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IMAGE PROCESSING USING ARTIFICIAL NEURAL NETWORKS

BY

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Abstract. Image processing using artificial neuronal networks (ANN) has been successfully used in various fields of activity such as geotechnics, civil engineering, mechanics, industrial surveillance, defence department, automatics and transport. Image preprocessing, date reduction, segmentation and recognition are the processes used in managing images with ANN.

An image can be represented as a matrix, each element of the matrix containing colour information for a pixel. The matrix is used as input data into the neuronal network. The small dimensions of the images, to easily and quickly help learning, establish the size of the vector and the number of input vectors. The transfer function used is a sigmoidal function. The learning rate includes values between [0,1] and the error it is recommended to be below 0.1.

Key words: artificial neuronal networks;digital and satellite images; image preprocessing; date reduction; segmentation; recognition.

1. Introduction

The image is a function defined on a spatial domain, it has a limited scale of numeric values (natural numbers – $\mathbb{N}$, real numbers – $\mathbb{R}$, or complex numbers – $\mathbb{C}$), values which can be used to form a matrix (Fig. 1).

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Vertan (2000, 2001) considers images to be abstract (mathematical functions with two variables, continuous or discrete) , non-visible (unperceived by naked eye, which imply a sum of bidimensional fields of parameters such as temperature, pressure, density, etc.) and visible (perceived by naked eye and generated as distributions of light intensity).

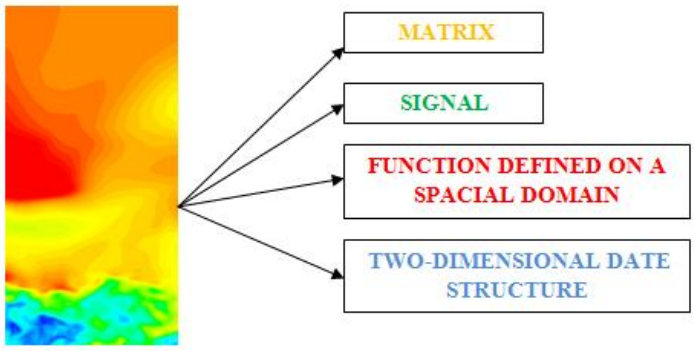

Fig. 1 – Image definition.

Depending on the type of data that is the matrix, the images are divided into images of intensity scale and indexed (each component being a unique number, a scalar) and vector images (each component being a vector, vector number which in turn splits into several parts). Scalar image intensity is an image where each pixel value (real or natural numbers) is considered a measure of luminous intensity. Scalar indexed image is an image in which the value of a pixel is an index where information can be associated with the colour of the pixel in question.

An image can be represented as a matrix $M_{m \times n}$, each element of the array containing information of colour for a pixel (Fig. 2).

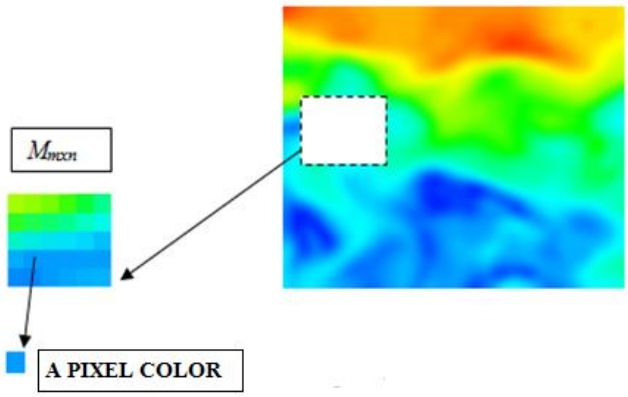

Fig. 2 – Scalar indexed image.

Each colour can be represented as a combination of three basic colours: red, green and blue (Fig. 3). The array is used as input to the neural networks that are aimed at identifying images or grading.

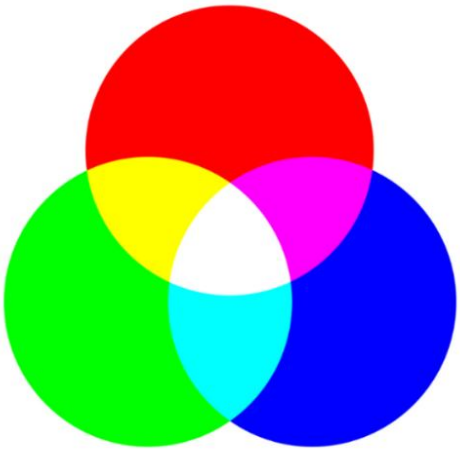

Fig. 3 – RGB system.

