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Image Processing Techniques: A Review

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Abstract:- Following recent trends, the domain of Image Processing is growing vastly. The modern world is becoming more and more digital, and hence the need for Digital Image Processing is essential in order to provide more effective solutions such as an image with better resolution and clarity or an image in compressed form to reduce the space it occupies. Image Processing can be considered synonymous to Signal Processing in the way that both involve techniques to improve a digital entity. This paper includes an overview of the different Image Processing Techniques.

***Keywords*:-** *Image Processing, Enhancement, Segmentation, Representation, Transform, Compression.*

I. INTRODUCTION

Before defining Image Processing, the definition of an Image must be understood. An Image is a digital entity that is represented by its dimensions i.e. the number of pixels encapsulated within the given height and width. To understand it better, let us consider an image of size 200x200. This means that there are a total of 40000 pixels in that image.

➢ *There are 4 Major Types of Images:*

- Monochrome
- Greyscale
- Halftone
- Colour

Image processing is the method of converting an image into digital format and thereby performing certain operations on it in order to extract certain information from it. In simpler terms, it is a form of signal processing wherein, an image is provided as input and at the output we get either an improved form of the image or some form of information about the image itself. Furthermore, during image processing, an image is considered as a 2-dimensional signal. This makes it quite similar to signal processing techniques. One of the most useful tools to aid image processing is the MATLAB software.

➢ *A Few Benefits of Image Processing are as Follows:*

- Improves the quality of the image.
- Reduces the storage size of the image by compressing it.
- If the image acquisition system were to have certain limitations, then image processing techniques can aid in improving the quality of the obtained image.
- Mathematical and logical operations such as addition, subtraction, AND, OR etc.
- Image segmentation techniques are used to detect anomalies in the image such as missing information or broken pixels.

