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GPU-based parallel optimization of immune convolutional neural network and embedded system

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ABSTRACT

Up to now, the image recognition system has been utilized more and more widely in the security monitoring, the industrial intelligent monitoring, the unmanned vehicle, and even the space exploration. In designing the image recognition system, the traditional convolutional neural network has some defects such as long training time, easy over-fitting and high misclassification rate. In order to overcome these defects, we firstly used the immune mechanism to improve the convolutional neural network and put forward a novel immune convolutional neural network algorithm, after we analyzed the network structure and parameters of the convolutional neural network. Our algorithm not only integrated the location data of the network nodes and the adjustable parameters, but also dynamically adjusted the smoothing factor of the basis function. In addition, we utilized the NVIDIA GPU (Graphics Processing Unit) to accelerate the new immune convolutional neural network (ICNN) in parallel computing and built a real-time embedded image recognition system for this ICNN. The immune convolutional neural network algorithm was improved with CUDA programming and was tested with the sample data in the GPU-based environment. The GPU-based implementation of the novel immune convolutional neural network algorithm was made with the cuDNN, which was designed by NVIDIA for GPU-based accelerating of DNNs in machine learning. Experimental results show that our new immune convolutional neural network has higher recognition rate, more stable performance and faster computing speed than the traditional convolutional neural network.

1. Introduction

Nowadays, based on the embedded system, some portable image recognition systems are required in an increasing number of applications such as the security monitoring, the smart home furnishing and the outdoor remote monitoring (Park et al., 2013). For example, the Google glasses symbolized the great leap of image recognition technology in some mobile embedded devices (Feng et al., 2014; Benninger, 2015). Compared with some PC-based image processing systems, the embedded image processing system has many advantages, which include better portability, more advanced code firmware, smaller software, less power consumption, stronger anti-interference performance, and more reasonable cost etc (Kyo et al., 2007). However, the embedded image processing platform has many technology problems. For example, the computing speed of the embedded CPU cannot calculate fast enough, its memory is too small, and its computing frequency is not high enough. Due to these crucial bottlenecks and the real-time application requirements, some complex intelligent algorithms cannot be used in many embedded image processing systems.

Before solving these bottleneck problems, we analyzed the hardware and software designs of the embedded image recognition system firstly. Moreover, we discussed such relative design problems as the embedded hardware equipment selection, the collection and screening of the image sample database, the recognition algorithm and so on. The reason was that the solutions to these problems could increase the performance and stability of the embedded identification system. We firstly proposed an immune convolutional neural network algorithm on both the Linux operating system Ubuntu and the ARM microprocessor such as S3C6410, to achieve the automatic image detection and recognition system. We integrated the immune algorithm of the artificial immune network and the convolutional neural network through the new embedded image recognition operator, and attained better recognition results adaptively. In recent years, some researchers have investigated the theories and applications of the immune computation. The observer-based fault diagnostics and

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prediction (FDP) scheme for a class of nonlinear discrete-time systems via output measurements was introduced by using artificial immune system (AIS) and a robust adaptive term (Thumati et al., 2013). A multiobjective algorithm was presented to reduce power losses while improving the reliability index using the artificial immune systems technique applying graph theory considerations to improve computational performance and Pareto dominance rules (Alonso et al., 2015). An artificial immune system inspired by the fundamental principle of the vertebrate immune system, for solving constrained optimization problems, was proposed. (Zhang et al., 2014). The robustness of the artificial immune recognition system (AIRS) for the gases/odors identification problem was discussed (Sunny et al., 2013). A new approach was presented to detect and classify voltage disturbances in electrical distribution systems based on wavelet transform and artificial immune algorithm (Lima, et al., 2015). A general framework of the AIS based IDS was discussed from three aspects: antibody/antigen encoding, generation algorithm, and evolution mode (Yang et al., 2014). From neurorobotics, cognitive, self-organizing and artificial immune system perspectives, some selected studies of bio-inspired systems were used to discuss how robust behaviors evolve or emerge in these systems, having the capacity of interacting with their surroundings (Fernandez-Leon et al., 2014). The job-shop and flexible job-shop scheduling problem and the method of artificial immune systems (AIS) in solving these problems were discussed (Muhamad and Deris, 2013). An artificial immune system (AIS) was combined with population-based incremental learning (PBIL) and collaborative filtering (CF) to develop a classifier for network intrusion detection (Chen et al., 2016).

Our research motivation is to propose a novel GPU-based immune computation and improve traditional convolutional neural network by increasing the recognition accuracy and speed. In Section 2, the relationship between the artificial immune network and the convolutional neural network was analyzed to propose a new schema. In Section 3, we designed the embedded image recognition system and the GPU-based server, in order to integrate them into the better system. In Section 4, we proposed a new algorithm to this immune convolutional neural network. Section 5 summarized the experimental results and made some comparison between the new results of our approach and those of the traditional methods. At last, we made some conclusions.