Each input neuron represents colour information in the image, and each output neuron corresponds to an image. All images will be scaled to the same size (width and height) and small to be easy and quick to learn. On the sizes of the images shall be determined on the size of the input vector and the number of neurons. The transfer function for this type of problem is called sigmoid function. The rate of learning has values in the range [0.1] and the error it is recommended to have less than 0.1.

Processing of images with ANN involves different processes, such as:

1. Image preprocessing, an operation which shows a picture (contrast enhancement, noise reduction) with the same dimensions as the original image. The objective of images preprocessing with ANN consists in improving, restoring or rebuilding images. The resolved issues are the cartographic types, to optimize a function, an approximation function for the reconstruction of an image.

2. Data reduction or feature extraction involves extracting a number of features smaller than the number of pixels in the input window. The operation consists in compressing the image followed by extracting geometric characteristics (edges, corners, joints), facial features, etc.

3. Segmentation is a division of an image into regions.

4. Recognition involves the determination of objects in an image and their classification.

Image processing with ANN is used in various domains, such as:

a) industrial inspection (quality control) in order to detect the defective products in the production of steel, textiles, fruits, vegetables, plants and food;

b) medicine for detection of tumours and the establishment of a medical diagnosis;

c) defence system to identify targets for various navigation systems, orientation, recognition;

d) service of documents, namely automatic processing of forms, sorting emails, the possibility of learning a handwritten text, etc.;

e) identification and authentication for registration number recognition, fingerprint analysis in order to identify persons;

f) optimization problems;

g) geotechnical engineering, in order to classify the hazardous areas with possible landslides, to determine the characteristics of the soils;

h) civil engineering, for the study of the rubberized concrete`s homogeneity, to identify the fissures/cracks in different structures.

2. The Current Status of Artificial Neural Networks Used for Image Processing

2.1. Issues Resolved with ANN in Civil Engineering

At the moment, the Civil Engineering is the most poorly developed in terms of image processing with ANN. A branch of Civil Engineering which has used artificial intelligence to solve the problems of cracks' identification is the composite structures.

Composites are increasingly being used in aerospace, naval and cars due to increased strength and rigidity in relation to its weight. Composite materials could be damaged in the presence of fissures. Seed (2014) proposed the use of neural networks to classify the images obtained by scanning. These pictures include characteristics of ultrasounds.

In 2015, Pandelea A. et al. studied homogeneity of concrete samples with added rubber using ANN by analysing the sample surface images.

2.2. Issues Solved Using ANN in Geotechnical Engineering

Regarding to the determination of soil moisture in a manner as practical, rapid, non-destructive, given the relatively low costs there have been several studies that have been evaluated the effectiveness of ANN (Arsoy *et al*., 2013; Namdar-Khojasteh *et al*., 2010; Elshorbagy & Parasuraman, 2008; Persson *et al*., 2001, 2002; Persson, 2005).

Relying on the fact that the soil changes its colour depending on the amount of water, ANN were used to estimate the soils moisture using colour

photographs obtained by a digital camera with a resolution of 7.1 megapixels (Zanetti *et al*., 1986).

Landslides is due to the interaction of several factors such as earthquakes, rainfall, snow melt, weather, human activities (construction of roads and buildings) etc. Starting from the idea of satellite images classification (Civco, 1993, Atkinson and Tatnall, 1997, Bandibas and Kohyama, 2001), the recognition of forms and texture of the soil (Khotanzad and Lu, 1991), Melchiorre have used artificial neural networks for classification of areas prone to landslides.

In order to reduce the number of casualties, Chauhan et al. (2010), Kawabata and Bandibas (2015) have created a network that generate maps concerning the susceptibility of lands from landslides. To get this map, there are necessary two stages: the first stage consists of gathering images ASTER and GIS and the second phase intend to train the network with these images. Choose to study an area where there have been landslides in the aftermath of an earthquake. Data entry of the network are images relating to landslides, the slope of the terrain, elevation, aspect, distance from the nearest geological boundary and density of geologic boundaries. The obtained images from satellite are slope, elevation, aspect and the rest are images of GIS. The output consists of a network map that shows whether they have or not landslides.

2.3. Issues resolved with ANN in transportation

Mackeown et al. (1994) proposed a method for the recognition of rural roads and urban colour images through the involvement of a network which to classify objects in the image. The performance of the network lies in the recognition of 70% of the region and to 90% of the image area.

Ahmadi (2008) processed satellite images with high resolution for the purpose of road extraction and vectorization.

The problem of detecting a vehicle from an area in real time has been resolved by the Gader (1995). The network was trained initially with images in infrared with tanks in their purpose of detecting in real time. Another set of data which has been coached network includes images of cars from a parking lot. For these set of images, the network can detect a specific type of vehicle.

