THERMAL IMAGE STEGANOGRAPHY ON MULTIMEDIA DATA USING PIXEL VALUE DIFFERENCING ALGORITHM

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ABSTRACT

In this research, the Pixel Value Differencing (PVD) algorithm is implemented and analyzed in multimedia content and verified for the best possibility to hide the secret data or the payload in a thermal image, without spoiling the essence of maintaining the innocence of the original file and providing no clue of the existence of the data in it. Based on the range and width the PVD is processed to provide large capacity and high imperceptibility. In this paper a new approach of pixel wise analysis is performed for steganographic purpose only on the low intensity colored pixel, and are fused with the multimedia contents like Text, Image, Audio and Video. The Steganography on thermal images that are fused with the multimedia content is found to provide better image clarity with high capacity; this in turn depends on the cover image used which is carefully done; further adequate theoretical analysis is also presented.

Keywords*—PVD Algorithm, Thermal Image, Multimedia Content, PSNR, MSE, Capacity and Quantity.*

I. INTRODUCTION

Human brain can easily interpret, perceive and process information of image very easily (visual information) as 1/3rd of its power is dedicated to visual information processing. Instead, the image processing techniques performance process like image acquisition, storage, enhancement, restoration, preprocessing and transmission. Transformation techniques could be applied to an image that could convert it from one domain to another. A set of protocols or procedure programmed to perform many complex operations or functions to convert and generate the sophisticated performances.

Digital Image Processing (DIP) is the only practical technology for classification, feature extraction, multi-scale signal analysis, pattern recognition, and projection of Images which is performed using various task like using image editing, restoration pixilation, point feature matching were in demand of secret data transmission with ultimate security. Fortunately, securing techniques are implemented throughout the images, like in all the pixels in an image, irrespective of the resolution. Hence in this research, only few pixels of low intensity are selected and manipulated to hold the secret data. This helps in overcoming the techniques used by intrigue hackers [1].

Several research methodologies implement the data hiding process in an image using compressed and transform based technique, but when embedding is intended to hide the secret data directly into the pixel is less complex and highly combustive than the other techniques [17-22].

The research work of Junk [xx – J Real Time Image Proc.14:127-36, 2018] was the first to implement PVD and LSB simultaneously on a single image, but it was not an adaptive method since it does not consider the vertical and diagonal edges of the image to hide data. Later, Samayveer Singh [16] proposed an advanced scheme of analyzing the vertical, diagonal and horizontal edges to hide secret data in large amount without any perceived change. However, the multimedia contents security has become a serious concern in the public medium, Internet [15]. The LSB and PVD are the most popular spatial-domain based data hiding technique [16], that are simple and easy to embed but it may cause frequency attacks on the stego image. Wu and Tsai [23] proposed a PVD approach to hide a secret message into gray-valued images by determining the difference of each pair of the pixels and embed into the cover image using the vertical, horizontal and diagonal edges without perceiving any change. The quality of the image at the receiver end is analyzed with the measurements of PSNR and MSE. The following section presents the research in various aspects and it is discussed, formulated in detail

II. METHODOLOGY

- Embedding using PVD algorithm is made by dividing the cover images (i.e., thermal image) into adjacent non-overlapping pixels.
- Existing hybrid schemes implemented on all the pixels of the cover image, considering vertical, horizontal and diagonal edges to increase the capacity.
- In this paper, the existing algorithm is replaced with the proposed scheme by selecting the region of interest based on the color component available in the cover image.
- The stego image is hidden in the multimedia components like text, audio, image and video to analyze the capacity, robustness without reducing the quality of the innocent image.
- Since the secret data is appended only in few pixels of the cover image, the decoding may require several iterations even for the desired receiver. To solve this issue, the steganography is implemented only in the low intensity colors available in the thermal image, say blue, which has 3% visibility comparatively with red and green.

Basically, the algorithm uses the difference value between the two consecutive pixels in a block, in order to determine how many secret bits shall be embedded. Therefore, the number of bits that could be embedded to the maximum in every channel that an image possessed is decided by PVD algorithm [2]. Every thermal image has 3 basic colors say Red, Green and Blue. The secret data is aimed to append or can be fused onto any of the colors. In this paper, fusion was done on Red color with the data which might be an image, Text; audio and video were analyzed on its capacity and robustness. Adharsh et al, stated that the embedding capacity is moderate while with random selection process imperceptibility is reported high [3].

