EVALUATION OF CONTENT BASED IMAGE RETRIEVAL (CBIR) SYSTEM USING PRECISION MEASURE

BY

SITI AISHAH KAMALIAH MOHAMED

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Kulliyyah of Information and Communication Technology
International Islamic University Malaysia

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ABSTRACT

Content based image retrieval (CBIR) is an application of the computer system for image retrieval, where it will aid searching for digital images in a large database. CBIR operates on a totally different principle from keyword indexing. Content based means that the search will analyze the actual content of an image, which will be done automatically by the system, where the cost and time will be reduced greatly. The study sets out to assess the retrieval performance of a CBIR system with regards to the users' evaluation and precision measure and was modelled after Cranfield Test by Cleverdon. To collect the queries and relevance criteria used during the searching activities, a semi structured interview was carried out where two users from different professional backgrounds; school teacher and graphic designer were interviewed. Users' relevance judgment of the retrieved images were collected and later used to calculate the precision values. The precision values measured were varied among the two users because their professional backgrounds reflected their final judgments of the relevance criteria and the retrieved images. The precision values differed greatly between the two users and the low precision values were indicated as a poor retrieval performance by Retrievr. In conclusion, Retrievr did an image clustering based on the focus in the image queries whereby queries with fewer objects are more accurately matched and retrieved.

خلاصة البحث

نظام استرجاع النص الصوري (**CBIR**) هو برنامج من البرامج الحاسوبية المستعملة لاسترجاع الصورة من حيث إنه سوف يساعد على بحث الصور الرقمية من قاعدة بيانات كبيرة. يعمل (**CBIR**) على مبادئ مختلفة من فهرسات الكلمات الرئيسية. يقصد ببحث النص الصوري أنه سوف يحلّل المحتوى الحقيقي من الصورة الذي سوف يتمّ تلقائيا باستخدام برنامج (**CBIR**) بدون التكلفة من حيث الوقت والمال. حدّدت هذه الدراسة على تقويم أداء نظام (**CBIR**) بناء على تقويم المستخدمين ومقياس الضبط الذي تمّ اختياره بعد اختبار"كرانفيلد " لكليفردون. وبالنسبة لجمع الصورة والمعايير المستخدمة خلال أنشطة البحث، قامت هذه الدراسة المقابلة المنظمة شبه على مستخدمَي النظام من مختلف الخلفيات المهنية، وذلك أجريت المقابلة على المدرسين ومصممي الجرافيك، ثم جمعت الدراسة آراء المسخدمين المتعلقة باسترجاع الصور وذلك لحساب القيمة الضبطية لتلك الصورة. وقد تفاوتت القيمة الضبطية للصورة بين المستخدمَين بسبب خلفياتهما المختلفة حيث تؤثر آراؤهما عن معايير استرجاع الصور على النتيجة النهائية. وتختلف القيمة الضبطية اختلافًا كبيرًا بين المستخدمَين، وانخفاض القيمة الضبطية أشار إلى ضعف النظام في عملية استرجاع الصور. والخلاصة، قام نظام استرجاع النص الصوري (**CBIR**) بتجمّع الصورة بناء على استعمال الصورة حيث إن قلّة الأجسام في الصورة تساعد على دقة الاسترجاع والمعادلة.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Library and Information Science

……..
Roslina Othman
Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Library and Information Science

……..
Mira Kartiwi
Examiner

This dissertation was submitted to the Department of Library and Information Science and is accepted as a fulfilment of the requirement for the degree of Master of Library and Information Science

……..
Yushiana Mansor
Head, Department of Library and Information Science

This dissertation was submitted to Kulliyyah of Information and Communication Technology and is accepted as a fulfilment of the requirement for the degree of Master of Library and Information Science

……..
Abdul Wahab Abdul Rahman
Dean, Kulliyyah of Information and Communication Technology

DECLARATION

I hereby declare that this dissertation is the result of my own investigation, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Siti Aishah Kamaliah Mohamed

Signature……. Date ….....

