A Concise Report on Image Types, Image File Format and Noise Model for Image Preprocessing

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Abstract - *An image is a visual presentation of something or someone and a numeric presentation of that image is said to be as a digital image. Each numeric value is called as pixel and this pixel value defines the intensity or gray level of the image at that point. The technology used to manipulate these pixel values either to enhance the quality of the image or to create different perspectives for human usage or to fetch data from the image digitally, with the help of computer algorithms is called digital image processing (DIP). DIP can be used in numerous fields, the only way to understand its field of application is based on source of image i.e. electromagnetic energy spectrum, acoustic, ultrasonic, and electronic. Random deviation of brightness or color information in image is called as noise. Noise can be introduced in an image during image acquisition. Approximate quantity of noise in an image can be useful, like to prevent discretization artifacts (color banding or posterization), increases acutance (apparent sharpness). Such noise is called as diter, it increases the image perceptually but lowers SNR. High level of noise is undesirable, and this paper speaks of these kinds of noise. Before applying any technique to improve the image quality understanding of these kinds of noise is a very important task. Beforehand knowledge about image types and various image file formats is very much required which is also discussed in this paper.*

Keywords: Color models, image file format, image types, noise models, PDF.

1. INTRODUCTION

Digital image is an appearance of an image in a form which computer can store. This form is easy to manipulate and is appropriate for image processing [1][5][12][20]. Any image which are stored in memory are either raster image or vector image [30].

- Raster image comprises pixel values arranged in regular matrix. If image is stretched, then image gets blur and image quality reduces. Adobe Photoshop industry standard program works on a pixel grid, each pixel is assigned a color to create an image, these images are presented at a set size, this type of image is ideal for photos, web graphics and illustrations with complex coloring and shadows. Example: JPEG, GIF, PNG, TIFF
- Vector image characterizes geometric objects using continuous coordinates. Coding is used to create an

image and image quality is good when compared to raster image. Vector image works on a mathematical point-based system and can be scaled indefinitely. This type of image is ideal for logos, type work and icons.

Example: SVG, PDF, EPS

Understanding of the image, its type and introduction of the noise in the image either during acquition or transmission is very important in order to preprocess an image. This preprocessed image can be applied for further application such as analysis of an image for diagonalizing, planning in surgical operations, object identification, removal of background from a video, localization of tumours, measuring tissue dimensions, localize objects in satellite images(roads, forests, water, etc.), montoring the traffic systems, locating features in face recognition, iris recognition, agricultural imaging and medical imaging [24][32].

2. IMAGE TYPES

Images can be broadly classified into four types [21]:

2.1 Black and white image

- Binary image or primary image is the other name for black and white image in digital image processing. (figure 2(i))
- Image have only two values either a 0 or a 1 which indicates a black or white color.
- This kind of image is simple to process and analyze.
- Binary image can be obtained from gray level or color image by thresholding.
- Binary image is very useful for industrial application.
- The storage space required for a monochrome image of size 640 x 480 is 37.5 KB.

2.2 Monochrome image

- Gray scale image or one-color image is the other name for monochrome image. (figure 2(ii))
- No color values are obtained in this image, only gray level information can be obtained.

- The number of different gray levels existing are decided based on the number of bits used.
- When a small portion of the image is made larger to discern details then these extra gray levels are helpful.
- 8 bits per pixel data gives 256 different gray levels
- Gray scale image is used in medical imaging and astronomy.
- The storage space required for a monochrome image of size 640 x 480 is 300 KB.

2.3 RGB image

- Color image is the other name of RGB image. (figure 2(iii))
- Gray scale information is obtained from a monochrome image and color information is from a three-band monochrome where each band relates to each color of RGB.
- Each spectral band gives the gray level information which is the actual data stored in the digital images.
- 8 bits are used for each of the 3-color band hence a color image corresponds to 24 bits per pixel.
- The storage space required for a monochrome image of size 640 x 480 is 921.6 KB.
- There are three types of color models [1][19]: Considering a particular pixel, the amount of each color present in that pixel is defined by the color models in a 3 dimensional coordinate axis. It also indicates if there are any buildable color models. Any single point being considered within the subspace can be correlated to any color that can be specified using a model. Each color model is aligned in the direction of say either specific hardware (RGB, CMY color model), or image processing applications (HIS color model). Colors can be stipulated using CIE chromaticity diagram as shown in Figure 1(i), which shows the color composition.

