Compute SVD of a Matrix  
 and   
Image compression

A Project Submitted

in Partial Fulfillment of the Requirements

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in

# Computer Science and Engineering

# &

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# &

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***ABSTRACT***

This project briefs about the solutions of three different matrices into their SVD form. The steps considered in view of solving them into their Singular Value Decomposition and the MATLAB demonstration of use of Singular Value Decomposition for Image Compression. Both Grayscale images and colored images compression codes have been inserted along with the application of it in the field of Image Processing

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***INTRODUCTION:***

**Singular Value decomposition-**

The **Singular**-**Value Decomposition**, or **SVD** for short, is a matrix **decomposition** method for reducing a matrix to its constituent parts in order to make certain subsequent matrix calculations simpler. For the case of simplicity, we will focus on the **SVD** for real-**valued** matrices and ignore the case for complex numbers. It is the generalization of the eigen decomposition of a positive semidefinite normal matrix to any {\displaystyle m\times n} matrix via an extension of the polar decomposition. It has many useful applications in signal processing and statistics. It is also used in image compression.

In this method a data related matrix is expressed in three different forms of matrix to compress the image into the different compositions.

![A close up of a logo

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RD+RXhpZgAATU0AKgAAAAgABAE7AAIAAAARAAAISodpAAQAAAABAAAIXJydAAEAAAAiAAAQ1OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAGhlbWFudGgmaGFyc2hpdGgAAAAFkAMAAgAAABQAABCqkAQAAgAAABQAABC+kpEAAgAAAAM4NQAAkpIAAgAAAAM4NQAA6hwABwAACAwAAAieAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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**Procedure to calculate SVD:**

* Firstly, we need to compute the transposed matrix of the given matrix
* Now consider Step 1 where we need to calculate the matrix U which is the so obtained matrix of solving A x AT and solving for eigen values and eigen vectors
* Secondly, we need to calculate the matrix V which is obtained by solving the AT x A and therefore obtaining the eigen values and the eigen vectors for finding V
* Now the last step is to find the  which is the square roots of the eigen values so arranged in the same order matrix as of the same which is given as a question.

**SVD in digital Image compression**

SVD approach can be used in image processing, image compression, face recognition, water marking, data retrieval etc., SVD is most widely used in face recognition, noise reduction in images, image de-blurring, signal processing etc.

***Details of The Work***

**We Solved all the sums into singular value decomposition. Here we decomposed each of the given matrices into three matrices named UVT**

**1.** **A =**

**Solution:**

To decompose into SVD we need to find UVT

Step 1: T calculate U matrix

For that Consider A.AT

AT=

Now,

A.AT=

=

Now let us find eigen values for that

(2- λ) (1- λ) =0

λ =2, λ=1

For λ=1

Is the matrix obtained

Where y is the free variable

So, let us say y=t, x=0

span

One vector is

For λ=2

Where x1 is free variable

x1 = t

x2 = 0

Span is the other vector

2nd vector is

U=

Step 2: To Calculate VT matrix

A.AT=

=

Now we need to find eigen values and eigen vectors

=

1. λ) (1- λ)2- 1(1- λ) = 0

λ=0,1,2

λ has three values 0,1,2

We need to find eigen vectors for those values obtained

For λ=0

R2🡺R2-R1

Interchanging R1 and R2

=

x2 is the free variable

x2=t, x1+x2=0, x3=0

x1=-t

x2=t

x3=0

=span

For λ=1

=

Interchanging R1 and R2

=

x3=t, x2=0, x1=0

=

For λ=2

R2🡺R2+R1

=

Interchanging R1 and R2

=

x3=t, x2=0, x1=0

=span

Therefore, for all the values of λ we obtained the corresponding eigen vectors:

Hence the matrix VT is obtained as

VT =

Now Σ is nothing but diagonal matrix

Σ matrix has the same order as the A matrix that is 2 x 3

Σ=

Therefore, we found out all the U, Σ, VT matrices. Therefore, the SVD of the given matrix is:

