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# Retrieval of Visual Image from a Highly Robustive and Invisible Thermal Image Using Curvelet Transformation Technique

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**ABSTRACT**

Secured transfer of information through steganographic technique plays a vital role in the recent trend. The information to be transmitted might be hidden in an image, text, video or audio. This research article presents an effective method to retrieve the visual image from an invisible thermal image. The presence of thermal image of any radiative bodies can be located using a thermal sensor camera. The pictured thermal image is then transformed to a visual image by analyzing the boundary values using curvelet transformation technique. The thermal imaging system has been chosen due to its high robustive characteristics towards extraordinary ambient light changes. Therefore it is possible to hide the stego content in the thermal image, also provides high security for the content from the interpreter. Thus in this proposed system, the visual image is retrieved from thermal image even in the absence of the radiative body.

***Keywords:*** Steganography, boundary detection, curvelet transformation technique, thermal image, visual image.

## 1. INTRODUCTION

The Facial Recognition (FR) have been widely used in the biometrics, enforcement of law and also in surveillance, but only the visible image of humans were used in most cases. The FR records the spatial geometry of classifying features of the face. The different vendors use different methods of FR, however, all focus on measures of key features of the face [1]. Recently, literatures on FR based on fusion of visual image and thermal image has begun and have been published. In the proposed system, the transformation of visual image from thermal image has been concentrated. The thermal sensors measure the emitted heat energy and its intensity at different points of the shot objects. The measured temperature graph shows the distribution of the energy throughout the object.

Information security has become a very factor of concern because of the electronic eavesdropping [8]. The surveillance in any field plays an important role, but it also fails in any system due to different light conditions for visual images, whereas thermal energy can only be pictured by thermal imaging cameras, even in the absence of light whose temperature is above the absolute zero. By fact, visualizing the thermal image is an actually difficult and challenging task. Moreover, developing a thermal image for one object needs different images of the same at different conditions of light, and basically the thermal condition of an object is not constant either. The biggest barrier of the thermal image spectrum is that, the resolution; which is tremendous in visual image spectrum.

## 2. IMAGE PROCESSING

The image processing is basically, manipulating or enhancing the input (probably image) like a picture of jpeg, bmp format or a video frame. The image processing or generally referred as digital image processing

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is done to improvise the pictorial information and it is mostly implemented with the help of computer algorithms. The image input is processed using computer algorithm thereby preventing the intrusion of noise and distortion of the signal during the process. The basic processes of image processing are Image acquisition, Image preprocessing, Image segmentation, Image representation, Image description, Image recognition, and Image interpretation.

The image acquisition has another issue of having a smaller image (sometimes further more smaller) than the predicted size, which is approximately 20 × 20 pixels, whereas the face image sizes used is 128 × 128. Small sized images are not convincing for the recognition process, moreover it makes it more difficult to segment and accurate detection of the original image [3].

Registration is an important pre-processing step in an eigenvector recognition system. A Face is an input image that must be located and registered in a standard size frame before being processed [4]. In preprocessing, the thermal image is acquired, that comprises RGB from which Red component is extracted, thereby imRed is the output, and image segmentation classify the given input image into different parts or objects. Image representation used to convert the input data to a form that is compatible for computer processing. Finally, the image is recognition to assign a function provided by its descriptors [5]. Recognition is carried out by finding a local representation of the facial appearance at each of the anchor points [6]. The main aim of recognition is to separate the characteristics of a face, which are determined by the shape and color of the surface of the interested area[7].

## 3. THERMAL IMAGE

The Infrared cameras or thermal infrared cameras are used to capture the thermal image of any object, provided the object should emit heat. The object that emit heat energy around the range of electromagnetic spectrum (900 – 14000 nm or 0.9 - 14µm) can be pictured by the thermal infrared camera, and the measured values are defined as thermograms. Since all the objects emit infrared radiations above the absolute zero, the thermography enables to see one's environment with or without visible illumination. The amount of radiation emitted from any object is directly proportionate to the temperature of the same.

