UNIVERSITI PUTRA MALAYSIA

# THE DEVELOPMENT OF COLOR BASED VISUAL SEARCH UTILITY

AL MABRUK S. MOHAMED

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By

AL MABRUK S. MOHAMED

Thesis Submitted in Fulfilment of the Requirement for the Degree of Master of Science in the Faculty of Engineering
Universiti Putra Malaysia

January 2001

*This work is dedicated to my parents.*

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirement of the degree of Master of Science.

# THE DEVELOPMENT OF COLOR-BASED VISUAL SEARCH UTILITY

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**January 2001**

**Chairman: Md. Mahmud Hasan, Ph.D.**

**Faculty: Engineering**

During the past few years, much attention has been paid to manage the overwhelming accumulation of rich digital images. In order to improve the traditional text-based or (Structured-Query-Language) SQL-based databases, researches focused on accessing large image databases by the contents of images, such as colors, shapes, and textures. As a result, several content-based image searching systems or methods were developed.

In this thesis, the issue of color-based image search was addressed with special emphasis on color feature. An introduction to color perception, the theoretical foundations of the human image retrieving process, and the content-based image systems and their uses was presented.

Several systems were developed. These systems modelled image data using features such as color, texture and shape. Such features are usually extracted from

images and stored into database index. Color is one of the most recognisable features exercised by people for visual distinction.

Based on observations on how humans measure the perceptual similarity of images, recent studies concluded that human beings have a limited color perception range. Expediting these conclusions, firstly, perceptual color palettes to be used as the perceptual threshold were defined. Secondly, the color algorithm was developed to interpret natural expressions of content such as 10%, 20%, etc. The database-indexing algorithm designed to be independent to the database. Finally, a binary search algorithm was used to match and display images requested. This approach is unique because it is based on hybrid approach to the color based image search.

This developed system can be used for any real-world online database. The system was implemented using Microsoft Visual C++ programming language and HTML. Using 200 images as an experimental database, results of the prototype software demonstrated the achievement of the perceptual concept in image content search.

Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia
Sebagai memenuhi keperluan untuk ijazah Master Sains

# PEMBANGUNAN UTILITI MENCARI VISUAL BERASASKAN WARNA

**Oleh**

**AL MABRUK S. MOHAMED**

**Januari 2001**

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Sejak beberapa tahun yang lepas, pelbagai perhatian telah ditumpukan untuk mengurus jutaan imej digital yang terkumpul. Demi memperbaiki pencarian pengkalan data berasaskan teks atau bahasa bertanya berstruktur, ramai penyelidik telah bertumpu di dalam mencari pengkalan data imej yang besar melalui kandungan imej seperti warna, bentuk dan tekstur. Daripada ini, beberapa sistem atau cara pencarian berasaskan kandungan imej telah dihasilkan.

Tesis ini menyelesaikan masalah pencarian imej berasaskan kandungan warna di mana ciri-ciri warna diutamakan. Suatu pengenalan kepada warna, persepsi, asas teori proses mengenali imej oleh manusia, sistem imej berasaskan kandungan dan cara penggunaannya akan dibentangkan.

Sehingga sekarang, pelbagai sistem telah dibina. Sistem-sistem ini membentuk data imej dengan menggunakan ciri-ciri seperti warna, tekstur dan

bentuk. Ciri-ciri demikian biasanya diekstrak melalui imej-imej dan disimpan di dalam indeks pengkalan data. Warna merupakan satu daripada ciri yang sering digunakan oleh manusia untuk membezakan suatu gambaran.

Berdasarkan pemerhatian bagaimana kita mengukur persamaan persepsi imej-imej, suatu kajian menyimpulkan bahawa manusia mempunyai rangkaian persepsi warna yand terhad. Daripada kesimpulan ini, pertamanya, kita memberi definasi bahawa palet warna persepsi akan digunakan sebagai had persepsi kita. Keduanya, ciri-ciri warna adalah berdasarkan kepada perterjemahan bahasa asli iaitu algoritma yang dibina untuk memperterjemahkan cungkilan kandungan asli sebagai 10%, 20%, dan sebagainya. Algoritma indeks pengkalan data direka supaya ia bebas daripada pengkalan data dan proses pertanyaan pengkalan data. Pendekatan ini adalah unik kerana ia berasaskan pendekatan bercantum terhadap pencarian imej berasaskan warna.

Teknik ini boleh digunakan untuk sebarang pengkalan data yang terdapat didunia ini. Sistem ini telah diimplementasikan dengan menggunakan bahasa programming Microsoft Visual C++ dan HTML. Dengan menggunakan 200 imej sebagai ujikaji pengkalan data, keputusan prototaip software ini mendemonstrasikan kejayaan konsep persepsi didalam pencarian kandungan imej.

# ACKNOWLEDGEMENTS

I wish to express my profound gratitude and thanks to my supervisor and chairman of the supervisory committee, Dr. Md. Mahmud Hasan for his guidance, enthusiastic supervision, encouragement and help throughout the duration of the research. Special thanks go to him for his knowledge and expertise in the field of the study.

