Chapter 2

Literature Review

2.1 Previous study

This chapter explain all subjects and topics that are involved in this research. In addition, it reviews related works and previous studies that inspires this research criterion.

In[1] Reshmala kshmi, Color prediction is still a critical issue in computer vision and image processing. It is necessary to ensure that the perceived color of object remains constant under varying illumination conditions. Novelty of this paper lies in introduction of new color space called linguistic color space designed using fuzzy system for better color constancy. In addition, mapping from RGB to linguistic space retains the precision and accuracy. While evaluating the algorithm, it is clear that the color components are preserved effectively and accurately with the help of combination of different types of membership functions. Inference rules with membership functions results intuitive and efficient color space.

In [2] Sang-Geol Lee propose a method based on the HSI model and new inference process that resembles the human vision recognition process. that method allows the user to add, delete, or update inference rules. In that method, membership intervals are designed with sine and cosine functions in the H channel and trigonometric style functions in the S and I channels. The membership degree is computed via an interval merging process. Then, inference rules are applied to the result in order to infer the color information. Experimental results show that this method is more intuitive and efficient than that based on the RGB model.

The work in [3] B. Somayeh Mousavi presents a comprehensive laboratory using fuzzy logic for color sensing applying the fuzzy inference system using MATLAB implementation on a low-cost educational microcontroller-based system. Hardware details of the intelligent sensor and

the software implementation of fuzzy logic algorithm are also given in this work.

In [4] Dr. Abbas Hussien Miry,Fuzzy logic is used to cover the difference in the parameter of face. The method provides a suitable method for extracting information. The proposed method has been tested on various real images and its performance is found to be quite satisfactory with detection accuracy 94.74%[4].

The article in [5] Waiwit Chanwimalueng, presents a method to personalize user interface(UI) such as icon to suit each users' age by using fuzzy logic. First, the color of the icons is analyzed as RGB color values then converted to the HSV color model to make them more suitable to fuzzy membership functions. Then, the rules to define the color components to suite the perception of each user's group range were defined. These rules can then be used as a model to select appropriate icons suitable for the design of human-computer interfaces on smart mobile phones.

In[6] Sheffali Bamba, proposed a latest color edge detection technique based on the mixture of hue factor and principal component analysis to resolve the problems with existing methods. First, a novel computational method of hue transformation has been used to estimate the hue in the given image, and then image gradient operators also come in act to gain the precise edges in hue factor. Also the edges of the original image will also be evaluated by using the fuzzy edge detector operator to illustrate the edges. In addition, complete object edges has been acquired by using the edge based fusion of the hue component, first principal component and Edge detection using fuzzy templates for color images. The experimental result has shown that the proposed technique outperforms over the available techniques.

In[7] Mohd Alif Syami Bin Azmi, present great help in identifying objects for many years. Color is the byproduct of the spectrum of light, as it is reflected or absorbed, as received by the human eye and processed by the human brain. Most likely use three models: HSV,CMYK and RGB. The RGB model have been focused. The RGB color model combines Red, Green, and Blue light in various ways to reproduce a broad array of colors.

The RGB color of an object will be classified by using Fuzzy logic according to the data given by the analog sensor. Aims providing a better understanding on applying Fuzzy Logic in solving real life application for engineering technology students. Experiments will be conducted and the results will be used to demonstrate the color classification using Fuzzy Logic.

2.2 Sensors

Color is the most vital visual feature for humans. By color representation we mean the overall color of image content when used as a "global" feature.

In this research talk about few fundamental definitions such as image, digital image, and digital image processing. Different sources of digital images will be discussed. The continuum from image processing to computer vision will be covered in this project. Finally we will talk about image acquisition and different types of image sensors.

With knowledge of color models and different color formats we can represent the color information of the input digital image acquired by a camera or scanner that can recognize three primary ingredient spectrums; red, green, and blue from the light beam that considered the primary components. The properties that used to distinguish different colors are brightness, hue, and saturation; these parameters are classified into two components; luminance (the brightness) and chrominance (hue and saturation), so each color is represented with two characteristic components luminance and chrominance that are suitable for human interaction .

