SEMANTICS ORIENTED APPROACH FOR IMAGE RETRIEVAL IN LOW COMPLEX SCENES

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“Dedicated to my beloved family and friends, without their understanding, support, and most of all love, the completion of this work would not have been possible.”

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ABSTRACT

The explosive growth of image data leads to the need of research and development of image retrieval. Image retrieval researches are moving from keyword, to visual features and to semantic features. Drive towards semantic features is due to the problem of the keywords which can be very subjective and time consuming as low level features cannot always describe high level concepts in the users' mind. The main problem encountered in the image retrieval research is the semantic gap that exists between the low-level features and high-level semantics in the images due to the unavailability of low level image features in describing high level concepts in the users' mind. The aim of this research is to design and validate the semantics oriented approach for image retrieval in low complex scenes. In order to achieve the aim and objectives of the research, the object extraction method for identifying and extracting the objects in a complex scene based on the colour features has been proposed. The semantic extraction and representation method with the semantic image similarity has also been proposed to bridge the semantic gap in image retrieval. In addition, the semantic visual user query, namely Semantic Visual Query Builder (SeVQer), which enables users to express their need and intent at semantic level that reduces the semantic gap in content based image retrieval has been introduced and evaluated. The prototype has been developed to validate the proposed approach in image retrieval. The result of the evaluation shows that the proposed system can achieve the retrieval accuracy of 95.8% and 89.5% for the experiments of semantic object extraction and semantic object and their spatial relationship. The usability evaluation indicated that the proposed semantic visual query achieved higher efficiency and user satisfaction compared to image search by example, keyword and sketch.

ABSTRAK

Pertumbuhan mendadak data imej membawa kepada keperluan penyelidikan dan pembangunan dapatan kembali imej. Penyelidikan dapatan kembali imej bergerak daripada kata kunci kepada ciri-ciri visual imej dan seterusnya kepada ciri-ciri semantik. Kecenderungan ke arah ciri-ciri semantik disebabkan oleh masalah kata kunci yang mengambil masa yang panjang dan juga sangat subjektif, manakala ciri-ciri visual imej tidak boleh sentiasa menggambarkan konsep tahap yang tinggi dalam minda pengguna. Masalah utama yang dihadapi dalam penyelidikan dapatan kembali imej ialah jurang semantik yang wujud antara ciri visual dan ciri semantik peringkat tinggi dalam imej yang disebabkan oleh ketiadaan ciri-ciri visual yang boleh menerangkan konsep tahap yang tinggi dalam minda pengguna. Tujuan kajian ini adalah untuk mereka bentuk dan mengesahkan pendekatan berorientasikan semantik untuk mendapatkan kembali imej dalam adegan kompleks rendah. Dalam usaha untuk mencapai matlamat dan objektif penyelidikan, kaedah pengekstrakan dan pengecaman objek dalam mengenal pasti dan mengekstrak objek dalam adegan kompleks rendah berdasarkan ciri-ciri warna telah dicadangkan. Kaedah pengekstrakan dan perwakilan objek semantik bagi mengekstrak objek semantik serta hubungannya dalam kalangan objek yang wujud dalam imej secara automatik dengan persamaan semantik objek juga telah dicadangkan untuk merapatkan jurang semantik dan seterusnya meningkatkan prestasi gelintaran imej pengguna. Sebagai tambahan, satu pertanyaan pengguna visual semantik iaitu Pembina Pertanyaan Visual Semantik (SeVQer) yang membolehkan pengguna mengungkapkan keperluan dan niat pertanyaan pada peringkat semantik yang merapatkan jurang semantik dalam bidang dapatan kembali imej dicadangkan dan dinilai. Prototaip telah dibangunkan untuk mengesahkan pendekatan yang dicadangkan. Hasil penilaian menunjukkan bahawa sistem yang dibangunkan boleh mencapai ketepatan dapatan kembali 95.8% dan 89.5% bagi eksperimen pengekstrakan dan perwakilan semantik. Penilaian daya guna menunjukkan bahawa Pembina Pertanyaan Visual Semantik yang dicadangkan mencapai kecekapan dan kepuasan pengguna yang lebih tinggi berbanding dengan gelintaran imej dengan contoh, kata kunci dan lakaran.