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TABLE OF CONTENTS

Abstract ii
Abstract in Arabic iii
Approval page iv
Declaration v
Copyright Page vi
Acknowledgements vii
List of Tables x
List of Figures xi
List of Equations xii

CHAPTER ONE:1NTRODUCTION 1
1.1 Preamble 1
1.2 Problem Statement 5
1.3 Research Objectives 7
1.4 Research Questions 7
1.5 Significance of the Study 7
1.6 Expected Outcome 8
1.7 Assumption 8
1.8 Contributions 8
1.8.1 Theoretical 8
1.8.2 Practicality 9
1.9 Limitations 9
1.10 Operational Definition of Terms 9
1.11 Organization of the Dissertation 10
1.12 Summary 11

CHAPTER TWO: LITERATURE REVIEW 12
2.1 Introduction 12
2.2 The Cranfield Test and an Overview of Content based Image Retrieval (CBIR) System 12
2.3 Image Retrieval Techniques by Low Level Features 14
2.3.1 IMG (Anaktisi) 15
2.3.2 LIRE 16
2.3.3 RETRIEVR 17
2.3.4 IMG (Rummager) 19
2.4 Open Issues on CBIR 19
2.5 Precision Measurement for Images 20
2.6 Image Information Needs 20
2.7 Chapter Summary 21

CHAPTER THREE: RESEARCH METHOD AND EXPERIMENTAL DESIGN 23
3.1 Introduction 23
3.2 Methodology 23
3.3 Sampling 23

3.4 Data Collection 24
3.5 Instrument 25
3.6 Data Analysis 26
3.6.1 Flowchart 27
3.7 Pilot Test 29
3.7.1 Sample Searching 31
3.8 Chapter Summary 33

CHAPTER FOUR: DATA ANALYSIS AND FINDINGS 34
4.1 Introduction 34
4.2 Image Queries and Relevance Criteria 35
4.3 Relevant Images and Precision Value 38
4.4 Relevance Criteria and Users' Judgement 50
4.4.1 Relevance Criteria and User's Judgment (School Teacher) 50
4.4.2 Relevance Criteria and User's Judgment (Graphic Designer) 51

CHAPTER FIVE: DISCUSSION, RECOMMENDATION AND CONCLUSION 53
5.1 Introduction 53
5.2 Discussion 53
5.2.1 To Identify the Relevance Criteria for Queries Submitted by Users From Two Different Areas 53
5.2.2 To Compute Precision Values for the Image Retrieval Database System. 55
5.2.3 To Identify the Causes of Low Precision Values of the Retrieved Images during the Retrieval Process 55
5.3 Recommendation 56
5.4 Conclusion 57

BIBLIOGRAPHY 59

APPENDIX 69

LIST OF TABLES

Table No.		Page No.
3.1	Relevance Judgment from User	31
4.1	List of Image Queries for School Teacher	36
4.2	List of Image Queries for Graphic Designer	37
4.3	Image Query, Relevant Images and Precision Value for School Teacher	38
4.4	Image Query, Relevant Images and Precision Value for Graphic Designer	44
4.5	Relevance criteria employed by School Teacher; the number indicates the number of images (N=15) which applied each criteria.	50
4.6	Relevance Criteria Employed by Graphic Designer; the Number Indicates the Number of Images (N=15) Which Applied Each Criteria.	51

LIST OF FIGURES

Figure No.		Page No.
2.1	Block diagram of CBIR.	14
2.2	The screenshot of the img(Anaktisi)	15
2.3	LIRe general architecture	16
2.4	Interface for sketching	17
2.5	Interface for uploading the image file or entering the image URL	18
3.1	The research flowchart	28

LIST OF EQUATIONS

Equation No.	Page No.
3.1	26

CHAPTER ONE

INTRODUCTION

1.1 PREAMBLE

Interest in the digital images has been drastically increased since decades ago. With the emergence of the technology in digital imaging in various fields such as archive, crime prevention, architecture, automotive and even fashion; image repositories are widely developed. In addition, with faster file transfer over the Web as well as the rapid growth of cloud computing usage for the organizations, remotely stored images are high on demand.

Traditionally, image searching has been done through keyword based query or text based image search. Metadata will be built and the images will be assigned with categories. This method easily works for small image collections; however as the collection grows bigger, the task to assign metadata to each picture might be time consuming and costly, tedious and prone to errors.

In addition, assigning an index term to an image is complicated due to the different perception about the image itself among users. Not everything can be described in the text and not everything is described in the text itself. One simple image might give different meaning to different people. The abstract and concrete meaning of the image will be perceived differently by users. This is where the image retrieval technique for Content Based Image Retrieval (CBIR) has come to light.

Content based image retrieval (CBIR) is the application of the computer system for image retrieval, where it will aid searching for digital images in a large database. CBIR operates on a totally different principle from keyword indexing.

Content based means that the search will analyze the actual content of an image, which will be done automatically by the system and as stated by Maurya, Oza, Shah, and Patel (2011), without the ability to examine image content, the searching process must depend entirely on the metadata which may make it costly.

