Colour Matting Algorithms

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By

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CERTIFICATE

This is to certify that the project work entitled "**Colout Matting Algorithms**" being submitted to University of Hyderabad by **M. Sreenivasulu** (Reg. No. 08MCMT21), in partial fulfillment for the award of the degree of Master of Technology in Computer Science, is a bona fide work carried out by him under my supervision.

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M. Sreenivasulu

Abstract

This project deals with image matting techniques. Matting refers to the process of extracting foreground objects from a known or partially known background. The extracted foreground objects may then be placed in scenes containing arbitrary backgrounds. Matting is heavily used in motion-picture industry. There exist a variety of algorithms for matting based on foreground and known background properties. In the project, two standard algorithms for matting opaque foreground objects on known fixed colour backgrounds are implemented. In addition, a new algorithm that enables matting of opaque objects on variable colour background is also implemented.

The second part of the work concerns matting of transparent, reflective and translucent objects. Matting algorithms in these cases are much more complex as they involve not only extraction of the foreground object but the reflections of the background on the foreground and the distortions induced in the background by the optical properties of the foreground object. In literature, these effects are given the title, *environment matting*. This part of the work is only partially completed because of the difficulty in generating the necessary images for extracting matting information.

The algorithms implemented and their results are shown on several images. It is concluded that matting of transparent objects is still a challenging research problem and its solution would lead to creation of many special effects.

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Chapter 1

Introduction

1.1 Problem Definition

Our aim is to study the color image matting and composition operations. Digital image matting is a critical operation in commercial television, advertisement design and film production. The basic process of matting techniques is to extract embedded foreground objects from background image by estimating a color and opacity for the foreground element at each pixel.The opacity value at each pixel is typically called its α, and the opacity image,taken as a whole is referred to as the α matte. Usually, the extracted foreground objects and their corresponding mattes are used to composite new images or video clips.

In case of solid transparent and translucent foreground matting, we should capture not only just a foreground object and its alpha matte from a composite scene, but also need a description of how solid transparent object refracts and reflects light and which parts of the background is contributing and effecting the position on which pixel of foreground. This is called as *environment matting* in literature. Objects captured in this way exhibit not only specular,glossy and translucent effects, as well as scattering of light according to wavelength. Applications of this work include the relighting of objects for virtual and augmented reality, more realistic 3D clip art, and interactive lighting design.

1.2 Motivation

Matting and composition are fundamental operations in graphics and computer vision. The goal of computer vision is to make computer work like human visual perception, namely, to understand and recognize the world through visual information, such as, images or videos. Human visual perception, after millions of years of evolution, is extremely good in understanding and recognizing objects or scenes. But some times the resultant images or videos from computer vision may not seems to be realistic.

Photography and special effects of film making to combine two or more image elements into a single, final image. Usually, mattes are used to combine a foreground image (such as actors on a set, or a spaceship) with a background image (a scenic vista, a field of stars and planets). With the recent advances of digital cameras, using matting techniques to create novel composites and various editing tasks has gained increasing interest from both professionals as well as consumers. Consequently, various matting techniques and systems have been proposed to try to efficiently extract high quality mattes from both still images and video sequences.It is very challenging.

Principle of Environment Matting is extensively applicable in production of 3D images and videos.

Some time in photography, shots may require mattes that change, to mask the shapes of moving objects, such as human beings or spaceships. These are known as traveling mattes. Traveling mattes enable greater freedom of composition and movement, but they are also more difficult to accomplish. Bluescreen techniques, originally invented by Petro Vlahos, are probably the best-known techniques for creating traveling mattes.

1.3 Related Work

Petro Vlahos defined the problem and invented solutions to the matting in film and then in video in 1950's. A. R. Smith and J. F. Blinn[11] described the blue screen matting method which is a special case of separating a desired opaque foreground image from a background of almost constant backing color and foreground is distinct from the background.

A.Shikaripur Nadig[10], R.Smith and Blinn[11] described the matting process in case of opaque foreground object shares the colour with constant background.This is also called as triangulation matting. We did not find any matting method which deals with the extraction of opaque foreground on variable background in literature. We proposed a method of extraction of foreground without sharing any colour components with variable background. We don't fined the solution for extraction of solid foreground sharing colour components with variable background.

Y.Wexler, A.W.Fitzgibbon[13] and Y.-Y.Chuang, D.E.Zongker[5], Werner[14] given methods of solution to matting of solid transparent foreground object on simple and complex background.But they did not considered foreground effects on background and specular effects into consideration and their methods needs set of images in matting process.The size of the set depends on size of the image is to be matte.

