A New Method for Intelligent Multimedia Compression Based on Discrete Hartley Matrix

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Abstract

Multimedia data (video, audio, images) require storage space and transmission bandwidth when sent through social media networking. Despite rapid advances in the capabilities of digital communication systems, the high data size and data transfer bandwidth continue to exceed the capabilities of available technology, especially among social media users. The recent growth of multimedia-based web applications such as WhatsApp, Telegram, and Messenger has created a need for more efficient ways to compress media data. This is because the transmission speed of networks for multimedia data is relatively slow. In addition, there is a specific size for sending files via email or social networks, because much high-definition multimedia information can reach the Giga Byte size. Moreover, most smart cameras have high imaging resolution, which increases the bit rate of multimedia files of video, audio, and image. Therefore, the goal of data compression is to represent media (video, audio, images, etc.) as accurately as possible with the minimum number of bits (bit rate). Traditional data compression methods are complex for users. They require a high processing power for media data. This shows that most of the existing algorithms have loss in data during the process of compressing and decompressing data, with a high bitrate for media data (video, audio, and image). Therefore, this work describes a new method for media compression systems by discrete Hartley matrix (128) to get a high speed and low bit rate for compressing multimedia data. Finally, the results show that the proposed algorithm has a high-performance speed with a low bit rate for compression data, without losing any part of data (video, sound, and image). Furthermore, the majority of users of social media are satisfied with the data compression interactive system, with high performance and effectiveness in compressing multimedia data. This, in turn, will make it easier for users to easily send their files of video, audio, and images via social media networks.

Keywords: Multimedia Data; Social Media; Compression; Compression speed; Low BitRate

1. Introduction

Since the beginning of the computer era, data growth has accelerated to previously unheard-of levels. The rapid development of technology supported by software and applications allows information to be disseminated more and more rapidly via the Internet, especially the applications of social media around the world. In addition, the development of digital cameras with very high resolution increases the size of multimedia files of video, sound, and image [1]. However, not all information as video, audio, and images can be easily transmitted with the same resolution and size. Due to their large size with the limited transfer speed in the application of social networks [1,2]. Therefore, we need to figure out how to efficiently store large amounts of data in a limited space. There are two main components to the concept of data compression: lossy compression and lossless compression [3,4]. When a file is decompressed using lossless compression, all of the main data can be retrieved. It is assumed that no part of the file can be changed through the compression/decompression process. Therefore, the framework must ensure that all information is fully resaved [5]. This is done by choosing a parameter value that represents a compressed

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copy of the main file. In contrast, "lossy compression" describes scenarios in which some data is inevitably lost during the compression process [6]. In other words, when you unzip the file, only part of the main file remains. Moreover, almost all redundant information is usually removed [7,8]. Video data compression is one of the most significant uses of data compression. It is totally dependent on the analysis of each image in the actual video stream [9,10]. On the other side, audio data compression offers a wide range of useful uses, including cellular technology and digital audio storage. Sound compression allows long messages to be saved in a limited size of memory. Audio signals are typically sampled at a rate of 8K or 16K samples per second [10]. Using lossy compression schemes, the 8K rate, can be reduced to levels that are almost unrecognizable in speech. A key aspect of this paper is the use of compression schemes that somewhat reduces the amount of information lost in the audio signal. Ultimately the compression ratio is passed entirely in an array [10,11].

Therefore, many compression algorithm techniques can be applied to compressed data, such as Lempel-Ziv-Welch, Run-Length Encoding, Tunstall, and Shannon-Fano methods. As a result, existing compression algorithms are too slow with high bitrates of multimedia data [10–12]. Currently, there is no reliable solution to reliably compress multimedia data without data loss or low bitrates. Therefore, understanding multimedia compression requires a more thorough search of the literature. Thus, the new design of the proposed algorithm model focuses on multi-level compression and reconstruction of video, audio, and image, simultaneously improving performance, lossless reducing multimedia data bit size and compressing considering the data obtained are a low bit rate. Moreover, maintaining the resolution of multimedia compressed files of video, audio, and image, when transmitted through applications of social media networks.