Many researches have been done for CBIR in various fields. Zare, Ainon, and Seng (2009) wrote a paper about blood cell images retrieved using low level features. Akgül et al. (2011) focused on digital images in radiology by integrating pixel-based and metadata-based image feature analysis. Whereas Dongsun and Junchul (2011) discussed about drug images retrieval by shape and colour similarity. All these researchers are aiming to improve the current image retrieval technique in their respective field.

In addition, Caban, Rosebrock, and Yoo (2012), researchers from the US National Institutes of Health have developed the CBIR software (ID MyPill) that can identify a pill from a phone camera image. The software extracts the shape, color and imprint of a pill from its image and had 91.13% accuracy in automatically identifying the correct medication. They tested the system on images of 568 of the most prescribed pills, taken from different angles and in a range of lighting conditions. ID My Pill is a simple iPhone software where users just need to capture the pill using the iPhone and once a match is made, the information will be provided about the medication. The experiment returned the top matches of a given pill in less than 1 second and concluded that it has the potential to be used in the dynamic and rapidly changing clinical environments. This application is not only intended for personal use, it can assist caregivers and nurses in doing their work as well. Committing errors in handling medications will lead to serious problems. 12.2% of all hospitalized patients is estimated to involve in some form of adverse drug event (ADE) and a large

amount of ADEs results is from handing the incorrect drug to a patient or prescribing the wrong medication (Lucado, Paez, & Elixhauser, 2011as cited in Caban et al. (2012)). Thus, this application will be a great help to those involved with the medications and drugs business as well as for the patients. Other example of CBIR application is Chicengine.com; a fashion search engine and an art database collection from Fine Arts Museums of San Francisco.

Content based image retrieval (CBIR) also includes query by example and query by memory. Query by example (QBE) requires samples, whereas query by memory (QBM) requires a sketch. Searching by using QBE is simple whereby the users will provide samples during the early stage of retrieval. The samples can be derived digitally by uploading to the system or by providing the link of the sample. The sample can also be scanned from its original condition such as documents or paintings. QBM is different whereby it uses sketch; where the users will use the sketching that has been made as queries. Both QBE and QBM use shape, color, and texture as their retrieval technique.

In the last few years, trends indicated that application-oriented aspects such as interface, visualization, scalability, and evaluation have traditionally received lesser consideration (Datta, Joshi, Li, & Wang, 2008). A good and robust system should be able to fulfill users' information needs by retrieving the relevant results and to reject the irrelevant ones. This is why the evaluation of the system's performance is critical in order to develop an efficient and effective retrieval technique of the images. Cleverdon (1962) has introduced relevance based measures called recall and precision during his Cranfield tests. Since then, recall and precision have been used by the researchers as a measurement aid in the system evaluation. Recall measures the ability of the system to retrieve relevant items while precision is computed to measure the

ability of the system to reject the irrelevant items. Furthermore, researchers from various fields have implemented precision and recall as the performance metric in their research (Daisy, Selvi, & Mol, 2013; Gali, Dewal, & Anand, 2012; Ya-Shu & Han-Bing, 2010) and as Müller, Müller, Squire, Marchand-Maillet, and Pun (2001) pointed out, in order to gain an objective view of the system, a set of standard performance measure and a standard image database is needed. Considering the fact that many researchers has taken on the precision and recall for the system evaluation, it can be assumed that it has been accepted as a standard performance measure for image retrieval as well.

For CBIR, user interaction with the retrieval system is crucial since flexible formation and modification of queries can only be obtained by involving users in the retrieval procedure. Human perception of image similarity is subjective, semantic and task dependent. To further enhance the retrieval process of CBIR, it is very important to gain relevance feedback pertaining to the queries and retrieval process. The basic idea behind relevance feedback is "to show the user a list of candidate images, ask the user to decide whether each image is relevant or irrelevant, and modify the parameter space, semantic space, feature space, or classification space to reflect the relevant and irrelevant examples"(Lew, Sebe, Djeraba, & Jain, 2006, p.9). This way, the developer can improve the way its system works because the current image storage has various levels of users; ranging from college students to the users with professional background such as radiologists, archivist, fashion designer and surgeon, thus raised the needs for the system retrieval to be more user friendly and accommodating to each of their information needs.

1.2 PROBLEM STATEMENT

The issue of having the standardized performance measurement for CBIR has been debated at least since 1990(Müller et al., 2001). Many researchers have attempted to find the best standardized measurement to understand how well a system works with the image retrieval technique; which concentrated on image segmentation based on low level features like color, shape and texture.