B.Choudhury, D.Singla, and S.Chandran[4] explained the better method of extraction of transparent,translucent and specular foreground on any background.They used multiple colors as cues. If c colors are used for the cube each of whose faces is kxk, the number of images they needed is $log_c 6k^2$. This method takes less number of input images and less time for computation compared with Zongker and Wexler methods.

1.4 Approach

Generally any real composite image can be composition of foreground component, background component and boundary component. The fundamental composition equation in literature is as follows, if B is backing color component and F be a foreground component,then composite color C is given as, also called as *matting equation*,

$$\boxed{C = \alpha F + (1 - \alpha)B}$$

Where α is called as *alpha matte*, it has traditionally played a dual role: it is used to represent, simultaneously, both the coverage of a pixel by a foreground element(shape), and the opacity of that element(transparency).

The problem we address here is that of extracting a matte for a foreground object, given only a composite image containing it. We shall see, in general, this is an underspecified problem. By using matting equation and applying it to all channels individually and simultaneously, we can extract a foreground matte under some constraints.

According to our survey, we can divide matting process into two parts. They are, *Opaque foreground object matting.* Simply called as *Image Matting.* Algorithms which are discussed in chapter 2, have been applicable for only if foreground is not solid transparent and translucent(glassy) and *Transparent foreground object matting.* It is also called as *Environment Matting*. Algorithms which are discussed in chapter 3 describe transparent foreground matting.

1.5 Organization of the Report

Thesis is organised in following order. Chapter 1, gives the introduction to the project,problem definition ,its motivation,related work and basic approach of matting process. Chapter 2, gives brief introduction and explanation about the different image matting algorithms,implementation,results and comparison of algorithms. Chapter 3, tells about description of different environment matting algorithms. Chapter 4, explains the image composition process of size independent images as well as results. Chapter 5, deals with the conclusion and future work.

Chapter 2

Colour Matting Algorithms

2.1 Introdution

Concentration of this chapter is on matting of non-transparent foreground objects. In this chapter, we described some of the basic and well known matting algorithms which we found in literature and as well as our proposed algorithms with results and these algorithms are only the specific cases of separating the the desired foreground image from a composite image. There is no matting algorithm in literature which is best for all types of images.

As we know that Matting is the problem of separating an input image C into three output images: a background B, foreground F , and matte that represents the sub-pixel coverage of the background by the foreground at each pixel. The matting equation is given by $C = \alpha F + (1 - \alpha)B$.

This equation has been applying for Red, Green and Blue channel to estimate alpha matte and foreground Red, Green and Blue component values. This gives three equations and four unknowns and it leads to an underspecified problem.But this problem can be solved by imposing some constraints on matting process.Algorithms described in this chapter are Blues screen matting algorithm, Triangulation matting algorithm,Gray-scale matting algorithm and our proposed Variable background matting algorithm.

The RGB components of an element only retain the color information. A separate component is needed to retain the matte information.We shall use alpha channel and matte interchangeably. The use of an alpha channel to form arbitrary compositions of images and it gives shape and transparency to a color image. It is the digital equivalent of a holdout mattea gray-scale channel that has full value pixels (for opaque) at corresponding pixels in the color image that are to be seen, and zero valued pixels (for transparent) at corresponding color pixels not to be seen. We shall use 1 and 0 to represent these two alpha values, respectively. Fractional alphas represent pixels in the color image with partial transparency.

2.2 Blue Screen Matting Algorithm

Petros Vlahos invented blue screen matting in the 50s.His Ultimate is still the most popular equipment. He won an Oscar for lifetime achievement.It is most common form of matting algorithm in TV studios and movies.

Blue screen matting algorithm can be work well for specific types of images. Algorithm needs a known and uniform backing color along with desired composite and foreground component should not have any backing color information i.e. foreground should not tie with background colour.

The backing color has often been blue, so the problem, and its solution, have been called blue screen matting. However, other backing colors, such as yellow or (increasingly) green or Red, have also been used.But blue has been preferred for several reasons.We know that blue is a complementary color of flesh tone.Since the most common color in most scenes is flesh tone. So,the opposite color is the logical choice to avoid the conflicts.Green has more flexible and more reflectance than blue and which can make matting easier. But disadvantage of using green background is that green spill is almost always objectionable and obvious even in small amounts of change, while blue can slip by unnoticed.