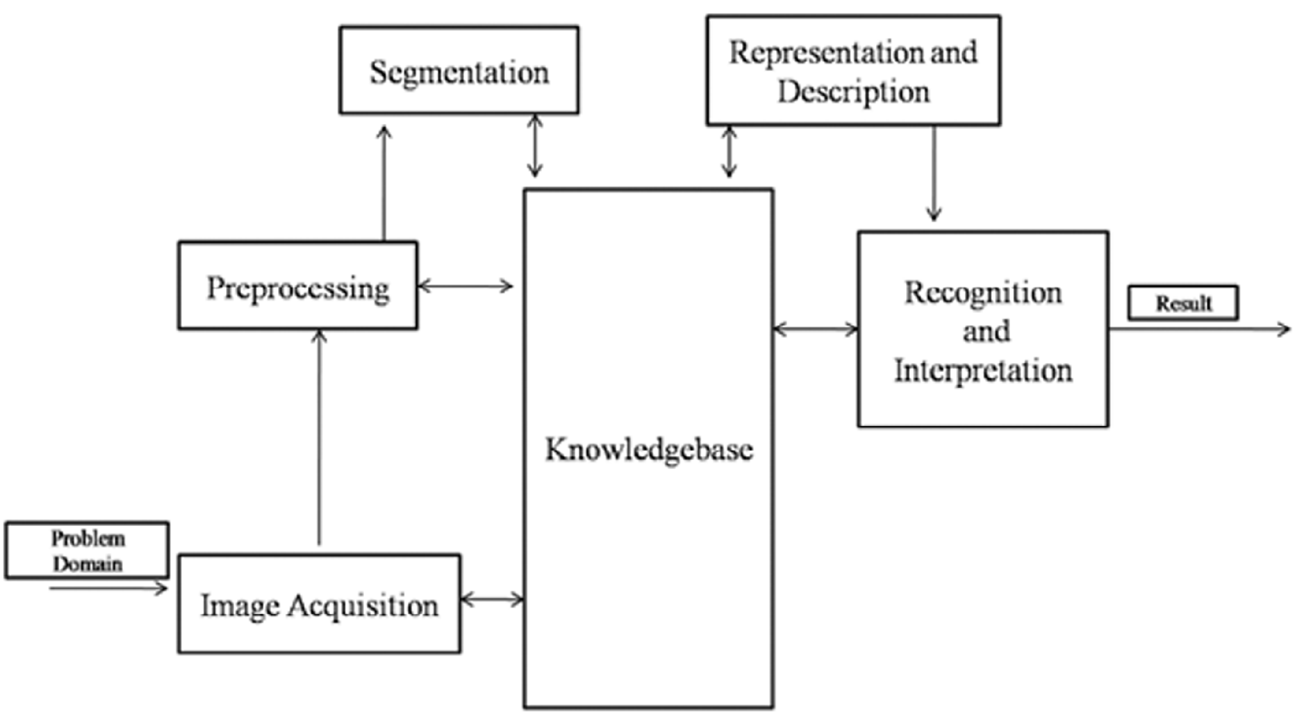


**Figure 1: Basic steps in image processing**

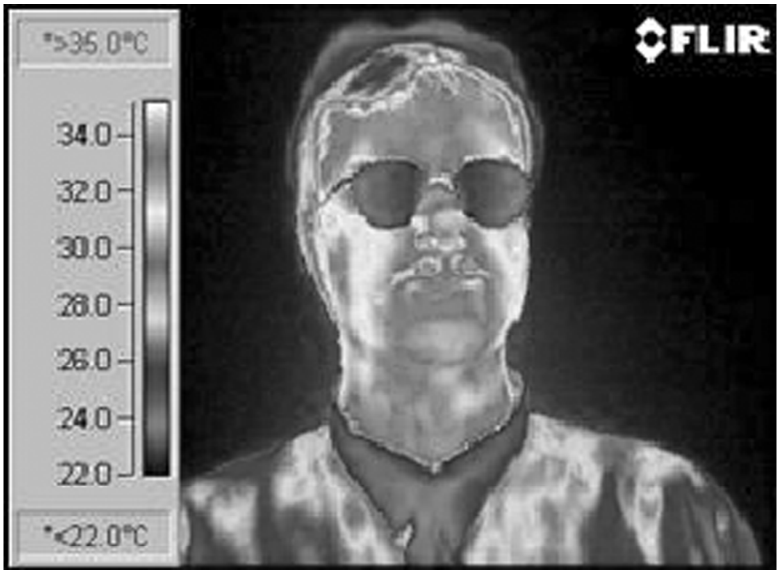


**Figure 2: Color thermograph of a person**

The thermal image is formed due to emission (of IR radiation from anybody above 0 K), not due to reflection. It is independent of intensity, angle of incidence and illumination factors and hence consistent for both indoor and outdoor.