However, the most important thing is the relationship between the end user and the system. The users' searching behavior will reflect greatly upon system performance because once the researchers have better understanding about it, they can increase the effectiveness of the retrieval system (Fidel, 1997). Although the use of precision and recall as performance measurement was not recommended by Fidel (1997) as this measurement is being used in text retrieval, she felt that it might not be an adequate test in image retrieval. However, there are countless interests that have been put forward towards research in CBIR during the recent years, whereby many CBIR systems use precision and recall as the performance metric for analyzing the performance (Rajam, Valli, & Nadu, 2013).

By including users' relevance criteria (relevance feedback) in the evaluation, it is possible to narrow the gap between high-level concepts and low-level features (Long, Zhang, & Feng, 2003) and finally being able to improve the system retrieval for the users. Lakdashti and Ajorloo (2011) stated in their paper that the relevance feedback image retrieval system based on an interactive genetic algorithm should be proposed in order to reduce the semantic gap of the present CBIR systems. They stated that it is possible to design an image retrieval system based on relevance feedback by letting the system learns the user's semantics and stores them in its rule base by using n-dimensional hypercubes. Thus, users' relevance judgment in system

evaluation is as important as the performance measurement in order to have a user centered CBIR system. They measured the system performance by Euclidean distance (ED) similarity measure in order to calculate visual similarities between a query image and images in a database.

Meanwhile, Mussarat, Muhammad, Sajjad, & Isma (2013) combined multiple features of shape, color and relevance feedback in their experiment for CBIR and implemented precision and recall as the metrics. They stated that "images with fewer objects are more accurately matched and retrieved because images with many objects are capable of having more chances to be matched with other images of the same objects"(Mussarat et al., 2013 p. 3162). While the concern addressed by Mussarat et al.*(*2013) will be taken into consideration when practicing the searching activities for Retrievr, Datta et al. (2008) and Lew(2006) mentioned the purpose of CBIR systems is to allow users to retrieve pictures from large image repositories based on the submitted queries. As that being said, this concern will influence the measurement of precision values; if for example Retrievr's retrieval performance is the same as CBIR system used by Mussarat et al.(2013).

This research is meant to determine the effectiveness and efficiency of the Retrievr system by using the precision measurement and the involvement from users. The researcher will also observe the causes of low precision value computed for this system and thus finding out whether the relevance criteria submitted by the users during the early searching activities as well as different professional backgrounds will change or affect the way they chose the relevant image.

1.3 RESEARCH OBJECTIVES

1) To identify the relevance criteria for queries submitted by users from two different areas.
2) To compute precision values for the image retrieval database system.
3) To identify the causes of low precision values of the retrieved images.

1.4 RESEARCH QUESTIONS

The following research questions are constructed according to the research objectives:

RO1 - To identify the relevance criteria for queries submitted by users from two different areas

1) What are the queries submitted by users for CBIR?
2) What are the users' relevance criteria for the CBIR queries?

RO2 - To compute precision values for the image retrieval database system

1) What are the retrieved relevant images using the CBIR techniques?
2) What are the precision values for the images retrieved using the CBIR technique?

RO3 - To identify the causes of low precision values of the retrieved images during the retrieval process

1) What are the low precision values of images retrieved using the CBIR technique?
2) What are the causes for such low precision values?

1.5 SIGNIFICANCE OF THE STUDY

The findings of this research will identify the current state of CBIR technique and CBIR systems as it publicly available; in terms of retrieval performance and precision.

Moreover, as this research will also include the end-users, it will give an insight into future enhancement areas of the system and identify the possible executable improvements and tend to them accordingly. Lastly, this research will also study the nature of the queries that would be submitted to an IR system, such as the CBIR systems.

1.6 EXPECTED OUTCOME

Precision values for queries submitted to a CBIR system will determine the improvements either on the user interface or query formulation or the retrieval techniques.

1.7 ASSUMPTION

From this research, it can be assumed that image queries are needed before image searching and user's relevance criteria will be used to refine their needed image while browsing.

1.8 CONTRIBUTIONS

This research has contributed theoretically and practically to the research community as the following:

1.8.1 Theoretical

This research has developed and tested a theoretical model for precision measurement on the content based image retrieval (CBIR) system. The model was developed based on the Cranfield test (Cleverdon, 1962; Cleverdon & Aitchison, 1963) which was used in evaluation of information retrieval. According to the Cranfield test, all the elements

were controlled whereby no users were involved, queries were artificially compiled, and the results were judged artificially (Cleverdon, 1962). However, in this study, the two users were selected from a different working background, thus the queries and results were collected and judged accordingly by the users.