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INTRODUCTION

1.1 Motivation

The recently digital visual contents production has become more common and affordable. The recent technology advancement has resulted in an enormous increase in multimedia data. Researches (Datta, 2009; Lyman and Varian, 2003) reported that the annual productions of images are approximately 80 billion, and home video is approximately 1.4 billion. Online photo sharing sites are increasing such as Flickr, Photoblog and Fotopages. By December 2010, Flickr had more than 21.3 million unique registered users and there are some five billion photos and short videos stored on the site (Mellor, 2011). Thus, image retrieval research has been introduced and has been a very active research area since the 1970s (Rosenfeld, 1969; Tamura and Mori, 1977) for better image management.

Image retrieval is the field of study concerned with searching and browsing digital images from a collection of images. Due to rapid generation of images in digital form, image retrieval attracts interest among researchers in the fields of image processing, multimedia, digital libraries, remote sensing, astronomy, database applications and other related area. Effective and fast retrieval of digital images has not always been always easy, especially when the collections grow into thousands.

An effective image retrieval system is needed to operate on the collection of images to retrieve the relevant images based on human perception.

However, most common methods of image retrieval are based on visual features or utilize some index methods. The metadata of images are indexed by keyword, image caption or image descriptions so that retrieval can be performed based on sample query image with indexed annotation words. As getting more visual information is available in digital archives, the need for effective image retrieval has become greater (Liu *et al.*, 2007; Datta, 2007). In image retrieval research, researchers are moving from keyword based to content based, and then towards semantic based image retrieval.

The main problem encountered in the image retrieval research is the semantic gap that exists between the low-level features and high-level semantics in the images due to the unavailability of low level image features in describing high level concepts related to the users' need. A machine is only able to perform automatic extraction by extracting the low level features which are represented by the colour, texture, shape and spatial from images with a good level of efficiency. Describing images in semantic terms is an important and challenging task that needs to be carried out to fulfill human satisfaction and defining a semantic meaning and representation of the input query in describing user's needs remain as major challenges (Russ, 1999)

Therefore, research efforts are required to bridge the semantic gap in Content based Image Retrieval (CBIR) to have more intelligent image retrieval system in order to retrieve images that are comfort to human perception.

1.2 Problem Statement

"A picture is worth a thousand words"; this familiar proverb emphasizes that visual information is inherently ambiguous and semantically rich. Human beings are able to interpret images at different levels, both in low level features (colour, shape, texture and object detection) and high level semantics (abstract objects and event). However, a machine is only able to interpret images based on low level image features. Thus, it introduces an interpretation inconsistency between image descriptors and high-level semantics called semantic gap (Liu *et al*., 2007; Smeulders *et al*., 2000). In addition, users prefer to articulate high-level queries (Kherfi *et al*., 2004; Smeulders *et al*., 2000) but CBIR systems index images using low-level features. In general, there is no automated direct link between high-level semantic concepts and visual image features. There is a persuasive need for CBIR systems to provide maximum support towards bridging the semantic gap between the visual features and high level concepts to fully support the query by semantic concept (Liu *et al*., 2007; Guan *et al*., 2009). Researchers (Chang *et al*., 2009; Idrissi, 2009) found that bridging the semantic gap for image retrieval is a very challenging problem yet to be solved.

The semantic content representation has been identified as an important issue to bridge the semantic gap in visual information access (Wang *et al*., 2006). The semantic features especially the semantic object and their semantic spatial relationship features in the images are not fully captured and extracted (Belkhatir, 2009; Muda *et al*., 2009; Hollink *et al*., 2004). It often leads to unsatisfactory search results (Zha *et al.*, 2010). Representation of spatial relations semantics among objects are important as it can convey important information about the image and to further increase the confidence in image understanding contribute to richer querying and retrieval facilities. In addition, the computer usually processes semantic similarity based on low-level feature similarity, however the user queries are supposed to be based on semantic similarity (Agrawal, 2009). Current semantic based image retrieval are either based on visual features or the image similarity is measured based

on semantic matching instead of semantic similarity (Belkhatir, 2009; Muda *et al*., 2009; Pratikakis, 2011; Yong, 2011).

User query has become one of the main challenges of research in the field of CBIR which is to find exactly what a user is looking for in more effective ways. Most of the researches in CBIR is aimed at improving retrieval performance. Comparatively little effort has been directed towards improving the scalability properties of retrieval methods (Heesch, 2008). So, an intuitive and visual user query design that allows users to express their need and intent easily is needed.

1.3 Research Questions

Research questions of the study are specified as follows:

1. What is the semantic gap in image retrieval and how to bridge them?
2. How to design and demonstrate the semantics oriented approach for image retrieval in low complex scenes?
3. How to design and demonstrate an intuitive and visual user query which allows users to express their need for the image retrieval?
4. Will the use of the proposed object detection techniques, semantic extraction and representation, and the visual user query be validated by the proposed prototype?