III. LITERATURE REVIEW

In this section, the existing least significant bit substitution and pixel value differencing methods which are frequently used in steganography process is discussed. In [23] the secret message (an image) is embedded into the least significant bit of the pixels in the cover image. The maximum number of pixels or LSBs required to hide the secret data is decided based on the length of the data be hidden. To overcome this an optimized pixel adjustment procedure (OPAP) method is used and it provides better quality when a smaller number of bits are involved to hide data, but for large number of bits it provides distortion [24]. Das et al. discuss an LSB based data hiding method using extended LBP [25] which is an extension of [24]. Later, a number of methods using PVD technique [26, 27, 28, 29, 30, 31and 34] have been proposed to improve hiding capacity as well as the quality of the stego image, by dividing the cover image into non-overlapping blocks with two pixels and the difference those pixel values is used for embedding process. This scheme provides high hiding capacity; but unfortunate the quality of the image received is not so appreciable.

This paper discusses a method in which the multimedia content is used to hide the secret information without applying any compression techniques but only few pixels are selected in an image especially with low intensity. Prema et al. discussed image steganography using modified PVD in [29] where image is decomposed into non overlapping blocks of two consecutive pixels. Swain in [30] suggested two adaptive PVD based steganography to improvise the data hiding capacity and high PSNR. The existing techniques of data hiding schemes provide either good capacity or quality. To address this issue, and to increase the robustness the research is extended towards all the multimedia component integrated in thermal images.

Generally, in the field of Steganography[36] multimedia contents will be used as a carrier by performing spatial domain or frequency domain logic, irrespective of the information signal formats. In this research, the analysis is performed on thermal images to test and verify the efficiency of the innocence of the stego image and the quality of the received signal at the receiver end. According to the analysis of Hecht [32], the colors in thermal images are different in exposing its visibility, say red color has 63%, green color has 33% and blue color has 2%. The survey of Vijayananth [32], stated that dark images are best suited to hide the secret information which remains or maintains the innocence even after integrating the data, but that is guaranteed only for small sized data. Hence, this proposed research work is aimed to increase the data size, by performing the analysis by integrating the large sized multimedia content and are carried by a thermal image.

IV. THERMAL IMAGE

Thermal imaging is the process of converting the radiated energy from any object into visible images that illustrates the spatial distribution of temperature differences in the image captured using a thermal camera. A minute difference existing between thermal and IR sensor camera is that the thermal camera is best to detect any object, whereas, during night vision IR sensor camera is best to recognize and identify the objects and its features like facial recognition and supports deep analysis. FLIR make pictures from heat, not from visible light. Heat and light are both parts of the electromagnetic spectrum, but a camera that scales the visible light can't read the thermal energy and vice versa.

Thermo graphic camera is used to capture thermal images using infrared radiation, whereas the normal images are captured by normal visible light cameras. The visible camera using light works in 450 nm to 750nm range [13]. The Infrared cameras work in as maximum as 14,000 nm. Thermal images are basically the display of the amount of energy radiated from an object, hence the temperature value is greater than zero for every parameter of the thermal image when the heat is emitted. The colors in the thermal image describe the various temperature level available in the following Fig 1.

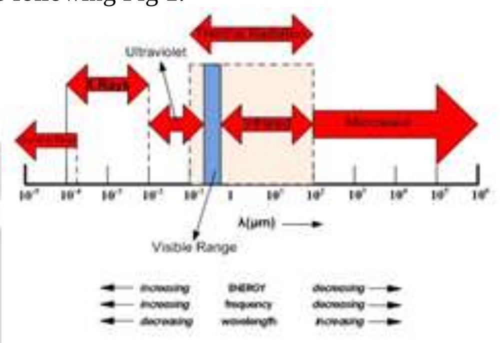

Fig 1. Thermal image Temperature range

V. PROPOSED METHODOLOGY

As a special case Thermal Images are processed in this work. The working principle of PVD [12] as explained above is implemented in thermal image and the characteristics of it is tabulated. First the implementation process is done in such a way that a text as an input is hidden in a thermal image and fused with visual image. Secondly, a visual image is fused with thermal image and visual image. Thirdly, an audio is converted to an image and hidden in a thermal image. Finally, fusion process is done between video files. Upon these analyses, the capacity of data could be hidden by increasing the size of the input data say text, image, audio and video. Also, the quality of the image is verified by applying them in different thermal image and calculating the PSNR and MSE [10][33] values obtained. The following Fig 2 shows the implementation model.

