UNIVERSITI PUTRA MALAYSIA

CONTENT-BASED IMAGE RETRIEVAL THROUGH IMPROVED SUB-BLOCK TECHNIQUE

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By

MAS RINA BINTI MUSTAFFA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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TO MY HUSBAND, PARENTS, FAMILY, AND FRIENDS…

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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August 2006

Chairman: Associate Professor Hajah Fatimah Ahmad, PhD

Faculty : Computer Science and Information Technology

Traditional Content-Based Image Retrieval (CBIR) systems mainly relied on the extraction of features globally. The drawback of this approach is that it cannot sufficiently capture the important features of individual regions in an image which users might be interested in. Due to that, an extension of the CBIR systems is designed to exploit images at region or object level. One of the important tasks in CBIR at region or object level is to segment images into regions based on low-level features. Among the low-level features, colour and location information are widely used.

In order to extract the colour information, Colour-based Dominant Region segmentation is used to extract a maximum of three dominant colour regions in an image together with its respective coordinates of the Minimum-Bounding Rectangle

(MBR). The Sub-Block technique is then used to determine the location of the dominant regions by comparing the coordinates of the region's MBR with the four corners of the centre of the location map. The cell number that is maximally covered by the region is supposedly to be assigned as the location index. However, the Sub-Block technique is not reliable because in most cases, the location index assigned is not the cell number that is maximally covered by the region and sometimes a region does not overlap with the cell number assigned at all. The effectiveness of this technique has been improved by taking into consideration the total horizontal and vertical distance of a region at each location where it overlaps. The horizontal distance from the left edge to the right edge of a region and the vertical distance from the top edge to the bottom edge of a region are calculated. The horizontal and vertical distances obtained for that region are then counted. The cell number with the highest distance would be assigned as the location index for that region. The individual colour and location index of each dominant region in an image is extended to provide combined colour-spatial indexes. During retrieval, images in the image database that have the same index as the query image is retrieved.

A CBIR system implementing the Improved Sub-Block technique is developed. The CBIR system supports Query-By-Example (QBE). The retrieval effectiveness of the improved technique is tested through retrieval experiments on six image categories of about 900 images. The precision and recall is measured. From the experiments it is shown that retrieval effectiveness has been significantly improved by 85.86% through the Improved Sub-Block technique.

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

DAPATAN SEMULA IMEJ BERASASKAN KANDUNGAN MELALUI PEMBAIKKAN TEKNIK SUB-BLOK

Oleh

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Ogos 2006

Pengerusi: Profesor Madya Hajah Fatimah Ahmad, PhD

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Sistem tradisional Dapatan Semula Imej Berasaskan Kandungan biasanya bergantung kepada perwakilan ciri secara global. Pendekatan ini mempunyai kelemahan di mana ia tidak dapat menangkap ciri-ciri penting bagi sesuatu kelompok di dalam imej yang mungkin menjadi kepentingan kepada seseorang pengguna. Oleh yang demikian, pembaikan terhadap Sistem Dapatan Semula Imej berasaskan Kandungan telah direka bentuk untuk mengeksploitasi imej pada peringkat objek atau kelompok. Salah satu tugas penting Sistem Dapatan Semula Imej berasaskan Kandungan peringkat kelompok atau objek adalah untuk membahagi imej kepada beberapa kelompok berdasarkan kepada ciri bertahap rendah. Di antara ciri bertahap rendah, warna dan kedudukan digunakan secara berleluasa.