2. Related Works

Many methods have been used in recent years with varying degrees of performance. Linear Predictive Coding (LPC) is widely used for signal compression [10]. However, The LPC approach is frequently employed in voice coding methods, a process that converts speech signals into a more compact form. Reference [10] suggests that using the LPC scheme results in a very lossy audio compression. That is to say not always does the input signal exactly match the output signal. A study in [11] suggested that the use of the when it comes to speech signal compression, the LPC approach plus quadrature phase shift keying (QPSK) modulation can easily outperform LPC systems. A hybrid lossless compression method using DWT, LPC, and Huffman is presented in ref. [12] for compressing medical images. System performance has been enhanced and compression ratios have been increased thanks to the integration of many methodologies.

The wavelet approach is another widely used method of audio compression. It is possible to separate an audio signal into its component frequencies by using wavelets depend on various positions and scales of the function of wavelet [13]. These frequency ranges represent the function coefficients that serve as the compression parameters. Choosing an appropriate wavelet function is a significant obstacle for wavelet compression techniques. In order to reduce the disparity between the input and output signals, picking the right mother wavelet is crucial [12–14].

For this reason, neural networks are also applied to the problem of image compression. A method described in [12] combines discrete wavelet coding and a neural network acting as a prediction system. It is suggested under this setup that a neural network can be used to make accurate predictions. The Fast Hartley Transform is utilised by researchers [15–17] to encrypt the audio stream into a significant number of coefficients. These coefficients are quantized and then encoded into a binary stream that represents the input signal's compressed form. Based on the findings, the fast Hartley transform is preferable to the wavelet transform when compressing voice samples [18,19]. The audio signal's compression technique was Pulse Code Modulation (PCM). Specifically, it was employed for the purpose of transforming analogue impulses into digital ones [20]. This technique quantizes each sample of the signal to the nearest integer within the bounds of the digital value at regular intervals. PCM, on the other hand, is susceptible to sampling limitations and quantization errors as compared to other approaches [15]. Ref. [21] has suggested a vocoder-based low-bit-rate solution to compress the spoken stream to the limit that the signal can be transmitted during transmission with a small bandwidth lines (such as military lines).

3. Methods

As shown in Figure (1), the method of the proposed compression algorithm can be summarized as follows.

Compression Media File:

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Phase 1: Input media data (video, audio, and image) into the system (the original File)

Phase 2: Convert video, audio, or image representations to frequency representations (Encoding Coefficients based on 0, and 1). This domain transformation reduces the bit rate of the media data by reducing redundancy, decorating the media samples, and concentrating most of the media signals on the lower frequencies.

Phase 3: The original multimedia file will be into fixed-length frames of data (128 array) to facilitate conversion to a 64*64 array based on the Hartley matrix (Square Hartley Matrix (SHM) of 128) by the following Equations:

Put x (n), and n=0 and 1 to N-1 a real value, the Discrete Hartley Transform based on:

$$V(N) = N\text{-}1 \sum N\text{-}1\ x(n)\left(\cos(2\pi kn/N) + \sin(2\pi kn/N)\right) \quad \text{……………… (1)}$$

Now, it can be represented in a matrix based on:

$$VN = (1/N) * HN, N * (N) * XN \quad \text{…………………………..…… (2)}$$

Here HN, N is the SHM of N:

$$H = \cos(2\pi kn / N) + \sin(2\pi kn / N) \quad \text{……………………… (3)}$$

k & n: integers (0 until N-1).

Phase 4: Convert frequency representation to the 0 and 1 coding by quantization and encoding data in the array.

Phase 5: Archive the compressed multimedia file into the file location.

A. Decompression Media File

Phase 1: Input decompressed media data (video, audio, and image) into the system.

Phase 2: To extract the compressed multimedia file (at decompressing), convert 0 and 1 coding of encoding coefficients inside the array to the frequency representation by disquantization and decoding the data

Phase 3: Based on decoding coefficients into the array, the system will recreate the original multimedia file by inverse square Hartley matrix of order (128) as in the below equation:

$$X(n) = \sum N\text{-}1\ V(N)\left(\cos(2\pi kn/N) + \sin(2\pi kn/N)\right) \quad \text{………………(4)}$$

The Hartley matrix can be invertible, therefore the Inverse Discrete Hartley Transform can be computed as in the below matrix equation:

$$XN = H\text{-}1\ N, N \times VN \quad \text{…………….………………...……… (5)}$$

The achieved error (E) based on the inversion of the matrix, the E of Hartley matrix can be:

$$E = \| HN,N \times H\text{-}1\ N, N \| - \| IN,N \| \quad \text{……………….…………(6)}$$

I N, N: identity matrix for N.

