



بسم الله الرحمن الرحيم

∞∞∞∞

تم رفع هذه الرسالة بواسطة / سامية زكى يوسف

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى

مسئولية عن محتوى هذه الرسالة.

ملاحظات: لا يوجد





Scientific Computing Department  
Faculty of Computer and Information Sciences  
Ain Shams University

# Content Based Image Retrieval

Thesis Submitted in Partial Fulfillment of the Requirements for the Degree  
of Master in Computer and Information Sciences

To

Department of Scientific Computing  
Faculty of Computer and Information Sciences  
Ain Shams University

By

**Moshira Saad El-Din Ghaleb**

BSC. Computer Science Department  
Faculty of Computer and Information Sciences,  
Ain Shams University

Under Supervision of

**Prof. Dr. Mohamed Fahmy Tolba**

Professor in Scientific Computing Department,  
Faculty of Computer and Information Sciences,  
Ain Shams University

**Prof. Howida Abdelfattah Saber Shedeed**

Professor and Head of Scientific Computing Department,  
Faculty of Computer and Information Sciences,  
Ain Shams University

**Prof. Hala Mousher Ebied**

Professor in Scientific Computing Department,  
Faculty of Computer and Information Sciences,  
Ain Shams University

August - 2022  
Cairo

## **Acknowledgment**

In the first place, I would like to thank God for his endless help and blessing for giving me the force to continue and to complete this research. And also I would like to express my special thanks of gratitude to my supervisors; Prof. Dr. Mohamed Fahmy Tolba for his guidance, patients and support (*god bless him*), Prof. Dr. Howida shedeed who gave me the golden opportunity to do this wonderful research and for her continuous technical support and encouragement, and Prof. Dr. Hala Mousher who advised me to work on the topic (Content based image retrieval ) and for her special supervision and experience, which also helped me in doing a the research and I came to know about so many new things, I am really thankful to them.

Secondly I would like to thank all my family and special my Dad for his advice to take this step; I wish he could deliver that I finished my degree (*mercy on his soul*); my mum for her support, advices, and for her continues prayer for me . Special thanks to my husband for his deep support and uncountable advices, he is the most amazing person in my life, and I adore and value him. Also many thanks to my brothers “my backbones”, my great daughters and son for letting me doing what I love without disturbing and helped me a lot in finalizing this work within the limited time frame.

Last but not least, I would like to thank my dear friends Sara Mohsen and Sherin Moussa who have helped me through the past time and kept on encouraging me to get this work done. God bless them all.

*Moshira*

August - 2022  
Cairo

# Abstract

Multimedia became a primary aspect for all different social and business categories. This day, societies figure out using images, videos, and sounds. Productions, marketing, and people's communication depend on social media using texting and multimedia. Servers hold huge datasets according to the huge numbers of users and their media. The search became a daily manner. Search by text is very easy for the labeled datasets but a search by image is very useful for unlabeled seen. Last few days search by image became a trend for many search engines. Developers built different programs to help users find locations, shops, people, and objects using a single image. This technology is called content-based image retrieval (CBIR). Content refers to the whole image or part of the image. Unfortunately, there is no accurate retrieval accuracy over the huge image datasets. Researchers find in the CBIR topic hot challenging points to propose more accurate models using intelligent methods with the lowest complexity.

In this thesis, we proposed recent approaches using machine learning and deep learning to classify images into categories and retrieve relevant images to the input image from different sizes of datasets. Image classification is a part of computer vision and it splits the datasets into categories to make the retrieve operation easier.. In this study, we utilize various types of algorithms such as; supervised, unsupervised and deep learning. Convolution neural network (CNN) is applied as a main deep learning model. We proposed a model using CNN, model fused CNN with recurrent neural networks like LSTM and GRU, and model fused it with traditional algorithms like Decision tree (DT) and Support Vector Machine (SVM). Also, we used a variety of datasets in sizes and types. The datasets is an important factor to measure the evaluation of the CBIR system, so we used different datasets in types and size. There is many images type like; people, objects, medical and digital numbers.

The first model applied in the small dataset to train and classify the images into ten categories. The model fused SOM+ MLP is used to train the dataset with 100% recognition accuracy. The second proposed approach applied to biomedical images which are the X-rays chest images to classify the images into three categories; infected chest with covid-19 virus, infected chest with other viruses, and normal X-ray chest. The model

applied CNN for feature extraction and classification and the accuracies reached 96%, 95%, and 99.5% for the three classes: Covid-19, Pneumonia, and normal chests. The model achieved the highest accuracy in compare to the state of the art techniques for Covied19 classification.