Bagi mengekstrak maklumat warna, segmentasi Kelompok Dominan berasaskan Warna digunakan untuk mengekstrak sekurang-kurangnya tiga kelompok yang mempunyai warna yang dominan beserta dengan koordinat pengsempadanan minima segiempatnya**.** Teknik Sub-Blok kemudiannya digunakan untuk menentukan kedudukan kelompok dominan dengan membandingkan sempadan minima segiempat kelompok tersebut dengan empat pepenjuru bahagian tengah peta lokasi. Dalam hal ini, nombor sel yang diliputi secara maksima oleh kelompok tersebut sepatutnya ditetapkan sebagai indeks kedudukannya. Walau bagaimanapun, kebergantungan teknik Sub-blok ini diragui kerana di dalam kebanyakan situasi, indeks kedudukan yang ditetapkan bukanlah nombor sel yang diliputi oleh kelompok tersebut secara maksima dan kadangkala, kelompok tersebut tidak langsung menindih sel tersebut. Keberkesanan teknik ini telah diperbaiki dengan mengambil kira jumlah jarak melintang dan menegak sesuatu kelompok di setiap kedudukan di mana ia bertindih. Jarak melintang daripada sisi kiri ke sisi kanan dan jarak menegak daripada sisi atas ke sisi bawah bagi sesuatu kelompok akan dikira. Jarak melintang dan menegak yang diperoleh bagi kelompok tersebut akan dijumlahkan. Nombor sel dengan jumlah jarak yang tertinggi akan ditetapkan sebagai indeks kedudukan untuk kelompok tersebut. Indeks warna dan indeks kedudukan bagi setiap kelompok di dalam sesuatu imej akan digunakan untuk menghasilkan beberapa gabungan indeks warna-kedudukan. Sewaktu dapatan semula, imej di dalam pangkalan data yang mempunyai indeks yang sama dengan imej carian akan diambil (papar).

Sistem Dapatan Semula Imej berasaskan Kandungan yang melaksanakan teknik Pembaikan Sub-Blok telah dibangunkan. Sistem yang dibangunkan menyokong carian berdasarkan contoh. Keberkesanan dapatan semula menggunakan teknik yang diperbaiki telah diuji ke atas enam kategori imej yang mengandungi 900 imej melalui eksperimen dapatan semula. Ketepatan dan perolehan telah diukur. Hasil eksperimen menunjukkan peningkatan yang jelas dari segi keberkesanan dapatan semula iaitu sebanyak 85.86% telah dapat dicapai melalui teknik Pembaikkan Sub-blok.

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Mas Rina Binti Mustaffa

2006

I certify that an Examination Committee has met on 9 August 2006 to conduct the final examination of Mas Rina Binti Mustaffa on her Master of Science thesis entitled "Content-Based Image Retrieval Through Improved Sub-Block Technique" 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 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.

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MAS RINA BINTI MUSTAFFA

Date:

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LIST OF ABBREVIATIONS

CBIR	Content-Based Image Retrieval
CLI	Colour-Location Index
ISB	Improved Sub-Block
MBR	Minimum-Bounding Rectangle
QBE	Query-By-Example
SB	Sub-Block

CHAPTER 1

INTRODUCTION

1.1 Background

Content-Based Image Retrieval (CBIR) is an exciting and in-depth area of research, which has garnered much interest over the past few years. The relevance of visual information retrieval for many applications which includes art galleries, museum archives, criminal investigation, medical, and geographic databases makes this research field one of the important and fastest growing in information technology. Image retrieval has come a long way where it started off with text-based retrieval. However, there are many problems associated with retrieving images based on text such as manual annotation of keywords, differences in perceptions and interpretations, and a few others. Due to this, researchers came up with CBIR where images are retrieved based on the information extracted from the content of the image globally. Later, CBIR has been extended to exploit images at region or object level, which gives more explicit information of the image structure and configuration.

One of the important task in CBIR at region or object level is to segment images into regions on which the user can perform queries, based on low-level features such as colour, shape, texture, location, etc. Among these low level features, colour plays an important role in CBIR because of its robustness to complex background and independent of image size and orientation. However, where CBIR is concern, using

colour alone is not sufficient to characterise an image. For example, there are two different images; one contains a red ball at the left side while another image contains a red ball at the top. Based on human observer, these two images are different. However a colour-based retrieval system will assume that these two different images are the same since both of them do have the same colour composition despite that their location is different. In order to rectify this problem and produce a better retrieval system, multiple but related features are usually used. If we look at the example above again, since everything is the same, the spatial pattern will possibly distinguish the image content. There are several colour descriptors incorporated with the location feature such as Colour Coherence Vectors (Pass *et. al*, 1996), Binary Thresholded Histogram (Walczak, 2001), Spatial Chromatic Histogram (Cinque *et. al*, 2001), Major Colour Set and Distribution Block Signature (Yoo *et. al*, 2005), and a few others. Colour-spatial features can really help in differentiating images having pixels with the same colour distribution but different location information. However, the methods must be able to retrieve images that a user requires.

