NEURAL NETWORKS IN IMAGE PROCESSING: A REVIEW OF CURRENT APPLICATIONS

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ABSTRACT
This paper describes current applications of neural networks in image processing. Artificial neural networks (ANNs) are methods of computation and information processing modelled by the brain. Many recent attempts to improve the flexibility and effectiveness of ANNs have focused on the implementation level. In this article, we look into ANNs used in the different stages of image processing, specifically in the pre-processing, data reduction, segmentation, object recognition and image understanding phases. The focus is on current and future ANNs, including feed-forward networks, Kohonen feature maps, Hopfield networks, goal-seeking neuron (GSN) and cellular neural network (CNN). New types of ANNs are fast increasing. Through this survey of introducing the findings, implementations and recent advances of ANNs in image processing, it is hoped that this paper will serve as a summary, or base to accelerate further development and use of ANNs in the field of image processing, and improving the accuracy and speed of image processing tasks in the future.

INTRODUCTION

There has been much interest recently in developing neural network models and applications to solve complicated information processing problems. Several recent applications that use artificial neural networks (ANN) in image processing have obtained results in solving real world problems such as gender recognition (David, 2001) and gender classification (Sun, 2000) from facial images using neural network and Genetic Algorithm (GA). Jakubowska *et al.* (2004) presented the classification of the thermal images in order to discriminate between healthy and pathological cases during breast cancer screenings.

Oktem and Joouny (2004) implemented the detection of malignant tumours at an early stage which is an important stage in diagnosis of cancer regions in mammograms by using back-propagation network and a self-organizing map. There is a significant and growing usage of ANNs in image processing to solve complex problems automatically. ANNs give professionals, as well as non-specialists, the tools to train, visualize and validate neural network models to solve interesting problems in image processing.

Neural networks for image processing have been largely derived from the use of conventional techniques, for example: a Laplacian operator with thresholding (Cheng *et al.*, 1993; Kendall *et al.*, 2002) and moment-preserving techniques (Cheng, 1993). The term "image processing" refers to enhancing and manipulating an image, such as by adjusting its size, resolution, or colour palette. Image processing consists of five different tasks, namely pre-processing, data reduction, segmentation, object recognition and image understanding. Optimisation is used as an auxiliary tool that is available in all steps of the image processing chain (Figure 1).

This paper attempts to provide a brief survey of ANN techniques developed for the mentioned tasks, provide a foundation for the reader to work on further development of ANN techniques in other image processing applications.

PRE-PROCESSING

In pre-processing, image analysis techniques are used to enhance and extract desired characteristics of the image by applying algorithms such as filtering and edge detection. Image pre-processing is necessary to facilitate the remaining image processing tasks for identifying the portion of an image to be studied. Neural networks are

used in terms of algorithm application, with the numerical parameters of the image, such as the gray scale intensity and contrast taken in as the input. Chang *et al.* (2004) utilized a statistical pattern recognition algorithm to identify defects of images of real life objects, based on their numerical representations. The same concept was applied by Bishop (1996), where statistical pattern recognition was used in the pre-processing of intensity images.

Pre-processing operations are categorised into image reconstruction, image restoration, and image enhancement (Petersen, 2002). Applications of several ANNs used in pre-processing, mainly Hopfield ANNs, ADALINE, regression feed-forward, Cellular Neural Network (CNN), random neural network, and Fuzzy Cellular Neural Network (FCNN), and Arbitration Neural Network are discussed below.

Image reconstruction

Images are frequently reconstructed from data obtained from a number of sensor measurements. Wang *et al. (*1997) trained a Hopfield ANN for reconstruction of 2D images from pixel data obtained from various projections. The ADALINE network is trained to perform an electrical impedance tomography (EIT) reconstruction, a 2D image based on 1D measurement on the circumference of the image Peterson *et al.* (2002). Srinivasan *et al.* (1993) trained a Hopfield ANN to perform the inverse Radon transform for reconstruction of computerised tomography (CT) images.

The Hopfield ANN consists of "summation" layers to avoid having to interconnect all units. In (Srinivasa's study (1993), a regression feed-forward network is trained to learn the mapping E(y/x), with x the vector of input variables and y the desired output vector to reconstruct images from electron holograms.

Image restoration

Image restoration removes aberrations introduced by the sensors, including noise. In general, one wants to restore an image that is distorted by the (physical) measurement system. Such distortions include noise, motion blur, out-of-focus blur, distortion and low resolution. Image restoration employs information about the nature of the distortions introduced by the system. In the studies by Celebi *et al.* (1997), a 3D CNN is applied for restoration of noisy and blurry images. Contrary to larger solutions offered using a discrete-time Hopfield network, only eight cells are used for each pixel, reducing the network size. The presented image restoration scheme does not have a convergence problem which is inherent in discrete-time Hopfield network solutions.

Image enhancement

Image enhancement is used in the accentuation of certain desired features, which may facilitate later processing steps such as segmentation or object recognition. The most well known enhancement is edge detection. In (Egmont-Petersen *et al.,* 2002), a statistical approach to multi slare edge detection was proposed. Chandrasekran (1992) reported a novel feed-forward architecture which was used to classify an input window in determining the existence of an edge as shown in Figure 2 (c). Edge detection significantly reduces the amount of data by filtering out useless information, while preserving the important structural properties in an image.

In recent studies by Gelenbe *et al.* (2001),

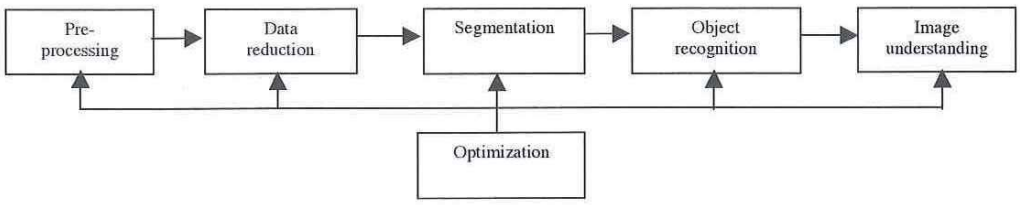

Figure 1. CImage Processing Chain