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An Extensive Analysis of Digital Image Compression Techniques by Using Different Image File and Color Formats

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***Abstract*— Data storage on the device can affect the access speed of the device used, for example files, images, data and others stored, of course, will affect the performance of the device, so that the device becomes slow to access, difficult to open images, difficult to download and save images, files and other data because the available storage capacity is limited, with the problems that arise, an image compression technique is needed that can minimize storage space and speed up the access process from a device. Image compression technique is a process that is used on a file, image, and data to reduce its size but does not reduce the quality of the file, existing image and does not lower the threshold during the sending or receiving process. The purpose of this research is to reduce the size used so that it can speed up the process of accessing data on devices and more importantly to minimize the use of memory space and can also affect the bandwidth used when sending and receiving files so that it can speed up the process of sending from source to destination. The method used in this study is Lossy Compression, lose less Compression by comparing RLE, Huffman, and LZW using different image file types. The test results carried out in this study can recommend reduced ratio are lossy compression with format image BMP (Jpg compression), for binary image using Lossless Compression have a good reduce ratio compression with average 99%.**

***Keywords*— Algorithm; Compression; Huffman; LZW; RLE.**

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I. INTRODUCTION

Digital image processing is a variety of techniques to manipulate and modify images with the aim of improving image quality through increasing contrast, image restoration, color transformation, rotation, scaling, translation, carrying out the process of retrieving information or object descriptions or object recognition contained in the image, select optimal feature images for analysis purposes and compress or reduce data for data storage, data transmission, and data processing time [1]. Image compression is a process carried out in digital image processing to reduce data redundancy in an image, minimize data storage capacity, also relates to the time used when sending or receiving data, the memory used when storing and sending becomes smaller so that the process transmission is faster but does not reduce the quality of the image sent. and can reduce the amount of data needed to represent the digital image [2].

In the lossless compression process is a compression technique that can produce image files with the same quality, but only change the size of the image to be smaller without losing information from the original image [3]. Both lossless and lossy compression techniques have their respective advantages, but what is prioritized the performance of the method used and does not reduce the quality of the existing image, both in terms of information and the results of the existing image and can reduce the existing distortion of the image [4]. In general, digital images can be compressed, one of which is with lossy techniques with much greater compression results when compared to using lossless techniques. Using compression techniques can reduce bandwidth communication and save transmission power, but still produce good quality images after being compressed with low bit rates [5].

Image compression or also known as image compression is a process to minimize the number of bits representing an image so that the size of the image data becomes smaller. Basically, image compression techniques are used in the process of data transmission and data storage. Using lossless techniques can produce compressed images that are the same as the original image, in the compression process, no

information is lost and the compression ratio is very low/limited [6]. The image compression process is one of the most important steps related to storage media and data transmission processes, in general the methods used are lossy and lossless and are adapted to the image to be compressed with techniques that are faster and save memory and are adapted to user needs [7]. The lossless compression process is related to the process of transmitting and storing data and is related to image classification, image recognition and others [8]. In lossless compression no information is lost, this technique is used for general purposes, lossless compression algorithms are classically used depending on the coding and generally using artificial neural networks can produce performance by getting better features [9]. Image compression is essential for many fields such as communications and data storage. One form of compression used is the Run-length encoding (RLE) method, which is a lossless data compression process using a sequence of data from the number of existing data elements [10]. The image compression process using both lossless and lossy methods have the same function which is to remove useless data with the aim of producing data with even smaller storage capacity [11]. The image compression process is used to reduce the size in bytes of the existing image, but still maintain image quality and reduce the time required for computing and uploading images in various applications, for this reason compression is needed [12]. DCT is one of the methods used in the image compression process, namely the lossy compression technique and is a digital compression technique into the JPEG format. This image compression aims to reduce data sets that are similar in images so that they can be stored with a smaller size or transmitted efficiently and to find image representations with reduced pixel correlation. In image compression, DCT receives input in the form of an image matrix which then converts it into a frequency matrix with the same size [13]. In the image compression process, one of the algorithms used is the Huffman algorithm and is a lossless compression technique by not changing the original existing image and the process is carried out by using coding in the form of bits to represent the character data in the image [14]. The image compression process using the HAAR Discreate Wavelet algorithm is a coding process of a simple and fast compression algorithm with a higher compression ratio and PSNR value [15]. The image compression method can be combined using RLE and Huffman by carrying out the stages of the compression process from the existing data sequences with RLE and the color component histogram features of an image using Huffman coding after the RLE process is applied [16].