### 3.1. Proposed Method

The proposed idea is an effective method to retrieve the visual image from an invisible thermal image. The presence of thermal image of any radiative bodies can be located using a thermal sensor camera. The pictured thermal image is then transformed to a visual image by analyzing the boundary values by using curvelet transformation technique. The original image and its color are segregated and they were converted to a grey scale image (Black and White), to which boundary detection algorithm fused with the morphological digital form, and are referred to as curvelet transform technique. The efficiency of the signal received at the reconstruction stage is measured using Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR).

### 3.2. Block Diagram of Working Model

In the below given Figure 3, the input, we provide one image: Thermal image. *IR Sensor* camera is used to capture the thermal image from the invisible room. *Thermal image*: Thermal image is formed due to emission of IR radiation from anybody above 0 K.

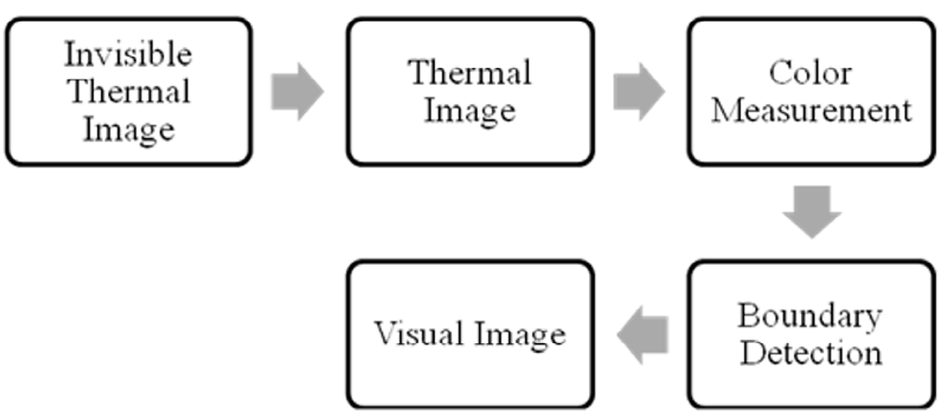


**Figure 3: Block diagram of invisible thermal image to visual image**

*Boundary Detection*: Curvelet transform technique is used to detect the boundary of the thermal image, the further process involved in this boundary selection are, 1. Red component, 2. Black and White, 3. Morphological operation. *Color Measurement*: By the respective histogram values, the images RGB values are added back for the retrieval process of the visual image. *Visual Image*: Thus, a visual image is retrieved from the thermal image obtained from thermal camera. The obtained accuracy for recognition is due to the thermal image that is comparable to visible images, upon usage of the feature selection technique [8].

### 3.3. Invisible Thermal Image

Using Infra-red camera, in absence of the object or human body, an image is picturised which is defined as dark invisible image. Generally, the heat energy emitted from a body, remains for some amount of time, even the object changes its position, or moving from one place to another. Almost all the radiation available in the electromagnetic spectrum infrared is also just a part of the thermal image. These radiations are compared and analyzed based on the length of the wave or wavelength. Due to the temperature, any object emits a considerable amount of black body radiation. Ultimately, more the object temperature, more the black body radiation. The special infrared cameras can study the invisible thermal image as a normal camera detects the visual image. The most advantageous fact is that the thermal infrared cameras can function even in total darkness with convincing efficiency, where light does not matter much and only the presence of radiation matters.

## 4. BOUNDARY DETECTION

The shape is one of the most powerful cue used to identify the objects in an image, individual objects from segmenting them. To express the information about the image, a system needs reliable fragments of object boundaries, which is difficult in itself. In the proposed system, reliable boundary detection is done by focusing the motion values and the appearance values by comparing the both. In the proposed system, 2 major issues of has been resolved using Boundary Detection.

i) Boundary Detection of images into shape cues

ii) Using boundary information in segmentation and also to recognize the tasks.