Sincere appreciation and gratitude is expressed to Dr. Abdul. Rahman Ramli and Puan Roslizah Ali for their numerous stimulating discussions and continues assistance throughout the research. Thanks are extended to the Computer and Communication Engineering faculty members and technical staff for their assistance with all types of technical problems.

I am grateful to my country Libya and the Bright Star University of Technology, New Brega for having offered me the scholarship for pursuing the graduate study at Universiti Putra Malaysia. Special thanks to friends in Malaysia for being the surrogate family during the many years I studied there and for their continued moral support there after.

Finally, I am forever indebted to my parents for their understanding, endless patience and encouragement when it was most needed.

I certify that an Examination Committee met on 15th January 2001 to conduct the final examination of Al Mabruk S. Mohamed on his Master of Science thesis entitled "The development of color-based visual search utility" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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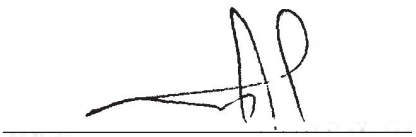
## DECLARATION

I hereby declare that the thesis is based on my original work expect for the 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.



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| | | |
|---|---|---|
| CIE | : | Commission Internationale de l'Eclairgeor. |
| RGB | : | Red-Green-Blue color space. |
| HSV | : | Hue-Saturation-Value color space. |
| QBIC | : | Query by Image Content. |
| MTM | : | Mathematical Transform of Munsell. |
| IBM | : | International Business Machine. |
| DB2 | : | Digital Library II. |
| URL | : | Uniform Resource Locator. |
| POIs | : | Points of Interest. |
| HTML | : | Hyper Text Markup Language. |
| Blobs | : | Image representation based on image regions. |
| GiST | : | Generalised Search Trees. |
| ALISA | : | Adaptive Learning Image and Signal Analysis. |
| AKP | : | Applied Knowledge Processing. |
| WISE | : | Wavelet-based Image Search Engine. |
| MIT | : | The Massachusetts Institute of Technology. |
| PPM | : | The Portable Pixel Map. |
| RAM | : | Random Access Memory. |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Large collection of images is growing rapidly due to the advent of cheaper storage devices, fast computers and communication technologies, Internet access of databases, etc. Searching images from such large collections efficiently and effectively, based on their content, has become an important research issue for database, image processing and computer vision communities.

Several image search systems have been developed so far (Pecenovic, et al., 1998). These systems module image data using features such as color, texture and shape. Such features are usually extracted from images and stored into database. Color is one of the most straightforward features utilized by people for visual recognition and discrimination. People show natural ability of using different levels of color specificity in different contexts. The inherent features of the color-based image search systems are imprecision, partial information and user preferences. To find images that have red roses in them from a database, the user has to select a red color palette and the approximate percentages of the red color expected in that image and ask the system to find images with the matching color and percentage.

Like traditional database systems, image database systems handle multi-dimensional point data and similarity based search. Feature extractor computes a set of features to describe the properties of image content - such as colors, textures, shapes, edges, and locations of objects. A multi-dimensional point or spatial data usually represents feature. Structures used mostly in database use one-dimensional ordering of key values that do work in image database systems, as it can describe the complexity of single property of image.

Moreover, image database systems handle search methods based on similarity as opposed to exact match. For example, images can be requested whose colors are similar to the color of an indicated image. In order to search for specific color in image, image database systems compute the color database that represents the images' content.

**1.2 Image Silent Feature**

There is a saying; "A picture worth a thousand words". This is somewhat of an understatement. It does however point to the fact that like words combine to make sentences, sentences to make paragraphs and paragraphs to whole texts, pictures too have a grammatical structure. Textures, colors and shapes combine to make objects and objects combine to make a picture. The information in a picture is wholly dependent upon these features and the way they are ordered. To take the analogy one step further, to learn a language the words must first be learnt, so too must the fundamental features of an image be understood before beginning to extract the

information contained in their ordering. And like words these feature themselves have attributes of there own to be understood.

### 1.3 Image Database

Notwithstanding, it can be seen that with the enormous capacity of modern technology casts amount of information can be stored. Outstandingly is the ease and speed of access via this media much of the world's information has been digitized and stored electronically. One of the obvious forms of information to be digitized is imagery. High resolution images can be stored and retrieved with ease and in quantities that would be impractical using a conventional paper filing system, and with the Internet these collections can be used anywhere in the world without the redundancy of having multiple copies. This is used to great effect in numerous areas; some examples are listed below.

- Lists and pictures of stolen and recovered property.
- Criminal's fingerprints and faces.
- Pictures of painting and other works of art in large collections.
- Trademarked and copyrighted logos and images.
- Scientific imagery.
- Medical imagery.

These databases can grow to gigantic sizes. It is estimated that American military satellites alone generate 15 terabytes of images every year, all of which is stored and processed. At the end of 1995, 49.8 million criminal history records were in the

criminal history files of the State criminal history repositories of the United States of America, of which 86% were automated, that's 42.8 million criminal history files on computer, (Cox, et al, 1996).

