Image Compression Intrim Report

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By:-

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Overview Of the Final Report:

In the final Project report, we'll be covering the following topics:

- **Motivation**
  - History of Image compression.
  - Need of Image Compression.
  - Benefits.
- **JPEG Technique of image compression**
  - we will be explaining the JPEG Image compression.
  - How SVD & Bias are used in JPEG compression.
  - We will try and illustrate image compression through a program (hopefully it'll be a python program).
- **WEBP**
  - we will be briefly explaining "webp" which is google's new image compression technique (which can be considered as State Of Art Technique in the field of Image Compression.)
- **Linear Algebra Topics Used**
  - SVD,
  - Concepts of Basis,
  - Orthogonality, etc.

- **Conclusion**

Timeline & Division of Work

- Ashwin Rudraraju
- Dikshant - Motivation & JPEG part [8-06-2023 to 11-06-2023] & Writing The Latex Part
- Srivarshitha Medarametla
- # Resources Referred:

  - Linear Algebra A Modern Introduction [page no. 630] (by~David Poole)
  - Image Compression And Linear Algebra (By~Sunny Verma, J.P. Krishna) (https://www.cmi.ac.in/~ksutar/NLA2013/imagecompression.pdf)
  - Linear Algebra In Image Compression: SVD and DCT (By~Andrew Fraser) (https://www.math.utah.edu/~gustafso/s2019/2270/projects-2019/presented/fraser/Linear%20Algebra%20in%20Image%20Compression_%20SVD%20and%20DCT.pdf)
  - JPEG Image Compression using Singular Value Decomposition (By~ Mrs. Rehna V.J, Mr. Abhranil Dasgupta) (https://www.researchgate.net/publication/351096054_JPEG_Image_Compression_using_Singular_Value_Decomposition)
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    (https://ieeexplore.ieee.org/abstract/document/4426357)
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Motivation:

Taking Black and white Picture as example($\because grey-scale\ has\ only\ two\ values$)

If we look at the above black and white picture. We will realize that a typical pixel gives us a grey-scale value.
$\because$ pixel is the value of X_i. s.t $X_i \in [0, 255) \implies 8\ bits$
Then we have that $\forall X \in \mathbb{R}^n, where\ n = (512)^2$
We can say that pixel is the vector of length $(512)^2$ through which image is generated.

If it was a coloured image than we would have length of vector as $3 \times (512)^2$ ($\because$ coloured picture has 3D co-ordinate system of RGB values).

"Which will be an enormous amount of info. $\implies$ sending these images would consume a lot of internet/time. Also storing these images would occupy a lot of space in hard-drive."

This gives rise to several "Compression Techniques of Images" like png, jpeg.

Since, JPEG being is widely used. So, we'll be discussing about jpeg in our project.

JPEG(Joint Photographic Experts Group)

- **HOW??**

  If we again have a look at this picture

What basis do it have??

since standard basis - every pixel given a value.

$\implies$

$$X = \begin{bmatrix} \cdot \\ \cdot \\ \cdot \\ \cdot \\ x\ (s.t\ x \in [0, 255) \\ \cdot \\ \cdot \\ \cdot \\ \cdot \end{bmatrix}_{512^2 \times 1}$$

so we might have few pixels that are very close for example:

$$X = \begin{bmatrix} \cdot \\ \cdot \\ 73 \\ 75 \\ \cdot \\ \cdot \end{bmatrix}$$

since 73 and 75 are very close on a grey-scale. And since these pixels are adjacent to each other i.e they are co-related. This gives rise to the possibility of Image Compression. Since if we compress them, we will not be able to identify the difference between the compressed pixels.

Second Example:

In the above picture all the pixels have same values. $\implies$ image where standard basis is Lossy.

Here, Standard Basis that gives the value of every pixel makes **no use** of the fact that **we are getting a whole lot of pixels who tends to have same grey level.**

So, if we keep this in mind and try to make a new standard Basis then it would be the following:

$$\begin{bmatrix} 1 \\ 0 \\ 0 \\ . \\ . \\ . \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 0 \\ 0 \\ . \\ . \\ 0 \end{bmatrix} \cdots\cdots\cdots \begin{bmatrix} 0 \\ 0 \\ . \\ . \\ . \\ . \\ 1 \end{bmatrix} \tag{Eq. 1}$$

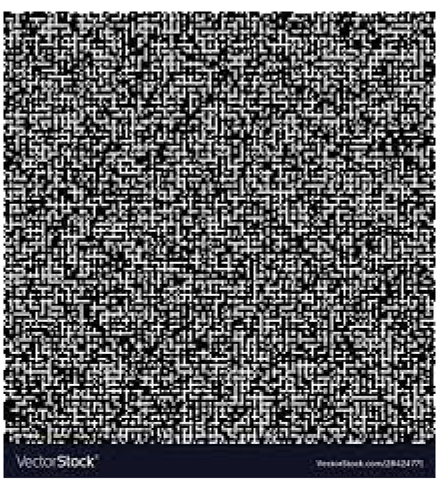
Creating a Better Basis

Since we are considering only 1 colour that is solid colour $\implies$ *basis could just be matrix of* 1

$$\begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$

Expanding It Further for other types of pictures as well

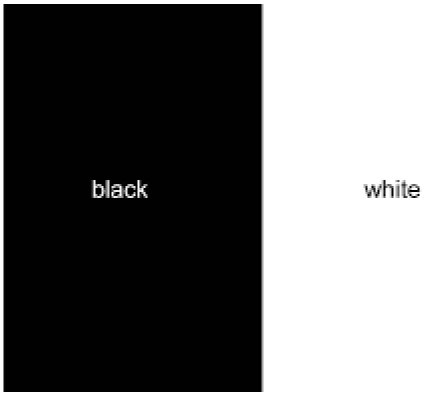
CASE 2:



Since the image is like black/white pixel image $\implies$ we will use a checkerboard vector

$$\begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \\ 1 \\ -1 \\ 1 \\ -1 \end{bmatrix}$$

CASE 3:



Since half of the image is light and half is dark $\implies$ basis vector will be like

$$\begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \end{bmatrix}$$

Combining CASE 2 and 3 with Second Example

We get the following basis vector:

$$\begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \\ 1 \\ -1 \\ 1 \\ -1 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \end{bmatrix}$$

- **BEST Basis Vector!!(Fourier/Wavelet)**

- **My Understanding And Observations**