This research attempts to answer the above questions.

The first question was carried out by understanding the meaning of semantic gap and next reviewing the techniques on how to bridge them in the field of image retrieval. For the second research questions, the model for the semantics oriented approach for image retrieval in low complex scenes was designed. Next, the visual

query that are allows users to express their need was also designed in research question three. Lastly, for the fourth research questions, prototype was developed and evaluated to demonstrate the system retrieval performance, user retrieval performance and subjective satisfaction of the model and system in the image retrieval for low complex scenes

1.4 Research Aim

The aim of this research is to design and validate the semantics oriented approach for image retrieval in complex scenes. This aim can be achieved by fulfilling the research objectives stated in Section 1.5.

1.5 Objectives

1. To design and develop algorithms for object detection using colour features for low complex scenes.
2. To design and develop the semantic object spatial relationship extraction and representation for bridging the semantic gap in image retrieval.
3. To design and develop the semantic visual user query design that allows a user to express their need in image retrieval.
4. To develop a prototype to validate the proposed approach in image retrieval.

1.6 Scope and limitation

In this research domain, low complex scenes images (traffic images with "right hand" perspective view) are chosen as dataset images to perform empirical evaluation of the proposed method. The complex scenes are scenes that contain irregular shapes of objects that is viewed from any direction, with self-occlusion or partially occluded by other objects and with uniform colour intensity (Garijo *et al.,* 2002) and complex scenes perception is humans' remarkable perceptual abilities to perceive, navigate and interact with natural environments dramatically eclipse those of current robotic systems (IGERT Complex Scene Perception, n.d.).

The colour features with spatial distribution are selected as it is able to use to identify the objects of building and road. The car can be identified by integrating the line detection and intersection. Cars are considered as the objects of interest and main objects in traffic images from the human point of view. In the images used, only non-overlapped cars are considered.

Since colour is the significance features of the car, thus colour feature with spatial distribution are needed to differentiate the cars, the attributes of cars as well as relations of the cars also can be identified. Whereas shape and texture features could lead to high possibility for getting the same shape or same texture between cars and building or background. Example, front window of car objects might have the same shape representation of building as indicated in Figure 1.1 using red dotted box. Same problem occurs to texture features.

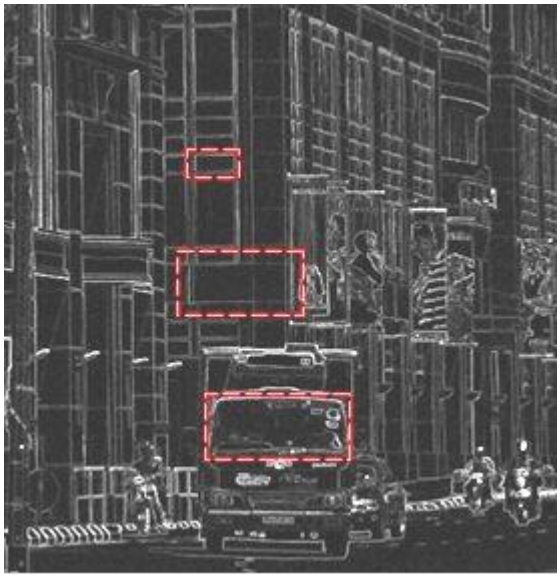

Figure.1.1: Edge detection of traffic images using Iplab's approach (Google Project Hosting, 2007).

The colour cues posses highly discriminative power as it is contrast to shape cues and invariant against scale and view (Ritter *et al.*, 1995). Micheli *et al*. (1995) stated that the most important advantage of having colour information in addition to image luminance is that the "colour" of a surface is more stable under changes in geometry than the corresponding image intensity value. The surfaces arrangement and lighting conditions can be greatly changeable as well. Thus, colour plays an important role in the images.

There are none of perfect visual features that can be selected to describe the object accurately as discussed above. Each feature has its own advantages and limitations. The more low level features are used, the more accurate result will be obtained. However it will be very expensive and complex. Hence, colour features have been selected as the low level features and could be used in extracting interested object in traffic images.

1.7 Research operational framework

The overview of the research operational framework is illustrated as shown in Figure 1.2.