Fig. 2.Implementation Model

A.TEXT IN THERMAL IMAGE

In the proposed text steganography method, text input is integrated to consistent sized image equal to the size of the cover image. The sample input text considered for the research is given below-

"

Step 1: Input sequence or statement is taken.

Step 2: Each and every character in the statement including alphabets, numbers and special characters were considered as ASCII code.
Step 3: The obtained ASCII codes were converted to hexa decimal numbers.
Step 4: The hexa decimal numbers were converted to binary numbers (this can be done in step 3 - directly. from ASCII to binary)
Step 5: The binary numbers are segregated into 8-bit values as shown in in Fig 3, which is stored in image form, generally it can be stored in any convenient form is shown in Fig 4.
Step 6: The values stored in memory unit is called as an image file for further manipulation. The sample text of larger size, occupying large space in the image is chosen with a restriction that, the size should be 1/3rd of the cover image, at least to provide best quality in the output file.

11111010000111100001001001000100
11000110100100001001110101100000
11101110100100001100110111101100
00000100101011001100110101000111
01110010010111110100110010000111
01011110101111100010101100001101
11001011001011000010101110110101
10001000001010100011000010111010
10000001101110100101111001010111
10010101001001101101000010011010
00011011110001010011011001001110
11110000111110111100101011000010
00111001111111000011011100100010
11110101001011110110110011111011
01111000010101100101011110110101
00000000111011100100100010101000

Fig 3. Binary values of the Text

Fig 4. Binary image

Description of the binary image shown in Fig 4,for the text input is given below.

- Image Color, Width, height: RGB (89, 145, 36)
- Binary Text Options: white
- Font Size: 20px
- Font: Roboto
- Font Style: Italic.
- Formt : PNG.

Since the text image [35] is composed from binary values, the impact on the carrier image is less and the innocence of the cover image is not broken in the stego image 1 as well. Analyzing the reason behind it was noticed that, the high intensity radiated energy (red color) is dominated in the carrier image.
A thermal image (cover image) is chosen as the carrier to hide the secret information within it. The pixel wise implementation using PVD algorithm with the input text image and the carrier image generates the **stego image** shown in Fig 5.

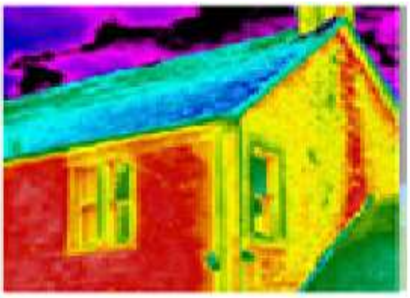

Fig 5. Thermal Image

Basically, the algorithm uses the difference value between the two consecutive pixels in a block. In order to determine how many secret bits shall be embedded or the number of bits that could be embedded to the maximum in every channel that an image possessed is decided by PVD algorithm [2]. Every thermal image has 3 basic colors say Red, Green and Blue. The intensity of red and green are much higher than the blue, hence changes made with difference value of neighborhood pixels will not be identified explicitly. The secret data is processed to append onto any of the colors, and the process is repeated for all the pixels throughout the image.

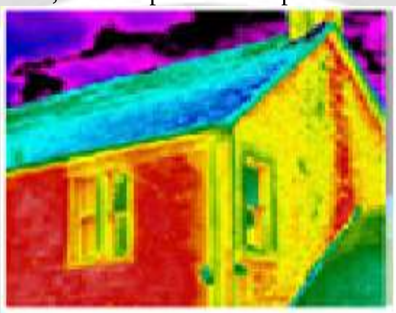

Fig 6. Stego image

Text + Thermal Image = Stego Image 1

Fusion of a visual image and a thermal image is performed by Spatial Domain Technique, and the principal component analysis algorithm is used for feature selection aids in comparing the input and database images [13]. In the receiver side the image received is decoded to extract the information without any data loss by using the inverse PVD algorithm applied at the transmitter side is shown in Fig 6.