Color models are a mathematical model that briefly convert the light color coordinates position into three color components in the three dimensional space using some mathematical functions.

2.2.1 The RGB color model

The RGB color model works exactly like those color receptors of the human eye: the RGB color model describes a color by using 3 variables, Red, Green and Blue. These variables can be compared to the strength of the signals from the 3 types of color receptors in the nerves as shown in figure (2-1). A computer or TV screen works this way too: it has 3 types of cells, Red, Green and Blue, and can make each type brighter or darker independently, exciting the correct receptors of the eye to create the desired color. If you look with a magnifying glass to a white area of your computer screen, you can see that the color white is actually made out of the 3 colors red, green and blue. This means the white emitted by a computer screen is different from white sunlight: while white sunlight contains photons of all frequencies (except a few), the computer screen only has 3 frequencies. The human eye can't see the difference between these two kinds of white.

  The RGB color model is the one you'll mostly be dealing with in computer graphics. It's also called the additive color model, because you add 3 color components together to form any color. In 24-bit color, each of the 3 components R, G and B is an 8-bit variable that can be an integer number between 0 and 255. 0 means the color component is off (black), while 255 means it's at its full intensity. 127 is half intensity. This means color 0,0,0 is the darkest black, color 255,0,0 is the brightest red, color 0,255,0 is the brightest green and color 0,0,255 is the brightest blue. 255,255,255 is the brightest white and 127,127,127 is gray. 32-bit color is the same but with an extra 8-bit alpha channel added that can be used for transparency of textures. The RGB color model isn't very intuitive, so here's a table(2-1) containing some common RGB values:

Table 2- 1:common RGB color values

| R	G	B	Hex Value	Color
0	0	0	000000	Black
255	0	0	FF0000	Red
0	255	0	00FF00	Green
0	0	255	0000FF	Blue
255	255	0	FFFF00	Yellow
255	0	255	FF00FF	Magenta
0	255	255	00FFFF	Cyan
255	128	128	FF8080	Bright Red
128	255	128	80FF80	Bright Green
128	128	255	8080FF	Bright Blue
64	64	64	404040	Dark Grey
128	128	128	808080	Intermediate Grey
192	192	192	C0C0C0	Bright Grey
255	255	255	FFFFFF	White
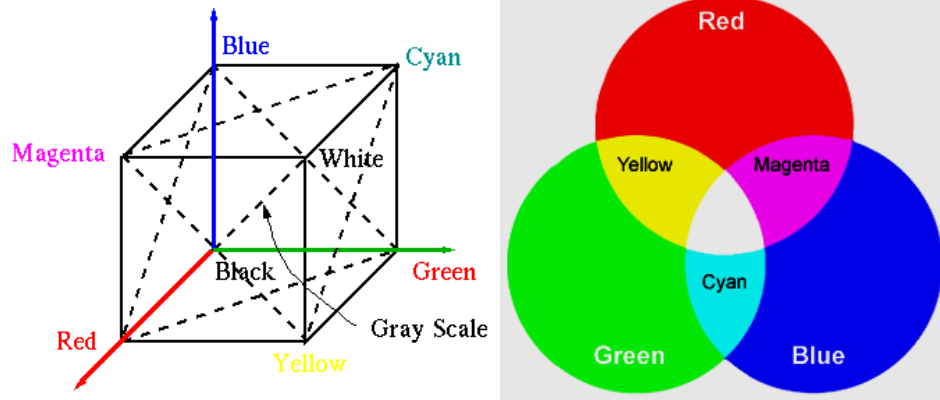
Figure 2- 1 : RGB color Model. A: Primary colors cube. B: Primary colors representation.

2.2.2 The HSL Color Model

HSL is another way to describe color with 3 parameters. RGB is the way computer screens work, but not very intuitive. HSL is more intuitive, but you need to convert it to RGB before you can draw a pixel with it. The nicest application of this color model is that you can easily create rainbow gradients or change the color, lightness or saturation of an image with this color model. HSL color obviously has the parameters H, S and L, or Hue, Saturation and Lightness.