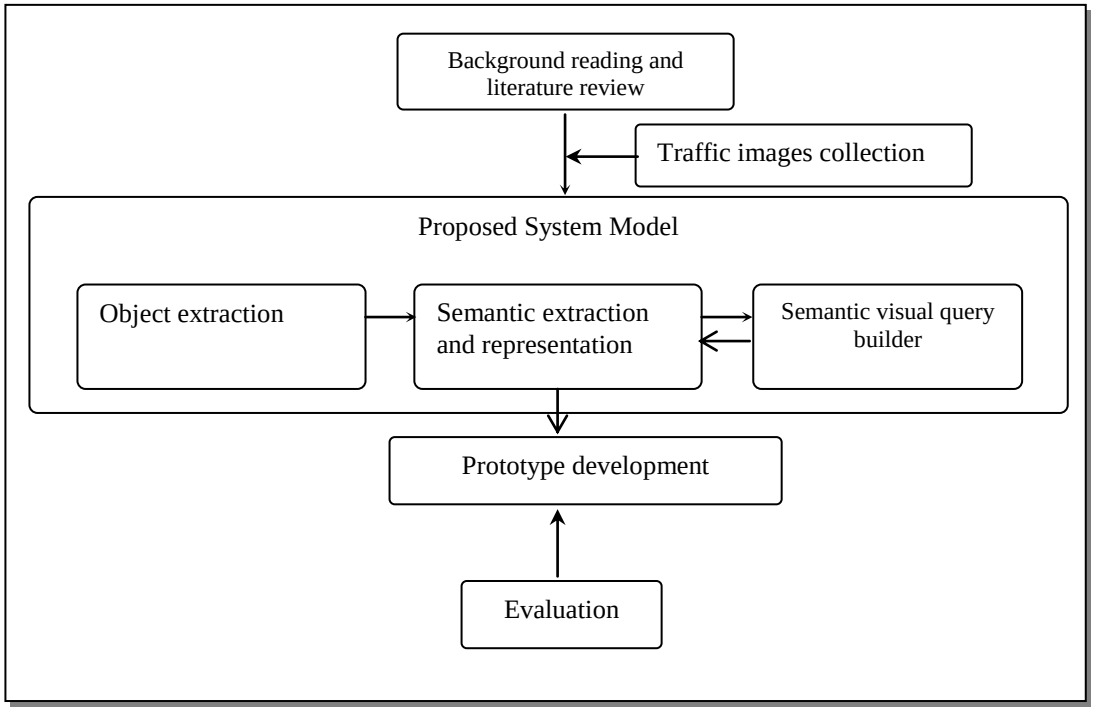

Figure 1.2: The overview of the research operational framework.

A proposed image retrieval system model was constructed based on a literature review that involves background reading, surveying and reviewing related research in the area of bridging the semantic gap in image retrieval. The studies of visual features, object detection using colour features, semantic extraction and representation, and image search were carried out. There are three main modules design of the system model, which are object detection, semantic extraction and representation and Semantic Visual Query Builder (SeVQer). In the prototype development, the Visual Basic programming, Microsoft Access database, ADO data access library were used as the enabling technologies to achieve the aim of this research. Evaluations are conducted to test the efficiency and effectiveness of the

proposed solutions. Usability test is also conducted to evaluate the user retrieval performance and subjective satisfaction of the system model.

1.8 Significance of the research

Introducing semantic feature extraction and visual query into image retrieval is necessary to cope with a variety of users having different needs. This study attempts to fill the gaps that exist in image retrieval. By incorporating the proposed semantic extraction and representation with visual query builder, it aims to create a more effective, efficient and accurate prototype for retrieving images that conforms to human perception.

1.9 Organization of Thesis

The thesis is organized as follows:

Chapter 2 reviews the literature of previous research relevant to this work. These include (a) the evolution of image retrieval; (b) gaps in content based image retrieval; (c) images features; (d) object detection techniques; (e) semantic extraction; (f) semantic representation and (g) user query for image retrieval. A comparison summary is also discussed.

Chapter 3 describes the research methodology, which includes object detection, semantic features extraction and representation as well as the semantic visual query builder used to achieve the research aim and objectives. The dataset used, parameters selection, related evaluation methods and experimental setup are also described and discussed.

Chapter 4 discusses the implementation and development of the proposed prototype. The proposed prototype model presents the implementation tools, main algorithms employed, data structure as well as the system model and their components. This chapter also illustrates and explains the capabilities of the proposed prototype.

Chapter 5 presents the results and analysis of the various experiments. The experiments that were carried out include: object detection, semantic extraction and representation, the system retrieval performance, the user retrieval performance and subjective Satisfaction.

Chapter 6 summarizes the research work, the contributions and presents the limitations and future work.

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