Previously, research on Comparative and improvement analysis of digital image compression algorithms with various image files. The digital image compression process is very important to use and with different techniques using both lossy and lossless, including the RLE technique, Huffman encoding, wavelet, LZW and other techniques based on compression ratios with different results and based on the images used in each study [17]. Lossless techniques are used for digital image compression processes and are related to image storage, image classification, and image recognition, in this study comparing the very sophisticated and popular lossless techniques based on bits per pixel or using compression ratios using 4 data sets and producing each Images have different characteristics [8]. The results of research conducted on medical images using wavelets without losing existing information with a high PSNR value ratio obtained indicate the compression process using existing techniques and adjusted to the characteristics of the data and image quality used [18]. In research that was carried out using images of several standard colors, producing 0.5 bits per pixel, and resulting in a very low bit rate of 0.25 using DWT, in this study it is also recommended to use background images that are in accordance with the recommended DWT technique [19]. In research related to image compression techniques with lossless compression processes, the performance of the test results with jpeg and jpeg2000 image types produces a lower bit rate which is better in the research conducted [20]. The process carried out in this study is related to using 4 types of compression, namely RLE, Huffman, EZW, DCT, the results obtained for lossless compression, the RLE algorithm is simpler and easier to implement on the image data used, in lossy techniques, the results from EZW are better than DCT. and produce better image compression than the results of the data processed in this study [21]. The RLE method is a process of decompressing digital images with type files and is a very simple method with a sequence of matrix values for each image that is compressed [22]. The compression process is used to reduce signal distortion, reduce large file sizes so that it can use more memory, making it difficult to perform analysis and use high bandwidth when sending image files. The advantages of the LZW compression technique are the very short compression time with a fairly good compression rate from the research conducted [23]. Research that has been carried out using the LZW and Huffman methods shows that the results with the LZW method are more efficient for compression ratios and the type of compressed image is a PNG image [24]. The research was conducted using 2 image compression methods, RLE and Huffman using several image samples, the compression ratio using the Huffman method produced a value of 28.91%, while using the RLE method the compression ratio reached 93.17%, it can be concluded that the best RLE method from research conducted with produces compressed output with optimal results and does not affect the quality of the compressed image [25]. Related research to lossless data compression techniques in trials that have been carried out aim to achieve the best compression ratio to predict entropy and focus on compressing existing images without losing image quality and information and depending on the block size and results the compression ratio can be increased from 8% to 15% [26]. The research was carried out using lossy and lossless compression with the DWT, DCT and Huffman techniques. The test results obtained from CR and PNSR on DWT were better, and the quality of the resulting image compression process was still good [27]. The compression process can be used to make storage space efficient and the data transfer process, in the research carried out produces smooth graphics and a good compression ratio and can remove redundant bits from existing images without losing image quality and existing information [28].

In research conducted using the DCT method, it can produce compression ratio results that are better than the original size, which is 4 to 5 times smaller [29]. In the image compression has a very important role and can save bandwidth usage and is used in the process of exchanging data

from one point to another and reduces power usage to produce an image decompression process with results and a smaller size than the original image [10]. The process carried out in this research is related to image compression using the discrete Fourier transform and discrete cosine transform with the aim of getting a smaller image size so that the data storage used is more efficient and data communication is faster but does not reduce the quality of the image [31]. In the compression process it is really needed to facilitate data processing so that it can minimize the use of resources and time but the results obtained are more optimal, by using a lossless method of data compression that is fixed and does not eliminate the information contained in the data, for example, image data that is used properly using the Huffman method to get optimal results [32]. The image compression process using lossy compression with RLE produces good quality so that it can save memory usage and communication time without losing the existing image quality [10]. Image compression algorithms are used to facilitate communication and minimize the use of storage space and currently the image compression process is used because of the importance and increasing demand for the compression process and is currently being implemented using machine learning [33]. Lossless data compression techniques are carried out based on the compression ratio by carrying out the classification process of existing data with the encoding process and encoding time and the results obtained are more optimal with lossless data compression techniques [34]. Currently the use of artificial neural networks can be used for image compression processes and has the same goal namely, to minimize data storage and process faster with the results of image compression, the process is carried out using repeated testing and using overfitting strategies but does not reduce quality existing image [35]. The image compression process is also currently needed in authentication systems, namely by scanning faces in image form, for this reason an image compression technique is needed so that the data used can save device resources and processing time and consider a fast and effective process [36]. The combination of artificial neural networks and deep learning has now been used in color image compression performance by processing each component and can produce better image quality, namely increasing the quality of grey image compression, without leaving any information contained in the original image [37].