Hue indicates the color sensation of the light, in other words if the color is red, yellow, green, cyan, blue, magenta, ... This representation looks almost the same as the visible spectrum of light, except on the right is now the color magenta (the combination of red and blue), instead of violet (light with a frequency higher than blue):

Figure 2- 2 : Hue

Hue works circular, so it can be represented on a circle instead. A hue of 360° looks the same again as a hue of 0°.

Figure 2- 3: Hue Circular

Saturation indicates the degree to which the hue differs from a neutral gray. The values run from 0%, which is no color, to 100%, which is the fullest saturation of a given hue at a given percentage of illumination. The more the spectrum of the light is concentrated around one wavelength, the more saturated the color will be. Saturation and Lightness will be presented as numbers between 0-255 instead, so that the HSL model has the same 24 bits as the RGB model.

Figure 2- 4: Saturation

Lightness indicates the illumination of the color, at 0% the color is completely black, at 50% the color is pure, and at 100% it becomes white. In HSL color, a color with maximum lightness (L=255) is always white, no matter what the hue or saturation components are. Lightness is defined as (max Color + min Color)/2 where max Colors the R, G or B component with the maximum value, and min Color the one with the minimum value.

Figure 2- 5: Lightness

2.2.3 The HSV Color Model

The HSV color model (sometimes also called HSB), uses the parameter **Value** instead of Lightness. Value works different than Lightness, in that the color with maximum value (V=255) can be any color like red, green, yellow, white, etc..., at its maximum brightness. Value is defined as max Color, where max Color is the R, G or B component with the maximum value. So the colors red (255,0,0) and white (255,255,255) both have a Value of 255 indeed.

In HSL, the Lightness showed the following behavior when increased:

Figure 2- 6: Lightness in HSL

In HSV, Value does the following:

Figure 2- 7: Value in HSV

The Hue and Saturation parameters work very similar to the ones in HSL. HSV is generally better at representing the saturation, while HSL is better at representing the brightness. However, HSV is again better to decrease the brightness of very bright images.
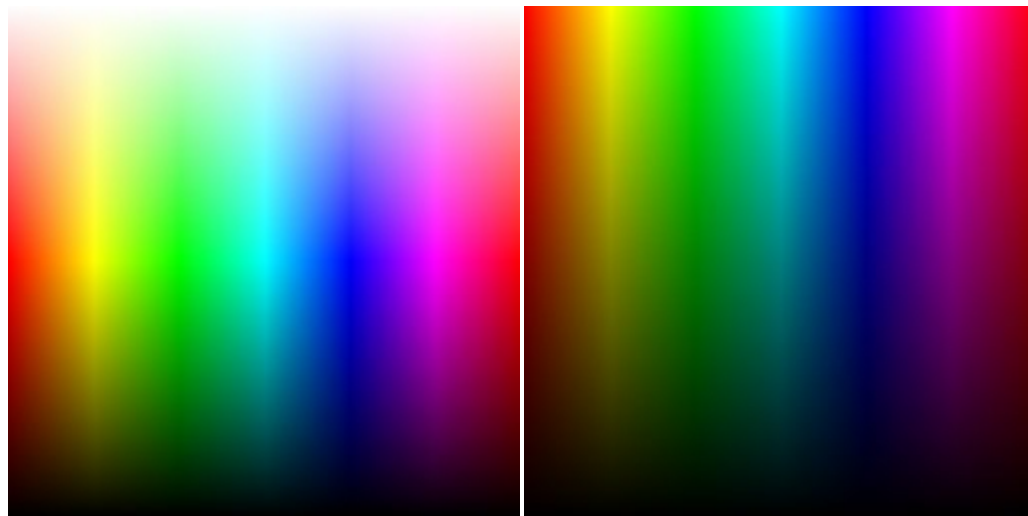
compare the HSL and HSV model a bit better by comparing their plots:

Figure 2- 8: HSL vs HSV when S=255

While the top of the HSL curve is white because white is the color with maximum brightness, the top of the HSV curve contains all colors,

because the saturation is 255 and in HSV, saturation 255 has to be a color while white should have 0 saturation. The top of the HSV curve is the same as the center horizontal line of the HSL curve, and the complete HSV curve is exactly the same as the bottom half of the HSL picture.

