Digital Video Watermarking for Copyright Labelling

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Abstract—The use of multimedia content in the internet is now growing, especially in digital video. Counterfeit, fraud, and plundering of video content cause problem because of resource supply for sharing contents. Copyright becomes crucial matter in digital video to avoid manipulation of the irresponsible ones. There are many ways to do for labelling copyright into a video. One of them is digital watermarking. Digital watermaking is used to prevent illegal replication or exploitation of digital content, protect digital content, and avoid multimedia manipulation illegally. The use of several methods such as Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT), and Discrete Fourier Transform (DFT) for labelling copyright of video will be compared based on the imperceptibility and robustness after several manipulations applied into inserted-watermark video. From the point of imperceptibility, DWT method results PSNR value at 45, 62435 dB, DCT method results PSNR value at 45,89422 dB, and DFT method results PSNR value at 45, 77747 dB. The PSNR mean from these three methods is 45,76535 dB. It means that the inserted-watermark video appears similar to the intercalated one. Thus, from the experiment, it can be sum up that the implemented DWT, DCT, and DFT method show that the watermarked video still in a good quality that it is reasonable and meets the imperceptibility. From the point of robustness, the NC mean of DCT method is 0,63974, DCT method is 0,755839, and DFT method is 0,745442. It tells that the result of watermark extraction from these three methods is the same as the original watermark. In other word, all of the watermarks on these three methods can be well extracted though the attacks are delivered to them. From the level of imperceptibility and robustness test on DWT, DCT, and DFT method, it can be said that DCT method is better than DWT and DFT method because it performs a high value on PSNR and NC.

Keywords-Digital Watermarking; DWT; DCT; DFT, PSNR; NC

I. INTRODUCTION

In this rapid era of technology, internet becomes one of information sources for people [1]. With the development of multimedia and internet, digital distribution and transmission are getting easier. The use of multimedia content is growing in the internet, especially digital video. Today, counterfeit, fraud, and plundering of video content cause problem. The technology of video is one of important technologies in multimedia communication in which the video provides information that completes other media such as image, text, and voice. The benefit of technology has been applied in application on several fields such as education, health, entertainment, bussiness, infromation, etc. It becomes new challenges to protect video distribution. Today, the protection of digital multimedia is very important because the resource supply for sharing contents illegally such as video, music, audio, and image [2]. Now, safety becomes one of important parts because it is related to the copyright of digital content to guarantee the ownership identification.

Copyright becomes crucial matter in digital video to avoid manipulation of the irresponsible ones. There are many ways to do for protecting copyright on distribution of electronic and multimedia information and publication by internet. One of techniques which can be used to protect copyright of digital video is watermarking [4] [5]. According to [6] the information can be in the form of digital image, audio, or video. In multimedia platform, digital watermarking becomes efficient technology in protecting data of digital video [7]. Digital watermarking is used to prevent illegal replication or exploitation of digital content and avoid the multimedia manipulation illegally [8]. Digital watermarking refers to insertion in multimedia document and file continually to protect them from illegal copying and identifies manipulation [9]. Watermarking technique used colored image as copyright protection from video and watermarking color which is implemented into video in invisible form. Invisible watermarking is a kind of technology which can solve the problem of copyright [4]. Ownership identification and hidden information use several methods such as Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT), Discrete Fourier Transform (DFT). The researcher will
There is a problem with the provided text. It seems to be a page from a document, but the text is not clearly legible or formatted correctly. It appears to be discussing watermarking techniques and their robustness against various types of attacks. The text mentions comparing different methods based on imperceptibility and robustness. It also talks about related works, research methods, and the implementation of watermarking using Transformasi Wavelet Diskrit (TWD). The method selected for watermarking was DCT, and the research selected this method because it showed a higher efficiency in terms of imperceptibility and robustness.

II. RELATED WORKS

According to [10], watermarking using Transformasi Wavelet Diskrit (TWD) had a quite good quality because the image of insertion inside the video was not visually seen. But after the extraction, the inserted image could be identified and the PNSR value was quite good with the maximal value almost at 30 dB. The calculation of PNSR showed that the original video and the watermarked video were almost similar so that it visually could not be differentiated. Based on [11], DFT method is resist toward attacks like cropping, resize and editing, and also it produced a low value of changing percentage on NPCR and UACI testing. It reached a high value on PSNR testing as well.