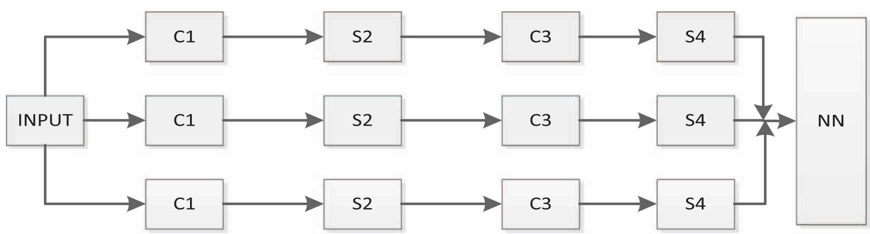

Fig. 1. Diagram of a convolutional neural network.

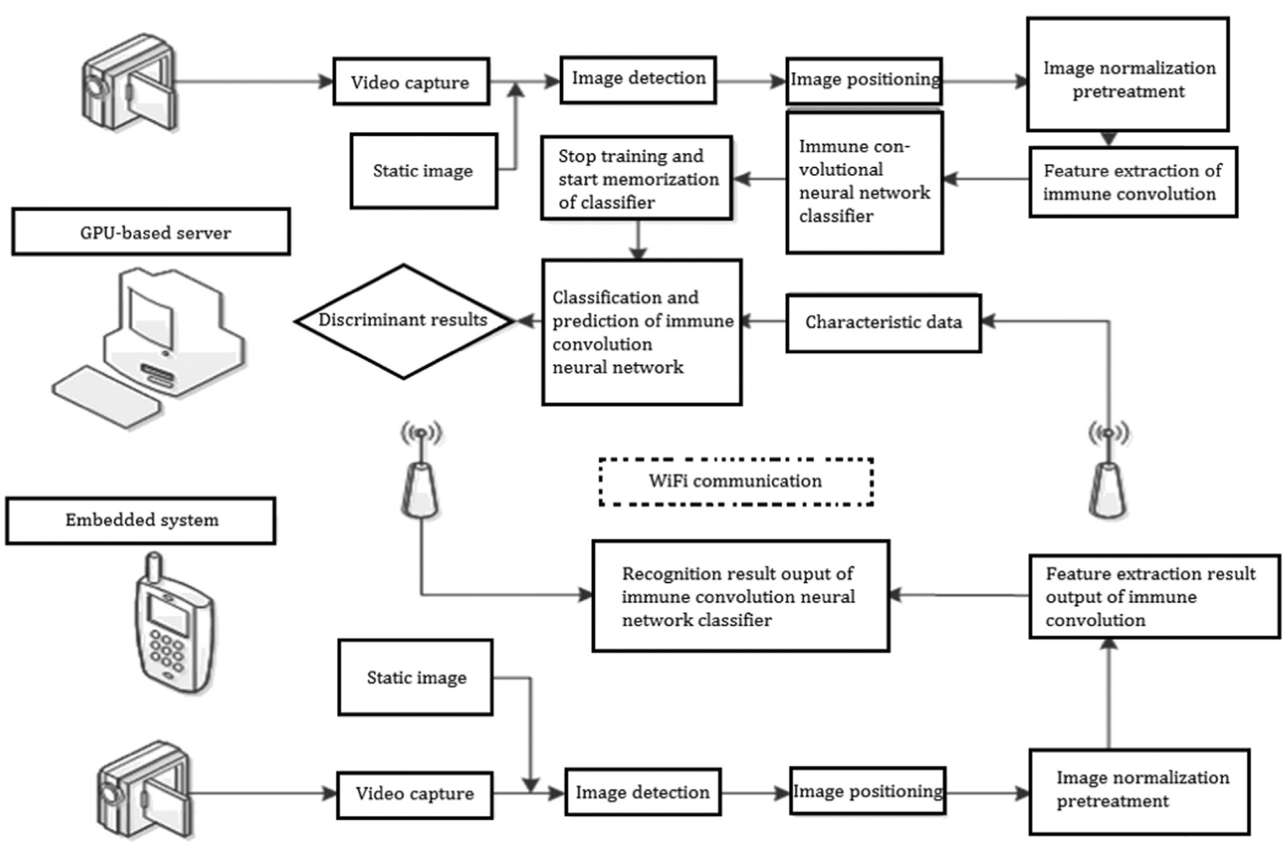

Fig. 2. Network architecture design of the embedded image recognition system and the GPU-based server.