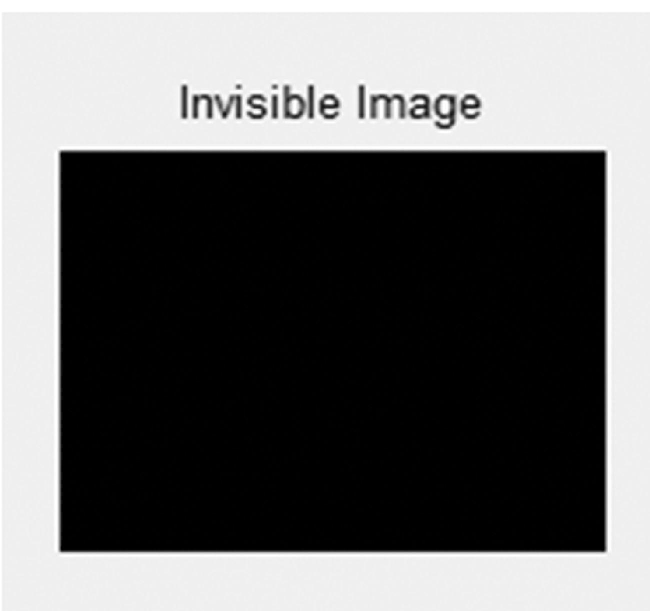


**Figure 4: Invisible Thermal Image**

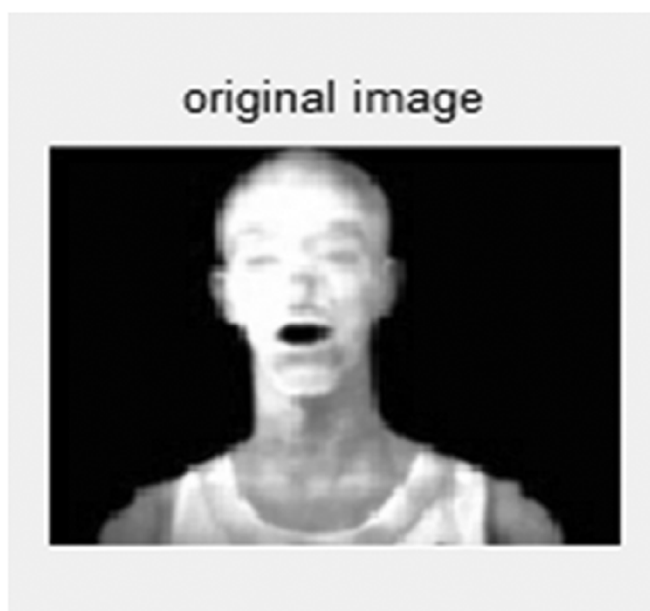


**Figure 5: Input Image**

The curvelet transform technique is used to detect the boundary of the thermal image, and the further process involved in this boundary selection are

i) Red component

ii) Black and White

iii) Morphological operation.

### 4.1. Curvelet Transformation Technique

The curvelet transformation is not a flexible technique for multi level scaling object. It is an extension of wavelet transformation technique and is being familiar in similar fields, like image enhancement. The faster and less redundant second generation Curvelet transform, in which ridget transform was discarded. The redundancy amount will be reduced to restore sparsity and the speed was also increased. Curvelet transform is used for multi-dimensional signals, and different levels of multi-scale ridget pyramid are used to represent different sub bands of a filter band output[9]. The relationship between the width and length of frame is

$$\text{Width} = \text{length}^2 \tag{1}$$

The sub bands is discrete curvelet transform of continuous function have non standard form $[2^{2s,}\, 2^{2s+2}]$

i) Polar co-ordinates are considered in the frequency domain

ii) Elements of curvelet techniques are locally being supported near the blocks.

