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A NEURAL NETWORK ACTIVEX BASED INTEGRATED IMAGE PROCESSING ENVIRONMENT

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Abstract. The paper outlines an integrated image processing environment that uses neural networks ActiveX technology for object recognition and classification. The image processing environment which is Windows based, encapsulates a Multiple-Document Interface (MDI) and is menu driven. Object (shape) parameter extraction is focused on features that are invariant in terms of translation, rotation and scale transformations. The neural network models that can be incorporated as ActiveX components into the environment allow both clustering and classification of objects from the analysed image. Mapping neural networks perform an input sensitivity analysis on the extracted feature measurements and thus facilitate the removal of irrelevant features and improvements in the degree of generalisation. The program has been used to evaluate the dimensions of the hydrocephalus in a study for calculating the Evans index and the angle of the frontal horns of the ventricular system modifications.

1. INTRODUCTION

Interest in image processing stems from two principal application areas: improving pictorial information to facilitate human interpretation (image enhancement) and processing scene data (image analysis) for autonomous machine perception of objects in the image. The latter case is also known as pictorial pattern recognition, image understanding, and computer vision.

Pictorial pattern recognition is a challenging problem of pattern recognition because the features describing objects in an image must be invariant to translation, rotation and scale transformations. In general, it involves the following steps [1]:

- image sampling and quantization;
- image segmentation, i.e. identification of regions of the image with uniform brightness, colour or texture;
- scene analysis, i.e. identification of objects in an image;
- shape description or object feature extraction;
- object classification or object labelling.

Image understanding is a complex process and involves many different disciplines. It is therefore not surprising that many researchers from diverse backgrounds have been involved in solving different sub-problems of the process. These sub-problems range from edge detection, low-level segmentation, feature selection, search and matching techniques to designing a heavily constrained special-purpose understanding system.

The system documented in this paper can be viewed as two environments that communicate with one another: an image processing environment and a neural network environment. The communication is facilitated via interfacing utilities. This structure is imposed by further extensions of the both environments with new facilities as for examples fuzziness etc.

2. GENERAL ENVIRONMENT ARCHITECTURE

The integrated environment is organised as a dispatcher on three layers (Figure 1): a mode dispatching level; a program dispatching level; and a program execution level. The mode dispatching level refers the following two modes: interactive execution mode and demo mode.

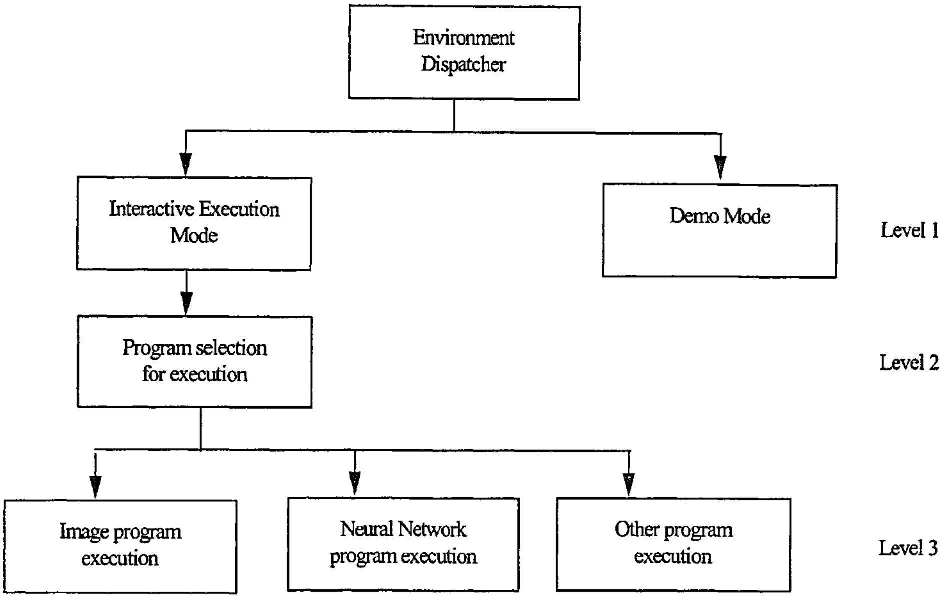

Fig 1 General environment architecture

3. IMAGE PROCESSING ENVIRONMENT

The image processing environment was designed to process both grey scale and colour images. The processing of colour images regards both the transformation of an image into a grey level image and also the processing of the colour image on the tristimulus components R, G and B.

