, 6] in 1999, but it should be employed when a large number of committed nodes (>1000) are expected. The supervised

ART-2 algorithm presented in this paper, based on improvement on algorithm [7], can work adaptively under the circumstances of a small training set.

The ART-2 network consists of two layers (short term memory), weights connecting the two layers (long term memory), and a vigilance testing factor to control the closeness of the groups to one another. The F1 layer receives the inputs and through a short term memory process obtains a result from the F2 layer. We provide input for ART-2 as training set. Because the training set belongs to a class, it can adjust vigilance testing factor to make output according to real requirements. The program is an iteration cycle until finishing adjustment. So, we modify ART-2 model to fit supervised algorithm.

ART-2 would compare the result from the short-term memory to long-term memory via the weights and places the input vector into a category. We modify comparison part in ART-2, i.e. we append a cache to the part. When supervised ART-2 is learning, if classification is an error, then adjusting vigilance testing factor, computing again, thus a vigilance testing factor would be an appropriate value.
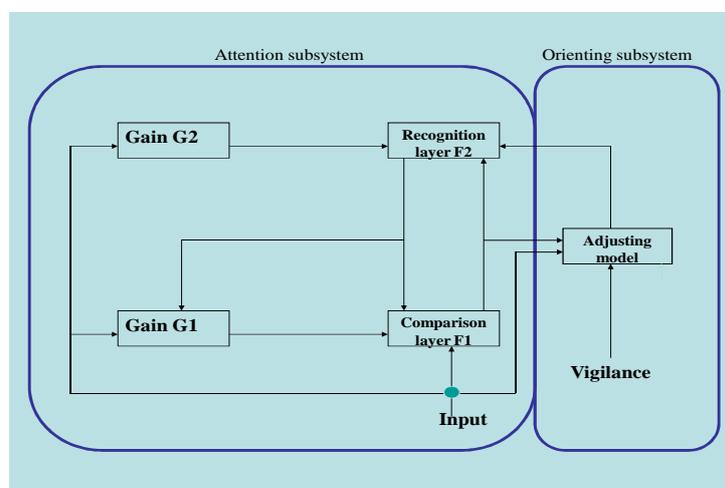

Figure 1. Basic Schema of ART

2.2. Biomimetic Pattern Recognition

Nowadays the high performance biomimetic ways have established the focus of biomimetic technology in the AI field. Sensory segmentation is the ability to attend to some objects in a scene by separating them from each other and from their surroundings. Pattern recognition and scene analysis can be substantially simplified if a good segmentation is available. These are biological instincts.

Biomimetic Pattern Recognition (BPR) first proposed by Wang Shoujue [8], this new model of Pattern Recognition based on "matter cognition" instead of "matter classification", so BPR is rather closer to the function of the human being, than traditional statistical pattern recognition using "optimal is separating" as its main principle. The method used by Biomimetic Pattern Recognition is "High-Dimensional Space Complex Geometrical Body Cover Recognition Method", which studies some kinds of samples' distribution in feature space and gives reasonable cover, so the samples can be "recognized". BPR has been used in many fields (such as rigid object recognition, multi-camera face identification, DOA estimation, speech recognition, etc.) and the results shown its superiority.

3. Biomimetic Edge Detection

Biomimetic Edge Detection is implementing edge detection based on Biomimetic ways. For ART-2 to do Biomimetic Edge Detection, the learning process is a primary step. First, we found nine kinds of basic edge pattern as training sample set shown in Figure 2. Then ART-2

can be trained through the nine kinds of basic edge pattern. Finally ART-2 can identify edge, which is a combination of nine kinds of basic edge pattern.
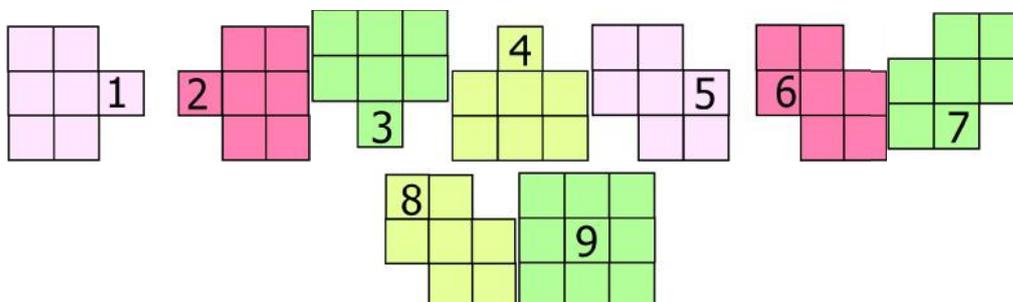

Figure 2. Nine Kinds of Basic Edge Pattern

4. Experiment Results

The algorithms were coded in java and MATLAB. The key resulting images are shown in Figure 3.
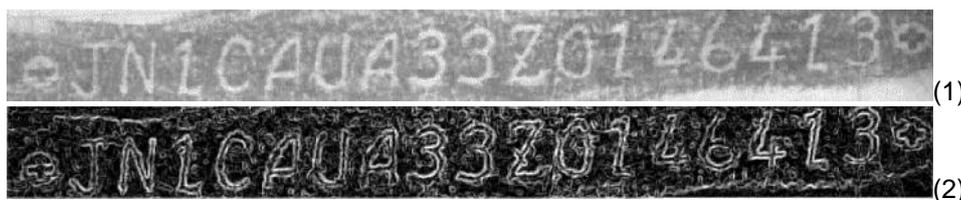

Figure 3. (1) Standard image, (2) Resulting of edge detection

We tested Biomimetic Edge Detection based on supervised ART-2 with 100 examples, and it had 29 blurred images. The Biomimetic Edge Detection based on supervised ART-2 network attained an accuracy of 71%.

5 Conclusion and Directions for Future Research

In this paper we proposed to use a supervised ART-2 combined with Biomimetic Edge Detection to solve gray-level image segmentation problems. The experiments show an accuracy of 71%, which is not perfect but can potentially be used to pretreatment the vast amount of images.

We would improve the technique in these sections: modification of algorithm of comparisons in supervised ART-2, such as using Hausdorff distance and appending algorithm to remove noise etc.

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