Phase 4: Phase 4: The original media file is restored with the same size before compression, by converting representations 0, and 1 (Encoding Coefficients) to the original media data of video, sound, and image.

Phase 5: Reconstruct the original file of media and extract the compressed media file to the Storage Location.

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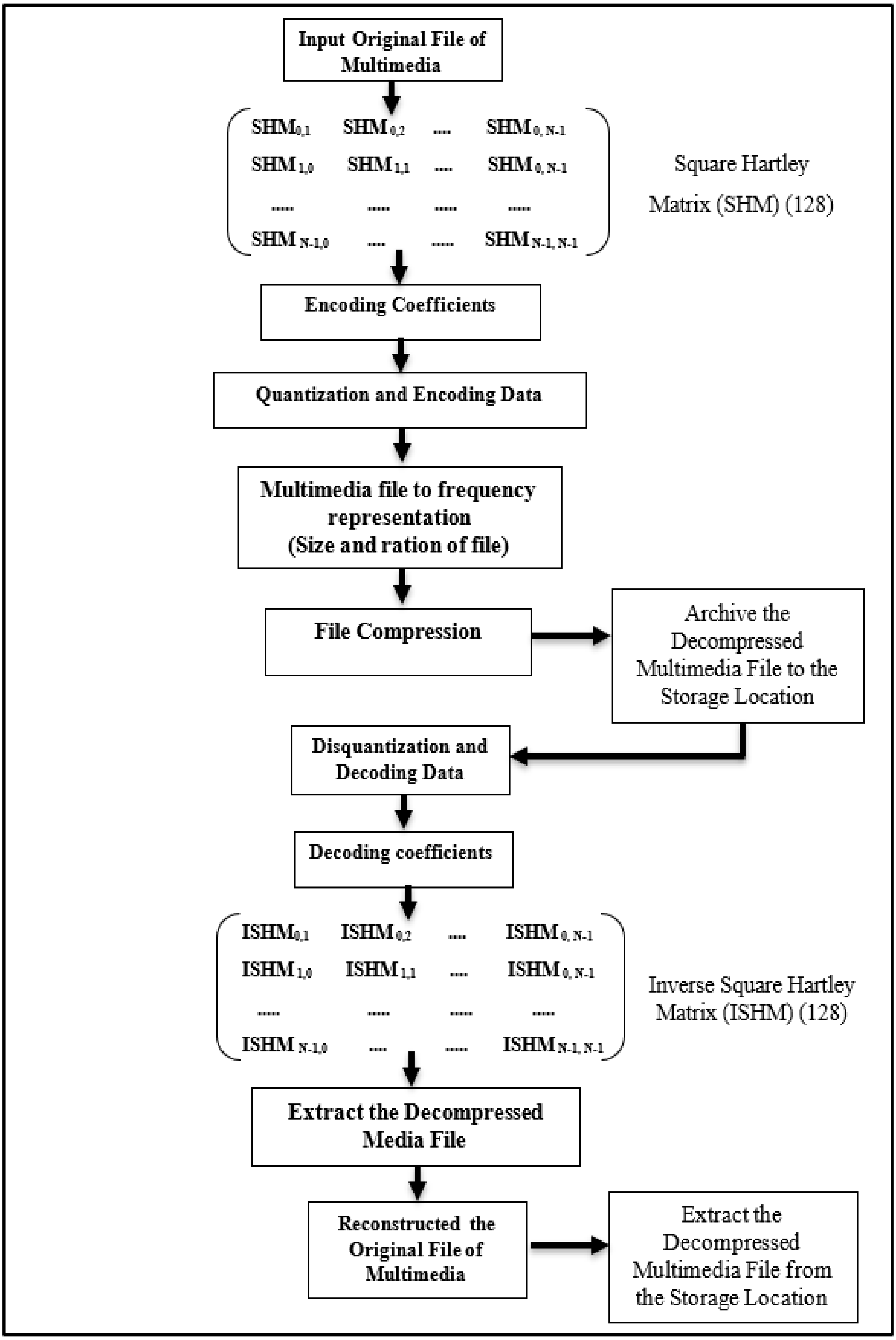

Figure 1. Method of the Proposed Algorithm

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4. The Proposed Algorithm

This proposed algorithm was designed by JavaScript through Node.js Zlib module, which is used to provide compression and decompression functionalities. It is implemented using Gzip and deflate/inflate. In addition, video, sounds, and image are important elements in compression and decompression application. Thus, the most libraries of the JavaScript are related to video, sound, and image imported to java applet library to enhance the effectiveness of the program [17].

