IEEE TRANSACTIONS ON

IMAGE PROCESSING

A PUBLICATION OF THE IEEE SIGNAL PROCESSING SOCIETY

AUGUST 1998 VOLUME 7 NUMBER 8 IIPRE4 (ISSN 1057–7149)

SPECIAL ISSUE ON APPLICATIONS OF ARTIFICIAL NEURAL NETWORKS TO IMAGE PROCESSING

GUEST EDITORIAL

PAPERS

Contents Continued on Back Cover

Guest Editorial
Applications of Artificial Neural Networks to Image Processing

ARTIFICIAL neural network (NN) architectures have been recognized for a number of years as a powerful technology for solving real-world image processing problems. The primary purpose of this special issue is to demonstrate some recent success in solving image processing problems and hopefully to motivate other image processing researchers to utilize this technology to solve their real-world problems. Finally, it is our hope that this special issue will increase the awareness of image processing researchers to the impact of the neural network-based algorithms.

From the response to the initial call for papers, ten manuscripts have been selected for inclusion in this special issue. Eight papers have been offered as full papers and two as correspondence items. These papers covered the following major topics:

1) neural network-based algorithms for character recognition;
2) automatic target recognition using artificial neural networks;
3) object identification, classification and segmentation;
4) image prediction and compression.

The first paper by Garris *et al.* provides an overview of the NN-based approaches to optical character recognition (OCR). In this paper the authors present results from the evaluation of several NN-based OCR systems. They also provide an end-to-end OCR recognition system based on an enhanced multilayer perceptron (MLP) classifier.

The next three papers deal with the topic of the automatic target recognition (ATR). The paper by Wang *et al.* proposes a new ATR classifier based on an NN architecture called the modular neural network (MNN) classifier. The MNN classifier consists of several independent neural networks trained on local features extracted from specific portions of the image. The final classification is achieved by combining the decision produced by each individual neural network by a method known as *stacked generalization*. This NN-based classifier is tested on a large set of real forward-looking infrared imagery.

Young *et al.* present a method for detecting and classifying a target from a multiresolution foveal image. In this algorithm target identification decisions are based on minimizing an energy function which is implemented by a novel multilayer Hopfield neural network. This energy function supports connections between nodes at the same level as well as interconnections between two sets of nodes at two different resolution levels. A simultaneous top-down-and-bottom-up search is implemented by using a multilayer Hopfield neural network to minimize this energy function.

The paper by Principe *et al.* focuses on target detection in synthetic aperture radar (SAR) imagery using linear and nonlinear adaptive neural networks. They propose to use a quadratic gamma detector (QGD) which is a nonparametrically trained classifier based on local image intensity. The linear processing element (output adder) of the QGD is further extended with a set of nonlinear processing elements to combine the input feature elements. Thus, they implemented a QGD as an MLP which was trained with a cost function based on a mixed norm weighting the false alarms and the missed detections differently.

The paper by Phillips presents a face identification algorithm that automatically processes an unknown image by locating and identifying the face. His algorithm is based on designing a net of matching pursuit filters optimized for face detection and identification. For identification, the filters find features that differentiate among faces, whereas, for detection, the filters encode the similarities among faces. This algorithm has been evaluated on three sets of images. The first set was images from the FERET data base (a well-known benchmarking data set for face recognition). The second set was infrared and visible images of the same people. This demonstration was done to compare performance on infrared and visible images individually, and on fusing the results from both modalities. The third set was mugshot data from a law enforcement application.

Wang *et al.* present a probabilistic neural network-based technique for unsupervised quantification and segmentation of brain tissues from magnetic resonance images (MRI's). The proposed technique uses suitable statistical models for both the pixel and context images and formulates the problem in terms of model-histogram fitting and global consistency labeling. The quantification is achieved by probabilistic self-organizing mixtures and the segmentation by a probabilistic constraint relaxation network. Experimental results are presented for sequence of MRI brain scans. It is also shown that it can be applied to clinical problems such as those encountered in tissue segmentation and quantitative diagnosis.

The paper by Zhu *et al.* proposes an integrated system called road understanding neural network (RUNN) for a autonomous mobile robot to move in an outdoor road environment. The RUNN consists of two major neural network modules, a single three-layer road classification network (RCN) to identify the

Manuscript received May 21, 1998.
Publisher Item Identifier S 1057-7149(98)05309-3.

road category (straight: road, intersection or T-junction), and a two-layer road orientation network (RON) for each road category. Several design issues, including the network model, the selection of input data, the number of the hidden units and the learning problems are studied. Experimental results are presented for real scene imagery.

Finally, the last three papers focus primarily on applications of neural networks to image prediction and compression. In the paper by Wang *et al.*, a modular neural network vector predictor is proposed that is based on a mixture of expert predictors. In this algorithm five expert vector predictors are designed where each predictor is optimized for a particular class of input vectors. An integrating unit is used to select or combine the outputs of the experts in order to form the final output of the modular predictor.

The correspondence item by Karayiannis *et al.* presents an image compression system based on wavelet decomposition and vector quantization (VQ). In this paper the VQ codebook is designed by various fuzzy learning vector quantization schemes. The performance of the codebooks designed by these algorithms is tested on several images and compared with the classical Linde–Buzo–Gray (LBG) algorithm.

In the correspondence by Tzovaras and Strintzis, a nonlinear principal component analysis (NLPCA) method is combined with VQ for coding of images. The NLPCA is realized using the backpropagation neural network, while VQ is performed using learning vector quantization.

RAMA CHELLAPPA, *Guest Editor*
University of Maryland
College Park, MD

KUNIHIKO FUKUSHIMA, *Guest Editor*
Osaka University
Osaka, Japan

AGGELOS K. KATSAGGELOS, *Guest Editor*
Northwestern University
Evanston, IL

SUN-YUAN KUNG, *Guest Editor*
Princeton University
Princeton, NJ

YANN LECUN, *Guest Editor*
AT&T Laboratories-Research
Holmdel, NJ

NASSER M. NASRABADI, *Guest Editor*
U.S. Army Research Laboratory
Adelphi, MD

TOMAS A. POGGIO, *Guest Editor*
Massachusetts Institute of Technology
Cambridge, MA