UNIVERSITI PUTRA MALAYSIA

BACKPROPAGATION NEURAL NETWORK FOR COLOUR RECOGNITION

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By

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Dedication

To the soul of my Father

Abstract of thesis presented to the senate of university Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

BACKPROPAGATION NEURAL NETWORK FOR RGB COLOUR RECOGNITION

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March 2002

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Colour Image Processing (CIP) is useful for inspection system and Automatic Packing Lines Systems. CIP usually needs expensive and special hardware as well as software to extract colour from image. Most of CIP software use statistical methods to extract colours and some system use Neural Network such as Counter-Propagation and Back-Propagation .

Some researchers had used Neural Network methods to recognize colour of Commission Internationale de L'Eclairage (CIE) Models either L *u *v or L *a *b.

CIE colour components need special and expensive devices to extract their values from an image. However, this project will use RED, GREEN, BLUE (RGB) colour components, which can be read from an image.

In this research, RGB values are used to represent the colour. RGB values are used in two forms. The first form is the actual values that are used in PPM File Format within (0,255) and the second form is normalized RGB values within (0,1). Back-Propagation Neural Network is used to recognize colour in RGB values.

It is found that RGB is useful when used with Neural Network and the Normalized RGB value is faster in the learning of neural network.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi untuk ijazah Master Sains

RANGAIAN NEURAL BACKPROPAGATION UNTUK PENGECAMAN WARNA RGB

Oleh

ABDUL AZIZ HUSSIEN AHMED AL-NAQEEB
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Pemproses Imej Warna (CIP) sangat berguna untuk sistem pemeriksa dan Sistem Pembungkusan Automatik. CIP selalunya memerlukan perkakasan khusus yang mahal serta perisian untuk menyarikan warna daripada imej. Kebanyakan perisian CIP menggunakan kaedah statistik. Terdapat juga yang mengggunakan algoritma rangkaian neural seperti Perambatan-Berlawanan dan Perambatan-Kebelakang.

Beberapa orang penyelidik meggunakan kaedah rangkaian neural untuk mengenalpasti warna untuk model Commission Internationale de L'Éclairage (CIE) samaada L *u *v or L *a *b.

Komponen warna CIE memerlukan peranti khusus yang mahal untuk menyarikan nilai-nilai daripada imej. Projek ini menggunakan pendekatan yang lain iaitu dengan menggunakan komponen warna merah, hijau, biru (RGB), yang boleh ditentukan dengan bantuan komputer peribadi biasa.

Nilai RGB digunakan untuk menyesarkan warna daripada imej dan seterusnya dilaksanakan a dalam dua format, iaitu Format Fail PPM antara (0,255) dan format nilai

RGB dinormalkan antara (0,1), seterusnya Rangkaian Neural Perambatan-Kebelakang diguna untuk mengenalpasti warna yang diwakili. Di dapati RGB sangat berguna jika digunakan bersama Rangkaian Neural dan nilai RGB yang dinormalkan adalah lebih cepat dalam proses pembelajarannya.

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Lastly my deepest appreciation to all those who in one way or another have contributed to the success of my project and eventually completion of thesis.

I certify that an Examination committee met on 28th March 2002 to conduct the final Examination of Abdul Aziz Hussein Al-Naqeeb on his Master of Science thesis entitled "Backpropagation Neural Network for RGB Color Recognition" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that candidate be awarded relevant degree. Members for the Examination Committee are as follows

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Date: 08 MAY 2002

This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfillment of the requirement for the degree of Master of Science.

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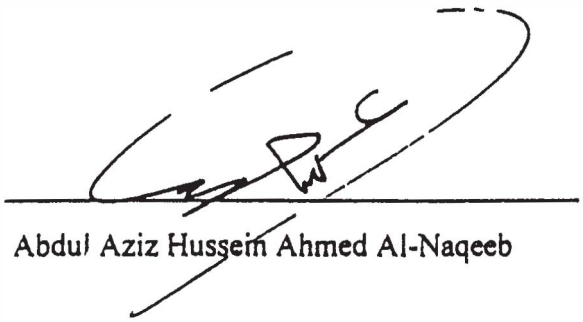
DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



Abdul Aziz Hussein Ahmed Al-Naqeeb

Date: 08 MAY 2002

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

General Overview

Since early years for industrial revolution in nineteenth century, researchers have been looking for the best method to automate the production lines. In the middle of twentieth century the production lines became more automated than manual but they still need human inspector to supervise and inspect the lines. At this point, they need the vision and intelligence, which can be only provided by human or intelligent machine (computer). During that time the computer was under research and development, and was very expensive to use in inspection system. In the 70's, the inspection system was automated completely with intelligent inspection machine (computers) and robots, but still very expensive. Eventually the cost of all technologies equipment decrease and building an inspection system is still costly especially for small enterprises. The other problem in vision is the colour; the inspection system in production line should consider the colour, to get devices to work with and furthermore analysis of colour really requires high cost devices (Brown and Dana, 1982).