2.3.1 RGB color model

In the RGB model (figure 1(ii), (iii)), an image is composed of three planes which are independent of each other, and each plane represents one of the primary colors R, G, or B. Each individual color specifies the amount of each primary color present in it. RGB model is said be an *additive* model, because the colors available in the light are included to construct a new color, and is appropriate for the mixing of coloured light. We obtain three secondary colors by addition of the three basic colors. The additive mixing of red and green gives yellow color, additive mixing of blue and green gives cyan, additive mixing of red and blue gives magenta ,and additive mixing of all three basic colors gives white color.

Video cameras and color monitors are the best example for RGB color model.

2.3.2 CMY or CMYK color model

The CMY (cyan-magenta-yellow) or CMYK (cyan-magenta-yellow-black) model (figure(iii)) is a *subtractive* model significant to absorption of colors, for instance due to pigments in paints. To get a specific color, in RGB model one needs to verify what is included in the black color, and in CMY model one needs to check what is removed in the white color. Here, the primaries colors are CMY (cyan, magenta and yellow), and secondary colors are RGB (red, green and blue). When a pigment is illuminated by white light to a surface which is coated with yellow, then no blue light is reflected, and similarly for other two colors as well. The RGB and CMY models can be related as:

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

2.3.3 HSI color model

Hue, saturation and intensity are the other three quantities through which color can be identified. Figure 1(iv) shows the HSI color model, and also the whole space of colors like white, black, red, green and blue are specified. Figure 1(iv) on the left shows the HSI solid and on the right shows the HSI triangle, obtained by considering a horizontal slice from the HSI solid at a particular intensity. Red is considered to be as the reference and hue is measured from it, and saturation value is obtained by considering the distance from the axis. Colors on the surface of the solid are completely saturated, i.e. pure colors, and the axis of the solid is the greyscale spectrum. For these colors, hue is undefined.
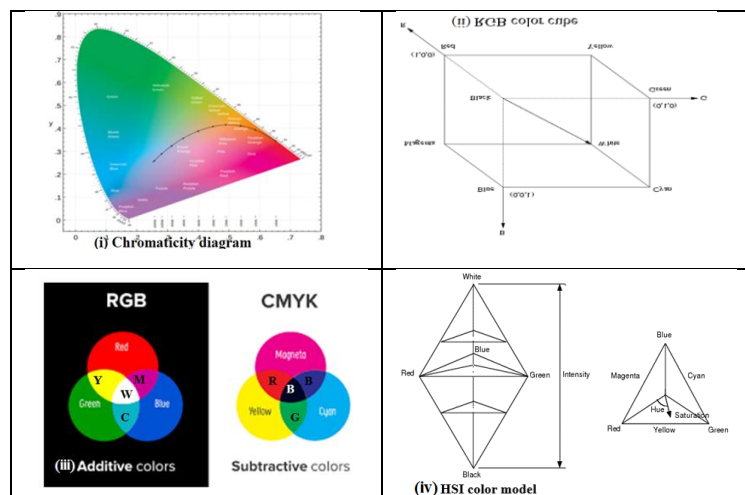

Fig 1: Color models (i) Chromaticity diagram, (ii) RGB color cube, (iii) additive colors (RGB) and Subtractive colors (CMYK), (iv) HSI color model representation