Image processing techniques are used to be able to arrange images by separating objects in the image from their background and the goal is to get only important information [38]. The filtering process on digital images can assist in enhancing and restoring images and can eliminate noise in existing images but the information contained in the image is not lost, the filtering process will later be used for feature extraction and image compression processes, where filtering techniques have a very important role in digital image processing [39]. Image resizing techniques are needed so that the process of communicating and exchanging images on the required device is faster and uses less memory, especially when using a mobile device. So that the communication process is higher if resizing the existing image is carried out and it affects the existing results, namely in the form of image quality [40]. The digital image processing process includes preprocessing stages that function to improve the quality of digital images and are related to the process of changing images into binary images, then followed by the stages of segmentation and feature extraction from images [41]. The image processing process will certainly help the image compression process so that any information in the image remains.

II. MATERIAL AND METHOD

The research stages for image compression with compare the different method the steps as follows with:

A. Image Acquisition

This stage is the stage of collecting image (object) data which is the initial input to this system. The image is taken using iPhone 14 Pro 48 mega pixels without using a flash. The image taken with background. The image used in this research with many extensions file (BMP, TIF, HDR, JPG, PNG) and use jpg quality compression 100.

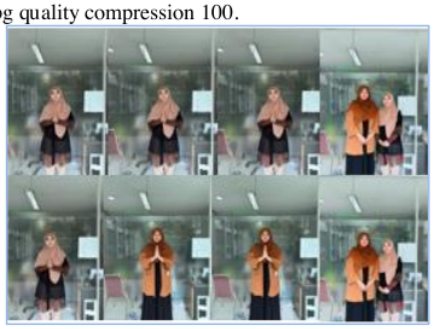

Fig. 1 Sample data collecting image with many extension files

From the Fig. 1 are sample image for compression with many extension files (BMP, TIF, HDR, JPG, and PNG). The next step image processing.

B. Image Processing

Image processing is a method to perform some operations on images, to obtain enhanced images or to extract some useful information from them. Input to image processing is an image and the output can be an image, or the characteristics/features associated with the image.

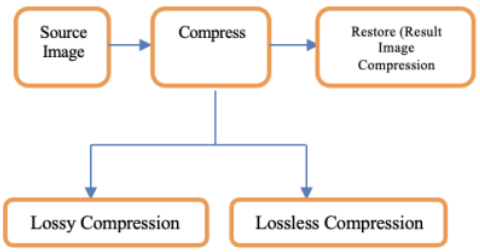

Fig. 2 Stage Image Compression

Fig. 2 stages the image compression with lossy compression and Lossless compression. The image compression process uses several images with different formats and performs the following steps:

- RGB image with background
- RGB image without background

- Grayscale image with background
- Grayscale image without background
- Image Binary with background
- Image Binary without background

Fig. 3 RGB Image with Background

From Fig. 3, RGB (original image use background and types save the image with extension BMP, TIF, HDR, JPG, PNG, the different file aims to understand the image compression process using 2 techniques, both lossy and lossless, so that a smaller storage image file is obtained without reducing the image quality and information contained in the image used.