Components and features collected from the literature are used to design media compression systems. Figures 2 and 3 respectively, show the multimedia compression and decompression interfaces in the proposed algorithm. On the other hand, the design of the model's user interface (multimedia compression and compression system) should take into account usability principles. This is due to the fact that an intuitive interface is a key factor in the user satisfaction. In addition, interface functionality and characteristics are important factors affecting interaction and control of system content.

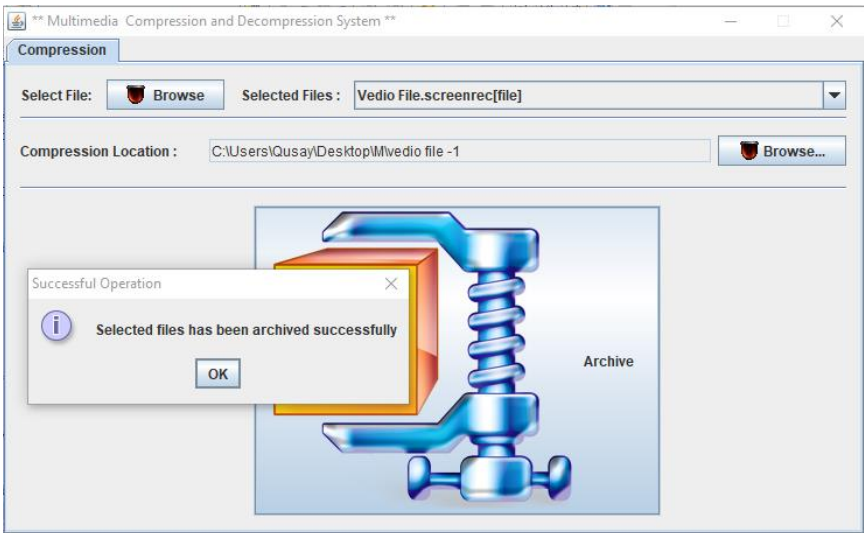

Figure 2. Compression Multimedia File

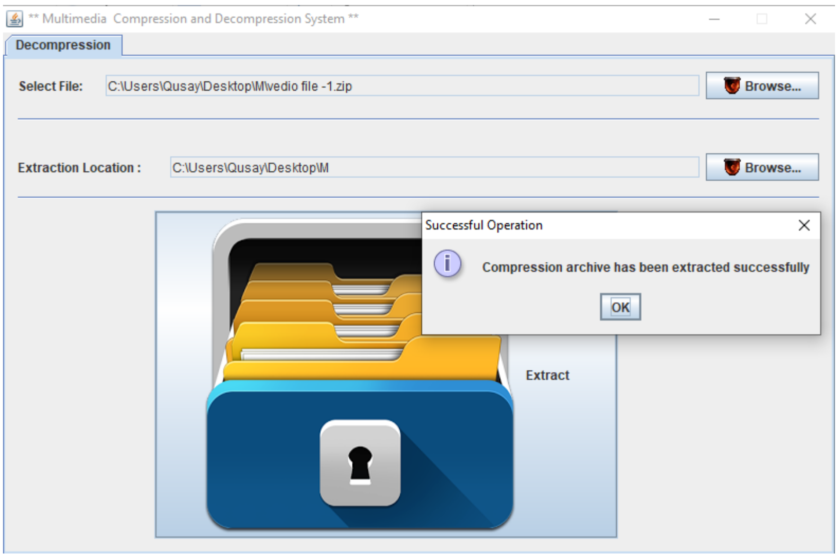

Figure 3. Decompression Multimedia File

The sub-features in the system such as selecting files, compression location, and decompression location should be available in all system activities and can be easily used by the user.

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5. Results And Discussion

The evaluation of the proposed algorithm was based on two phases: First is media file testing for Video, sound, and Image based on data size and loss, and the second is a questionnaire by social media users.