2.4 Indexed image

- An array and a color-map matrix together form an indexed image. (figure 2(iv))
- The color map is a catalogue which says about the various colors that are used in a particular image.
- Video cards and 24-bit color displays comprises of this type of representation. It is a 2D array of the same size as the image contains indices to a color map of fixed maximum size (i.e 256 colors).
- Direct mapping of the pixels element to color map is done in indexed imaging.
- The storage space required for a monochrome image of size 640 x 480 is 307.2 KB.
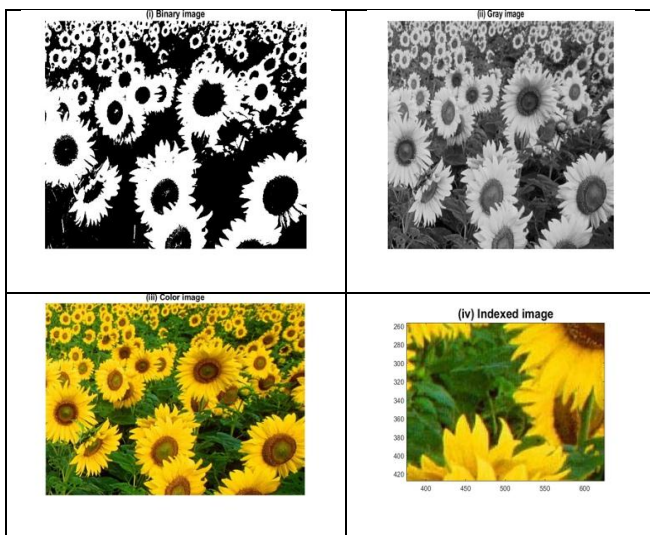

Fig 2: Image types (i) Binary image (threshold level is 128) (ii) Gray image (iii) RGB image (iv) Indexed image

3. IMAGE FILE FORMAT

Image file formats is organizing and storing of digital images in a systematic way. The information can be stored in one of the following ways: vector format, uncompressed format, and compressed format. In compressed format it can be again a lossy or lossless information that is stored. Image files are composed of digital data in one of these formats mentioned below[13][14]:

3.1 JPEG: Joint photographic expert's group

- This is a compressed file format which involves lossy compression i.e. Quality of interest (QOI) is lost when compressed and saved and hence cannot be recovered. (figure 3(i))

- When compared with original image we find no difference but if we observe a line or a pattern, we can find the blurrness.
- JPEG format is good for send or forward but not for taking printouts or high-quality images.
- Image quality is reduced.
  Example: Web images, e-mail, phones, laptop, photo download, and WhatsApp photo.

3.2 GIF: Graphic interchange format

- This is lossless compression i.e. does not degrade the QOI. (figure 3(ii))
- Image quality is better than JPEG
- GIF gives transparency.
- Two, three images move continuously and produce a small video.
- GIF supports 256 colors.
  Example: Animations, clipart, icons, logos, text.

3.3 PNG: portable network graphics

- PNG is lossless compression-compression without loss of quality. (figure 3(iii))
- This provides transparency.
- Supports many colors.
- Image quality is good.
- PNG supports 16 million colors.
  Example: web images, downloaded photos.

3.4 TIFF: tagged image file format

- TIFF is a very flexible format that can be lossy or lossless compression. (figure 3(iv))
- Uses good number of colors hence has larger file size.
- TIFF gives a very high image quality.
- TIFF provides a larger limit where pixels can be retained, if still stretched further then image quality detoriates.
  Example: desktop publishing, applications in 3 dimensions and medical imaging.

3.5 EPS: Encapsulated   postscript   vector graphics

- Images are created by the code written. (figure 3(v))
- Processor instructs where the code is.
- Image quality retained even if stretched or compressed.
  Example: Wall size printing, banners, charts.

3.6 BMP: Bitmap

- BMP is generally uncompressed or compressed with a lossless compression method. (figure 3(vi))
- Information loss with BMP files which allow images to have precisely high quality but also has very large file size.
  Example: Editing raster graphics, creating icons and wallpaper, on screen display.

Fig 3: Image file formats: (i) JPEG=216KB, (ii) GIF=544KB, (iii) PNG=1.3MB, (iv) TIFF=1.6MB, (v) EPS=690KB, (vi) BMP=2MB

The file format of an image appears to be the same for a viewer, but it has different file storage capacity as mentioned in the figure 3.

4. NOISE MODEL

Unwanted information present in the digital image is called noise. This noise can be introduced through various sources namely, device failure (image capturing devices like cameras, misaligned lenses, weak focal length, scattering), memory failure (location of image storage), surrounding atmosphere (weather conditions like too foggy) etc.

The effects of noise are artifacts, unrealistic edges, unseen lines, corners, blurred objects and disturbances in the background scenes.

