Faculty of Electrical and Electronic Engineering Technology

IMAGE COMPRESSION BY USING SINGULAR VALUE DECOMPOSITION WITH MATLAB SIMULATION

MUHAMAD IZZAT SYAFIQ BIN NORMAN

Bachelor of Computer Engineering Technology (Computer Systems) with Honours

2022

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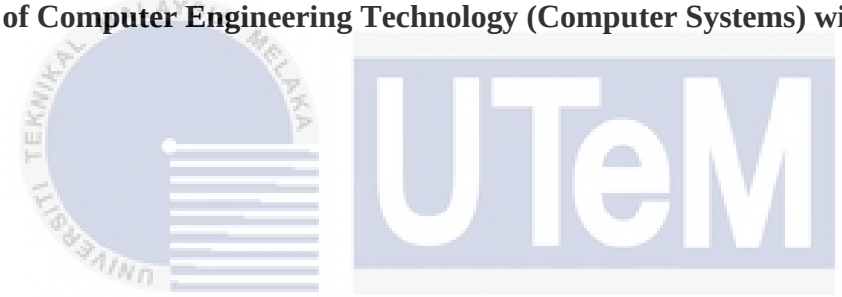
A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Computer Engineering Technology (Computer Systems) with Honours



Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI KEJUTERAAN ELEKTRIK DAN ELEKTRONIK

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : IMAGE COMPRESSION BY USING SINGULAR VALUE DECOMPOSITION WITH MATLAB SIMULATION

Sesi Pengajian : 2021/2022

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DEDICATION

This research is lovingly dedicated to my parents,

Hapizah and Norman

To my beloved brother and sister,

Edzuan and Fathehah

And to my long-time partner,

Atikah

ABSTRACT

Network bandwidth and storage capacity are becoming increasingly constrained as the demand for multimedia products grows. That's why it's so critical to reduce redundant data and save as much storage and bandwidth as possible. Data compression, also known as source coding, is a technique used in computer science and information theory to encode information using fewer bits or other information-bearing units than an unencoded version of the same information. Because it reduces the consumption of expensive resources like memory and transmission bandwidth, compression is a cost-effective method of data storage. Singular Value Decomposition (SVD) is used as an image compression method in this research. In addition, a MATLAB programme based on Singular Value Decomposition will be created to mimic the image compression algorithm (SVD).

ABSTRAK

Lonjakan kadar penggunaan dan permintaan produk multimedia dalam masa beberapa tahun ini menyebabkan jalur lebar rangkaian dan kapasiti peranti memori tidak mengcukupi. Hasilnya, pemampatan data menjadi lebih penting untuk meminimumkan data lewah dan ini dapat mengurangkan ruang di dalam perkakasan simpanan dan juga mengurangkan kadar jalur levar yang diperlukan.Di dalam sains computer dan teori maklumat, pemampatan data adalah pengekodan maklumat yang menggunakan bit yang lebih sedikit atau unit yang mengandungi maklumat lain daripada versi yang tidak dikodkan. Pemampatan memberi kelebihan kerana dapat menjimatkan wang dengan mengurangkan penggunaan memory dan jalur lebar yang kadang kala mahal. Kajian ini membincangkan kelebihan menggunakan Penguraian Nilai Singular (SVD) sebagai kaedah pemampatan gambar dalam kajian ini. Di samping itu, program yang menerapkan algoritma ini juga akan dicipta di dalam aplikasi MATLAB untuk melihat fungsinya.

ACKNOWLEDGEMENTS

Thank you to my mentor, TS. DR. ROSTAM AFFENDI BIN HAMZAH, for all of your help and wisdom, as well as your patience.

A special thanks to my parents and family members for their support and prayers while I was in college.

Finally, I would like to thank all of my classmates, faculty members, and other unnamed individuals for their cooperation and assistance.

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LIST OF SYMBOLS

m	-	Matrix m
n	-	Matrix n
^{T}	-	Transpose
A	-	Image matrix
U	-	$m\ x\ m$ orthogonal matrix
S	-	$m\ x\ n$ matrix
V	-	$n\ x\ n$ orthogonal matrix
$\sum$	-	Summation

LIST OF ABBREVIATIONS

SVD	-	Singular Value Decompostion
JPEG/JPG	-	Joint Photograhic Experts Group
PNG	-	Portable Network Graphics
MSE	-	Mean-Square Error
PNSR	-	Peak Noise-to-Signal Ratio
CR	-	Compression Ratio

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CHAPTER 1

INTRODUCTION

1.1 Background

In today's digital society, technology is becoming an increasingly important part of our daily lives. We produce ever-increasing quantities of data every day. There are many different types of data out there, including text, audio, video, and photos. Humans frequently use images to convey information, which makes photos one of the most popular data-sharing methods. When smartphones were introduced, the amount of data being shared and the size of the data that was being shared both increased. The amount of memory and bandwidth needed to store and transmit all of these photos is staggering. Storing these data has proven to be prohibitively expensive due to the high cost of storage technology. Many researchers are now looking into ways to reduce the amount of data that can be stored and transmitted before it can be used. This is especially true for fields like artificial intelligence or pattern recognition. In order to reduce the amount of storage space required for an image file, this research will concentrate on picture compression using singular value decomposition.