### 4.2. Curvelet Transform Boundary Detection

The digital images are two-dimensional matrices in an image. By varying the parameters of the matrices, a clear feature of image can be identified. The curvelet transformation technique uses angle polar blocks in frequency domain, so that the directional features can be resolved. Theoretically, the curvelet transformation boundary detection is easily understandable, but achieving discrete algorithm for the practical applications is really challenging.

The basic expressions of curvelet transform boundary detection.,

1. Decomposition of Sub-band

$$f \mapsto (P_0 f,\ \Delta_1 f,\ \Delta_2 f,\ \Delta_3 f,\ \Delta_4 f,\ ..) \tag{2}$$

2. Smooth partitioning

$$h_Q = w_Q \cdot \Delta_s f \tag{3}$$

3. Renormalization

$$g_Q = T_Q^{-1} h_Q \tag{4}$$

Where, $P_0$ – Low pass filter.

$\Delta_1$, $\Delta_2$ … – Band pass (high-pass) filters.

#### *4.2.1. Decomposition of Sub-Band*

Dividing the image into resolution layers.

$$f \mapsto (P_0 f, \Delta_1 f, \Delta_2 f, \ldots)$$

Each layer contains details of different frequencies:

$P_0$ – Low-pass filter.

$\Delta_1, \Delta_2, \ldots$ – Band-pass (high-pass) filters.

The original image can be reconstructed from the sub-bands:

$$f = P_0(P_0 f) + \sum_s \Delta_s(\Delta_s f) \tag{5}$$

### *4.2.2. Smooth Partitioning*

The redundancy is introduced in the smooth partitioning by adding the content of one pixel with that of the neighborhood pixels. There are two challenging strategies to enhance the analysis and synthesis: 1. The