A. First Phase: Media File Testing

The execution of the proposed algorithm has been applied by many levels of the discrete Hartley matrix (matrix and inverse), implemented by using Java programming. According to Table 1, it can be seen the original, compression, and decompression file size results of media files (Video, Sound, and Image).

Table 1: Results of Media File Testing

File Type	Original File Size (Mb)	Compression File Size (Mb)	Decompression File Size (Mb)	bit Loss
Video	50	15	50	0%
Sound	23	8	23	0%
Image	6	1.5	6	0%

Where the obtained compression ratios for the video, sound, and image are 15, 8, and 1.5 Mb respectively, without any loss in data. Based on the size of the original files it was 50, 23, and 6 respectively, as in Figure 4. This indicates that the proposed algorithm has a high performance (low bit rate) with zero loss in data.

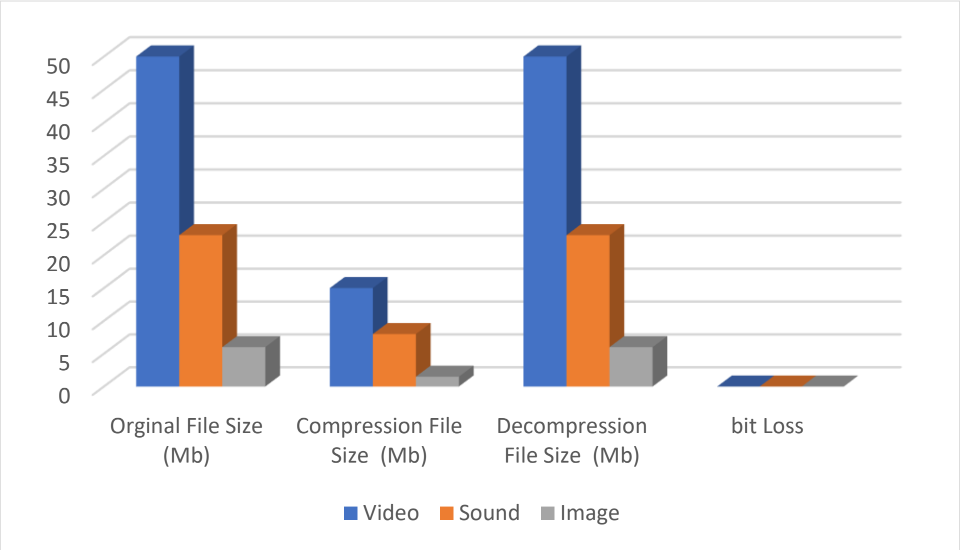

Figure 4. Results of Media File Testing

B. Second Phase: Questionnaire by the social media users

The design of the media data compression algorithm is tested and evaluated to get the benefits of a low bit rate with high-speed compression for multimedia files. The evaluation of the proposed algorithm was done by a questionnaire form to test the proposed design according to its efficiency in compressing and decompressing multimedia files based on two criteria: size (bit rate) and speed (time).

The research sample was selected based on three groups of participants who used the social media applications (WhatsApp, TelegramApp, and Messenger) to send their multimedia files. This test was based on Mean and Std. Deviation to measure the extent to which there are significant differences among the users (groups) during the use of the proposed algorithm. To determine the effectiveness of the proposed algorithm, the size (bit rate) and speed (Time) of the compressed media files are based on. Moreover, every group was statistically tested individually as reported in Table 2, Figure 5, Table 3, Figure 6, Table 4, and Figure 7 respectively.

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B. WhatsApp Group

Table 2: Results of WhatsApp Group

Criteria of Media compression and decompression	Group	N	Mean	Std. Deviation
size (low bit rate)	WhatsApp	25	4.8690	0.4145
speed (compression and decompression Time)	WhatsApp	25	4.9966	0.4783