Compression of digital images is a hot topic in the field of digital image processing. An image's storage and transmission bandwidth can be kept to a minimum by implementing various techniques for compression. When compressing images, the goal is to reduce the amount of information that is irrelevant or unnecessary, thus reducing storage space and increasing transmission speed. Image quality should not be reduced so much that the user is unable to decipher the content. It's important to use a suitable image compression method to

balance this trade-off the requirements of the application usually determine the compression/data quality trade-off.

For image compression, there are two main methods: lossy and lossless. To determine whether or not the original data can be recovered when a compressed file is decompressed, use the words "lossy" and "lossless." Lossless compression preserves all of the original data in a compressed file when it is decompressed. On the other hand, lossless compression shrinks a file without altering its content by removing redundant data permanently. When the file is uncompressed, only a small portion of the original data is recovered.

That which this paper discusses is the Singular Value Decomposition procedure (SVD). In the singular-value decomposition, a real or complex matrix is factored into its components using an extension of the polar decomposition to generalise the eigen decomposition, which only exists for square normal matrices. Examples include object detection, face recognition, field matching, and meteorological and oceanographic data processing.

1.2 Problem Statement

Currently available storage servers are becoming increasingly full due to the growing number of consumers who regularly share and exchange images. People working from home are increasing exponentially as a result of the pandemic, and the traffic of data exchange is becoming increasingly congested as the number of people working from home continues to rise.

The cost of equipment and data bandwidth prices went up as a result of this issue. SVD may be a potential solution to this problem, as this paper's research explores the possibility.

1.3 Project Objective

Methods for observing and simulating the application of the SVD algorithm as an image compression method using MATLAB are an important goal in this research. The following are the specific goals:

a) To investigate how Singular Value Decomposition can be used as an image compression approach.

b) To develop image compression script using SVD for both grayscale and colour images in MATLAB.

c) To reduce the size of the reconstructed image.

d) To analyse and compare the reconstructed image to the original image.

1.4 Scope of Project

The scope of this project are as follows:

a) Consumers who are just storing data on daily basis.

b) Consumers who prefer to lower their incoming and outgoing data to reduce the amount of bandwidth consumption.

c) Server operators that want to reduce the size data stored so it can reduce the cost of storage hardware.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In recent years, data compression has become more and more important in our daily lives. Powerful but unseen forces like data compression are at work in today's digital world. Without the numerous advancements in compression, our current computer age may not have taken off in the first place.

This chapter has a lot of. Additionally, this chapter will explain the fundamentals of SVD. Image compression, as well as the use of Singular Value Decomposition (SVD) in image compression, is examined.

2.2 Understanding Image Compression

An image compression technique is one in which the original image is encoded using a small number of bits, according to [10].It is the goal of picture compression to reduce the amount of redundant data in an image so that it can be stored or transmitted more efficiently. There are two types of image compression techniques, according to [5].

Lossless image compression:

Lossless compression preserves the integrity of the original image while reducing its file size. Here you can reassemble a compressed image. In this case, it is a reversible procedure. Some files will always be uncompressed by lossless data compression algorithms, and this is the case regardless of the type of algorithm used. [16]

According to [43] in their journal, attempts to compress previously compressed data as well as attempts to compress encrypted data often result in an expansion. This technique is

particularly well-suited for use in the medical field. In the case of medical images, technical drawings, clip art and comics, lossless compression is preferred for archival storage.

With image compression coding, the image is reduced to its smallest possible size, and the decoded image is shown on the monitor with the greatest possible accuracy. Researchers (Joshi et al., 2014) claim that current data compression methods may not have reached their theoretical limit.

Lossy image compression:

This is an irreversible compression approach, according to (Swathi et al., 2017), because the compound image cannot be reversed to its original image. Data and information that are no longer needed are deleted or rearranged in order to reduce and compress the file size. The most common application of this technique is to reduce the file size of extremely large bitmap images. For natural images, such as photographs, the lossy approach is ideally suited because it allows for a significant reduction in the bit rate while retaining some degree of fidelity. Lossy compression has a higher compression ratio than lossless compression. Fig. 1 shows the lossy compression algorithm.