= x x

2. A =

**Solution:**

**Step 1: To calculate U which is obtained by A x AT**

To decompose into SVD we need to find UVT

For that we first find M find U

Consider A.AT

AT =

Now,

A.AT=

M =

Now let us find eigen values for that

=

(2- λ) (1- λ) ^2-1(1- λ) +1(λ -1) =0

(2- λ) (1- λ) ^2+ λ-1+ λ-1=0

- λ^2+3 λ=0

λ =0, λ=3, λ=1

For λ=1

M- λ I=

Is the matrix obtained

R2=R2-R1, R3=R3-R1

=

R3=R3-R2

=

Infinite solution

Let us say

Z=t

Y=0

X+Y=0

X=0

Span

One vector is

For λ=0

M- λ I=

Is the matrix obtained

R2=R2-R1/2, R3=R3-R1/2

=

R3=R3+R2

=

Infinite solution

Let us say

Z=t

Y/2-Z/2=0

Y=Z

2X+Y+Z=0

2X+2t=0

X=-t

Span

One vector is

For λ=3

M- λ I=

R2=R2+R1

=

Unique solution

Span

One vector is

U =

**Step 2: To calculate V matrix**

For this we need to consider AT A which comes out as:

=

Now, lets us consider the matrix and find the eigen values and vectors:

- λ = 0

The eigen values obtained after solving are: λ1 = 1, λ2 = 3

The corresponding eigen vectors obtained are as follows

For λ = 1

We obtain

span

and for λ = 3

We obtain

span

Therefore, the matrix VT is obtained as

VT =

**Step 3: To find the Σ matrix.**

The Σ matrix has same rows and columns as of the A matrix. Therefor the Σ matrix also has 2 x 3 size. Here the values of the Σ matrix are the square roots of the eigen values obtained arranged diagonally.

Now Σ is nothing but diagonal matrix

Σ 1= Σ 2= Σ 3=

Σ

Therefore, we found out all the U, Σ, VT matrices. Therefore, the SVD of the given matrix is:

= x x

**3. A =**

**Solution:**

To compute Singular Value Decomposition, we need to find out U, Σ, VT

To calculate these, we need to consider the transpose matrix of the given question. Say that the given question is A. So, the transposed matrix of A is

AT =

Step 1: To calculate U which is obtained by A x AT

**🡺**A x AT = x

**🡺**

Now we need to compute the vector space for the so obtained matrix. For which we need to compute the eigen values first.

To compute eigen values we need to consider (A-λ x I) = 0

🡺 - λ x = 0

🡺 = 0

Now after computing we obtain the eigen values as

λ 1= 0 λ 2 = 4 λ 3 = 9

Now Substituting back these values and obtaining eigen vectors.

For λ = 0

The eigen vector obtained is the span

For λ = 4

The eigen vector obtained is the span

For λ = 9

The eigen vector obtained is the span

Therefore, we obtained the matrix of U as

Step 2: To calculate VT which is obtained by AT x A

**🡺** AT x A = x

**🡺**

Now we need to compute the vector space for the so obtained matrix. For which we need to compute the eigen values first.

To compute eigen values we need to consider (A-λ x I) = 0

🡺 - λ x = 0

Now after computing we obtain the eigen values as

λ 1= 4 λ 2 = 9

Now Substituting back these values and obtaining eigen vectors.

For λ = 4

The eigen vector obtained is the span

For λ = 9

The eigen vector obtained is the span

Therefore, we obtained the matrix of VT as

Step 3: To find the Σ matrix. The Σ matrix has same rows and columns as of the A matrix. Therefor the Σ matrix also has 2 x 3 size. Here the values of the Σ matrix are the square roots of the eigen values obtained arranged diagonally.

The Σ matrix is: Σ =

Thus, we found out all the U, Σ, VT matrices. Therefore, the SVD of the given matrix is

**=**  x x

***Appendices***

**Application in field of Image Processing**

As we discussed before Singular variable decomposition is very useful and can be used in many application areas. We will only mention a few.