### 1.4 The Problem with Content-Based Image Searching

To date, image databases and search systems have typically relied on human supplied textual annotations to enable indexing and searches. The text-based indexes for large image archives are time consuming to create. They necessitate that each image and video scene is analyzed manually by a domain expert so the contents can be described textually. The language-based descriptions, however, can never capture the visual content sufficiently. For example, a description of the overall semantic content of an image does not include an enumeration of all the objects and their characteristics, which may be of interest. A content mismatch occurs when the information that the domain expert ascertains from an image differs from the information that the user is interested in. A content mismatch is catastrophic in the sense that little can be done to approximate or recover the omitted annotations. In addition, a language mismatch can occur when the user and the domain expert use different languages or phrases. Because text-based matching provides only hit-or-miss type searching, when the user does not specify the right keywords the desired images are unreachable without examining the entire collection.

Recently, this bleak situation is improved by allowing the computer to provide support in the domain it is most suited for: management of low-level features. The computer can analyze the image and extract pertinent information such as colors, color patterns, textures and shapes. By automatically extracting these features and

constructing the corresponding indexes the image database and search system are given tremendous new power. The feature indexes will not supplant the text domain, but rather will enhance it. This allows for images to be searched for by queries that use image content or that combine keywords and features. For example, when the user provides a sample of content, such as a percentage of certain color in the image, the computer extracts the low-level features of the image and uses the feature indexes to search the database for images with similar color content. In the other queries, the text-searches are modulated with visual features such file names and categories. Although the text index must be created manually, the low-level feature indexes are automatically generated and managed by the computer. As such, the capacity to search using visual features is an enhancement of database system capabilities.

## 1.5 Research Objective

The purpose of this thesis is to develop a color-based image searching software in which the color feature extraction approach is fundamentally based on human perception of colors. The proposed approach is designed for color extraction and for quick and efficient low-level image indexing. In view of the fact that the full set of perceptual color palettes can represent an images feature index that would be the vehicle for our query, a weighable perceptual threshold for each color palette derived form a color spectrum using two color spaces is determined. The indexing is based upon color palettes containing possible many colors, the color palette approach enables great power in searching the database.

Since it has been experimentally found that the user can only recognise a small set of feature values in general (Carson, et al, 1996). Hence taking the human

perceptual range into account, our implemented prototype system distinguishes between nine colors only. The main research objectives are:

- Defining acceptable set of perceptual color palettes.
- Extracting, ranking and indexing image's colors.
- Developing a system that allows the user to search based on perceptual color and color feature preference.

## 1.6 Thesis Organization

The thesis is divided into five chapters. Following this Introduction Chapter, Chapter Two presents a brief background on content-based Image Searching. Also, methods to extract image features approaches and query concepts used. A general study about the applications, algorithms and packages used to create databases and perform multiple searching platforms included. The efficiency of the query results and the matching techniques are also discussed. This chapter also presents the multiple color spaces that are used to extract colors from images. The Third Chapter is the methodology, the single color indexing approach is discussed in the first section followed by the determination of perceptual color palette process. Also, the perceptual color palette description is considered and the extraction and indexing algorithms are illustrated. Finally, the query answering mechanism is system is discussed. Chapter Four presents the prototype system results and the discussion of the implemented algorithm. General conclusion and suggestions for future work, based on findings from the research, are given in Chapter Five.

# CHAPTER 2

# LITERATURE REVIEW

The basic idea of content-based image search is that, when the user provides a description of some of the prominent visual features of an image, the system can search the archive and return the images that best match the description. At present, research on content-based image search mainly focuses on the visual features of color, texture, and shape.

Vision is the most important sense that we have. Belying its complexity, visual interaction with the world is straightforward and seamless. Objects in a scene can be recognized almost instantaneously, scenes can be recognized in a fraction of a second, and the memory of something seen can last a lifetime. Computer scientists have tried to emulate these capabilities with computational methods, resulting in only limited success.

Although the human visual system is very remarkable, it can also be very unreliable. Images, which are remembered, cannot be placed temporally or spatially, objects, which are recalled, were never really there, and sometimes-different scenes are confused and combined in memory. This problem is less noticeable when we recall visual scenes or locations, with which we have interacted, rather than when the recall of static images is required. This latter case is becoming more common as the

storage and searching of large quantities of visual data has been increasing due to the higher storage and processing capacities of modern computer systems.

As a result, a system that can be used as an aid for searching among a large number of images becomes desirable. Different content-based image indexing has been proposed and implemented in several systems to date (Pecenovic, et al., 1998). Some of these have been made available commercially, while most are still only research projects. These systems rely primarily on color and texture information. Only a few attempts have been made at using configuration and color perception. Although most of these systems perform acceptably well for generic searches, they run into the same difficulties that general text-based search engines encounter.

The problem is that images are noisy, the search vocabulary supplied is very non-descriptive, and the rules of image composition are complex and ill understood. Thus, although text-based search could be built based on phrase structure, and translation between languages is a feasible exercise nowadays, this is not yet possible for images, because the structure of images in terms of their human perception is not understood well enough. Image matching, and thus the translation of an image into another equally meaningful image is currently on the border between difficult and impossible.

## 2.1 Introduction

Current research in cognitive science has shed light upon some of the generalities and specifics of the visual processing being performed by the