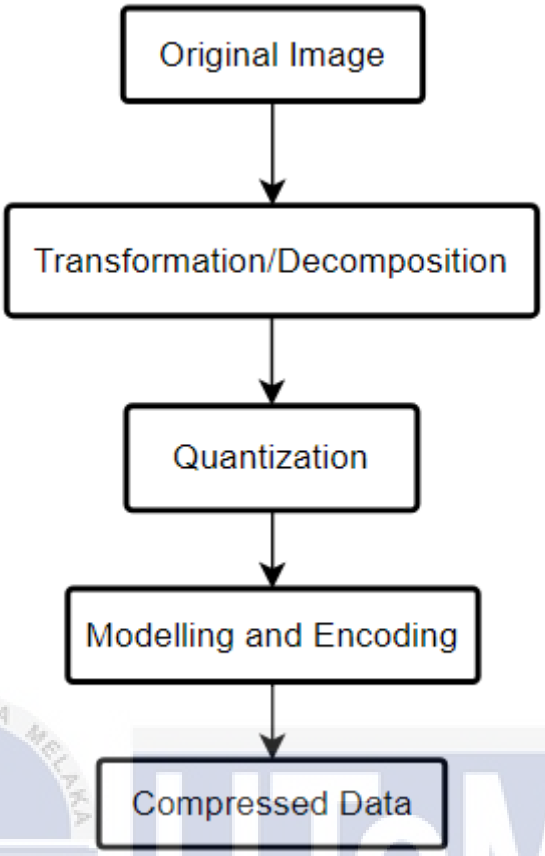

Figure 1 shows the lossy compression algorithm

The original image is processed in four stages: decomposition, quantization, modelling, encoding and compression. The image loses portion of its original size while maintaining its original quality, but in compressed form, as a result of this procedure. Lossy approach, as a schematic approach for compressing photos, could be used with any of the following methods:

i. Chroma subsampling: The human eye is more sensitive to variations in visual brightness than to color variances connected with it. As a result, this method makes use of the human eye by lowering or diminishing the image's chrominance data while enhancing the brightness data. This technique is used to decrease or compress an image to a lesser resolution while maintaining its quality.

ii. Transform coding: This method entails compressing natural data, such as photographic photographs, to a lossy or lossless format. The image is reversible in a lossless method, but the benefit is that it enables greater quantization of the image. Its method converts images into coefficient values, resulting in a low-resolution or low-quality output. There is no information loss, resulting in an equal number of coefficients and pixels altered. The coefficients are quantized, and the output is used to generate the final output using a symbol encoding approach.

iii. Fractal coding: Parts of textures and natural images are turned to mathematical data known as fractal codes, which are then employed to generate the encoded image. When this happens, the image's resolution is lost, making it resolution dependent. The input image's low self-similarity index is blamed for the image's degradation.

Lossy compression that produces negligible differences may be called visually lossless. Singular Value Composition is a type of lossy compression

2.2.1 Data Redundancy

It is the process of reducing the amount of data needed to convey a given amount of information. An important and commercially successful method in Digital Image Processing is picture compression, which attempts to reduce the number of bits needed for an image description by eliminating redundant information. This study by (seshaiah et al., 2016) found three types of redundancy in their datasets:

A. *Coding redundancy*: Coding redundancy consists of variable length code words selected as to match the statistic of the original source. In the case of Digital Image Processing, it is the image itself or processed version of its pixel values. Examples of image coding schemes that explore coding redundancy are the Huffman codes and the Arithmetic coding technique. [43][7]

B. *Spatial redundancy/Inter-pixel redundancy*: Here because the pixels of most 2D intensity arrays are correlated spatially that is each pixel is similar to or independent on neighbouring pixels, information is unnecessarily replicated in the representation of the correlated pixels. Similar to how [6] define which it said that original 2D pixel array is mapped into a different format. Other names of inter-pixel redundancy are spatial redundancy. Examples of this type of redundancy include Constant area coding and many Predictive coding algorithms. [7]

C. *Psycho-visual redundancy:* Human eyes is not fine-tuned to process every band of frequencies. Hence all the incoming data is not responded to with equal sensitivity. Some parts of the information will be more prominent than the others. This fact can be exploited when image redundancies are being removed. Psycho-visual redundancy makes use of this factor. [36]

2.3 Singular Value Decomposition

We'll be focusing on the singular value decomposition method for image compression in this paper. An SVD (Singular Value Decomposition) is an algorithm for reducing a real or complex matrix in linear algebra. [14]SVD outperforms other linear approximation techniques. As stated by [16], the least squares matrix decomposition, the SVD, is the best method for cramming the most signal energy into the smallest number of coefficients. SVM is a stable and