In The third proposed approach, CNN model is applied to two types of images to classify them and evaluate the CBIR approach. The first dataset type is a single object image and the second is a digital numbers dataset image. The models applied on Cifar10 and Mnist datasets. The CNN model achieved 92.9% mAP for Cifar10 and 99.8% for Mnist dataset. The model achieved the highest accuracy compared with the state-of-the-arts on both datasets. The fourth proposed approach is for weather images classification. The proposed technique fused CNN with two different traditional supervised algorithms DT and SVM to classify the weather images into five categories shiny, sunny, foggy, cloudy, and rainy. The study reached 92%, 63%, 94% average accuracies for CNN, CNN+DT, and CNN+SVM models. The models achieved high accuracies in contrast with the state-of-the-art and can help in weather forecasting to reduce transportation accidents.

The last proposed approach is the CBIR approach that used three deep learning models. The three models are similar in the feature extraction phase but use different techniques in the classification phase. The models start with extracting the important features from the images using CNN, classifying them into categories, retrieving the relevant images to the input image from the trained dataset, and finally evaluating the CBIR process using the measurement metrics. The classification for the first model used the fully connected layers but used LSTM and GRU in the second and third models respectively. CNN+GRU achieved the highest results with high complexity reduction compared with the state-of-the-art models. CNN+GRU reached 97%, 91.5%, and 99%, 96%, 87.5%, and 99.9% for Corel1k, Corel8k, AloI 74K, Cifar-10, Cifar-100, and Mnist dataset respectively.

The study made extensive research on different images to detect the object, classify images, and return the most relevant images. Classification is a very powerful technique that can help in many fields like face recognition, biomedical diagnosis, object detections, and CBIR. The proposed models based on machine learning and deep learning

were effectively increased the classification accuracy and the CBIR performance for different datasets types. The study presented four deep learning approaches and one machine learning with the highest accuracies compared with the state-of-the-art models.

### **List of Publications**

1. Ghaleb M.S., Ebied H.M., Shedeed H.A., Tolba M.F., “ Image Retrieval based on self-organizing feature map and Multilayer perceptron Neural Networks Classifier.” Ninth International Conference on Intelligent Computing and Information science (ICICS), pp. 189-193, Cairo, Egypt, 2019.
2. Ghaleb M.S., Ebied H.M., Shedeed H.A., Tolba M.F., “COVID-19 X-rays Model Detection Using Convolution Neural Network,” International Conference on Artificial Intelligence and Computer Vision (AICV2021), Springer International Publishing , pp. 3-11, Morocco, 2021.
3. Ghaleb M.S., Ebied H.M., Shedeed H.A., Tolba M.F., “ Content based image retrieval based on convolutional Neural Network.” tenth International Conference on Intelligent Computing and Information science (ICICS), pp. 149-153, Cairo, Egypt, 2021.
4. Ghaleb M.S., Ebied H.M., Shedeed H.A., Tolba M.F., “Weather Classification using Fusion Of Deep Convolutional Neural Networks and Traditional Classification Methods,” IJICIS journal , Cairo, Egypt, 2022
5. Ghaleb M.S., Ebied H.M., Shedeed H.A., Tolba M.F., “Image Retrieval Based on Deep Learning,” Journal of System and Management sciences, JSMS , Q3, indexed in Scopus, accepted 2022.
6. Ghaleb M.S., Ebied H.M., Shedeed H.A., Tolba M.F., “Content Based Image Retrieval Using Fused Convolution Neural Network” The 8<sup>th</sup> International Conference on Advanced Intelligent Systems and Informatics (AISI2022), accepted 2022.

# Table of Contents

Acknowledgment.....	2
Abstract.....	3
List of Publications.....	6
Table of Contents.....	7
List of Tables.....	12
List of abbreviations:.....	13
Chapter 1.Introduction.....	15
1.1 Overview.....	15
1.2 Content based image retrieval.....	17
1.3 Artificial intelligence.....	19
1.4 Key Contribution.....	21
1.5 Study Outline.....	23
Chapter 2. Literature Review & comparative Analysis.....	25
2.1 Traditional Content-based image retrieval.....	25
2.2 Intelligent Content-based image retrieval.....	28
2.3 Comparative analysis with the SOTA models.....	32
Chapter 3. Scientific Background.....	35
3.1 Feature extraction.....	35
3.1.1 SOFM.....	35
3.1.2 Convolutional neural network.....	37
3.2 Classification.....	38
3.2.1 Multilayer perceptron MLP.....	38
3.2.2 Fully connected layers.....	39
3.2.3 Long Short Time Memory (LSTM).....	39
3.2.4 Gated Recurrent Unit.....	41
3.2.5 Decision Tree (DT).....	41
3.2.6 Support vector machine (SVM).....	41
3.3 Evaluation Metrics.....	42