2.4. Issues Resolved with ANN in the Field of Mechanics

Based on an intelligent system that uses infrared thermal imaging, diagnosis can be established for cooling radiators (Taheri-Garavand, 2015). The radiator also met under the name of heat exchanger is a very important element in the cooling system of vehicles. The procedures underlying this system are: the acquisition of thermal images, the images preprocessing and processing, the

wavelet for decomposition of thermal images, extracting features of an original image to a thermal one, selection features using genetic algorithms and their classification using ANN. It was used a network having 16 inputs (images) and 6 output (defects of cooling radiators). After analysing the image, the ANN produces a diagnostic for the radiator.

2.5. Items solved with ANN in automation

For many years the problem of automatic identification of people was studied. Juell and Marsh (1996) used four back-propagation neural network arranged in a hierarchical structure and a powerful pre-processor in order to detect human faces. The method has proved a successfully one just for images with people wearing glasses and those images where there were more faces.

Gutta and Wechsler (1997) used hybrid classifiers for facial identification. A facial recognition method for low resolution images is proposed by Daiand Nakano (1998) based on Hopfield model and ANN and by Tamura et. al (1996) specifying the sex of identified person. Schofield et al. (1996) develops with ANN a system for counting the people in video images.

In 2000, Maxim made an analysis of local and global facial features in order to identify strengths and weaknesses in the system of face recognition while Venkatesh and Rishikesh have created a network based on self-organization to locate and extract the outline of objects from an image.

Wang and Yuan (2001) proposed a system for identifying human faces from colour images that detects the skin colour pixel regions and regions segmentation from image to detect the possible facial features (eyes).

Aitkenhead and McDonald (2003) created FADER (Face Detection and Recognition), program that comprises three models of neural networks and a number of its optimizations to obtain an efficient system.

Nagi and Ahme (2008) created a human face identification technique using ANN and DCT (discrete cosine transform). The advantage of this method is speed processing and limited computed needs. The DCT extracts features from face images based on skin colour and after that a self-organizing map using an unsupervised learning technique is used to classify DCT-based feature vectors into groups to identify if the subject from the input image is “present” or “not present” in the image database.

Khashman (2010) developed a new neural network to model cognitive and emotional processes. Compared to conventional ANN, it also includes two hidden neurons, one dorsal and one ventral to process cognitive and emotional information. Fernández-Caballero et al. (2010) created a human detection system using an infrared camera that is placed on a mobile robot.

Starting from the idea that training ANN for large datasets is a time consuming task, Huqqani (2013) developed and analysed the back-propagation

algorithm of neural network for facial recognition problems. Omaima and Al-Allaf (2014) proposed the identification of human faces using artificial neural networks of back-propagation type and pattern net.

Bluet (1994) evaluated the classifying patterns for digital fingerprints, Jin Wang and Jack Jean (1993) solved with neural network the problem of confusing similar characters and Kim (1994), Kang (2008), Goltsev (2012), Martinez et al. (2014) developed a neural network capable to learn and recognize the writing. Chen et al. (2003) used a combination of the ANN and multiwavelets to identify the handwriting.

Ravichandran and Yegnanarayana (1995) had created a network that recognize objects in a degraded image; Su and Basu (2002) had processed the blurred images.

Anwar (1994) developed a network of waste areas to classify the texture (the surface texture of wear particles) found in the engine lubrication oil (lubricating oil of engines). Kong and Guan (1996) introduced a filter with ANN in order to eliminate noise pulses in digital images. Filter consists of a classification of pixels by a neural network with auto-organization to be able to detect the positions of the pixels produced by the noise.

Upadhyay and Chhabra (2015) proposed a method of image segmentation based on modified self-organizing feature map, a method which involves a classification of pixels in the image, depending on the value of their intensity.

Kim et al. (1996) presented a grid that categorizes welds (solder joints) of the PCB (printed circuit boards).

2.6. Issues Resolved with ANN in Military Defence Field

One of the practical applications with ANN from this domain, evidenced by Rogers (1995) is the automatic identification of the target.

Alippi (1995) conducted a real-time analysis of radar images with ANN. The network improved the radar images (obtained under conditions of poor visibility) and categorized them in order to identify ships.

2.7. Issues resolved with ANN in field of industrial inspection

Murase et al. (1997) developed control strategies based on the liability of the plant. The network uses as input the characteristics finite element extracted from the image and the moisture content of the plant. The aim of the network was to predict the water level of a plant using a digital image with a wilted plant.

In 2012, Husin created a system based on ANN which identify whether plant species are dry, wet, torn or bent. Recognition system of plant leaf texture was created in Matlab. With a digital camera was carried out with the same

resolution photos, out of which extracting traits (grayscale, threshold, edge detection), them representing input data network. The output of the network lied in the recognition and display of species of plants.

