



The application of SVD method in image compression and digital watermarking

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Abstract

In terms of digital files, compression is the act of encoding information using fewer bits than what's found in the original file. When we say image compression, we have in mind an image that has fewer bytes than the original image but has the most important features that describe the original image. So, the aim of image compression is to reduce the image size without degrading image quality below an acceptable threshold. In MATLAB, an image is stored as a matrix. One approach is to apply the Singular Values Decomposition (SVD) to the image matrix. This method is implemented in MATLAB. In order to divide the matrix of the given image into three other matrices in MATLAB, we can use the function `svd()`. As performance metrics, we can use PSNR and Compression ratio. Digital Watermarking is defined as the process of hiding a piece of digital data in the cover data which is to be protected and extracted later for ownership verification. In an SVD-based watermarking scheme, the singular values of the cover image are modified to embed the watermark data. All tests and experiments are performed using MATLAB as the computing environment and programming language. Also, in the RStudio programming language we can see the implementation of the SVD method in image compression.

Introduction

The main objective of image compression is to reduce the redundancy of the image data to be able to store or transmit data in an efficient form. Image compression may be lossy or lossless. Lossy methods are especially suitable for natural images such as photographs in applications in which minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. In other hand the Lossless compression is preferred for archival purposes.

Digital Watermarking is used for a wide range of applications, such as: copyright protection, source tracking, broadcast monitoring etc. A digital watermarking can be visible or invisible A visible watermark typically consists of a conspicuously visible message or a company logo indicating the ownership of the image. On the other hand, an invisible watermarked image appears very similar to the original. The existence of a watermark can only be determined using an appropriate watermark extraction or detection algorithm.

In MATLAB (or in RStudio), we first have to find the optimal number of singular values that we need in order to have a compressed image with the essential information. After that, we can see the error in values (numbers) or even in images. This means that we can take an image with the features that we removed from our original image during the compression process.

Also, in MATLAB we can make a digital watermarking of a given image by using the SVD and DWT (Discrete Wavelet Transform) methods.

Material and Method

Singular Values Decomposition (SVD) is a numerical technique used to diagonalize matrices in numerical analysis. SVD aims to approximate the dataset of large number of dimensions using fewer dimensions. SVD

considers a highly variable, high dimensional data points and exposes the substructure of the original data by reducing the higher dimensional data into lower dimensional data. Exposure of the substructure orders the data from most variation to the least. This helps to find the region of most variation and then later SVD can be used for reduction. The steps we need to follow to compress an image using SVD method are:

- i. Read the input image
- ii. Convert integer to double data type
- iii. Calculate the required rank
- iv. Perform SVD to obtain the three component matrices
- v. Apply approximation on the diagonal component matrix
- vi. Regenerate the matrix and remove singularity
- vii. Convert double data type to integer
- viii. Compressed image is created and displayed

We have implemented those steps on MATLAB and the result is as in the Figure 1. The compression ratio and PSNR value when we used 11 singular values are 540.5542 and 10.4012 respectively.



Figure 1. Image Compression using 11 Singular Values



Figure 2. The error or the part of part of the image that we “removed”

Singular Value Decomposition can be used for digital watermarking. The Figure 3 show us the steps that we have to follow.

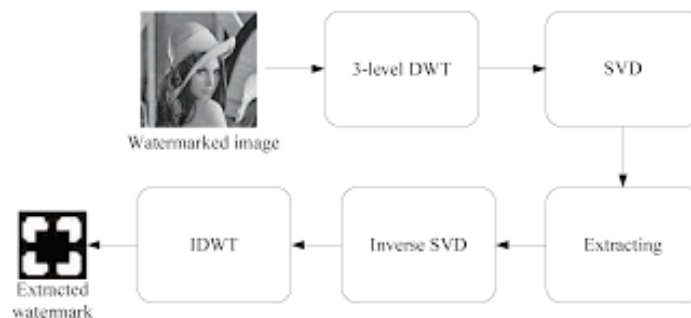


Figure 3. The flow chart of the watermarking embedding

In MATLAB, we need to use `svd()` and `dwt2()` to watermark a given image or to watermark a given image to another image.

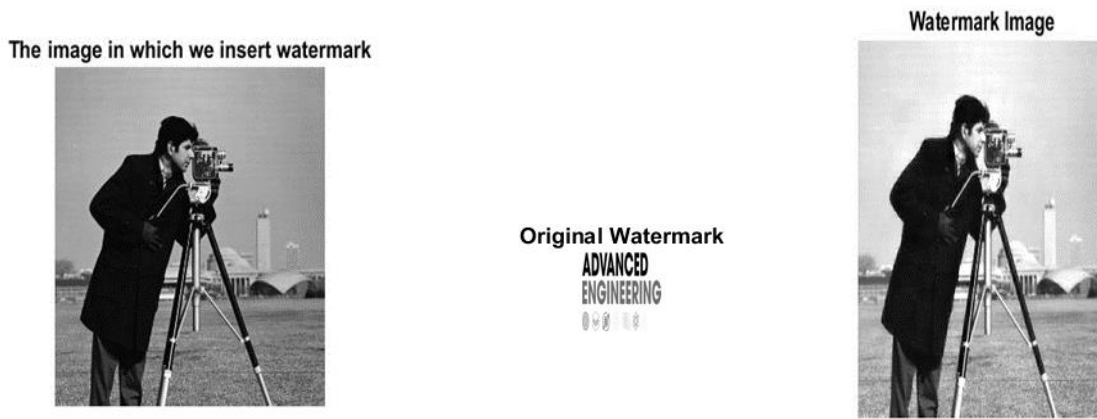


Figure 4. Watermark an image to another image

Results

In the Table 1 we can see what happened if we use different number of singular values.

Table 1. Number of singular values

Number of singular Values	PSNR	Compression Ratio
11	10.4012	37.6809
31	13.5235	13.3706
51	16.1671	8.1272
71	18.8835	5.8379
91	21.9250	4.5548

We see that if we increase the number of singular values the value of PSNR will increase and the value of compression ratio will decrease. Our duty is to see where the increase of the PSNR value is insignificant and similarly where the decrease of the Compression Ratio is insignificant.

When we watermark a given image "1" to another image "2", we have to decide what percentage of the image "1" we want to watermark to the other image "2". In the Figure 4 we have decided that 90% of the image "Advanced Engineering" will be watermark in the first given image.

Conclusion

SVD has many different applications. We decide to show you two of them: image compression and digital image watermarking. This is because we can use image compression to do digital watermarking. So, first we can do a compression of the image and then we can use this compression as a "watermark".

To do watermarking, which nowadays is heavily used in marketing, we can use other methods, for example, PSO.

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