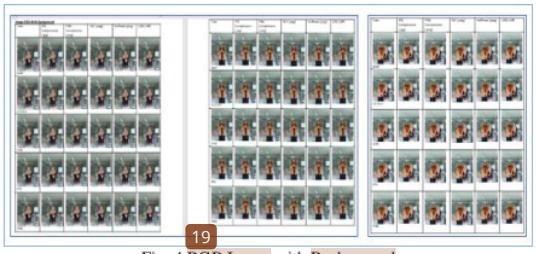

Fig. 4 RGB Image with Background

Fig. 5 RGB Image without Background

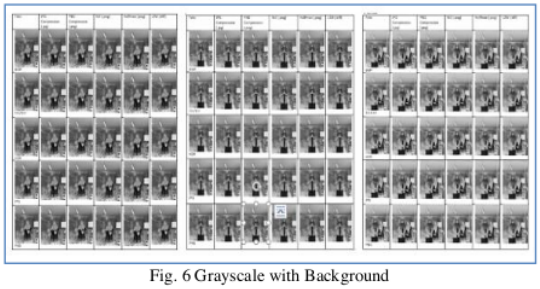

Fig. 6 Grayscale with Background

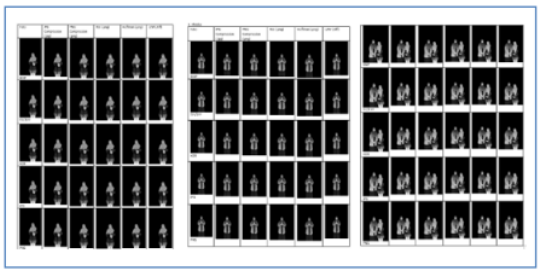

Fig. 7 Binary Image with Background

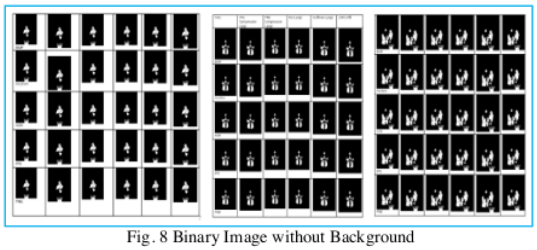

Fig. 8 Binary Image without Background

From the Fig. 4 – Fig. 8, many images for testing and implementation compress with lossy and lossless technique. From figure 4 the real image RGB with background and types of file extension are BMP, TIF, HDR, JPG, and PNG until the figure 9 the original image processing is carried out from the original image (RGB) to a grayscale and binary image with the same file types.

III. Results and Discussions

A. *Scenario Testing RGB Image*

TABLE I
LOSSY COMPRESSION RGB IMAGE

Format	Original Size (MB)	Lossy Compression	
		JPG (MB)	JPG (%)
.BMP	36,5	4,4	87,95%
.TIF/.TIFF	36,5	4,5	87,67%
.HDR	36	4,4	87,78%
.SVG	can't be compresses using these method		
.JPG	2,1	4,3	-104,76%
.PNG	8,9	4,4	50,56%
.HEIC	can't be compresses using these method		
.GIF	can't be compresses using these method		

From TABLE I the compression results using RGB image files with various file types, namely BMP, TIF, HDR, SVG, JPG, PNG, HEIC and GIF, seen in the test results on BMP, TIF and HDR file types the compression ratio is very good reaching 87%, using files with the JPG compression file type is not recommended for the compression ratio, as well as for the SVG, HEIG and GIF file types in the data in this study (scenario RGB with Background).

TABLE II
LOSSLESS COMPRESSION RGB IMAGE

Format	Original (MB)	Lossless Compression							
		PNG (MB)	PNG (%)	PNG with RLE (MB)	PNG with RLE (%)	PNG with Huffman (MB)	PNG with Huffman (%)	TIFF With LZW (MB)	TIFF with LZW (%)
.BMP	36,5	4,4	87,95%	14,6	60,00%	14,6	60,00%	12,5	65,75%
.TIF/.TIFF	36,5	4,5	87,67%	14,6	60,00%	14,6	60,00%	12,5	65,75%
.HDR	36	4,4	87,78%	14,7	59,17%	14,7	59,17%	12,7	64,72%
.SVG	can't be compresses using these method								
.JPG	2,1	4,3	-104,76%	14,6	-595,24%	14,6	-595,24%	12,5	-495,24%
.PNG	8,9	4,4	50,56%	14,6	-64,04%	14,6	-64,04%	12,5	-40,45%
.HEIC	can't be compresses using these method								
.GIF	can't be compresses using these method								

From TABLE II with Lossless Compression with RGB image for Lossless compression 77.26% PNG Compression, 60% PNG compression with RLE, 60% PNG Compression with Huffman, and 65.75% TIFF Compression with LZW (scenario RGB Image with background).