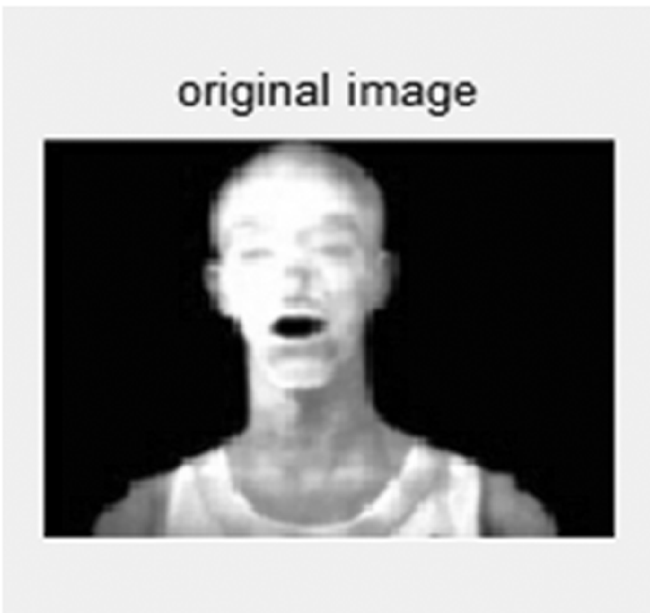


**Figure 6: Frequency**

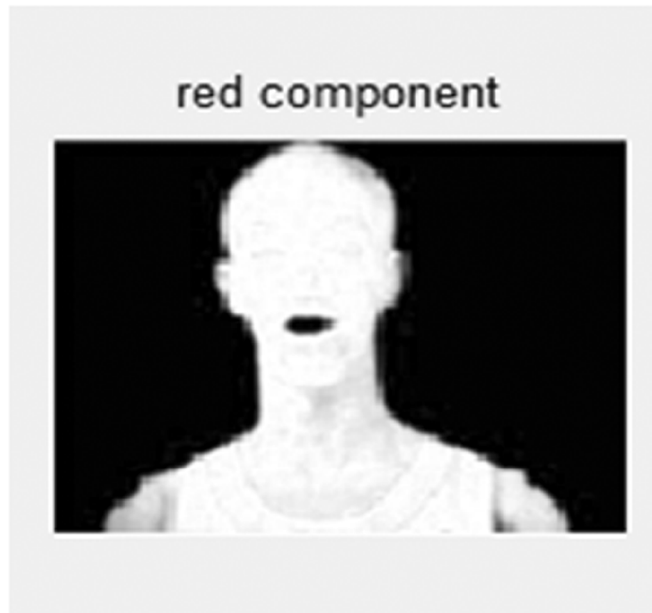


**Figure 7: Low pass filter**

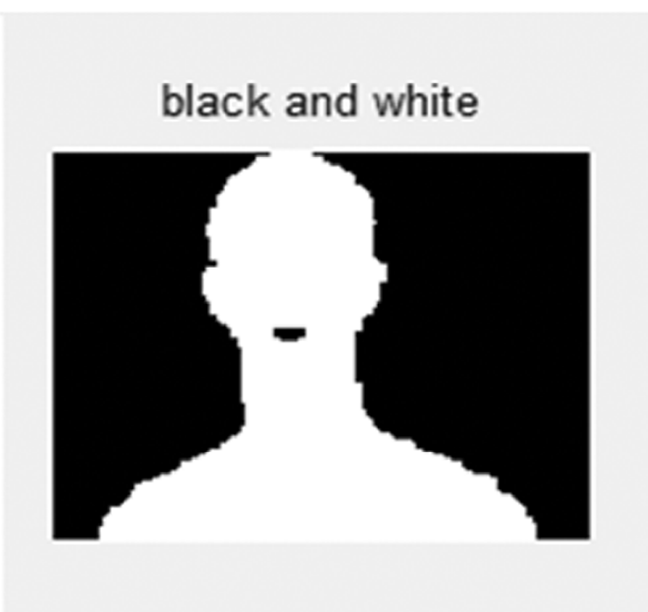


**Figure 8: Band pass filter**

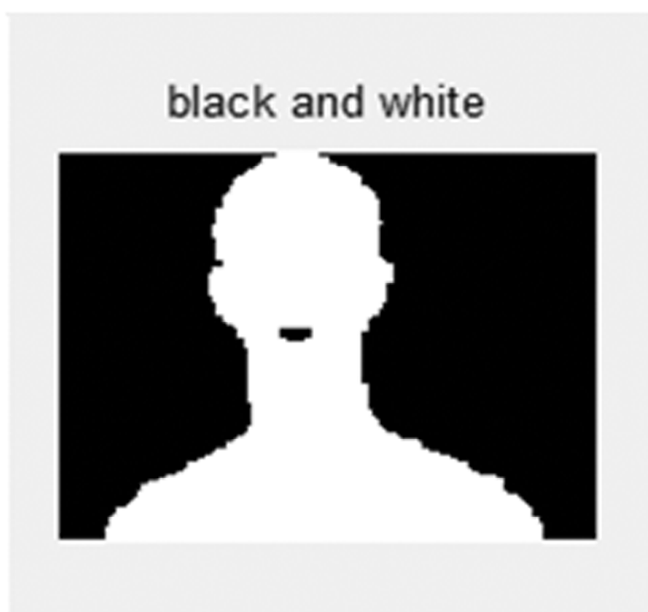


**Figure 9: Smooth partitioning**

block values are calculated by performing addition process with all the neighboring values (which is referred to as analysis) to reproduce the original pixel value, (which is called as synthesis). 2. The block values are those of the values of the pixel values, but are weighted when the image is reconstructed.

#### *4.2.3. Renormalization*

Renormalization is centering each dyadic square to the unit square [0, 1] × [0, 1] for each $Q$, the operator $T_Q$ is defined as:

$$\left(T_Q f\right)\ \left(x_1, x_2\right) = 2^s f\left(2^s x_1 - k_1,\ 2^s x_2 - k_2\right) \tag{6}$$

each square is renormalized:

$$g_Q = T_Q^{-1} h_Q \tag{7}$$

### 4.3. Output Characteristics

The analysis of the input and its characteristics when it is enhanced with different components used to provide and efficient and robust signal at the output or output section. In the proposed model, the output characteristics have been calculated as MSE and PSNR. The efficiency of the output derived provides a convincing analysis for the images taken (visual and thermal images).