In order to estimate the best time of the gathering of olives, Gatica (2013) developed an ANN which recognize the fruits of the olive tree depending on the weight, colour and size. As input to the network used 30 images.

Nakano (1997) provided for the possibility of replacing a worker at sorting of the apples in order to gather, with an intelligent system that classifies the apples depending on the shown colours. Bonieckia et al. (2015) has supported the hypothesis that ANN is an efficient system that helps producers to identify pests from the apple orchards.

Zhao et al. (2012) developed a new algorithm for the pests identification of occurring in the rapeseed leaves and Abirami (2014), using image processing with ANN, was studying how the seed development, having a research accuracy of the results by 98.70%.

Aryee and Poehlman (1991) created a clever back-propagation type identification image of parasites or worms from fish cod and Feng (2015) creates a program for automatically identifying moths.

2.8. Issues Solved Problems Using ANN in Medical Field

Medical imaging is a branch of biomedical engineering, which can diagnose diseases like kidney stones, glaucoma, brain tumours, etc.

The most common imaging technology to examine various factors of the human body is the radiography, added during computed tomography, nuclear magnetic resonance, ultrasonography and scintigraphy.

Slow processing of films, image modification, limitation in terms of exposure to x-rays, misdiagnosis by analysing scanned images because of abnormalities (speckle noise) in ultrasound scans, MRI images, CT, US, the artefacts were the reasons that have been studied to resolve these problems. Thus, the problem has been solved through the implementation of an algorithm for image segmentation with wavelets filters and ANN that detects, in real-time, the diagnosis.

Rao et al. (2015) has collected 300 databases of images, with or without glaucoma from different hospitals and different patients. Glaucoma is an eye disease that occurs due to the build-up of pressure within the eye and undiscovered at the time that can lead to vision loss. CDR is an important indicator for glaucoma, so setting for a healthy eye it must be between 0.2-0.3. To calculate the pointer, the image is striped, after which is calculated the ratio between the diameter of the optic cup and the optic disk. Implementation of the segmentation algorithm and the graphical user interface were made using the Matlab program.

Sharif *et al.* (2015) used neural networks to categorise the many images that contain the normal or abnormal cornea, in addition to other researchers the possibility of visualization of a 3D ill cornea.

Other researchers has established algorithms based on wavelet for determining ANN and real-time diagnostics such as: kidney stones (Viswanath, Gunasundari, Hussan, 2015), cholesterol (Adi, Rao and Adi, 2015), obesity and cirrhosis (Mala K. *et al.*, 2015), etc. Kondo (2012) used two systems to diagnose cancer in liver, one for the recognition and extraction of the image of the liver and the other for the identification and extraction of cancerous areas of the liver. Ortiz (2013, 2014) actually improve diagnosis of degenerative diseases by analysing MRI images of the brain using self-organizing maps.

2. Final Remarks

Processing images with artificial neuronal networks successfully resolve the problems of classification, identification, authentication, diagnostics, optimization and approximation.

Importance of processing images with ANN in the field of medicine has emerged due to the need to lay down, in a real time, adequate diagnosis.

In the qualitative inspection, ANN plays a major role in detecting defective products for the production of steel, textiles, food stuffs, plants.

In geotechnical engineering, landslides problem was resolved by training network with ASTER images and GIS and a generation after learning maps. Also, it has been determined through training network lands humidity with a set of small images for that learning to be done more quickly.

The defence system of the country, a number of ANN resolves important issues such as fingerprint analysis and identification of the person, identification of target issues for various navigation systems, orientation, and facial identification.

Structural engineering is a domain in which image processing with ANN, is just starting and is very promising.

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PRELUCRAREA IMAGINILOR CU REȚELE NEURONALE ARTIFICIALE

(Rezumat)

Prelucrarea de imagini cu rețele neuronale artificiale au fost folosite cu success pentru diverse probleme din inginerie geotehnică, medicină, mecanică, inspecția industrială, sistemul militar de apărare, etc. Preprocesarea imaginilor, reducerea datelor, segmentarea şi recunoaşterea sunt procesele folosite în prelucrarea imaginilor cu ANN.

O imagine poate fi reprezentată sub forma unei matrici, fiecare element din matrice conținând informații de culoare pentru un pixel. Matricea este folosită ca date de intrare în rețeaua neuronală. Dimensiunile mici ale imaginilor (pentru a favoriza mai uşor şi rapid învățarea) stabilesc mărimea vectorului şi numărul neuronilor de intrare. Funcția de transfer este o funcție sigmoidală. Rata de învățare cuprinde valori în intervalul [0,1] iar eroarea se recomandă să fie sub 0.1.