There are some applications some of them were:

* Digital Signal Processing
* Image Processing
* Mechanical Vibrations

**Digital Signal Processing**

The concept behind this is minimizing the sound by representing the noisy signal with the standard matrix, by discarding them to small singular values which depicts us the less noisy signal as compare to original sound

**Image Processing**

As this is the important concept for what we use SVD, this was focused nowadays to reduce the storage value by having the compressed file of it as like as zip file which we use to have the reduce the space required by storage Image compression deals with the problem of reducing the amount of data required to represent a digital image.

Compression is achieved by the removal of three basic data redundancies:

1) coding redundancy, which is present when less than optimal

2) interpixel redundancy, which results from correlations between the pixels

3) psychovisual redundancies, which is due to data that is ignored by the human visual.

As like as the above two applications all can be done, the concept behind the SVD is given below

Now in these concepts we use all U, SIGMA, transpose of V for the respective uses. We use U for the number of columns in matrix used in RGB color code, SIGMA is used to adjust the resolution, this is the main concept in the SVD which use to adjust the pixel/ modes of the picture. At last for the number of rows we use transpose of V matrix. In calculating the number of bytes (size of picture) we use to get {(number of columns+ number of rows) \*#modes} Instead of (columns \* rows).

For color images we get thrice the size of grey image. This is because that the RGB values will differ in color image whereas in grey image all three colors as same values.

***MATLAB Code for Gray Scale Images***

close all

clear all

clc

%reading and converting the image

inImage=imread('image.jpg');

inImage=rgb2gray(inImage);

inImageD=double(inImage);

imwrite(uint8(inImageD), 'original.jpg');

% decomposing the image using singular value decomposition

[U,S,V]=svd(inImageD);

% Using different number of singular values (diagonal of S) to compress and

% reconstruct the image

dispEr = [];

numSVals = [];

N = 1

% store the singular values in a temporary var

C = S;

% discard the diagonal values not required for compression

C(N+1:end,:)=0;

C(:,N+1:end)=0;

% Construct an Image using the selected singular values

D=U\*C\*V';

% display and compute error

figure;

buffer = sprintf('Image output using %d singular values', N)

imshow(uint8(D));

imwrite(uint8(D), sprintf('%dbw.jpg', N));

title(buffer);

error=sum(sum((inImageD-D).^2));

% store vals for display

dispEr = [dispEr; error];

numSVals = [numSVals; N];

for N=2:2:20

% store the singular values in a temporary var

C = S;

% discard the diagonal values not required for compression

C(N+1:end,:)=0;

C(:,N+1:end)=0;

% Construct an Image using the selected singular values

D=U\*C\*V';

% display and compute error

figure;

buffer = sprintf('Image output using %d singular values', N)

imshow(uint8(D));

imwrite(uint8(D), sprintf('%dbw.jpg', N));

title(buffer);

error=sum(sum((inImageD-D).^2));

% store vals for display

dispEr = [dispEr; error];

numSVals = [numSVals; N];

end

for N=25:25:100

% store the singular values in a temporary var

C = S;

% discard the diagonal values not required for compression

C(N+1:end,:)=0;

C(:,N+1:end)=0;

% Construct an Image using the selected singular values

D=U\*C\*V';

% display and compute error

figure;

buffer = sprintf('Image output using %d singular values', N)

imshow(uint8(D));

imwrite(uint8(D), sprintf('%dbw.jpg', N));

title(buffer);

error=sum(sum((inImageD-D).^2));

% store vals for display

dispEr = [dispEr; error];

numSVals = [numSVals; N];

end

% dislay the error graph

figure;

title('Error in compression');

plot(numSVals, dispEr);

grid on

xlabel('Number of Singular Values used');

ylabel('Error between compress and original image');

***MATLAB Code for Colored Image:***

close all

clear all

clc

filename = 'image.jpg';