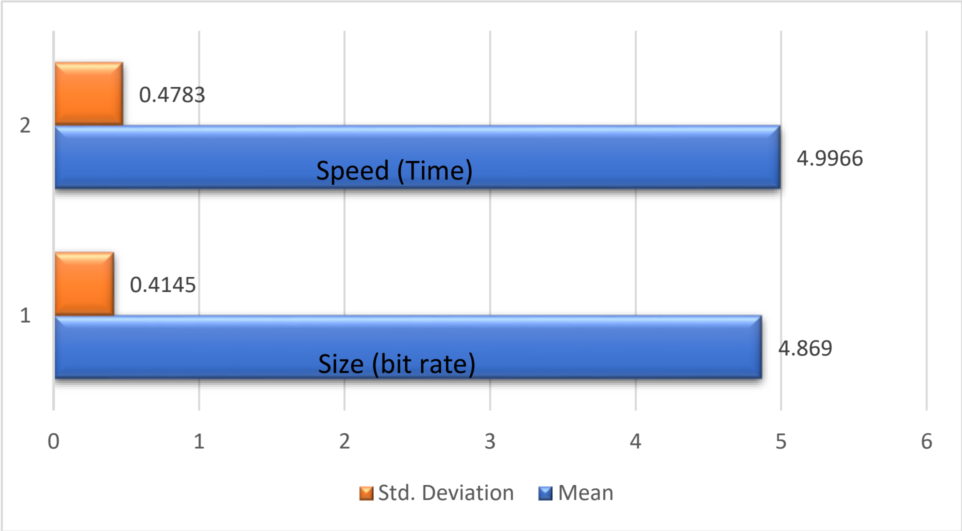

Figure 5. Results of WhatsApp Group

C. Telegram Group

Table 3: Results of Telegram Group

Criteria of Media compression and decompression	Group	N	Mean	Std. Deviation
size (low bit rate)	Telegram	25	4.0169	0.43585
speed (compression and decompression Time)	Telegram	25	4.8886	0.42623

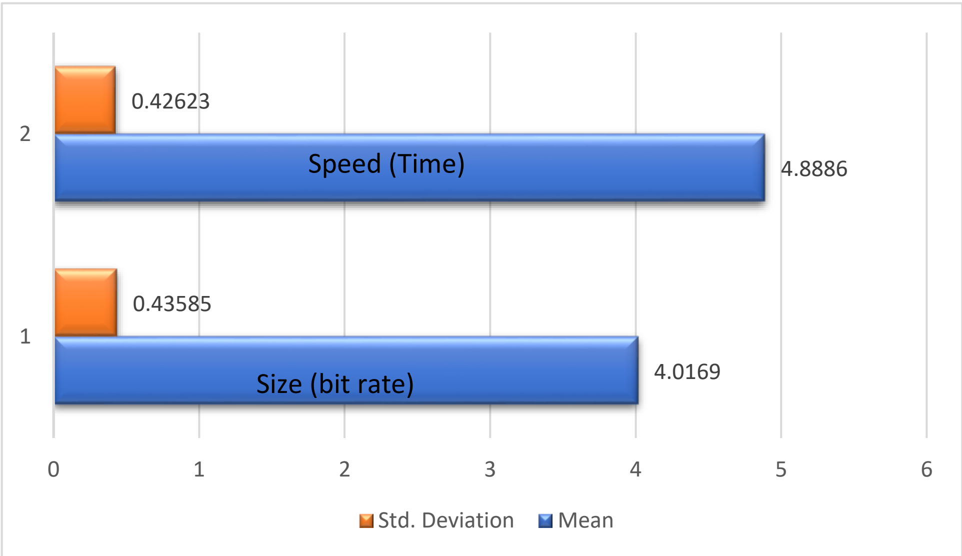

Figure 6. Results of Telegram Group

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D. Messenger Group

Table 4: Results of Messenger Group

Criteria of Media compression and decompression	Group	N	Mean	Std. Deviation
size (low bit rate)	Messenger	25	4.3169	0.34015
speed (compression and decompression Time)	Messenger	25	4.7886	0.43313