Noisy image can be modelled as
$g(x, y) = f(x, y) + n(x, y)$
Where

$g(x, y)$ is the representation for noisy image
$f(x, y)$ is the representation for original image
$n(x, y)$ is the representation for noise image

Types of Noise model [4][26]

It is feasible to "represent" random noise as a mathematical function. The "distribution" of noise is based on probability. Hence the noise model is known as a Probability Density Function (PDF). Once noise has been identified, creating filters to eliminate noise becomes a lot more easier. In this paper we will brief about five different noise models along with their representation and PDF and also figure 4(ii) to figure 4(vi) shows how each of the noise will appear in an image where figure 4(i) shows the original image

4.1 Salt and pepper noise [7][9][10][11][15][16][25][28]

- This noise is also called as impulse noise, shot noise, spike noise or data drop noise. (figure 8(ii))
- This noise is seen during data transmission.
- Sharp and sudden interruption in the image signal is called impulse noise.
- This noise is randomly distributed white or black or both pixels over the image.
- PDF equation and plot for salt and pepper noise can be represented by:

$$P(g) = \begin{cases} Pa & \forall\ g = a \\ Pb & \forall\ g = b \\ 0 & otherwise \end{cases} \quad (2)$$
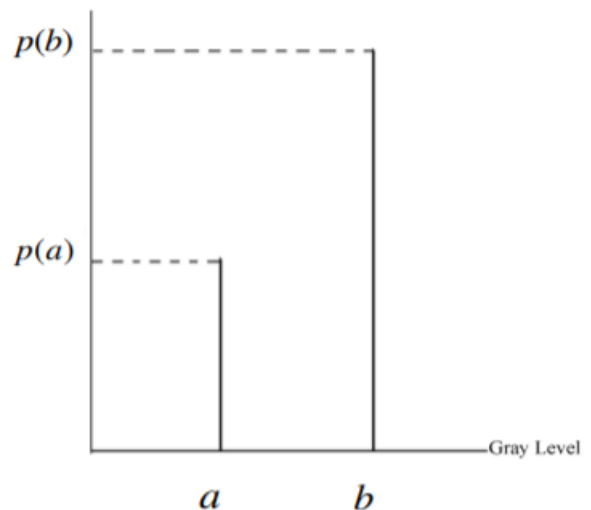

Fig 4: Probability density function of salt and pepper noise model

4.2 Gaussian noise [2][22][23][29]

- This noise is also called as amplifier noise or electronic noise. (figure 8(iii))

- Sensor noise caused by poor illumination and/or high temperature, and/or transmission leads to Gaussian noise.
- This produces a local degradation.
- PDF equation for Gaussian noise can be represented by:

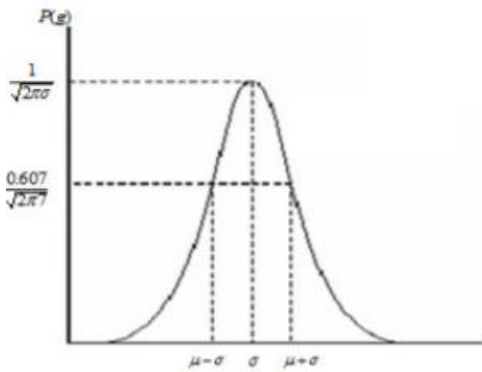$$P(g) = \frac{1}{\sqrt{2\pi}.\sigma} \, e^{\frac{-(g-\mu)^2}{2\sigma^2}} \quad (3)$$

Fig 5: Probability density function of Gaussian noise model

4.3 Poisson noise [22][23][27]

- This is also called as shot noise. (figure 8(iv))
- Poisson noise occur when there is a statistical variation in the measurement.
- Statistical variations can be either due to finite number of particles like electron in an electronic circuit that carry energy, or because of photons in an optical device.
- PDF equation for Poisson noise can be represented by:

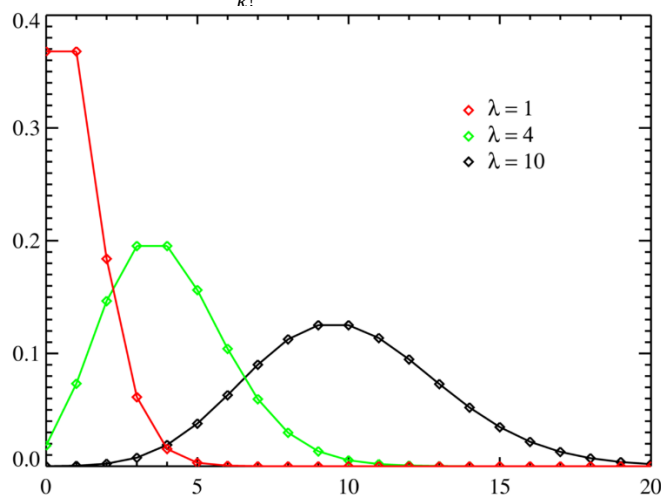$$P\left(f(p_i) = k\right) = \frac{\lambda^k e^{-\lambda}}{k!} \quad (4)$$