[X, map] = imread(filename);

figure('Name','ORIGINAL component of the imported image');

imshow(X);

imwrite(X, '!original.jpg');

R = X(:,:,1);

G = X(:,:,2);

B = X(:,:,3);

Rimg = cat(3, R, zeros(size(R)), zeros(size(R)));

Gimg = cat(3, zeros(size(G)), G, zeros(size(G)));

Bimg = cat(3, zeros(size(B)), zeros(size(B)), B);

figure('Name','RED component of the imported image');

imshow(Rimg);

imwrite(Rimg, '!red.jpg');

figure('Name','GREEN component of the imported image');

imshow(Gimg);

imwrite(Gimg, '!green.jpg');

figure('Name','BLUE component of the imported image');

imshow(Bimg);

imwrite(Bimg, '!blue.jpg');

Red =double(R);

Green = double(G);

Blue = double(B);

N = 1;

% Compute values for the red image

[U,S,V]=svd(Red);

C = S;

C(N+1:end,:)=0;

C(:,N+1:end)=0;

Dr=U\*C\*V';

% Rebuild the data back into a displayable image and show it

figure;

buffer = sprintf('Red image output using %d singular values', N);

Rimg = cat(3, Dr, zeros(size(Dr)), zeros(size(Dr)));

imshow(uint8(Rimg));

imwrite(uint8(Rimg), sprintf('%dred.jpg', N));

title(buffer);

% Compute values for the green image

[U2, S2, V2]=svd(Green);

C = S2;

C(N+1:end,:)=0;

C(:,N+1:end)=0;

Dg=U2\*C\*V2';

% Rebuild the data back into a displayable image and show it

figure;

buffer = sprintf('Green image output using %d singular values', N);

Gimg = cat(3, zeros(size(Dg)), Dg, zeros(size(Dg)));

imshow(uint8(Gimg));

imwrite(uint8(Gimg), sprintf('%dgreen.jpg', N));

title(buffer);

% Compute values for the blue image

[U3, S3, V3]=svd(Blue);

C = S3;

C(N+1:end,:)=0;

C(:,N+1:end)=0;

Db=U3\*C\*V3';

% Rebuild the data back into a displayable image and show it

figure;

buffer = sprintf('Blue image output using %d singular values', N);

Bimg = cat(3, zeros(size(Db)), zeros(size(Db)), Db);

imshow(uint8(Bimg));

imwrite(uint8(Bimg), sprintf('%dblue.jpg', N));

title(buffer);

% Thake the data from the Red, Green, and Blue image

% Rebuild a colored image with the corresponding data and show it

figure;

buffer = sprintf('Colored image output using %d singular values', N);

Cimg = cat(3, Dr, Dg, Db);

imshow(uint8(Cimg));

imwrite(uint8(Cimg), sprintf('%dcolor.jpg', N));

title(buffer);

for N=2:2:20

% Recompute modes for the red image - already solved by SVD above

C = S;

C(N+1:end,:)=0;

C(:,N+1:end)=0;

Dr=U\*C\*V';

% Rebuild the data back into a displayable image and show it

figure;

buffer = sprintf('Red image output using %d singular values', N);

Rimg = cat(3, Dr, zeros(size(Dr)), zeros(size(Dr)));

imshow(uint8(Rimg));

imwrite(uint8(Rimg), sprintf('%dred.jpg', N));

title(buffer);

% Recompute modes for the green image - already solved by SVD above

C = S2;

C(N+1:end,:)=0;

C(:,N+1:end)=0;

Dg=U2\*C\*V2';

% Rebuild the data back into a displayable image and show it

figure;

buffer = sprintf('Green image output using %d singular values', N);

Gimg = cat(3, zeros(size(Dg)), Dg, zeros(size(Dg)));

imshow(uint8(Gimg));

imwrite(uint8(Gimg), sprintf('%dgreen.jpg', N));

title(buffer);

% Recompute modes for the blue image - already solved by SVD above

C = S3;