Based on [12], by using DWT, DCT, and SS method, the result of system testing using layer blue, sub band LL, mother wavelet dB and the measurement rate of 80% had average PNSR value at 86,9216 dB, MSE value at 27,39059667 and BER value at 0,162519. The system could endure well toward attack of Noise Gaussian Blur. According to [7], the proposed DWT technique showed a high efficiency and was proved that it was able to endure toward several attacks such as Gaussian, salt and pepper, rotation, frame dropping, cropping and averaging. The proposed technique also showed a high imperceptibility in which there was no visual degradation seen inside the video clip after the watermark implemented and extracted with average PNSR, all watermarks frame were 57.3118. There was no quality decline on PNSR which was marked by watermark.

According to [8], DWT was used as the domain of insertion or watermark extraction. The firm of this technique was tested by implementing any kinds of attacks such as geometric, noise, compression format, and attack of image processing. The result of simulation showed the effectivity and good performance and also could save the system resource, memory capacity, and bandwidth of communication. Based on [13], the main benefit of DWT and DCT method were strong and resist toward any kinds of attacks such as image cropping, rotation, Gaussian noise, salt and pepper noise, poison’s noise, speckle noise with implementation of result showed that the inserted video was really good with high PSNR.

Based on [4], the performance analysis of invisible watermarking could be measured by comparing Mean Square Error (MSE) dan PNSR because each of them implanted and extracted image. Based on Nagajyothi and KrJain (2020) the analysis was shown by different matrix such as PNSR to measure the transparant effect with value of 160,7011 dB. Besides, the other matrices such as MSE and NCC were to describe the watermark quality with similar measurement. The MSE value for proposed approach was 0,0068 and 1 for NCC which proved that the watermarked image was free from attacks.

According to [14], the proposed system might cause watermarking by using DCT which had a higher embedding capacity and gave a better result with a high accuracy. The framework was based on Hartung technique which was dependent on spectrum spread communication in issue. The result of the experiment considered several JPEG-compression approaches, geometric distortion and noise. The result showed a good performance toward the proposed method, the provided technique not only for MPEG-2 video but also for coding video DCT and many others such as MPEG-1, H261 and H 26[15].

According to [1], the research selected DCT as the method because this method was firmer toward image manipulation, especially the compression. The watermark insertion is conducted toward high frequency of coefisien of DCT. The JPEG compression testing toward the watermarked image produced watermarked image which resist toward compression until 50% and resulted a quite high PNSR value of 30 dB. The testing in the form of screen capture resulted watermark image in low quality with average PNSR value at 25 dB. In the testing of image in the form of cropping, the watermark image will disappear in the cropped area. The testing in the form of color changing and text addition produced watermarked image extraction with a good quality of imperceptibility. However, the watermarked image had a low value of PSNR because its value was under 30 dB. But in the background changing and filter addition in the form of emboss and blur filter, it produced an extraction of poor watermark image. It was because of poor PSNR value or the value was under 15 dB.

III. RESEARCH METHODS

This research will be done through several steps as follows:

A. Collecting Literature

It aims at collecting complete literature about the topic observed. Collecting the literature is conducted by searching books, journals, and thesis related to the topic observed. Based on the collected materials, it is then conducted the developing toward watermarking algorithm which will be observed.

B. Analyzing and Designing Software

At this step, flowchart is arranged based on algorithm which will be improved. The arrangement of flowchart aims at easing the software arrangement. The analysis can also be done by creating Data Flow Diagram (DFD) of improved software. The arrangement is made by creating face-to-face design between software and the arrangement of procedures which will be used.

C. Arranging Software

The result of flowchart design then is implemented using Matlab R2013a. The arrangement of software goes through process of embedding, attacking, and extracting.

D. Testing of Software

The arranged software is then tested using the data of the selected video. At this step, the testing is conducted to identify whether the software has already worked as it is planned. And a revision can be conducted if it is out of the plan.
D. Variable
The data which will be used in this research are a video and image.