Fig 6: Probability density function of Poisson noise model

4.4 Speckle noise [3][17][18][29]

- This noise is also called as multiplicative noise (figure 8(v))
- This noise can be modeled by random values multiplied by pixel value.
- Speckle noise is seen in coherent imaging systems such as laser, radar and acoustics.
- PDF equation for Speckle noise can be represented by:

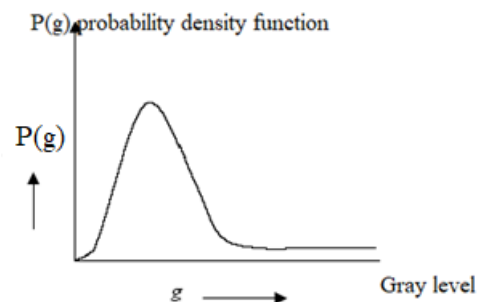$$P(g) = \frac{g^{\alpha-1} e^{\frac{-g}{a}}}{(\alpha-1)! \, a^\alpha} \quad (5)$$

Fig 7: Probability density function of Speckle noise model

4.5 Periodic noise [6][8]

- This noise is generated during image acquisition from electronic interferences especially in power signal. (figure 8(vi))
- Periodic noise has a global effect.
- Spatial domain masks cannot be used to remove periodic noise fully
- This type of noise can only be eliminated by studying their response in frequency domain.
- Any periodic function like sine, cosine, exponential etc. can be used to reduce this noise.
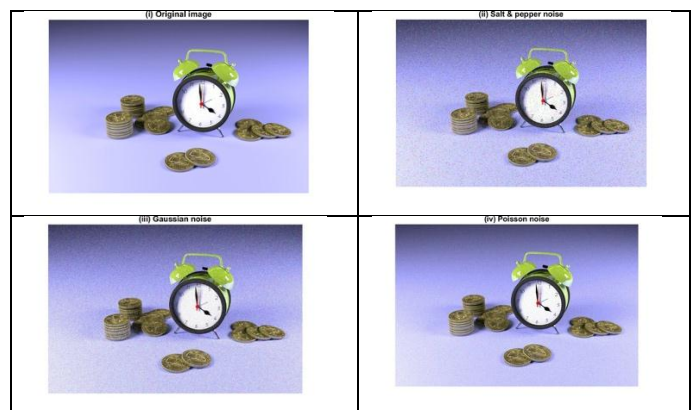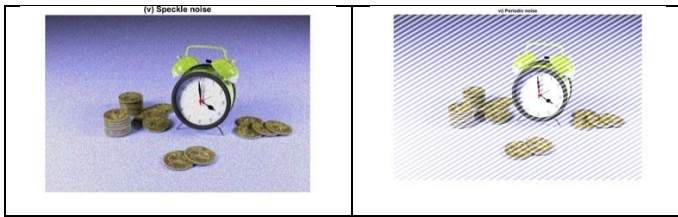
Fig 8: (i) Original image, (ii) Salt and pepper noise, (iii) Gaussian noise, (iv) Poission noise, (v) Speckle noise, (vi) Periodic noise

5. CONCLUSION

Noise can be added in an image either during its acqution or processing or transmission. For majority of the applications noise is unwanted signal which has to be removed for this we have to understand the behaviour of the noise which is called as noise model. Prior to this we need to understand types of images and various types of image format. Hence, here we have reviewed and presented various images and its format where in noise gets added. From the source of origin, noise models can be identified. With the help of mean and variance (Probability Density Function) as well noise model can be designed. Our work will provide a susceptible information for freshers as well as for the researchers in the field of Image processing. This is the very basic step for any image to be further processed and apply any technique for enhancement or feature extraction.

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