#### *4.3.1. Peak Signal to Noise Ratio (PSNR)*

Peak Signal-to-Noise Ratio (PSNR) is defined as the ratio between the maximum powers of the signal to the maximum power of corrupting noise that affects the originality of the signal representation. PSNR is measured in logarithmic decibel scale. The quality of the watermarked image can be tested by the value of PSNR and it is normally a measurement of ratio of the image reconstruction and is defined by the Mean Square Error value (MSE). MSE is calculated for the two m × n images [1]. The first image is the original image and the second image is the thermal image. PSNR is used in any secured system to measure the quality of re-framing or re-constructing the data which is coded and decoded using any lossy compression techniques. Higher the PSNR, higher the quality of re-construction of the input data. But still, the above statement is not true in all the cases. PSNR is frequently identified via the MSE.

The PSNR is calculated using the following equation

$$\text{PSNR} = 10 \log_{10}(\text{I}^2_{\text{max}} / \text{MSE})\ \text{dB} \tag{8}$$

If $\hat{Y}$ is a vector of $\eta$ predictions, and $Y$ is the vector of the true values, then the (estimated) MSE of the predictor is:

$$\text{MSE} = \frac{1}{n}\sum_{i=1}^{n}\left(\hat{Y}_i - Y_i\right)^2 \tag{9}$$

Where, $n$ is the size of the image.

This is a known, computed quantity given a particular sample (and hence is sample-dependent).The resultant is conclusive valid when it is used to compare from same coding to decoding techniques with same content and of same content type. Here, maximum number of pixels that could occupy in an image is called MAXI. Subsequently when a pixel value is represented using 8 bits, the MAXI will be +e $2^8$, which are around 256 in numbers [2]. Therefore, the range of pixels count will extend from 0 to 255. The color ranges from full white to full black., where full white was represented by all 1's (1111 1111) and full black was represented by all 0's. (0000 0000). For thermal images, which is of three values, say RGB per pixel,