The stego image quality and its efficiency are measured to prove its robustness using the PVD [11] algorithm is tabulated as in Table 1

Table 1. Comparison of PVD with other technique

	Visual Images		Thermal Images (0.2)		Proposed Methodology
	PVD + LSB	Khodaei and Faez	Generation Technique	MLSB	PVD + Thermal Image
PSNR (0.2)	42.37	41.21	49.412	31.062	48.7542
(0.4)	38.97	39.16	48.89	31.709	49.0149
MSE (0.2)	57.89	58.05	29.635	60.078	60.0845
(0.4)	52.09	50.89	31.65	53.645	62.8061

Table 2. PSNR and MSE comparison of Various input images

	PSNR	MSE
Bat	31.062	48.7542

Cycle	31.709	49.0149
House	60.078	60.0845
Car	53.645	52.8061

B. AUDIO IN THERMAL IMAGE.

There are so many techniques for hiding data and alterations made in and as audio, are perceptually indiscernible [4]. Generally, data understood as ones and twos. But audio is understood as one-dimensional and image as two-dimensional files. In this research, a random audio signal of 16 bit-stream is converted to a decimal number of 8- or 16-bit representation, which in turn were converted to a binary value later on to an image file format, and fused with the cover image, and the same is converted back to an audio signal at the receiver end. The audio input of .mp3 format is taken as input and is processed to obtain bit wise sequence shown in Fig 7.

```
filename = 'HalloRathika.mp3';
fid = fopen(filename, 'r');
file_bits = fread(fid, [1 inf], 'bit1=>uint8');
fclose(fid);
```

Fig 7.

The audio file bitsare now a vector of binary values which are segregated as 8- bit representation and converted to an image as discussed text steganography, by understanding and altering the ones and zeros of the binary sequence of a sound file upon applying the following steps.

Step 1: Audio file of M4A Audio type of size 125.8KB is given as an input.
Step 2: The one-dimensional audio file is converted to a two-dimensional image file.
Step 3: The information signal is transformed to an8-bit integer and are segregated into a 4x4 matrix image.
Step 4: Converting the matrix into an image.
Step 5: Integrating the audio image with the thermal image using PVDalgorithm.
Step 6: Stego Image is generated and transmitted.

The Fig 8.a, shows the input visual image in which the audio data is aimed to fuse with, and the Fig 8.b, shows the thermal image in which the visual image will be fused to hide the existence of the secret data within it.

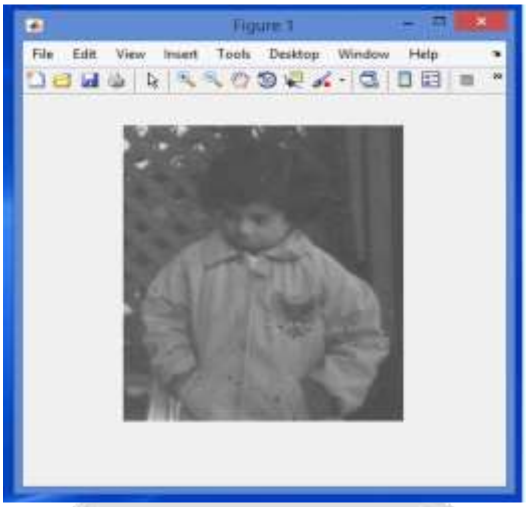

Fig 8.a. Visual Image without Audio Information

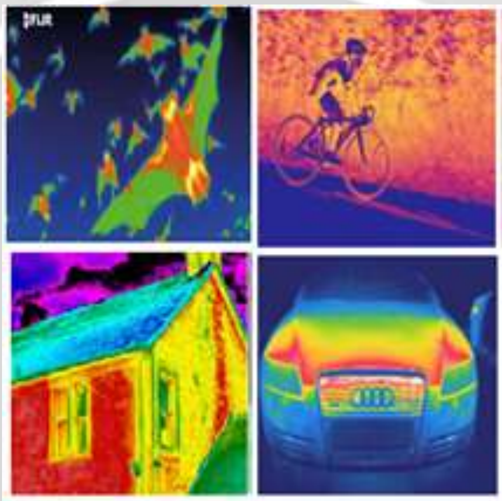

Fig8.b. Thermal Image used
(1,1 – Bat, 1,2- Cycle; 2,1 – House; 2,2 – Car)

The above steps were carried out in the reverse manner to decode the data using PVD algorithm. The Audio Steganography [9] dealt here has a constraint that the size of the audio file used less compared to the size of the cover image. Vijayananth et al, analyzed the audio steganography of equal size using LSB technique and ended with a complete damaged output file of a monochrome image file that explicitly declared the existence of the information with in it. Since the mechanism of PVD algorithm can produce large capacity by arranging the difference of four pixels of the binary audio image using horizontal, vertical and diagonal of every block into the pixels of the cover image. Hence, audio signal of different sizes and types were tried in order to determine the maximum possible size that could be integrated into a thermal image of standard size shown in Fig 8. This has been a challenge in this research, to select a thermal image of size less than the audio file, so that the fusion process may not provide any clue for the existence of the information hidden.