E. Method of Analyzing
There are three main processes: process of embedding, attacking, and extracting.

In the embedding process, the image of watermark appears as image in the form of copyright message which will be inserted inside a video and the original video as the original video which will be inserted with copyright message. Image of watermark and original video which are included into digital watermark system results watermarked video in which the video contains watermark in the form of image.

In the attacking process, attacks are added to the already-watermarked video in order to result the already-watermarked video which has been added with attacks to analyze the influence of attacks toward video.

In the extracting process, the watermark of watermarked video which contains attacks is described to identify the influence of attacks toward watermark image.

IV. FINDINGS AND DISCUSSION
In the testing of video watermarking program with Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT), and Discrete Fourier Transform (DFT) method, it is used a mp4 extended video host as can be seen in Figure. 4. The video host used as testing sample is a mp4 video host. Figure.5 is the image used as the image of watermark which has jpg. extension.

After the watermark insertion in the video host is done and the watermarked video is obtained, then it is followed by two kinds of testing, imperceptibility and robustness testing.

A. Testing in Imperceptibility Level
The inserted watermark should not damage the quality of video host. To understand the influence of watermark insertion toward the quality of video host, Peak Signal Noise Ratio (PSNR) is used in the imperceptibility testing.

PSNR uses a logarithmic scale with decibel to evaluate the similarity between video host and watermarked video. The higher the PSNR value, the better the quality of watermark video. The PSNR value under 30 dB shows a poor quality of video and it is not qualified. This following Table 1 is the result of imperceptibility testing which purposes to find out the sensitivity of human vision sensory on detecting the difference between the host and watermarked video.

| METHOD                                | PSNR       |
|---------------------------------------|------------|
| Discrete Wavelet Transform (DWT)      | 45.6235 dB |
| Discrete Cosine Transform (DCT)       | 45.8922 dB |
| Discrete Fourier Transform (DFT)      | 45.7747 dB |

Based on the result of imperceptibility testing, DWT method has PSNR value at 45.6235 dB, DCT method results PSNR value at 45.89422 dB, and DFT method gets PSNR value at 45.77474 dB. From these three methods, the mean of PNSR value is 45.76535 dB which means that the inserted-watermark video visually seems similar to the intercalated one. Thus, from this testing, it can be concluded that the implemented DWT, DCT, and DFT method show that the watermarked video is still in the reasonable quality and meets the imperceptibility factor.
TABLE 2. RESULT OF WATERMARK INSERTION INTO HOST VIDEO

| Method | Video Host | Watermark Image | Watermark Video |
|--------|------------|-----------------|-----------------|
| DWT    | ![Watermark DWT](image) | ![Watermark Image DWT](image) | ![Watermark Video DWT](image) |
| DCT    | ![Watermark DCT](image) | ![Watermark Image DCT](image) | ![Watermark Video DCT](image) |
| DFT    | ![Watermark DFT](image) | ![Watermark Image DFT](image) | ![Watermark Video DFT](image) |

The result shown in the Table 2 is the video host which has been inserted with watermark image. Visually, it is similar to the original video host. Besides, the inserted watermark does not appear (invisible). It means that the inserted watermark is well stored and does not damage the video quality. The detected PSNR value can also prove that the method used in this research has a good level of imperceptibility.

B. Testing in Robustness Level

Robustness testing aims at detecting the resistance level of watermark when it is added by several attacks -in the form of digital image processing- which try to delete or throw the watermark away from the watermark video. The resistance can be detected from how high the possibility of watermark can be called back during the extracting process. To find out the possibility, Normalized Correction (NC) is used to count it. NC value is reached by extracting the watermark from the watermarked video. NC indicates the similarity of watermark before and after the attacks are added on it. It also can be mentioned as the level of watermark extraction. The higher the NC value, the more similar the original watermark and the attacked one. NC value is in the range of 0 and 1. 0 value means that the attacked watermark has no similarity at all to the original one. In contrast, 1 value tells that both of the compared images are exactly similar.

In this robustness experiment, the previous attacks are applied in this watermark image. The applied attacks is in the form of digital image such as speckle noise, Gaussian noise, histogram equalization, contrast adjustment, salt and pepper noise, framing dropping, frame swapping, frame averaging, jpeg compression, resizing, rotation, gamma correction, and median filtering.