1.8.2 Practicality

The research is expected to calculate the precision value of the CBIR system and to improve the image retrieval technique by its content of the system and also to address the causes of low precision value of the retrieval with regards to the users' relevance feedback. This research will also demonstrate the features available for query formulation using an image retrieval system.

1.9 LIMITATIONS

The research was confined only to two users; a school teacher and a graphic design and the images retrieved by Retrievr were only from the selected images from Flickr.com storage. The process of collecting the retrieved images was also slowing due to the Retrievr's site maintenance. The maintenance usually lasted for two weeks before it can be accessed again. The site will be going under maintenance once for every few months.

1.10 OPERATIONAL DEFINITION OF TERMS

a) Content based image retrieval (CBIR)

A technique which uses visual contents to search images from large scale image database according to users' interest(Long et al., 2003). Among the available CBIR systems are Img(Rummager) and LIRe.

b) Precision measure

Precision measure computes the numbers of the retrieved items that are relevant (Cleverdon, 1962). Meanwhile Buckland and Gey (1994) define precision as a measure to purify the retrieval performance, as well as a measure to exclude non-relevant items from the retrieved set effectively.

c) Relevance feedback

"Relevance feedback inputs the user's judgments on previously retrieved documents to construct a personalized query or user profile."(Hiemstra & Robertson, 2001, p. 1)

d) Relevance judgment

"A user submits his/her perceptual judgments on the first round retrieval results to the CBIR system so that the system can retrieve more relevant images on the next round".(Lakdashti & Ajorloo, 2011, p. 241).

d) Relevance criteria

Users will submit their criteria of the desired images. These criteria will determine the relevancy of the retrieved images. According to Maglaughlin and Sonnenwald (2002) criteria are usually gathered directly from users through think aloud protocols, interviews and questionnaires.

1.11 ORGANIZATION OF THE DISSERTATION

This research is divided into five chapters. Chapter 1 discusses the introduction and foundation of CBIR, statement of the problem, research objectives which are; firstly to identify the relevance criteria for queries submitted by users from two different areas, secondly to compute precision values for the image retrieval database system and lastly to identify the causes of low precision values of the retrieved images. Chapter 1 also discusses research questions, significance of the study, expected outcomes,

contributions of the research; theoretically as well as practicality, limitations and lastly definition of terms. Chapter 2 covers the literature review of the past studies. Chapter 3 provides the discussion of the research methodology used in the research. The data analysis and the discussion of results are discussed in chapter 4 while conclusions and recommendations are in chapter 5.

1.12 SUMMARY

This chapter introduced Content based Image Retrieval (CBIR) to the readers by explaining the evolving image retrieval process and image databases over the years. The researcher also explained several special image collection database systems and applications that are using CBIR approach such as ID my Pill, Chicengine.com and an art database collection from Fine Arts Museums of San Francisco. Those applications and systems are the proof of the endless interest put forward by the industry people to fully utilize CBIR in our daily life. This research is meant to determine the effectiveness and efficiency of a CBIR system by using precision measurement and involvement from users. The low precision values computed will determine whether the relevance criteria submitted by the users during the early searching activities will affect their behavior and preferences while choosing the relevant images. This research also will identify the causes of low precision values of the images as it indicates a poor retrieval performance of the CBIR system and finally the improvements either on the user interface, queries formulation or the retrieval techniques will be taken into consideration.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the discussion is being divided into four parts; an overview of content based image retrieval (CBIR) system, open issues on CBIR, precision measurement, and lastly image information needs. The literature review of all sub-topics is important and related in a way that it will give an insight view of the research. The purpose of this literature review is to understand the change and improvement made for the CBIR over the years. The initial study of the CBIR with regards to the precision measure and users' relevance judgment is purportedly to keep the ideas behind this research stay focused. Discussion of the literature will be done in several focus points as follows

- The Cranfield Test And An Overview Of Content Based Image Retrieval (CBIR) System
- Image Retrieval Techniques By Low Level Features
- Open Issues On Content Based Image Retrieval (CBIR) System
- Precision Measurement For Images
- Image Information Needs

2.2 THE CRANFIELD TEST AND AN OVERVIEW OF CONTENT BASED IMAGE RETRIEVAL (CBIR) SYSTEM

An increase in computing and electronic storage capacity has led to a massive amount of digital content available to users in the form of images; whereby people in education, entertainment, medical, and commercial applications have used it widely in their respective field. As a result, the search for relevant information in the large space