Fig 9. Audio output

```
Filename = 'HalloRathika.mp3';
Outfid = fopen(filename, 'w');
fwrite(outfid, file_bits, 'bit1');
fclose(outfid);
```

The other end will now have a copy of the mp3 file, which can be played through whatever mp3 player the other end has. When the coefficients are selected randomly, it provides more security by itself, since only receiver and the transmitter have the key to access as agreed [5]. The process of conversion is basically done to understand by converting the audio [7] file to an image is binary values or numerical. Later those bits are understood by the system as an image shown in Fig 9 and Stego image output in Fig 10..

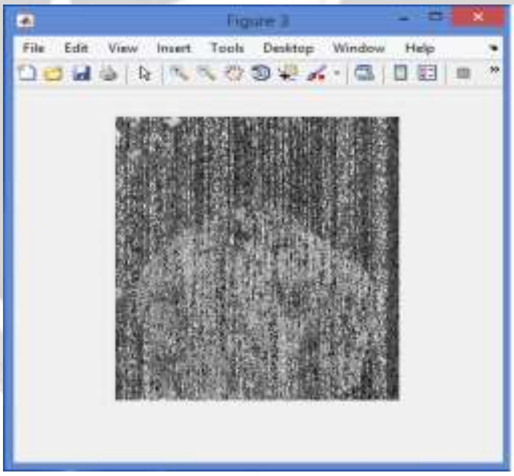

Fig 10. Stego Image

Else, the PSNR value will be inappropriate which may lead to worst fusion process resulting in very low trust worth process.

Fig 11. PSNR and MSE of Audio Steganography

Hence, the size of the file matters for Audio Steganography and Video Steganography [8]. The efficiency of the output audio file is tabulated in Fig 11.While integrating the audio binary image, it is identified some external noise also got mixed within it resulting with the noticeable changes in the binary values and in turn the innocence of the information image gets damaged. Hence, filtering the noise from the audio signal plays a vital role in general.

C.VIDEO IN IMAGE.

Video file is the collection of number of frames. The Fig 12, shows the GUI the front end of the proposed research work on video steganography. Input Video file are segregated in to number of frames and fused with the cover video file. Fig 13 shows the steps to extract video output.

Fig 12. Video Steganography

In this research, video file of both input and cover, fused in a way like, the first frame of input file is fused with the first frame of the cover video and this process is continued for rest of the frames of the both to generate a stego video file. The result of the fusion process of the video Steganography is given in the following Figs 13 & 14.

Frame 1 of 12. Frame 2 of 12. Frame 3 of 12.

Frame4 of 12. Frame 5 of 12 Frame 6 of 12.

Frame 7 of 12 Frame8 of 12 Frame9 of 12.

Frame 10 of 12. Frame 11 of 12 Frame 12 of 12.

Figs 13. Frames of Video Output

The thermal image used to guarantee the ownership is shown in Fig 13. The given image is used as a logo and are fused with the original video file using the PVD algorithm. Hence the originality of the file holding the secret data is not collapsed much.

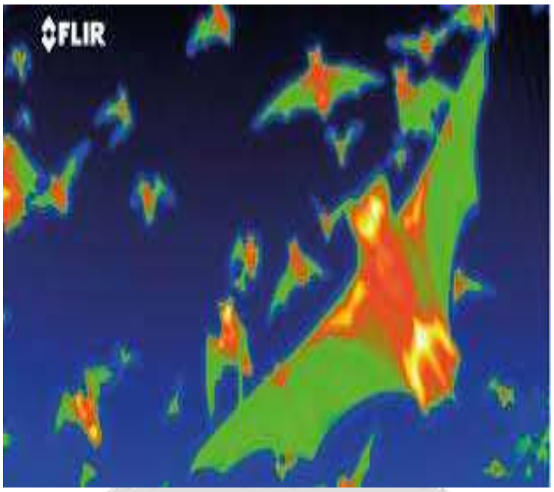

Fig 14. Thermal image used for Video Steganography

The thermal image can be fused using standard Least significant Bit algorithm to receive the stego video content at the receiver end with far better PSNR, but in this research it was decided to watermark only in few frames of the video file instead of all the frames, and only in those selected frames the logo thermal image is fused using PVD algorithm.Initially, the original video file of 1800 frames are selected to append the secret content. Secondly, few frames (say 12 as in this research) were picked from the total count for steganalysis process. The selected files were numbered from 1 to N. Most importantly the frames that were extracted from the video file depending the number of frames available as the secret video file. The secret file after embed with the logo is fused in to the cover video to generate the stego-video file, as shown in Fig. 15.