Here is the plot of HSL (left) and HSV (right) with L=255 and V=255 respectively, Hue on the horizontal axis, and Saturation on the vertical axis (maximum saturation at the bottom):
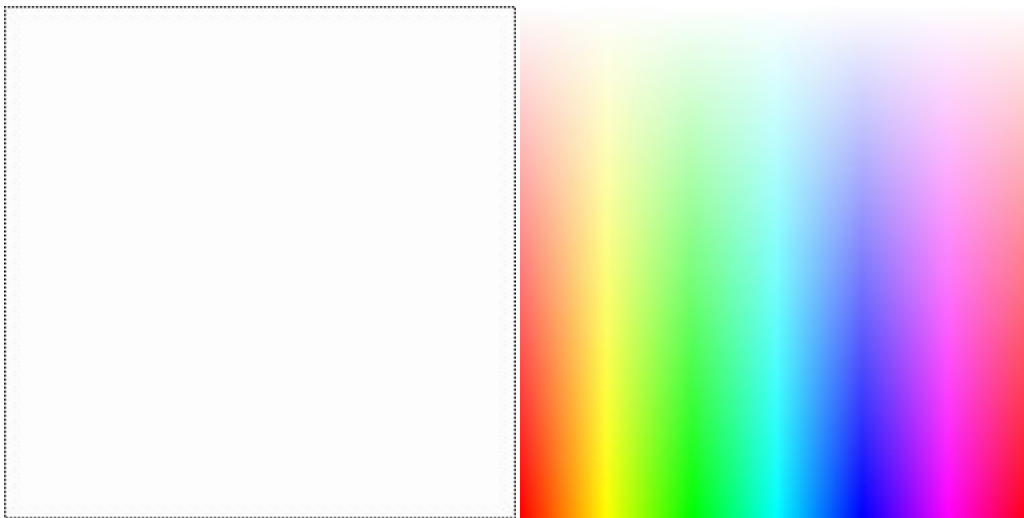

Figure 2- 9: HSL vs. HSV when S=255, L=255

The HSL curve is completely white, because white is the only color with L=255 in the HSL model. The HSV curve, now shows all colors that have one or more of their color components equal to 255. The HSV picture here, is exactly the same as the top half of the previous HSL picture where S=255.