B. Scenario Testing Grayscale, Binary Image with Background

TABLE III
GRAYSCALE IMAGE WITH LOSSY AND LOSSLESS COMPRESSION

Format	Original (MB)	Lossy Compression		Lossless Compression							
		JPG (MB)	JPG (%)	PNG (MB)	PNG (%)	PNG with RLE (MB)	PNG with RLE (%)	PNG with Huffman (MB)	PNG with Huffman (%)	TIFF with LZW (MB)	TIFF with LZW (%)
.BMP	12,2	3,9	68,03%	4,4	87,95%	14,6	60,00%	14,6	60,00%	12,5	65,75%
.TIF/.TIFF	6,4	3,9	39,06%	4,5	87,67%	14,6	60,00%	14,6	60,00%	12,5	65,75%
.HDR	35,9	3,9	89,14%	4,4	87,78%	14,7	59,17%	14,7	59,17%	12,7	64,72%
. SVG	can't be compresses using these method										
.JPG	2,4	3,9	-62,50%	4,3	-104,76%	14,6	-595,24%	14,6	-595,24%	12,5	-495,24%
.PNG	5,5	3,9	29,09%	4,4	50,56%	14,6	-64,04%	14,6	-64,04%	12,5	-40,45%
.HEIC	can't be compresses using these method										
.GIF	can't be compresses using these method										

From TABLE III, can be seen that using the lossy compression technique is at jpg compression which is 89.14% and by using lossless compression techniques it is 86.63% (PNG compression), 84.68% PNG Compression with RLE, 84.68% PNG Compression with Huffman, and 82.17% TIFF Compression with LZW. (Scenario Grayscale image with Background).

TABLE IV
BINARY IMAGE WITH LOSSY AND LOSSLESS COMPRESSION

Format	Original (MB)	Lossy Compression		Lossless Compression							
		JPG (MB)	JPG (%)	PNG (MB)	PNG (%)	PNG with RLE (MB)	PNG with RLE (%)	PNG with Huffman (MB)	PNG with Huffman (%)	TIFF with LZW (MB)	TIFF with LZW (%)
.BMP	12,2	2,4	80,33%	0,2	98,36%	0,3	97,54%	0,3	97,54%	0,5	95,90%
.TIF/.TIFF	0,5	2,4	-380,00%	0,2	60,00%	0,3	40,00%	0,3	40,00%	0,5	0,00%
.HDR	2,2	2,4	-9,09%	0,2	90,91%	0,3	86,36%	0,3	86,36%	0,5	77,27%
. SVG	can't be compresses using these method										
.JPG	1,6	2,4	-50,00%	0,2	87,50%	0,3	81,25%	0,3	81,25%	0,5	68,75%
.PNG	0,3	2,4	-700,00%	0,2	33,33%	0,3	0,00%	0,3	0,00%	0,5	-66,67%
.HEIC	can't be compresses using these method										
.GIF	can't be compresses using these method										

TABLE IV shows the results of image compression on using a background compressed with binary images in a lossy compression technique of 80.33% for the compression reduction ratio of the image used, for the lossless technique the results are 98.36% reduction ratio for PNG compression, 97.54% for PNG Compression with RLE, 97.54% PNG Compression with Huffman, 95.90%TIFF Compression with LZW.

C. Scenario Testing RGB, Grayscale, Binary Image without Background

TABLE V
RGB IMAGE WITHOUT BACKGROUND WITH LOSSY AND LOSSLESS COMPRESSION TECHNIQUE

Format	Original (KB)	Lossy Compression		Lossless Compression							
		JPG (KB)	JPG (%)	PNG (KB)	PNG (%)	PNG with RLE (KB)	PNG with RLE (%)	PNG with Huffman (KB)	PNG with Huffman (%)	TIFF with LZW (KB)	TIFF with LZW (%)
.BMP	7680,1	284,1	96,30%	494,9	93,56%	599,5	92,19%	599,5	92,19%	748,4	90,26%
.TIF/.TIFF	645,9	270,9	58,06%	492,3	23,78%	597,7	7,46%	597,7	7,46%	746,3	-15,54%
.HDR	1070,8	248,5	76,79%	468,7	56,23%	610,2	43,01%	610,2	43,01%	738,2	31,06%
. SVG	can't be compresses using these method										
.JPG	144,6	247,7	-71,30%	464,1	-220,95%	609,2	-321,30%	609,2	-321,30%	732,8	-406,78%
.PNG	684,6	284,1	58,50%	494,9	27,71%	599,5	12,43%	599,5	12,43%	748,4	-9,32%
.HEIC	can't be compresses using these method										
.GIF	can't be compresses using these method										

The results obtained in TABLE V for the type of RGB image without a background with a lossy technique get a reduction ratio value of up to 96.30% in PNG Compression. In the Lossless compression ratio technique, the decrease reached a value of 93.56% PNG Compression, 92.19% PNG Compression with RLE, 92.19% PNG Compression with Huffman, and 90.26% TIFF Compression with LZW.