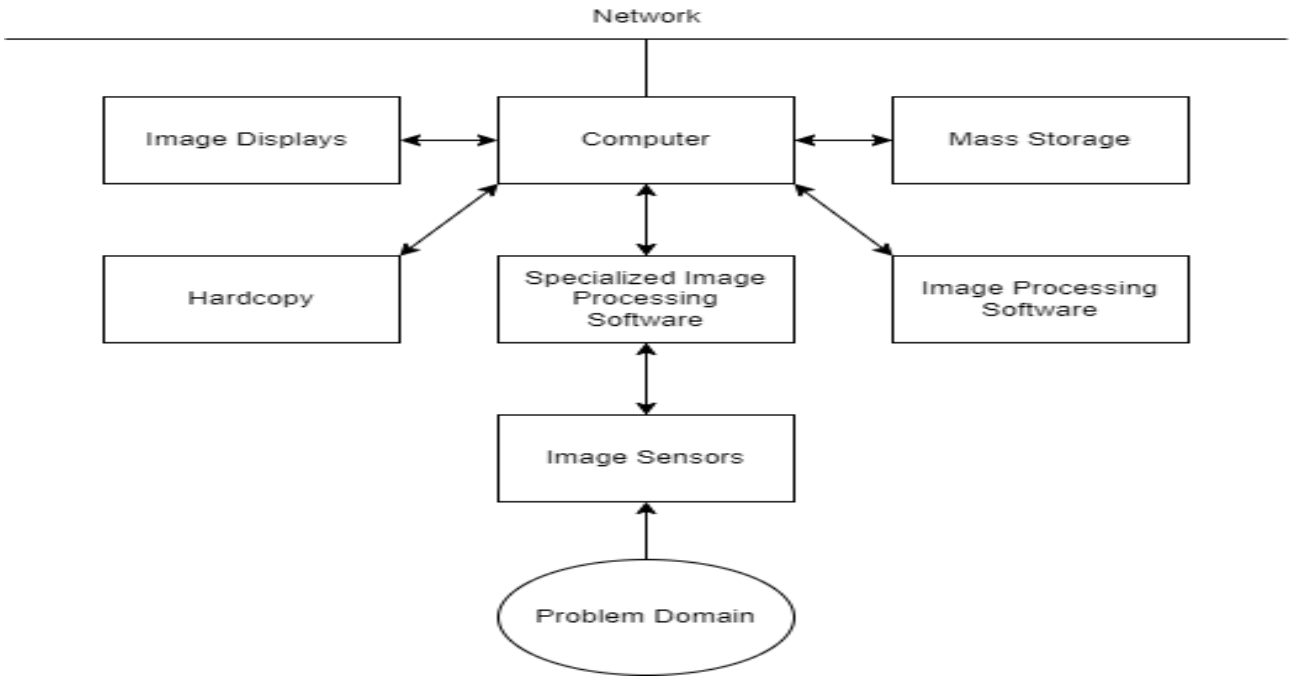

Fig 1 Components of General-Purpose Image Processing System

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➢ *Figure 1 Shows the Basic Components of a General-Purpose Image Processing System.*

- Image sensors – These are the physical devices that are sensitive to the energy radiated by the object in frame.
- Specialized Image Processing Hardware – Consists of a digitizer, used for converting analog output from the sensors into digital format, and the Arithmetic Logic Unit (ALU) which is used to perform mathematical operations.
- Computer – This is a normal general-purpose computer.
- Image Processing Software – Consists of special modules that can perform specific tasks.
- Mass Storage – A must in image processing, helps in storage on large image sizes.
- Image Displays – These are basically monitors that are driven by the output of images.
- Hardcopy – These are devices such as laser printers, camera devices, inkjet units etc., which record images.
- Network – This is the most basic and default unit in any image processing system, which takes care of image transmission.

II. IMAGE PROCESSING TECHNIQUES

A. *Image Enhancement*

Image Enhancement refers to the process of improving the quality of digital images, such that the resulting image is improved and hence more suitable for viewing or further processing. It is essential for processes like noise removal, image brightening, revealing details of an image that are blurred and adjusting intensity level to highlight specific details of an image. Enhancement includes methods like Contrast Stretching, Digital Negative, Noise Filtering and Histogram Modification.