And here's the plot of HSL (left) and HSV (right) with L=128 and V=128 respectively, and again Hue on the horizontal axis, and Saturation on the vertical axis (maximum saturation at the bottom):
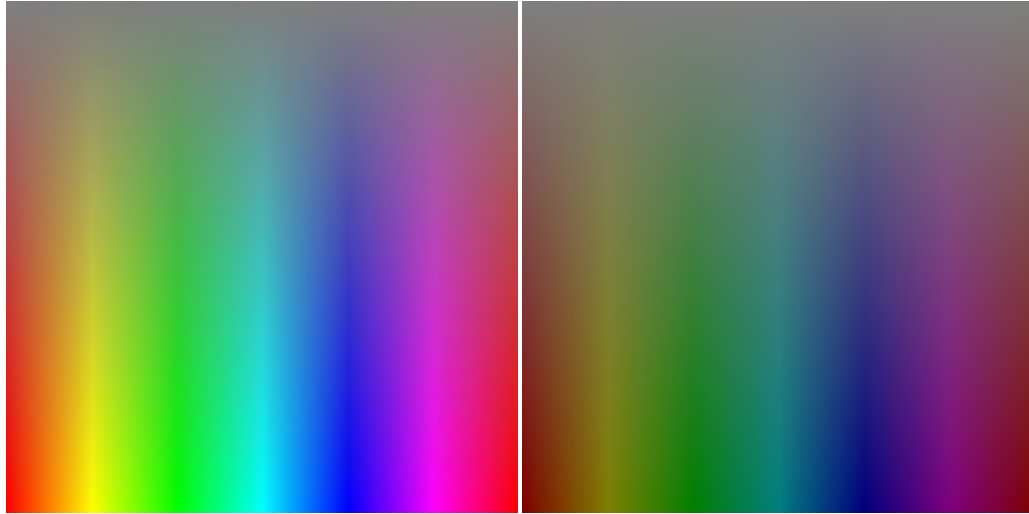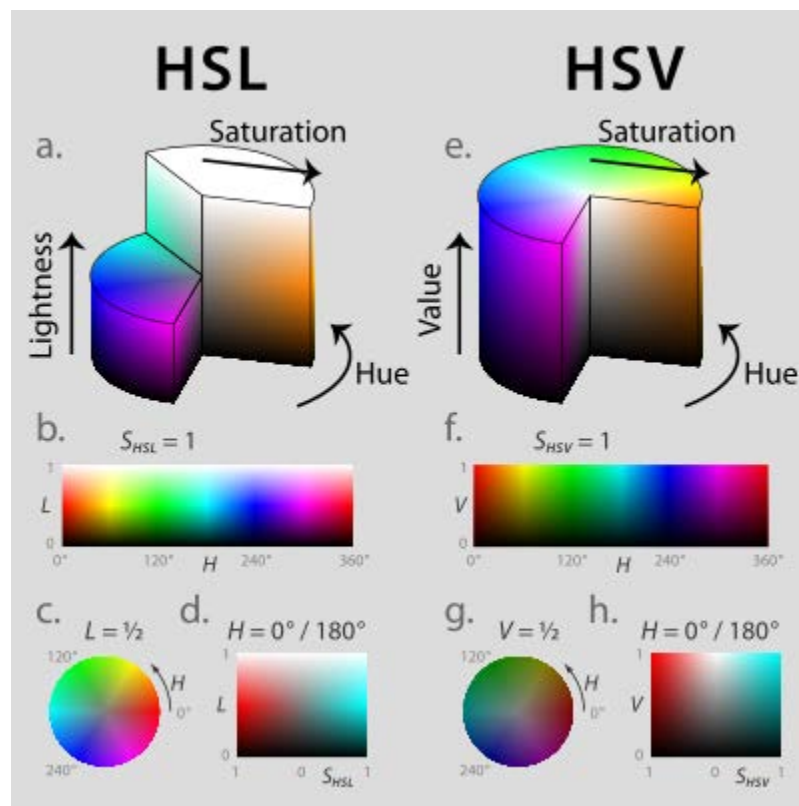
Figure 2- 10: HSL vs. HSV when L=128, V=128

Figure 2- 11: HSL and HSV

HSL (a–d) and HSV (e–h). Above (a, e): cut-away 3D models of each. Below: two-dimensional plots showing two of a model's three

parameters at once, holding the other constant: cylindrical shells (b, f) of constant saturation, in this case the outside surface of each cylinder; horizontal cross-sections (c, g) of constant HSL lightness or HSV value, in this case the slices halfway down each cylinder; and rectangular vertical cross-sections (d, h) of constant hue, in this case of hues 0° red and its complement 180° cyan.

2.3 Fuzzy Logic

Fuzzy logic is a technique for representing and manipulating uncertain information. In the more traditional propositional logic, each fact or proposition, such as 'it will rain tomorrow,' must be either true or false. Yet much of the information that people use about the world involves some degree of uncertainty. Like probability theory, fuzzy logic attaches numeric values between 0 and 1 to each proposition in order to represent uncertainty. But whereas probability theory measures how likely the proposition is to be correct, fuzzy logic measures the degree to which the proposition is correct.

The important distinction between probabilistic information and fuzzy logic is that there is no uncertainty about the age of the president but rather about the degree to which he matches the category 'young.' Many terms, such as 'tall,' 'rich,' 'famous' or 'dark,' are valid only to a certain degree when applied to a particular individual or situation. Fuzzy logic tries to measure that degree and to allow computers to manipulate such information.