C(N+1:end,:)=0;

C(:,N+1:end)=0;

Db=U3\*C\*V3';

% Rebuild the data back into a displayable image and show it

figure;

buffer = sprintf('Blue image output using %d singular values', N);

Bimg = cat(3, zeros(size(Db)), zeros(size(Db)), Db);

imshow(uint8(Bimg));

imwrite(uint8(Bimg), sprintf('%dblue.jpg', N));

title(buffer);

% Thake the data from the Red, Green, and Blue image

% Rebuild a colored image with the corresponding data and show it

figure;

buffer = sprintf('Colored image output using %d singular values', N);

Cimg = cat(3, Dr, Dg, Db);

imshow(uint8(Cimg));

imwrite(uint8(Cimg), sprintf('%dcolor.jpg', N));

title(buffer);

end

for N=25:25:100

% Recompute modes for the red image - already solved by SVD above

C = S;

C(N+1:end,:)=0;

C(:,N+1:end)=0;

Dr=U\*C\*V';

% Rebuild the data back into a displayable image and show it

figure;

buffer = sprintf('Red image output using %d singular values', N);

Rimg = cat(3, Dr, zeros(size(Dr)), zeros(size(Dr)));

imshow(uint8(Rimg));

imwrite(uint8(Rimg), sprintf('%dred.jpg', N));

title(buffer);

% Recompute modes for the green image - already solved by SVD above

C = S2;

C(N+1:end,:)=0;

C(:,N+1:end)=0;

Dg=U2\*C\*V2';

% Rebuild the data back into a displayable image and show it

figure;

buffer = sprintf('Green image output using %d singular values', N);

Gimg = cat(3, zeros(size(Dg)), Dg, zeros(size(Dg)));

imshow(uint8(Gimg));

imwrite(uint8(Gimg), sprintf('%dgreen.jpg', N));

title(buffer);

% Recompute modes for the blue image - already solved by SVD above

C = S3;

C(N+1:end,:)=0;

C(:,N+1:end)=0;

Db=U3\*C\*V3';

% Rebuild the data back into a displayable image and show it

figure;

buffer = sprintf('Blue image output using %d singular values', N);

Bimg = cat(3, zeros(size(Db)), zeros(size(Db)), Db);

imshow(uint8(Bimg));

imwrite(uint8(Bimg), sprintf('%dblue.jpg', N));

title(buffer);

% Thake the data from the Red, Green, and Blue image

% Rebuild a colored image with the corresponding data and show it

figure;

buffer = sprintf('Colored image output using %d singular values', N);

Cimg = cat(3, Dr, Dg, Db);

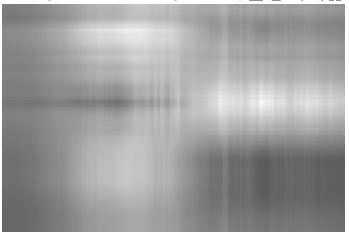
imshow(uint8(Cimg));

imwrite(uint8(Cimg), sprintf('%dcolor.jpg', N));

title(buffer);

end

*Images kept for compression obtained at different values are as follows while having the original pic at the end and the compressed images in the beginning*



![A picture containing cat, bird

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RD+RXhpZgAATU0AKgAAAAgABAE7AAIAAAARAAAISodpAAQAAAABAAAIXJydAAEAAAAiAAAQ1OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAGhlbWFudGgmaGFyc2hpdGgAAAAFkAMAAgAAABQAABCqkAQAAgAAABQAABC+kpEAAgAAAAM1MQAAkpIAAgAAAAM1MQAA6hwABwAACAwAAAieAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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***Conclusion***

Singular Value Decomposition (SVD) is a simple, robust and reliable technique. This SVD technique provides stable and effective method to split the image matrix into a set of linearly independent matrices. SVD provides good compression ratio and a practical solution to image compression problem. The results shown above clearly displays the compressed outputs for different values. Thus, selection of r value plays a crucial role in this SVD based image compression technique.

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