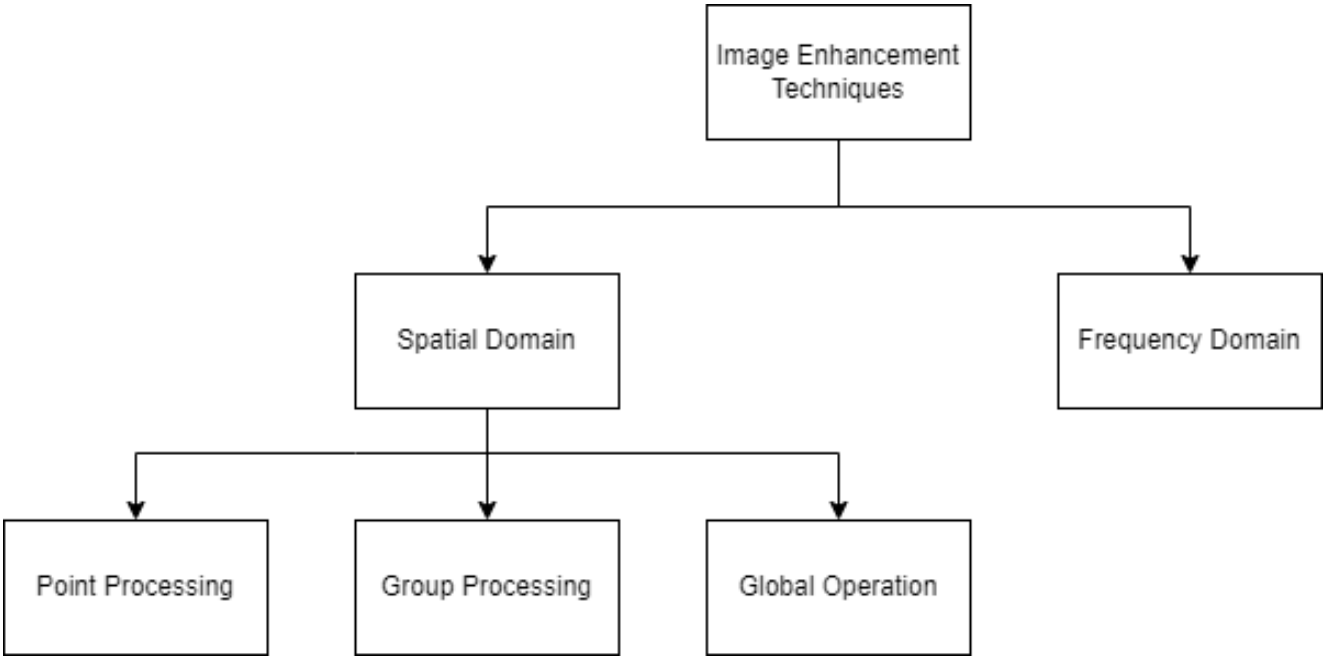

Fig 2 Types of Image Enhancement Techniques

➢ *Types of Image Enhancement Techniques:*

- Spatial Domain – This Technique Involves Modification Of Each Pixel In An Image, In Accordance With The Spatial Co-Ordinate Of Each Pixel. This Can Be Further Divided Into:

✓ Point Processing – In this method, processing happens pixel by pixel. Each pixel is taken, processed and then placed at the corresponding location in the resultant image.
✓ Group Processing – In this method, processing happens on a group of pixels. A group of pixels is taken, processed and the obtained intensity value refers to only the centre pixel of the group in the resultant image.
✓ Global Processing – The whole image is considered for processing.

- Frequency Domain – In This Technique, The Image Is First Converted From The Spatial Domain Into The Frequency Domain Using Appropriate Transforms, And Then The Pixels Are Operated Upon In Groups Or Individually. In The End, The Processed Or Enhanced Image Is Converted Back To Spatial Domain.

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Fig 3 Example of Image Enhancement

B. Image Segmentation

Image Segmentation refers to the process of segmenting or dividing the original image into a number of subparts, according to the requirements of the user. This is done with the objective of reducing the complexity of the original image and enabling in-depth analysis of each image segment. Image segmentation also helps in outlining certain features that are hidden in the original image and object recognition. The result of segmentation is often an image that is better to view.

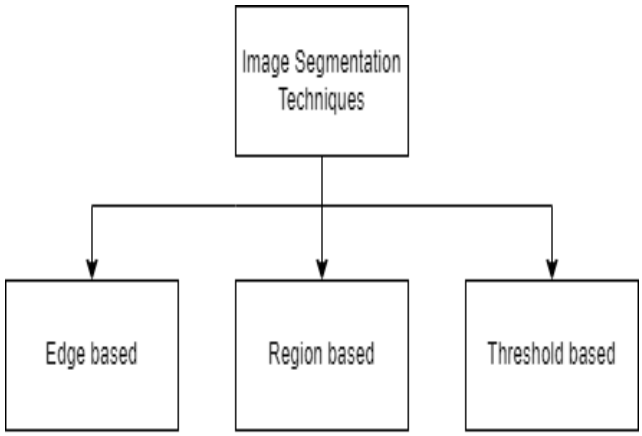

Fig 4 Types of Image Segmentation Techniques

➢ *Types of Image Segmentation Techniques:*

- Edge Based – In edge-based segmentation technique, the edges of various objects of the image are identified. This helps in displaying certain features of the objects by locating their edges. It works on the principles of contrast, saturation and texture.

Fig 5 Example of Edge Based Segmentation

- Region based – In region based segmentation, the image is subdivided into different regions. These regions are defined by grouping pixels with similar characteristics. Each region is identified using a seed pixel, which is like the origin of the region.