TABLE VI
GRAYSCALE IMAGE WITHOUT BACKGROUND WITH LOSSY AND LOSSLESS COMPRESSION TECHNIQUE

Format	Original (KB)	Lossy Compression		Lossless Compression							
		JPG (KB)	JPG (%)	PNG (KB)	PNG (%)	PNG with RLE (KB)	PNG with RLE (%)	PNG with Huffman (KB)	PNG with Huffman (%)	TIFF with LZW (KB)	TIFF with LZW (%)
.BMP	1921,1	232,3	87,91%	196,9	89,75%	207,4	89,20%	207,4	89,20%	298,8	84,44%
.TIF/.TIFF	298,1	222,4	25,39%	195,7	34,35%	206,4	30,76%	206,4	30,76%	298,1	0,00%
.HDR	1093,4	200,5	81,66%	198,3	81,86%	212,4	80,57%	212,4	80,57%	305,9	72,02%
. SVG	can't be compresses using these method										
.JPG	139,1	200,5	-44,14%	198	-42,34%	212,3	-52,62%	212,3	-52,62%	305,5	-119,63%
.PNG	207,4	232,3	-12,01%	196,9	5,06%	207,4	0,00%	207,4	0,00%	298,9	44,12%
.HEIC	can't be compresses using these method										
.GIF	can't be compresses using these method										

TABLE VI shows the results obtained using a grayscale image without a background with lossy and lossless compression techniques, a reduction ratio of 87.91% JPG Compression in the Lossy technique. In the Lossless technique, 89.75% PNG Compression, 89.20% PNG compression with RLE and 89.20% PNG Compression with Huffman, 84.44% TIFF Compression with LZW.

TABLE VII
BINARY IMAGE WITHOUT BACKGROUND WITH LOSSY AND LOSSLESS COMPRESSION TECHNIQUE

Format	Original (KB)	Lossy Compression		Lossless Compression							
		JPG (KB)	JPG (%)	PNG (KB)	PNG (%)	PNG with RLE (KB)	PNG with RLE (%)	PNG with Huffman (KB)	PNG with Huffman (%)	TIFF with LZW (KB)	TIFF with LZW (%)
.BMP	1921,1	172,6	91,02%	17,2	99,10%	21,8	98,87%	21,8	98,87%	54,2	97,18%
.TIF/.TIFF	53,6	165	-207,84%	16,4	69,40%	21,3	60,26%	21,3	60,26%	53,6	0,00%
.HDR	247,4	167,4	32,34%	17,7	92,85%	22,3	90,99%	22,3	90,99%	56,7	77,08%
. SVG	can't be compresses using these method										
.JPG	116,4	167,5	-43,99%	17,8	84,71%	22,3	80,84%	22,3	80,84%	56,7	51,29%
.PNG	21,8	172,6	-691,74%	17,2	21,10%	21,8	0,00%	21,8	0,00%	54,2	-148,62%
.HEIC	can't be compresses using these method										
.GIF	can't be compresses using these method										

TABLE VII shows the results obtained using a binary image without background with lossy and lossless compression techniques, a reduction ratio of 91.02% JPG Compression in the Lossy technique. In the Lossless technique, 99.10% PNG Compression, 98.87% PNG compression with RLE and 98.87% PNG Compression with Huffman, 97.18% TIFF Compression with LZW.

D. Chart Compression (RGB, Grayscale, and Binary Image with Background)

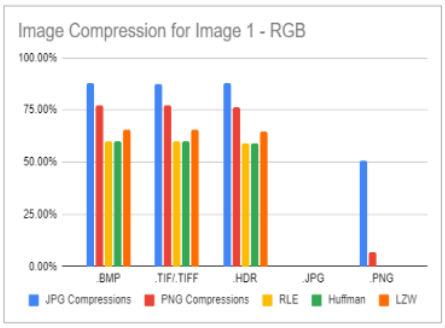

Fig. 9 Result Image Compression RGB Image with Background

From Fig. 9 can be seen that the results of jpg compression on the BMP file format type have a reduced ratio of 87.95% with RGB images.

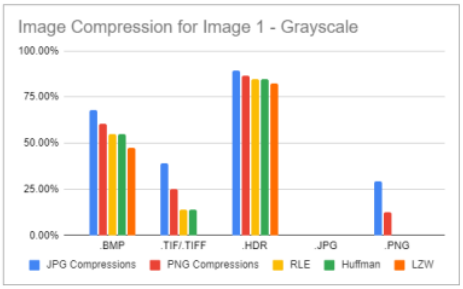

Fig. 10 Result Image Compression Grayscale Image with Background

From Fig. 10 can be seen that the results of jpg compression on the HDR file format type have a reduced ratio of 89.14% with Grayscale images.