A fuzzy set allows for its members to have degrees of membership. If the value of 1 is assigned to objects entirely within the set and a 0 is assigned to objects outside of the set, then any object partially in the set will have a value between 0 and 1. The number assigned to the object is called its degree of membership in the set as shown in figure (2-12) .
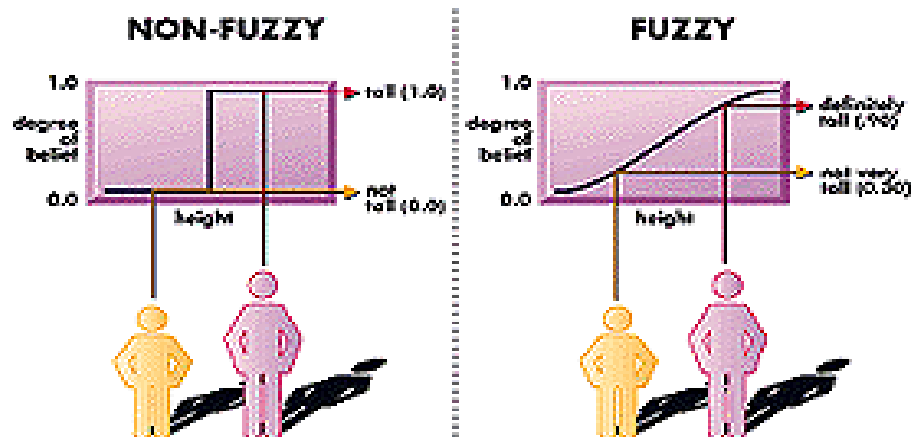
Figure 2- 12: Fuzzy and non-fuzzy logic

A paradigm is a set of rules and regulations which defines boundaries and tells us what to do to be successful in solving problems within these boundaries. For example the use of transistors instead of vacuum tubes is a paradigm shift - likewise the development of Fuzzy Set Theory from conventional bivalent set theory is a paradigm shift.
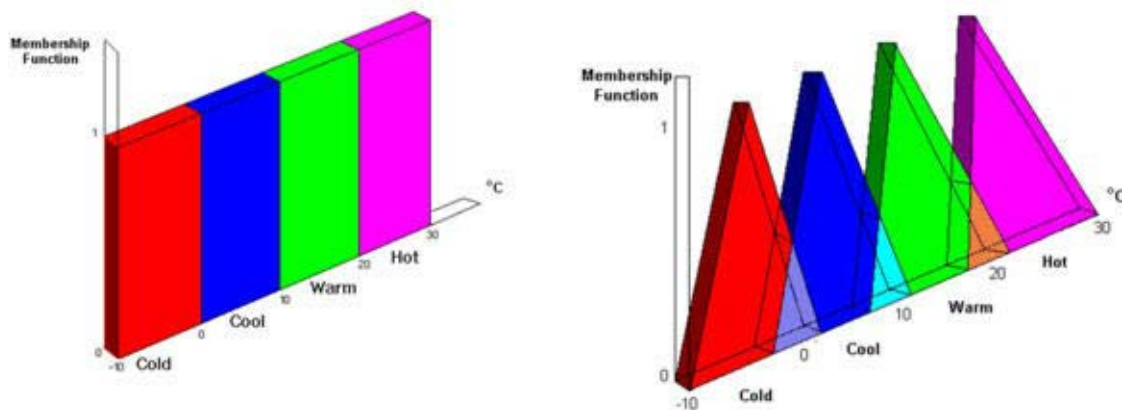

Figure 2- 13: Bivalent sets and fuzzy sets

The most obvious limiting feature of bivalent sets that can be seen clearly from the diagram is that they are mutually exclusive - it is not possible to have membership of more than one set (opinion would widely vary as to whether 50 degrees Fahrenheit is 'cold' or 'cool' hence the expert knowledge we need to define our system is mathematically at odds with the humanistic world). Clearly, it is not accurate to define a transition from a

quantity such as 'warm' to 'hot' by the application of one degree Fahrenheit of heat. In the real world a smooth (unnoticeable) drift from warm to hot would occur.

This natural phenomenon can be described more accurately by Fuzzy Set Theory. Figure (2-13) above shows how fuzzy sets quantifying the same information can describe this natural drift.

There are many benefits to using fuzzy logic. Fuzzy logic is conceptually easy to understand and has a natural approach [8]. Fuzzy logic is flexible and can be easily added to and adjusted. It is very tolerant of imprecise data and can model complex nonlinear functions with little complexity. It can also be mixed with conventional control techniques. There are three major components of a fuzzy system: fuzzy sets, fuzzy rules, and fuzzy numbers[18].