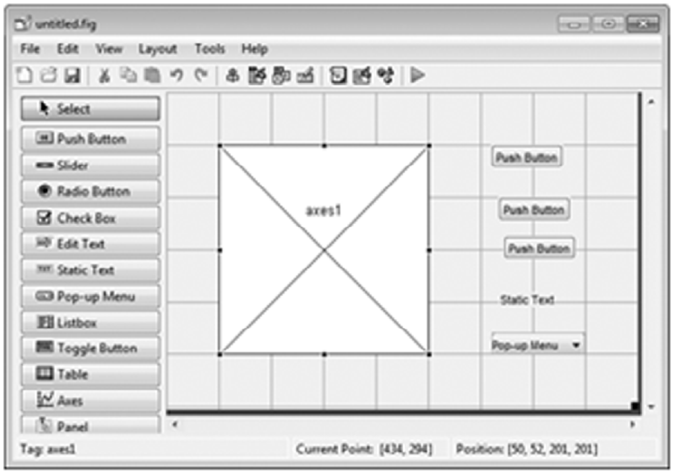


**Figure 10: Creating component pallet**

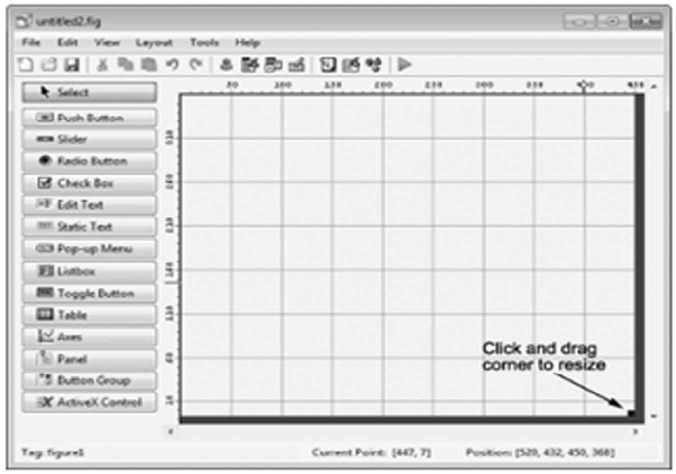


**Figure 11: Out resize window**

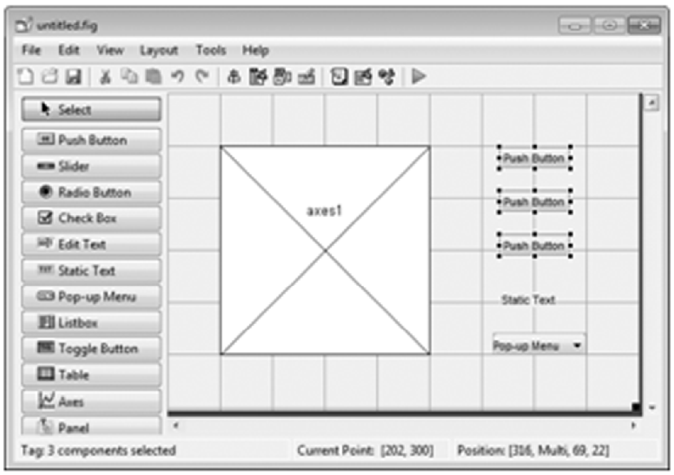


**Figure 12: Labelling window**

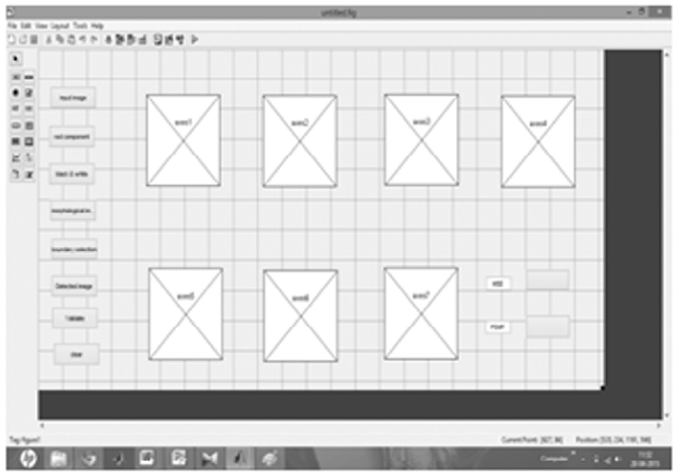

**Figure 13: Final layout design of GUI**

the PSNR is defined the same whereas the MSE will be the sum of the squared values of differences divided by the size of the image.

## 5. OUTPUT INTERFACE

Thus, the output contains thermal image and other components that are required to retrieve the visual image. Thus the thermal image is resolved into their components and at the last their boundary is detected using curvelet technique, then the boundary detected image applied with colors such that they would retrieve a visual image.

Thus various functions provided by output window are as follows

### Input:

Thus initially presence of image in an invisible room is detected using a thermal imaging camera; they are generally applied as the input using the input button.

### Red component:

The image is resolved into their components, the presence of red color is detected using the red component and they removed for further processing,

### Black and white:

They are used in partition of the thermal image and the purpose of black and white is to smooth partition of the image

### Morphological image:

The function is to renormalization of the image, thus they define exact square value, i.e the image is sharpened by using morphological operation.

### Boundary detection:

Thus the exact boundary of the image is detected using the curvelet transform and ridgelet analysis is applied that smoothens the presence of image i.e. the noise is removed and exact boundary is detected.

### Visual image:

Exact visual image is retrieved using this button, they are compared with their colours and thus the visual image is retrieved using this process.

### Clear:

This button will clear all the images present in the window screen, i.e a white screen obtained when clear button is pressed.

### Validate:

This validates the presence of the error and their peak to signal noise ratio of the visual image.

The Figure 14 & Figure 15 shows the PSNR and MSE valve of the obtained output visual image.

## 6. CONCLUSION AND FUTURE WORK

The proposed model is totally viable and can be implemented easily. The system is simple, user friendly and reliable. Obtaining high accuracy can be difficult due to varying emissivity of the different materials;


**Figure 14: Output Window**

**Figure 15: Output Command Window**

reflections from other surfaces; and other characteristics. The visual methodology suffers from the inherent disadvantages such as illumination variations, partial occlusions, etc. while the thermal methodology suffers from effects such as the temperature variations, etc. The developed system overcomes all these disadvantages by combining the features of both the systems. There are certain aspects that can be further enhanced as part of the future works for enhancing the proposed system. The system developed here requires Curvelet Technique and in future this idea would like to experiment it with other boundary detection techniques, do a comparative study and come out with a most efficient visual image.

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