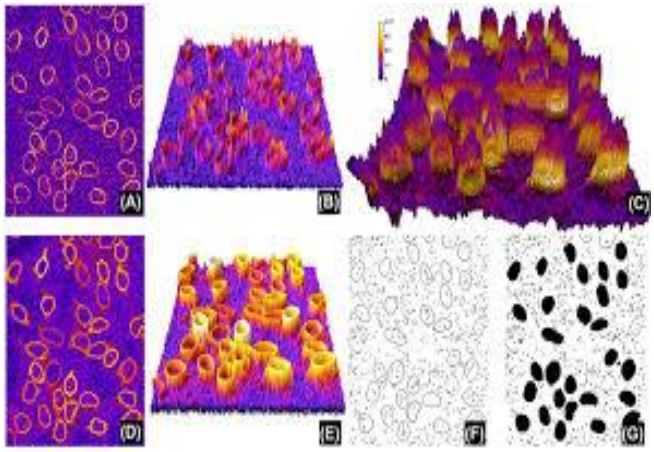

Fig 6 Example of Region based Segmentation

- Threshold based – Threshold based Segmentation is the simplest one. It divides pixels based on their intensity values, with respect to a specified threshold value. This kind of segmentation is most suitable is cases where the object has higher intensity compared to its background.

Fig 7 Example of Threshold Based Segmentation

C. Image Representation

Image Representation refers to the step taken after segmenting the image. During representation, the different segments or regions formed during the segmentation process are displayed in such a form that is apt and suited for further processing. Image representation is most suitable in knowledge based machine learning, where a certain model is to be formed. Image representation deals with the characteristics and properties pertaining to the image.

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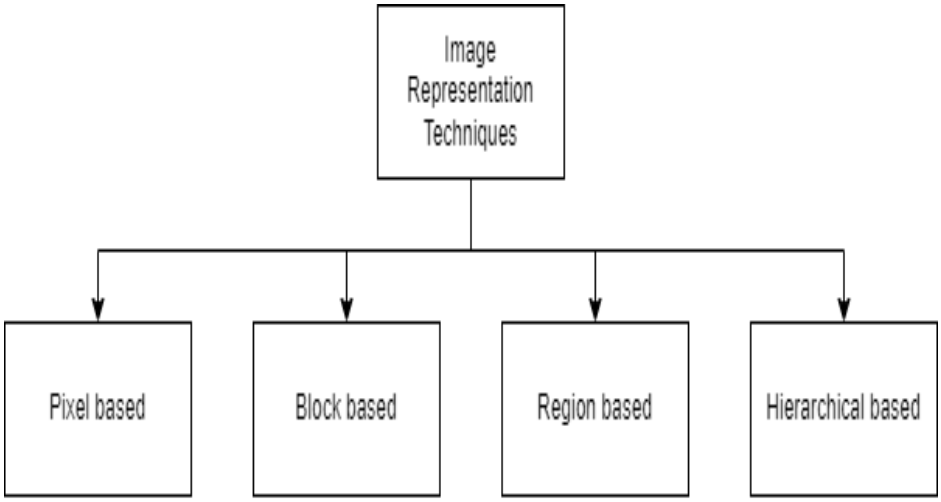

Fig 8 Types of Image Representation Techniques

➢ *Types of Image Representation Techniques:*

- Pixel based – Pixel based representation involves relating each pixel to its neighbouring set of pixels. Each pixel contains the information pertaining to only its neighbouring set of pixels and not beyond that. Since each pixel is considered, the number of elements is high. This is the simplest form of image representation and has applications in medical imaging where each pixel has importance.

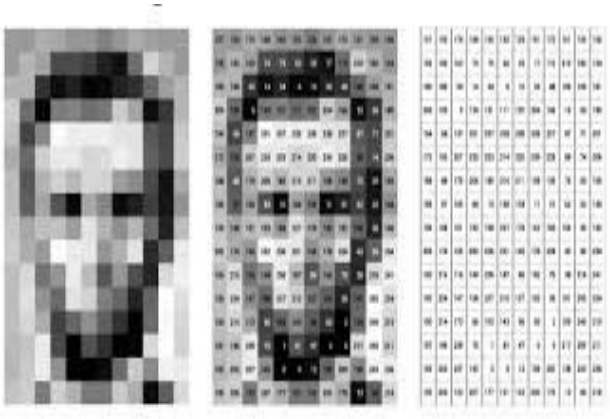

Fig 9 Example of Pixel based Image Representation

- Block based – In block based representation, the image that is to be processed is divided into rectangular blocks. Like pixel based representation, each block has information of only the neighbouring blocks. But, compared to pixel based representation, the number of elements is less since a group of pixels is considered for processing. This technique is applied in segmentation and in images where different features are to be displayed.