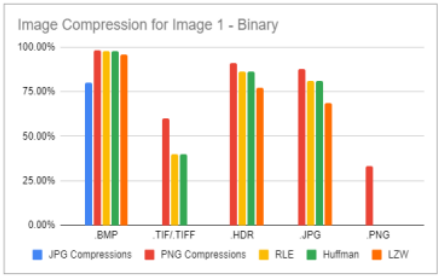

Fig. 11 Result Image Compression Binary Image with Background

From Fig. 11 use binary image, the result compression 98.36% can reduce the ratio with BMP extension format file images.

E. Chart Compression (RGB, Grayscale, and Binary Image without Background)

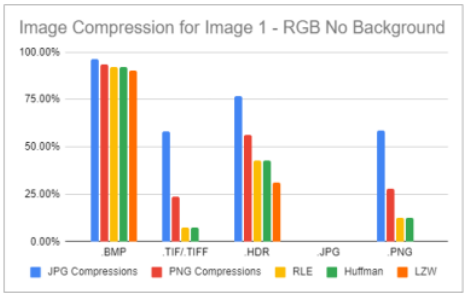

Fig. 12 Result Image Compression RGB Image without Background

Fig. 12 result image compression RGB, the result for reduced ratio of 96.30% (JPG Compression) with extension format image BMP.

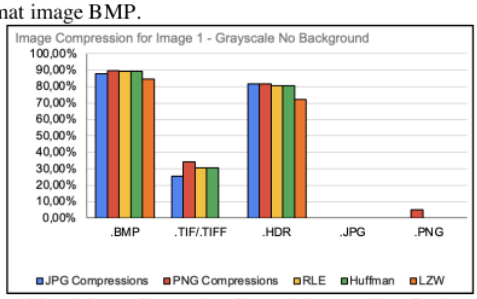

Fig. 13 Result Image Compression Grayscale Image without Background

From Fig. 13 can be seen that the results of PNG compression on the BMP file format type have a reduced ratio of 89.75% with Grayscale images.

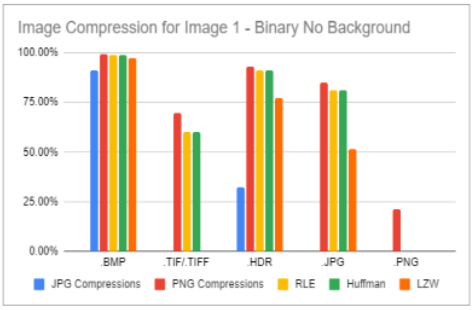

Fig. 14 Result Image Compression Binary Image without Background

From Fig. 14 can be seen that the results of PNG compression on the BMP file format type have a reduced ratio of 99.10 % with binary images.

IV. Conclusion

The results that have been carried out from images that use a background or do not use a background do not affect the results of the compression reduction ratio, as well as the type of image format with different file extensions used in this study.

For the Lossy Technique, the best quality reduction ratio is in RGB and Grayscale image types with the best value in BMP file types is 87.95% (JPG Compression), Grayscale in HDR file types 89.14% (JPG Compression) and 80.33 % (JPG

Compression) with a file type with the BMP extension (with an image using a background), whereas for an image without a background it produces almost the same value that the lossy technique has the best quality reduction ratio in the RGB image type with a value of 96.30% for the BMP file type (JPG Compression), 87.91% for grayscale image types with the BMP image file extension, 91.02% for the same file type, namely BMP (JPG Compression).

For the Lossless Technique, the best quality reduction ratio is in binary image types, whether using a background or not using a background, the best results obtained are 99.10% (PNG Compression) using the BMP file extension type.

JPG image file formats, both RGB and Grayscale, it is not recommended to use lossless and lossy compression techniques because the compression results are no better than the original file size based on the data used in this simulation data for data collect.

The results can produce an image compression process on binary images that produces the best value for the lossless compression technique. This relates to a more efficient value encoding process and the pixels in binary are black and white, making it easier to find redundancies and existing patterns, and the bottom line is that lossless techniques are simpler, easier, and more effective for binary image compression. without removing important information from the image used and in binary images, even small changes can change the meaning of the image significantly.

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