From this point, the research is involved in building a cheap inspection system using IBM-Compatible personnel computer without any additional devices apart from

IBM-Compatible PC and a video camera. The aim is to build a software module and integrate it with cheap hardware to provide colour inspection system.

Colour recognition usually requires special hardware and complex software. In this research the colour recognition system is presented using normal personal computer hardware with simple and powerful software using neural network.

RGB components are used as input for the neural network. Previous research in this field, do not use RGB components even though it is cheap, simple to extract and validated to represent colour, so RGB is used in this research and it is found that it is suitable for the recognition systems. (Soriano *et al.*,(2001), Razali (1999), Vlad, (1999))

Back-Propagation Neural Network (BPNN) is used to recognize colour. Even though there are some problems in BPNN that need to be solved, but it is a very powerful tool to recognize and classify patterns.

Colour Pattern Recognition

Pattern Recognition is part of image processing, and the image process techniques are used to identify object of interests among images. The object of interest is usually extracted by using statistical methods to identify the object shape and to measure the object size. It was only for a few years ago that the colour became considered as a

feature to recognize the object. Most of researchers use statistical method such as histogram to extract the main colour of an object. The histogram method is quite slow and complex, since the histogram algorithm needs to be implemented for each image (frame) of the on-line steam (Brown and Dana, 1982).

A colour is very important feature of an object to be identified, so a colour can be used as stand alone feature to recognize object especially when other vectors are fixed (constant).

Colour Science has many standards/space/module and theorems that are adopted by organizations such as Commission Internationale de L'Éclairage (CIE) and its sub-organization CIELAB, which adopted CIE XYZ Standards, L u* v* and L a* b*. These standards are usually used to represents colour in electronic and electromagnetic devices such as TV, Video, Printers, Colour Industry, and some IT devices (Poynton, 1997).

The RGB module which is well known and standardized is used in computer to represents colours. In fact, all computers systems represent colour in their memories using the RGB module. The RGB module is a module that represents colour using the three main colours, namely Red, Green and Blue. It is a reflection for actual colours in the life. Even the human's eye retina uses three nerves to catch the three main colours and then transfer the electro-chemical pulse to human brain where there are special neurons cells to recognize the colours (Brown and Dana, 1982). This study attempts to stimulate this mechanism.

RGB Colour model is the common used model. RGB values can be extracted from images using personnel computer, but other Colour models such as L u* v* values need special and expensive devices to be extracted (Poynton, 1997).

Artificial Neural Network

Artificial Neural Network (ANN) is part of Artificial Intelligence (AI), which is developed as a simulation for human brain neural network. ANN is a network of many simple processors (units), each possible of having a small amount of local memory. The units are connected by communication channels ("connections"), which usually carry numeric (as opposed to symbolic) data, encoded by any various means. The units operate only on their local data and on the inputs they receive via the connections. The restriction to local operation is often relaxed during training (Freeman, 1991).

ANN has so many modules of network that were developed by many researchers and groups since the middle of last century. Some ANNs are modules of biological neural network and some are not, but historically, most of the inspiration for the ANNs fields came from the desire to produce an artificial system capable of carrying out sophisticated models , perhaps "intelligent"(Freeman,1991).

The Back-Propagation Neural Network (BPNN) which is a multi layer network is used. BPNN has three layers, namely the input layer, hidden layer and output layer. Each layer may have one or more nodes/units. The numbers of nodes in each layer is

subject to be changed from one application to another. In others words, the number of nodes in each layer could be determined regarding to application requirements. In this research, the colour in term of three colour components RGB need to be recognized. For this purpose, BPNN architecture should have three unites/nodes in the input layer. For hidden layer, number of units/nodes should be around the number of learning patterns. For output layer, the number of units/nodes depends on the desired output. If the BPNN recognize one colour so the output nodes will be one only, if the output "1" the output is desired colour, if "0" the output is not desired colour. But if BBNN recognizes 4 colours, number of nodes in output layer should be at least 2 nodes. For 8 colours, 3 output nodes are used to represent 8 colours in binary digit.