Chapter 4. Image Retrieval Based on Self-Organizing Feature Map and Multilayer Perceptron Neural Networks Classifier .....	45
4.1 Proposed Models.....	46
4.1.1 SOM:.....	46
4.1.2 SOM+MLP: .....	47
4.2 Dataset.....	47
4.3 Experimental results.....	47
4.4 Summary and Discussion.....	51
Chapter 5. COVID-19 X-rays Model Detection Using Convolution Neural Network.....	53
5.1 CNN Model.....	55
5.2 Dataset.....	55
5.3 Experimental results and discussion .....	56
5.3.1 Experiment one .....	57
5.3.2 Experiment two .....	57
5.4 Summary and Discussion.....	58
Chapter 6. Weather classification with Deep Convolutional Neural Network.....	61
6.1 Models.....	62
6.1.1 CNN proposed model. ....	63
6.1.2 CNN+DT.....	64
6.1.3 CNN+SVM .....	64
6.2 Datasets .....	65
6.3 Experimental results.....	66
6.3.1 CNN .....	67
6.3.2 CNN+DT.....	67
6.3.3 CNN+SVM .....	68
6.4 Summary and Discussion.....	69
Chapter 7. Content-based Image Retrieval based on Convolutional Neural Networks.....	72
7.1 CNN proposed Model .....	72

7.2	Datasets .....	74
7.2.1	CIFAR-10 .....	74
7.2.2	MNIST .....	74
7.3	Experimental results and discussion .....	75
7.3.1	CNN proposed model for Cifar10 .....	75
7.3.2	CNN proposed model for Mnist .....	76
7.4	Summary and Discussion.....	78
Chapter 8. Content-Based Image Retrieval Using Hybridization Convolutional Neural Network.....		81
8.1	Models.....	81
8.1.1	CNN Model 1.....	81
8.1.2	CNN Model 2.....	83
8.1.3	CNN+LSTM Model 1.....	83
8.1.4	CNN+LSTM Model 2.....	85
8.1.5	CNN+GRU Model 1 .....	85
8.1.6	CNN+GRU Model 2.....	86
8.2	Dataset.....	87
8.2.1	Corel8K.....	87
8.2.2	Aloi74K.....	88
8.2.3	Cifar-100 .....	88
8.3	Experimental results.....	89
8.3.1	CNN Model 1.....	89
8.3.3	CNN Model 2.....	95
8.4	Summary and Discussion.....	102
Chapter 9. Conclusion and Future work.....		105
9.1	Conclusion.....	105
9.1	.....	107
9.2	Future Work .....	107
References.....		108

## List of figures

Figure 1-1. Block diagram of the artificial intelligence. ....	20
Figure 1-2. Comparison between machine learning and deep learning .....	21
Figure 2-1. Block diagram of traditional CBIR approach .....	26
Figure 2-2. Block diagram of the CBIR approach using Deep Learning .....	28
Figure 4-1. Block diagram of the CBIR approach using Neural Networks .	45
Figure 4-2. Sample images of Corel 1K dataset .....	47
Figure 4-3. SOM and SOM+MLP recognition accuracy for 10 categories .	50
Figure 4-4. SOM+MLP recognition accuracy .....	51
Figure 5-1. Block diagram of Covid-19 deep learning architecture.....	54
Figure 5-2. Sample images of different X-rays chest images; (a) COVID-19, (b) Pneumonia and (c) Normal chest X-ray sample images .....	56
Figure 5-3. CNN classification accuracies for COVID-19, Pneumonia and normal categories. ....	57
Figure 6-1. Block diagram of the deep learning architect. ....	62
Figure 6-2. CNN Model Architecture for weather database. ....	64
Figure 6-3. Sample images of weather dataset; (a) Rainy, (b) Cloudy, (c) Sunrise, (d) Shiny.....	66
Figure 6-4. CNN classification accuracy for rainy, cloudy, sunrise, shiny and foggy categories. ....	67
Figure 6-5. CNN+DT classification accuracy for rainy, cloudy, sunrise, shiny and foggy categories.....	68
Figure 6-6. CNN+SVM classification accuracy for rainy, cloudy, sunrise, shiny and foggy. ....	69
Figure 7-1. Sample of Cifar10 dataset.....	74
Figure 7-2. Sample of Mnist dataset.....	74
Figure 7-3. The mAP used Cifar10 dataset .....	76
Figure 7-4. The mAP used Mnist dataset. ....	77
Figure 7-5. Top 7 image retrieval results for the CIFAR10 dataset.....	78
Figure 8-1. CNN Model 1 Architecture for Corel 1K database. ....	82
Figure 8-2. Sample images of Corel 8K dataset.....	87
Figure 8-3. Sample images of different categories of Aloi 74K. ....	88
Figure 8-4 Sample of Cifar-100 Dataset.....	88
Figure 8-5 The average precisions for Corel1K .....	92
Figure 8-6 The average precisions of 40 selected class using Corel8Kdataset .....	92
Figure 8-7 The Average precisions of 70 selected class using Alio74K dataset.....	93