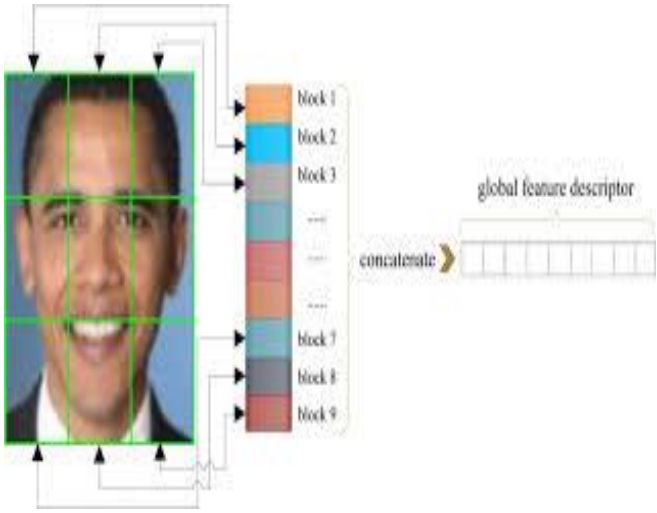

Fig 10 Example of Block based Image Representation

- Region based – Region based representation is similar to block based representation in the way that in both techniques, the pixels are grouped together. But, the difference is that in region based technique, the pixels are grouped according to a set of similar characteristics that they share. Connected pixels are grouped together. A Regional-Adjacency Graph is used to keep track of the regions formed. This technique is used for object recognition.

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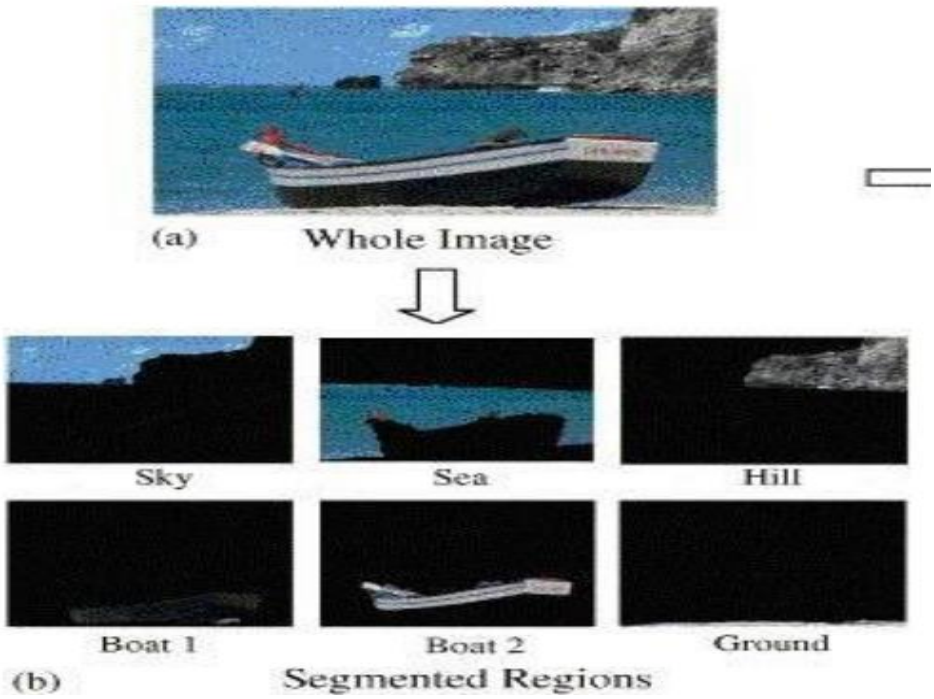

Fig 11 Example of Region based Image Representation

- Hierarchical based – This representation technique makes use of region based representation. It makes use of unions or combination of the regions formed using region based representation and orders them according to a set hierarchy. This technique finds applications in image and video segmenting and object detection.