Prasad *et. al* (2004) acknowledged the importance of combining colour and spatial information for better retrieval result. In their work, a maximum of three dominant colour regions in an image is extracted using Colour-Based Dominant Region segmentation (Ravishankar *et. al*, 1999) and the location of the regions is then determined using the Sub-Block technique (Prasad *et. al,* 2004). The Sub-Block technique works by finding the distance from the region's Minimum-Bounding Rectangle (MBR) to the coordinates of the centre of the location map. According to

them, the cell number that is maximally covered by a region would be assigned as the location index. However, in most cases, the location index assigned is the cell number having the highest distance from the region's MBR to the coordinates of the centre of the location map instead of the cell number that is maximally covered by the region. This will result in the wrong location being assigned to the region, thus it is not reliable.

The aim of this research work is to overcome the above-mentioned shortcoming existed in the Sub-Block technique. Having found the colour-spatial information, the information is then used for further image retrieval process through a CBIR system.

1.2 Problem Statement

According to Prasad *et. al* (2004), their approach is based on the Sub-Block technique where the image space is divided into nine sub-locations numbered one to nine. The classification is according to this numbered grid cell where the cell number that is maximally covered by the region is assigned as the location index. In order to determine the location of a region, the coordinates of the region's MBR will be compared with the four corners of the centre of the location map. If the MBR of a region falls within one grid cell, then the location of a region can be determined clearly and correctly. However most of the regions are likely to overlap more than one grid cell in the image space. When this happens, the distance from the region's MBR to the coordinates of the centre of the location map will be used to determine the region's location. However, in most cases, the location index assigned is the cell

number having the highest distance from the region's MBR to the coordinates of the centre of the location map instead of the cell number that is maximally covered by the region. This will usually result in the wrong location being assigned to the region.

This research focused on eliminating the above-mentioned weakness in the Sub-Block approach by taking into consideration the total horizontal and vertical distance of a region at each location where it overlaps. This will result in an enhanced technique that will be able to locate a region effectively thus, providing better retrieval results when implementing the technique on a CBIR system.

1.3 Research Objectives

The objectives of this research work are as follows:

1. Improving the Sub-Block technique so that it will be able to detect the location of a region in a more effective way.
2. Developing a colour-location CBIR system supporting Query-By-Example (QBE) that implements the improved technique.

1.4 Scope of Research

This study focuses on developing a colour-spatial technique for CBIR. The colour information is extracted using the existing Colour-Based Dominant Region segmentation while the location information is extracted using the Improved Sub-Block technique. This Improved Sub-Block technique is able to locate regions in an

image effectively compared to the original technique where the cell number that is maximally covered by the region is indeed assigned as the location index. The location index together with the colour index is combined to generate possible colour-location indexes. These colour-location indexes are used for retrieval.

A CBIR system implementing the colour-spatial technique is developed. The developed CBIR system consists of three main modules, which are the user maintenance module, category database maintenance module and the image retrieval and performance measurement module. User maintenance module is used to maintain users who have the access to the category database maintenance module. In the category database maintenance module, the system is able to extract colour and location information from an image, store the necessary extracted information into the database, and maintain the image database where new images can be added while stored images can be deleted. In the image retrieval and performance measurement module, querying and retrieval of images that have been processed by the category database maintenance module, can be done. The module is also able to automatically make the relevant judgement for each of the query image based on Area technique as the benchmark.

The CBIR system supports Query-By-Example (QBE). During retrieval, images having the same index as the indexes of the query image are retrieved. The CBIR system focuses more towards similar retrieval rather than speedy retrieval. Each of the query images is tested using the Sub-Block technique and the Improved Sub-