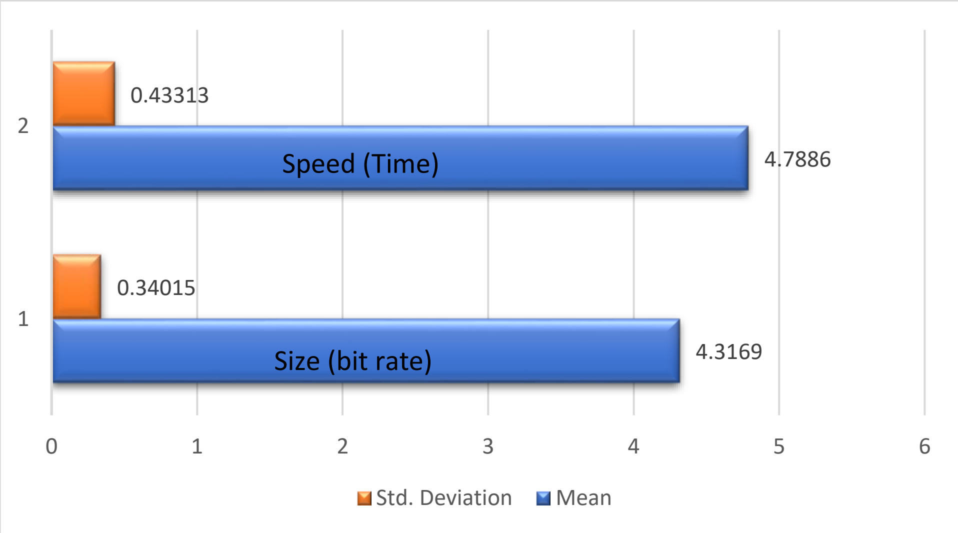

Figure 7. Results of Messenger Group

Tables 2, 3, and 4 respectively show that the means and the standard deviation of the three groups (WhatsApp, TelegramApp, and Messenger) are convergent in their results (the low bit rate of the size is bteween 4.8690 - 4.3169, and the compression time of the speed is between 4.9966 - 4.8886). They are also convergent in their results of the standard deviation. Thus, this indicates that there is no difference in the users' opinions about the effectiveness of the proposed algorithm that is related to the compressed files size (low bit rate) and the compressed files speed (Time) as displayed in Figure 5 that includes the result of the three groups.

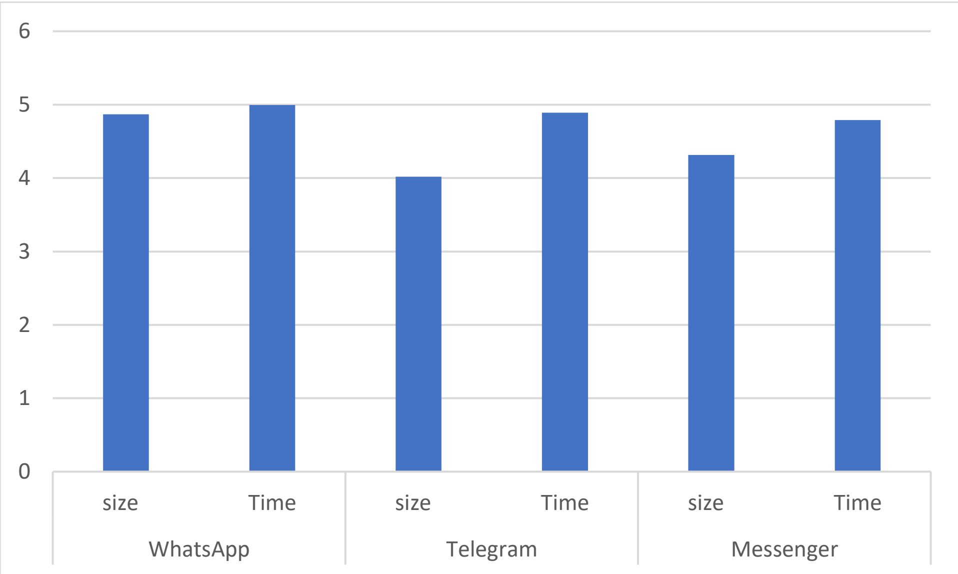

Figure 8. Final Result of three Groups

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6. Conclusions

This study introduced a new method of multimedia compression of video, audio, and image based on a discrete Hartley matrix that included array 128. This method of algorithm provided a new compression process that was characterized by high-speed processing during compression and decompression for media data, with low bitrate for data. And this will help social media users send their files via social media applications with ease and flexibility. Finally, the results of the proposed algorithm for media compression, achieve low bit rates and high speeds for the compressed data. It can be concluded that the obtained results support the efficiency of the system in compressing from a big size of media data to a small size in a short time. This makes it easy for social media users to send their media files with high flexibility via telecom networking or the web.

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