Figure 8-8 Sample of Query images and the retrieved images for Corel8K dataset.....	95
Figure 8-9 The mAP used Corel1K dataset.....	96
Figure 8-10 Top 5 image retrieval results for the Corel1K dataset.....	97
Figure 8-11 The mAP used Cifar-10 dataset .....	97
Figure 8-12 Top 5 image retrieval results for the Cifar-10 dataset .....	99
Figure 8-13 The mAP used Mnist dataset .....	100
Figure 8-14 Top 5 image retrieval results for the Mnist dataset .....	101

## List of Tables

Table 2-1. Comparison between state-of-the-art image retrieval methods .	33
Table 4-1. SOM classification accuracy using 16X16 lattice size .....	49
Table 4-2. SOM+MLP recognition accuracy (%) for three lattice sizes features vectors.....	49
Table 4-3 SOM+MLP recognition accuracy .....	50
Table 5-1. Classification accuracy to recognize between Covid-19, Pneumonia, and normal X-ray images.....	57
Table 5-2. Classification accuracy to recognize between covid-19 and normal x-ray images.....	58
Table 6-1. Setup of CNN's Model.....	63
Table 6-2. Classification accuracy comparison for proposed models and state-of-the-art. ....	69
Table 7-1. Setup of CNN's Model.....	73
Table 7-2. Map Comparison for Cifar10 Dataset.....	75
Table 7-3. Error Rates Comparison for MNIST.....	77
Table 8-1. Setup of CNN's Model 1.....	82
Table 8-2. Setup of CNN's Model 2.....	83
Table 8-3. Setup of CNN+LSTM's model 1 .....	84
Table 8-4. Setup of CNN+LSTM's model 2 .....	85
Table 8-5. Setup for CNN+GRU's model 1.....	86
Table 8-6. Setup for CNN+GRU's model 2 .....	86
Table 8-7. Performance of CNN proposed model and state-of-the-art models using Corel1K .....	89
Table 8-8. The average Precisions of CBIR approach using CNN proposed model for Corel1K dataset. ....	90
Table 8-9. Performance of CBIR using CNN with different datasets and different number of classes .....	92
Table 8-10. mAP of the proposed models and state-of-art models .....	94
Table 8-11. Performance of CNN proposed model and state-of-the-art models .....	96
Table 8-12. mAP comparison for Corel1K dataset. ....	96
Table 8-13. mAP comparison for Cifar-10 dataset.....	98
Table 8-14. mAP COMPARISON for Cifar100 dataset. ....	99
Table 8-15. Classification error comparison over Mnist dataset.....	100
Table 8-16. mAP of the proposed models and state-of-art models .....	101

## List of abbreviations:

<b><u>Abbreviation</u></b>	<b><u>Stands for</u></b>
A	Amplitude
AI	Artificial intelligence
ANN	Artificial Neural Network
BFS	Based Feature Selection
BSIF	Binaries Statistical Image Features
CBIR	Content-Based Image Retrieval
CEDD	Color and Edge Directivity Descriptors
CNN	Convolutional Neural Net-works
CT	computed tomography
DL	Deep Learning
DWT	discrete wavelet transform
FV	feature vector
GLCM	Gray-Level Co-Occurrence Matrix
GRU	Gate Recurrent Unit
HSV	Hue Saturation Value
IR	Image retrieval
K-NN	k-Nearest-Neighbor
LSTM	Long Short Time Memory
MR	magnetic resonance
MRI	magnetic resonance imaging
ML	Machine Learning
MLP	Multilayer perceptron
NB	Naive-Bayes
PCA	Principle Component Analysis
Phi	Phase
RGB	Red Green Blue
RBENN	radial foundation extract neural network
SOFM	Self-Organized feature Map
SVM	Support Vector Machine
SWT	Stationary Wavelet Transform

## **Chapter 1**

---

# **Introduction**

---