Figs 15. Pictures of Video Steganography

A video file is normally a continuous running image. Human visual perception resembles it as video file, over here is a video file of running time for twelve seconds is taken as the cover video file and the thermal logo image is fused in the information video file using PVD algorithm, with the same working principle as explained above. The twelve frames of the cover file are fused with the twelve frames of the informative file and the resultant watermarked stego video file is saved as directed.This watermarked video file is integrated with the original video file. When thousands of frames are played it is a bit tough job to identify the twelve frames where stego-data is invisibly hidden. The thermal image is used as a logo to authenticate the owner’s copyright. The extracted frames holding the secret data is segregated as shown in Fig 14. The stored file could be extracted so that the data can be retrieved in the receiver side. This fusion process could be entertained for n x n resolution of data to n x n cover file. The PSNR measured for the sample taken is tabulated below in which the research provides satisfactory analysis on this technique and are more suitable to hide the data more efficiently irrespective of the size of the cover file, the size of the data file can be modified.

VI.RESULTS AND ANALYSIS

The results obtained from Stenographic analysis of multimedia content using PVD technique on thermal images is presented below in the Table 5, highlighting the Payload, PSNR details of cover and thermal images. The chart with the payload, and PSNR for the cover image and thermal image is given in the Table 5 and in the Fig 16.a to 16.c.

Table.5. PSNR and Pay load comparison

Image	PayLoad (Bpp)	PSNR (Cover Image)	PSNR (Thermal Image)
Lena	4.708	41.283	36.79
Baboon	5.262	38.052	35.48
Airplane	4.469	40.964	36.05

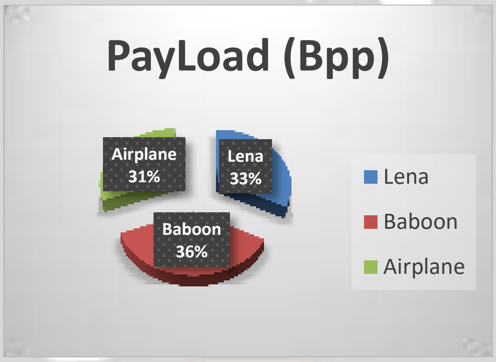

Fig 16.a. PSNR of Cover Image

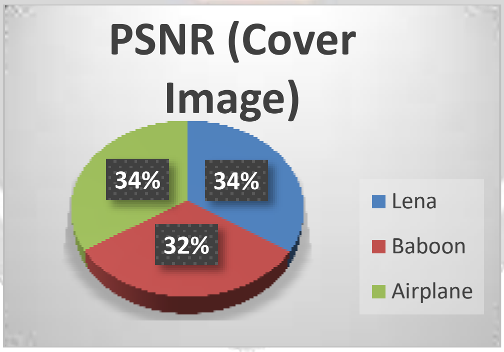

Fig 16.b. PSNR of Cover Image

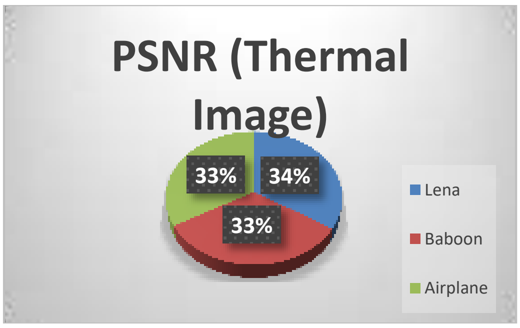

Fig 16.c. PSNR of Thermal Image

VII. CONCLUSION

Steganography analysis using PVD algorithm in this research was estimated and identified that the input data hidden in a thermal image effectively produces highly efficient and opaque outputs at the transmitter side and safe retrieval at the receiver end without much loss of data, except for the audio steganography. The efficiency is analyzed with other inputs like image, text and a video file and formulated that, the noise reduction algorithm or high filter could be incorporated to increase the efficiency of the audio steganography. This also depicts the possible amount of information that could be hidden in an image, text and in the video file is comparatively high with respect to the audio, since its size is invariably increasing with the length of the audio. The PSNR and MSE of the resultant for all the obtained signals in the receiver end are found to be more efficient while implementing in thermal image, especially in maintaining the innocence of the image holding the data. This analysis could be further improvised for different filters on better algorithms for audio steganography.

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