The image processing has a hierarchical scheme with the following sequential steps: quantization of the image; image enhancement; edge detection; image segmentation for obtaining the objects (pictorial patterns); object feature extraction; object classification using neural networks.

The first step in processing colour images as grey scale images is that of obtaining the luminance of the colour as a value of grey by a linear relation of the tristimulus components. Image enhancement regards image smoothing by neighbourhood averaging, low pass filtering, etc., and also image sharpening by differentiation, high pass filtering, etc.

For low pass and high pass filtering convolution theorem was used, working in frequency domain [2] and applying Multidimensional Fast Fourier Transform [3]. Edge detection is facilitated by using linear and non-linear transformation of the images. The linear transformation that were used the convolution operation with various operators (filters), namely Gradient, Sobel, Prewitt, Roberts, Canny, Deriche, Kirsh, Laplace, binomial filters, Gaussian filters, bandpass filters DoG and LoG.

The median filter was used as non-linear filters. Figure 2 presents a filtered image of an internal symmetric hydrocephalus using Laplace and Sobel filters. Image processing of an occiput radiographs pneumoencephalography showing a symmetric hydrocephalus reveals a much more precise calculation of the hydrocephalus [4]; that is extremely important in decision-making in neurosurgery.

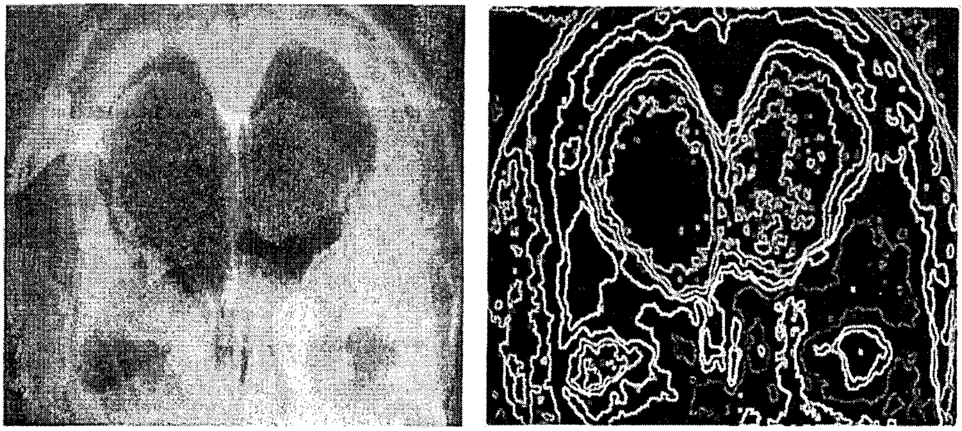

Fig. 2 A filtered image showing an internal symmetric hydrocephalus

Image segmentation is achieved using both edge and region methods. Edge methods detect the contour and then follow the respective contour. Region methods use threshold methods and region-growing methods (split-and-merge methods and pyramid-linking algorithms).

Object feature extraction works on binary objects using object transformation (translation, rotation and scaling) and obtains the features using morphological operators, Hit-or-Miss operators, etc. All the object information is obtained using chain code and quad-tree structures.

The features extracted are: object area, object perimeter, object circularity, object normalised moments, Zernike moments, Fourier descriptors (except for the first three parameters, all the other features are invariant to translation, rotation and scale transformations.)