The BPNN is a powerful tool to recognize and classify objects and it sometimes provides good result. Even though there are problems that need to be solved such as uncontrolled behavior of Learning Rate, never learned situation during the learning process (never reached successful learning). These problems of learning will be presented and discussed in Chapter Four.

Statement of Problem

Colour object inspection system is complex and expensive. In this research a method can be used in inspection system using IBM-Compatible PC and Video camera is developed without any special hardware. Back-Propagation Neural network is used as tool to recognize colours based on Red Green Blue (RGB) color space.

Studies and researches that applied neural network to recognize color have not use standard RGB components as feeding data for neural network, some of them use RGB histogram, Soriano *et al.* (2001). Some researcher used CIE models, (Razali Bin Yaakob, 1999, Cardei, 1999, Cai.and and Goshtasby, 1999, and Chen *et al.*, 1997). CIE model can be extracted from color object by special and expensive devices. It can also be founded by converting RGB values into *CIE L a* b** model through xyz model using complicated and long mathematical model which will effect the speed of recognition.

Thesis Objective

To develop a method to classify colour using back propagation neural network as classification tool and RGB colour model to represent the colours.

Summary of Thesis

The following is a brief description of the contents of each chapter. The next chapter reviews literature of previous related work in the area of colour image and neural network. It presents colour concepts, colour models and colour image representation, then presents neural network concepts; the Perceptron, multi-layer networks, back-propagation and historical overview.

Chapter Three focuses on methodology, first it traces an introduction about our research and tools used then presents a model diagram for the whole system. This chapter also describes the method and file format, which the system uses to extract RGB components, in neural network model, the Algorithm of BPNN is presented in details.

Chapter Four is dedicated to presenting the results of the development and running the program. All vectors that affect the speed of processing (learning) are discussed and their solutions are presented.

The thesis is concluded with a brief recap of the entire project in Chapter Five. The main objectives are presented and its respective achievements are discussed. This chapter is concluded with various suggestions for improvement and further study for future researches.

CHAPTER II

LITERATURE REVIEW

Soriano *et al.*, (2001) used the supervised Back-Propagation Neural Network (BPNN) to classify coloured fluorescent image and they used the RGB colours histogram as inputs for BPNN. They used two techniques for the major color search: cluster mean (CM) and Kohonen's self-organizing feature map (SOFM). Classification with SOFM-generated histograms as inputs to the classifier NN achieved the best recognition rate (90%) for cases of normal, scaled, defocused, photobleached, and combined images of AMCA (7-Amino-4- Methylcoumarin-3-Acetic Acid) and FITC (Fluorescein Isothiocynate)-stained microspheres.

Razali Bin Yaakob, (1999) used Multi-layer neural network method to recognize the colours automatically. The data that represent the colours are scanned using Minolta Chroma Meter which is capable in changing colour into values. It offers five different colour systems for measuring absolute chromaticity, that is, CIE Yxy, L*a*b*, L*C*Ho, Hunter Lab and XYZ. In this study, only L*a*b* is used. Two types of neural network were used in the early stage of study, i.e. backpropagation (BP) and counterpropagation network (CPN), where 100 data were used as a testing data. The results show that CPN recognized 100% of trained data and untrained data however BP can only recognized 49% of trained data and 48% of untrained data. When the number

of data is increased to 808, training process required a large size memory, learning time consuming and low percentage of recognization. To solve this problems, two combined CPNs model were proposed. The results are much improved compared to the previous study, whereby the percentage for trained data and untrained data are 99%.

Vlad, (1999) explores the possibility of recovering a lost color channel from an RGB image, based on the information present in the remaining two color channels, as well as on *a priori* knowledge about the statistics of sensor responses in a given environment. Different regression and neural network recovery methods are compared and the results show that even simple linear techniques suffice to obtain a good approximation of the original color channel. He represents data in two method the standard RGB and The CIE Lab coordinate. The camera provides the standard RGB, and then RGB is converted to xyz then CIE lab, the recovery methods applied for the both color data. Result has shown that the best is Standard RGB with Polynomial Regression.

Cai and Goshtasby, (1999) developed a method for detecting human faces in color images, which is described that first separates skin regions from nonskin regions and then locates faces within skin regions. A chroma chart is prepared via a training process that contains the likelihoods of different colors representing the skin. Using the chroma chart, a color image is transformed into a gray scale image in such a way that the gray value at a pixel shows the likelihood of the pixel representing the skin. An obtained gray scale image is then segmented to skin and nonskin regions, and model faces representing front- and side-view faces are used in a template-matching process to detect