TABLE 3. RESULT OF WATERMARK INSERTION BEFORE ATTACK DELIVERING

| Method | NC Value of Watermark Before Attacks Delivering |
|--------|-----------------------------------------------|
| Discrete Wavelet Transform (DWT) | 0.538985 |
| Discrete Cosine Transform (DCT) | 0.755901 |
| Discrete Fourier Transform (DFT) | 0.751341 |

Table 3 shows the level of reverting the watermark through DCT method is higher than through DWT and DFT. It means that extracting the watermark through DCT method is better than through DWT and DFT when the attacks are not delivered yet. The mean of watermark similarity between the original and the extracted one by these three method is 0.682076. It shows a good watermark reverting value. It also causes the original watermark and the extracted one quite similar.

The next step is delivering attacks to the watermarked image and counting the NC value by extracting the watermark. The NC value resulted from the robustness experiment through DWT method toward several attacks is showed in the following Table 4.

TABLE 4. RESULT OF ROBUSTNESS TEST THROUGH DWT METHOD USING NC

| Types of Attacks      | Value of Normalized Correction (NC) |
|-----------------------|-------------------------------------|
| Speckle noise         | 0.75952                             |
| Gaussian noise        | 0.67832                             |
| Histogram equalization| 0.51537                             |
| Contrast adjustment   | 0.48471                             |
| Salt and pepper noise | 0.52503                             |
| Poisson noise         | 0.62658                             |
| Frame dropping        | 0.665                               |
| Frame swapping        | 0.705                               |
| Frame averaging       | 0.56599                             |
| Jpeg compression      | 0.63745                             |
| Resizing              | 0.61702                             |
| Rotation              | 0.7193                              |
| Gamma correction      | 0.78775                             |
| Median filtering      | 0.66937                             |
Table 4, overall, the NC value is 0.63974 in average. It means that the result of extraction is similar to the original one. In other word, through the DWT method, all of the watermarks can be well extracted though the attacks are delivered to them.

**TABLE 5. EXTRACTION RESULT OF WATERMARK AND FRAME OF VIDEO AFTER ATTACKS DELIVERING**

| Types of Attacks   | Result of Extracted Watermark | Frame of Video After Attacks Delivering |
|--------------------|-------------------------------|----------------------------------------|
| Speckle noise      |                               |                                        |
| Gaussian noise     |                               |                                        |
| Histogram equalization |                           |                                        |
| Contrast adjustment |                               |                                        |
| Poisson noise      |                               |                                        |
| Frame dropping     |                               |                                        |
| Histogram equalization |                           |                                        |
| Frame swapping     |                               |                                        |
Table 6, overall, the NC value is 0.755839 in average. It means that the result of extraction is similar to the original one. In other word, through the DCT method, all of the watermarks can be well extracted though the attacks are delivered to them.

Table 6. Result of Robustness Test Through DCT Method Using NC

| Types of Attack       | Nilai Normalized Correction (NC) |
|-----------------------|----------------------------------|
| Speckle noise         | 0.74976                          |
| Gaussian noise        | 0.76531                          |
| Histogram equalization| 0.75431                          |
| Contrast adjustment   | 0.78304                          |
| Salt and pepper noise | 0.7689                           |
| Poisson noise         | 0.73749                          |
| Frame dropping        | 0.75752                          |
| Frame swapping        | 0.70526                          |
| Frame averaging       | 0.74203                          |
| Jpeg compression      | 0.77453                          |
| Resizing              | 0.78494                          |
| Rotation              | 0.7417                           |
| Gamma correction      | 0.74574                          |
| Median filtering      | 0.77122                          |

Table 7. Extraction Result of Watermark and Frame of Video After Attacks Delivering

| Types of Attacks | Result of Watermark Extraction | Frame of Video After Attacks Delivering |
|------------------|--------------------------------|----------------------------------------|
| Speckle noise    |                                |                                        |
| Gaussian noise                  | Frame dropping                     |
|--------------------------------|------------------------------------|
| Stained glass                  | Frame swapping                     |
| Contrast adjustment            | Frame averaging                    |
| Salt and pepper noise          | Jpeg compression                   |
| Poisson noise                  | Resizing                           |
The NC value resulted from the robustness experiment through DFT method toward several attacks is shown in the following Table 8.