- **Fuzzy sets:** Fuzzy logic and fuzzy thinking occur in sets. Consider an example of a vehicle. We all speak vehicle the same, but we think of vehicles on a different, personal level. It is a noun. It describes something. There is a group of devices that we call vehicles. These devices might include a semi-truck, a plane, a bus, a car, a bike, a scooter, or a skateboard. What I consider a vehicle to be could be something very different from what someone else considers a vehicle to be. Which is really a vehicle and which is not? Some seem closer to our idea of a vehicle than others. Fuzzy logic says that to a degree each of these devices is a vehicle. Some represent a vehicle more than others but all fall in the grayness between a vehicle and non-vehicle. The point is that the word vehicle stands for a fuzzy set and things belong to this set to some degree[18].

- **fuzzy rules**: Fuzzy rules are based on human knowledge. define fuzzy patches, along with grayness, are key ideas in fuzzy logic.

- **fuzzy numbers:** There are several ways to associate a fuzzy number to a description in words. The association takes place in the form of a certain shape. This shape is called a membership function. There are four shapes that are mainly used. These include a triangle, a trapezoid, a Gaussian shape, and a Singleton. Figure (2.14) shows the possible shapes to use for subset definition.

Triangle: [a,b,c]

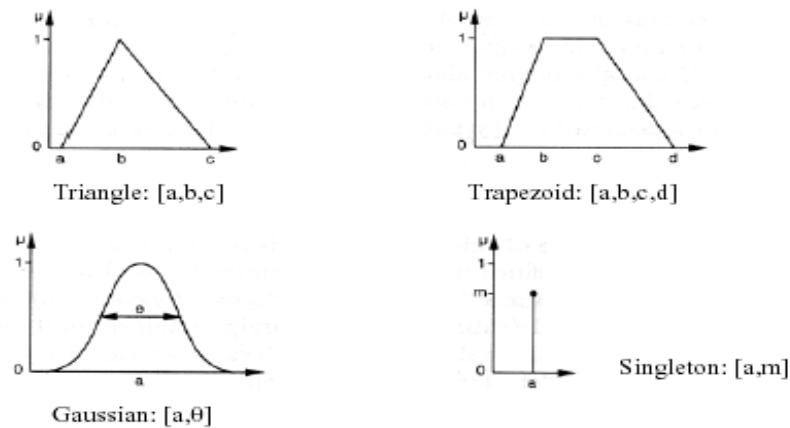Trapezoid: [a,b,c,d]

Gaussian: [a,θ]

Singleton: [a,m]

Figure 2- 14: Membership Function Shapes

Each of these membership functions are convex in shape meaning as the domain increases, that the shapes rising edge starts at zero, rises to a maximum value, and the decreases to zero again[18].

2.4 Digital Image Processing

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Nowadays, image processing is among rapidly growing technologies. It forms core research area within engineering and computer science disciplines too.

Image processing basically includes the following three steps:

- Importing the image via image acquisition tools.

- Analyzing and manipulating the image.

- Output in which result can be altered image or report that is based on image analysis.

There are two types of methods used for image processing namely, analogue and digital image processing. Analogue image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. Digital image processing techniques help in manipulation of the digital images by using computers. The three general phases that all types of data have to undergo while using digital technique are pre-processing, enhancement, and display, information extraction.

2.5 Computer Vision

Humans use their eyes and their brains to see and visually sense the world around them. Computer vision is the science that aims to give a similar, if not better, capability to a machine or computer.

Computer vision is concerned with the automatic extraction, analysis and understanding of useful information from a single image or a sequence of images. It involves the development of a theoretical and algorithmic basis to achieve automatic visual understanding.

Computer vision and image recognition are terms that are often used synonymously, but the former encompasses more than just analyzing pictures. That's because, even for humans, "seeing" also involves perception on many other fronts, along with a lot of analysis. Humans use about two-thirds of their brains for visual processing, so it's no surprise that computers would need to use more than just image recognition to get their sight right.