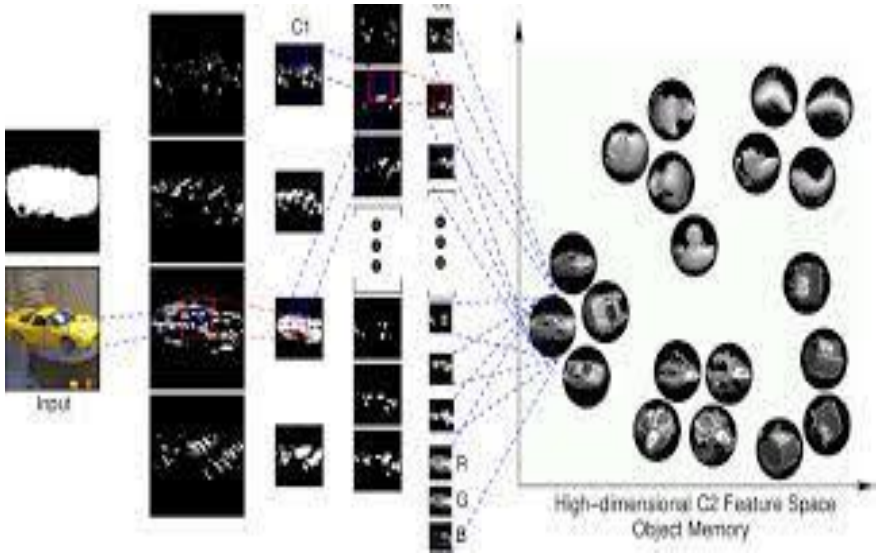

Fig 12 Example of Hierarchical based Image Representation

D. Image Transforms

Generally, an image is obtained in spatial co-ordinates i.e. its co-ordinates are obtained with respect to the X, Y and Z axes. The spatial co-ordinates can thus be written simply as (x,y,z), or if it is a 2 dimensional representation then (x,y). As advantageous as image processing in the spatial domain can be, converting the image into another domain unlocks new methods that are unavailable through spatial domain techniques. This conversion is done via a set of Image Transforms, through which the solution of potentially any problem can be found with ease.

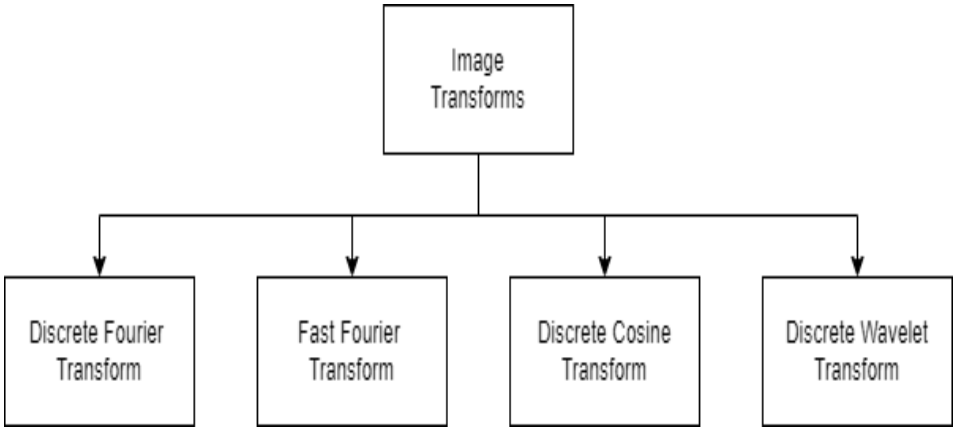

Fig 13 Types of Image Transforms

➢ Types of Image Transforms:

- Discrete Fourier Transform (DFT) – Fourier Transform is basically a way to represent the image using a sum of complex variables such as the intensity, magnitude and frequencies. Discrete Fourier Transform refers to the Furier Transform when the input and ouput are both discrete. The representation of a 2 dimensional Discrete Fourier Transform of a function f(m,n) can be given as:

$$F(p,q) = \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} f(m,n)e^{-j2\pi pm/M}e^{-j2\pi qn/N} \quad \begin{matrix} p = 0,\ 1,\ ...,\ M-1 \\ q = 0,\ 1,\ ...,\ N-1 \end{matrix}$$

Fig 14 Representation of 2 dimensional Discrete Fourier Transform

- Fast Fourier Transform (FFT) - Fast Fourier Transform is a common and easy way to convert images in spatial domain to the frequency domain. Unlike other methods, the Fast Fourier Transform preserves all the data pertaining to the original image. Another advantage of this transform is that it transforms the image completely into the frequency domain.

- Discrete Cosine Transform (DCT) – The Discrete Cosine Transform is similar to the Fourier Transform in the way that both are sums. The difference is that the Discrete Cosine Transform expresses an image in the form of a sum of sinusoids of varying magnitude and frequency. An interesting property of Discrete Cosine Transform is that most of the information of the original image can be expressed as only a few coefficients of the transform. The representation of a 2-dimensional Discrete Cosine Transform can be given by:

$$B_{pq} = \alpha_p\alpha_q \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} A_{mn}\cos\frac{\pi(2m+1)p}{2M}\cos\frac{\pi(2n+1)q}{2N}, \quad \begin{matrix} 0 \le p \le M-1 \\ 0 \le q \le N-1 \end{matrix}$$

$$\alpha_p = \begin{cases} 1/\sqrt{M}, & p = 0 \\ \sqrt{2/M}, & 1 \le p \le M-1 \end{cases} \qquad \alpha_q = \begin{cases} 1/\sqrt{N}, & q = 0 \\ \sqrt{2/N}, & 1 \le q \le N-1 \end{cases}$$

Fig 15 Representation of 2-dimensional Discrete Cosine Transform

- Discrete Wavelet Transform (DWT) – A wavelet is an oscillation in the shape of a wave, such that its amplitude begins at 0, reaches a peak value, and then comes back to 0. It is basically a function in time and frequency that has been concentrated around a certain point. The Discrete Wavelet Transform converts pixels into wavelets, for further processing on these wavelets. This technique overcomes the disadvantage of Fourier in the sense that it can provide temporal details as well, which Fourier Transform could not. The representation of Discrete Wavelet Transform is given by:

$$W_\varphi(j_0,k) = \frac{1}{\sqrt{M}}\sum_x f(x)\varphi_{j_0,k}(x)$$

$$W_\psi(j,k) = \frac{1}{\sqrt{M}}\sum_k f(x)\psi_{j,k}(x)$$

Fig 16 Representation of Discrete Wavelet Transform

E. Image Compression

Image Compression refers to the process used in image processing, where the size of the image is reduced such that its quality remains the same. By reducing the size of the original image, the bandwidth required during transmission of the image is also less, thereby speeding up content delivery. This reduction in size of the image also increases the number of images that can be stored in the same amount of storage space.

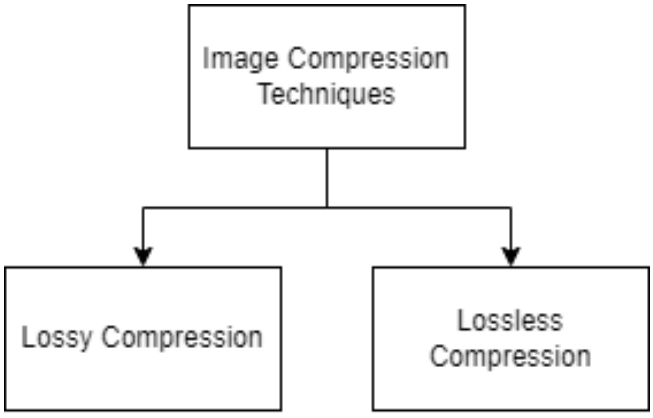

Fig 17 Types of Image Compression Techniques

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➢ *Types of Image Compression Techniques:*

- Lossy Compression – In Lossy Compression, certain information pertaining to the original image is permanently lost. This technique works by removing less relevant, generally redundant, information in the image, thereby reducing its size. Although this method greatly reduces image size, there is also a chance of degrading the image quality if over compression is done. Lossy Compression is usually done in cases where loss of data is acceptable upto a certain amount. This technique finds its applications in media streaming scenarios. One of the most common examples is the Joint Photographic Exports Group (JPEG) image format.