**TABLE 8. RESULT OF ROBUSTNESS TEST THROUGH DFT METHOD USING NC**

| Types of Attacks                      | Value of Normalized Correction (NC) |
|---------------------------------------|-------------------------------------|
| Speckle noise                         | 0.71039                             |
| Gaussian noise                        | 0.70341                             |
| Histogram equalization                | 0.74907                             |
| Contrast adjustment                   | 0.71176                             |
| Salt and pepper noise                 | 0.76082                             |
| Poisson noise                         | 0.75585                             |
| Frame dropping                        | 0.73329                             |
| Frame swapping                        | 0.78178                             |
| Frame averaging                       | 0.71653                             |
| Jpeg compression                      | 0.79964                             |
| Resizing                              | 0.71289                             |
| Rotation                              | 0.7833                              |
| Gamma correction                      | 0.73832                             |
| Median filtering                      | 0.77914                             |

Table 8, overall, the NC value is 0.745442 in average. It means that the result of extraction is similar to the original one. In other word, through the DWT method, all of the watermarks can be well extracted though the attacks are delivered to them.

**TABLE 9. RESULT OF WATERMARK EXTRACTION AND VIDEO FRAME AFTER ATTACKS DELIVERING**

| Types of Attacks | Result of Watermark Extraction | Frame of Video After Attacks Delivering |
|------------------|--------------------------------|-----------------------------------------|
| Speckle noise    | ![Speckle noise](image1)        | ![Frame after attacks delivering](image2) |
| Gaussian noise   | ![Gaussian noise](image3)       | ![Frame after attacks delivering](image4) |
| Histogram equalization | ![Histogram equalization](image5) | ![Frame after attacks delivering](image6) |
| Contrast adjustment | ![Contrast adjustment](image7)  | ![Frame after attacks delivering](image8) |
| Salt and pepper noise | ![Salt and pepper noise](image9) | ![Frame after attacks delivering](image10) |
| Poisson noise    | ![Poisson noise](image11)       | ![Frame after attacks delivering](image12) |
| Frame dropping   | ![Frame dropping](image13)      | ![Frame after attacks delivering](image14) |
| Frame swapping   | ![Frame swapping](image15)      | ![Frame after attacks delivering](image16) |
| Frame averaging  | ![Frame averaging](image17)     | ![Frame after attacks delivering](image18) |
| Jpeg compression | ![Jpeg compression](image19)    | ![Frame after attacks delivering](image20) |
| Resizing         | ![Resizing](image21)            | ![Frame after attacks delivering](image22) |
| Rotation         | ![Rotation](image23)            | ![Frame after attacks delivering](image24) |
| Gamma correction | ![Gamma correction](image25)    | ![Frame after attacks delivering](image26) |
| Median filtering | ![Median filtering](image27)    | ![Frame after attacks delivering](image28) |
| Salt and pepper noise | Jpeg compression | Median filtering |
|-----------------------|-----------------|-----------------|
| Poisson noise         | Resizing        | Gamma correction|
| Frame dropping        | Rotation        |                 |
| Frame swapping        |                 |                 |
| Frame averaging       |                 |                 |
V. CONCLUSION

Based on the experiment conducted in this research, it can be concluded that:

1) From the point of imperceptibility, DWT method results PSNR value at 45, 62435 dB, DCT method results PSNR value at 45, 89422 dB, and DFT method results PSNR value at 45, 77747 dB. The PSNR mean from these three methods is 45,7635 dB. It means that the inserted-watermark video appears similar to the intercalated one. Thus, from the experiment, it can be sum up that the implemented DWT, DCT, and DFT method show that the quality of watermarked video still in good quality. It means that it is reasonable and meets the imperceptibility.

2) From the point of robustness, the NC mean of DCT method is 0,63974, DCT method is 0,755839, and DFT method is 0,745442. It tells that the result of watermark extraction from these three methods is the same as the original watermark. In other word, all of the watermarks on these three methods can be well extracted though the attack are delivered to them.

3) From the level of imperceptibility and robustness test on DWT, DCT, AND DFT method, it can be said that DCT method is better than DWT and DFT method because it gets a high value on PSNR and NC.

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