Classification of objects is achieved using neural networks; the extracted features forming the input vector. (For comparison purposes, the results were compared with those achieved with more classical methods of classification, namely: box method, maximum probability method, minimum distance method or method of centre of mass, discriminant function method.)

4. NEURAL NETWORK ENVIRONMENT

The neural network ActiveX components can be incorporated into image processing environment and can be accessed via the main menu. From the main menu the desired neural network can be selected and executed, using the input file created by the utilities integrated into the image processing environment.

Among the specific features offered by the neural network components are: sensitivity analysis for irrelevant feature discarding; and, improved generalisation for mapping neural networks - achieved by avoiding over training [5].

The sensitivity analysis was implemented on Multilayer Feedforward Perceptron (MLP) error backpropagation neural networks, on all of the six variants of programs for both one hidden- layer and two-hidden layer architectures. A new type of sensitivity was introduced, the normalised input sensitivity [6], for both Jacobian and logarithmic sensitivity, in order to avoid problems caused by the output factors in the sensitivity expressions. These normalised sensitivities were successfully tested on a medical application for classifying meningitis, where the input space size was reduced from 29 to 18 for Jacobian normalised sensitivity, and from 29 to 16 for logarithmic normalised sensitivity.

Mapping neural networks have implemented procedures for improving the generalisation ability (accuracy) for both interpolation and extrapolation by avoiding over training. During the training phase a compromise was realised between fitting the training set examples but still exhibiting a reasonably good interpolation capability between these examples [5] and stopping the training when the error on the training test set started increase.

Neural Network Models Implemented as ActiveX

So far over 10 models of neural networks have been implemented as ActiveX, many of these being implemented also with several optimised algorithms, e.g. the multilayer feedforward neural networks (MLP) with six such algorithms: BPN = backpropagation standard, SDG = Steepest Descent Gradient, CGD = Conjugate Gradient, SAN = Simulated Annealing, EVP = Evolutionary Programming, QNW = Quasi Newton Method.

The main models implemented [7],[8],[9] are: Hopfield, Bi-directional Associative Memories, Hamming, Boltzmann//Cauchy Machine, Adaptive Resonance Theory (binary, fuzzy, and non-binary), Radial Basis Functions, Counterpropagation, Spatio-temporal, Self-Organising Map (Kohonen)

5. OBJECT CLASSIFICATION USING NEURAL NETWORKS

Neural network components can perform several functions, one of the most important of these being classification. Classification - as far as neural networks are concerned - can be subdivided into three groupings [10], namely:

- they can identify which class best represents an input pattern, where it is assumed that inputs have been corrupted by noise;

- they can be used as a content-addressable or associative memory, where the class exemplar is desired and the input pattern is used to determine which exemplar to produce. (A content-addressable memory is useful when only part of an input pattern is available and the complete pattern is required);
- they can perform vector quantizing, or cluster the input space in a number of clusters.

At present object classification using neural networks is achieved using extracted features that are invariant in terms of translation, rotation and scaling.

Classification on the basis of extracted features of objects from image is executed at present using moments of several orders and Fourier descriptors and other features invariant to translation, rotation and scaling transformations.

For medicine the most useful functions are classification and clustering.

6. CONCLUSIONS

The paper presents an integrated neural network ActiveX based image processing environment. The rapid evolution of research in both image processing and neuroscience has led to the desirability for developing such an environment, that can be readily extended to include additional functionality. Object (shape) parameter extraction is focused on the extraction of invariant features to the translation, rotation and scale transformation recognitions. The neural network model ActiveX components incorporated into the environment allow both clustering and classification of objects from the analysed image. Mapping neural networks and, among them, first the backpropagation with all its optimised variants, benefited a good deal from implementing mainly the sensitivity analysis, using normalised input sensitivities, and enhanced generalisation performances. The environment is developed under Windows and is delivered with installation instructions and examples for demonstration purposes.

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