- Lossless Compression – In Lossless Compression, all the information pertaining to the original image is retained, no data is lost. The compressed image can be restored without any distortion. The drawback here is that the reduction in image size is not as great as it is in the case of Lossy Compression. This technique is generally used in cases where the image quality is of utmost priority and loss of data is unacceptable. Medical repositories use lossless compression technique. One of the examples of lossless compression is the Portable Network Graphics (PNG) image format.

Fig 18 Example of Lossy and Lossless Image Compression Techniques

III. FUTURE SCOPE

With the advent of digitization, there has come a new wave of methods and techniques that can be used for image processing. Despite this, there is still great room for improvement in order to achieve the best and most satisfactory result possible. The upcoming field of artificial intelligence and machine learning can be used to great extent for this.

IV. CONCLUSION

In brief, Image Processing can be defined as any technique or method that is used to either enhance the quality of the image or used to process the image in order to highlight certain features. This paper enumerates some of the different Image Processing Techniques such as Image Enhancement, Image Segmentation, Image Representation, Image Transforms and Image Compression and gives a brief overview of each one. Ultimately, the technique chosen depends solely upon the area of application.

REFERENCES

[1] R. Gonzalez and R. Woods, "Digital Image Processing," Prentice Hall, Englewood Cliffs, NJ, 2002.

[2] N. Rani, "Image Processing Techniques: A Review", Journal on Today's Ideas –Tomorrow's Technologies, Vol. 5, No. 1, pp. 40–49, June 2017, doi: 10.15415/jotitt.2017.51003

[3] K. Sumithra, S. Buvana, R. Somasundaram, "A Survey on Various Types of Image Processing Technique", International Journal of Engineering Research & Technology (IJERT), Vol. 4 Issue 03, March-2015

[4] B. Kuriakose, P. K P, "A Review on 2D Image Representation Methods", International Journal of Engineering Research & Technology (IJERT), Vol. 4 Issue 04, April-2015

[5] R. Hegadi, "Image Processing: Research Opportunities and Challenges", National Seminar on Research in Computers, 13-12-2010, Bharathiar University, Coimbatore, India

[6] Image segmentation: The basics and 5 key techniques (2022) Datagen. Available at: https://datagen.tech/guides/image-annotation/image-segmentation/ (Accessed: February 19, 2023).

[7] Image enhancement MATLAB & Simulink. Available at: https://in.mathworks.com/discovery/image-enhancement.html (Accessed: February 19, 2023).

[8] Simplilearn (2023) What is image processing? meaning, techniques, segmentation & important facts to know, Simplilearn.com. Simplilearn. Available at: https://www.simplilearn.com/image-processing-article#:~:text=Representation%20and%20Description,image's%20characteristics%20and%20regional%20properties (Accessed: February 19, 2023).

[9] Discrete Wavelet Transform (DWT). In: Furht, B. (eds) Encyclopedia of Multimedia. Springer, Boston, MA. https://doi.org/10.1007/978-0-387-78414-4_305

[10] Discrete Cosine Transform - MATLAB & Simulink - MathWorks India. Available at: https://in.mathworks.com/help/images/discrete-cosine-transform.html (Accessed: February 21, 2023).

[11] Fast Fourier Transform (FFT) Background (no date) Fast fourier transform (FFT) background. Available at: https://www.l3harrisgeospatial.com/docs/backgroundfastfouriertransform.html#:~:text=The%20Fast%20Fourier%20Transform%20(FFT,time%2Dfrequency%20or%20wavelet%20transforms (Accessed: February 21, 2023).