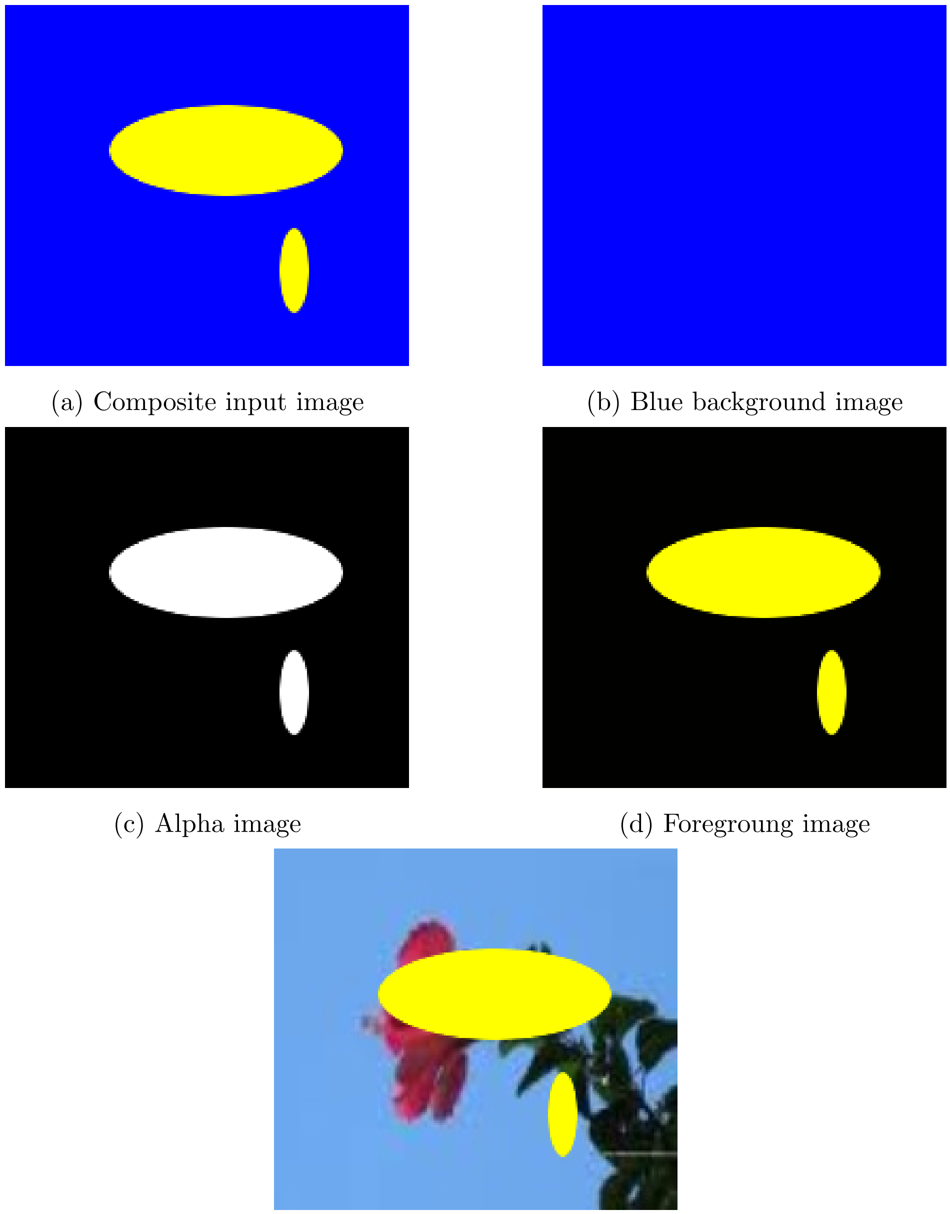
2.2.1 Procedure

The color at each pixel i of a desired composite can be represented as $C_i = [R_i\, G_i\, B_i]$, foreground component $C_o = [R_o\, G_o\, B_o\, \alpha_o]$ and background component $C_k = [R_k\, G_k\, B_k]$. The matting equation is $C = C_o + (1 - \alpha_o)C_k$. Applying the equation to RGB channels individually , we can have:

$$R_i = R_o * \alpha_o + (1 - \alpha_o)R_k$$
$$G_i = G_o * \alpha_o + (1 - \alpha_o)G_k$$
$$B_i = B_o * \alpha_o + (1 - \alpha_o)B_k.$$

Here we need to fined R_o, G_o, B_o and α_o.But we have three equations and four unknowns.It is an underspecified problem.Considered that the foreground element C_o does not contain any blue, $C_o = [R_o\, G_o\, 0]$ *i.e.* $B_o = 0$, and the constant backing color C_k contains only blue , $C_k = [0\, 0\, B_k]$, then $\alpha_o = 1 - B_i/B_k$.

2.2.2 Results



(a) Composite input image

(b) Blue background image

(c) Alpha image

(d) Foregroung image

(e) Composition output image

Figure 2.1: a and b are input images, c and d are output α and F images, e is output composite image for Blue Screen Matting algorithm respectively.

2.3 Triangulation Matting Algorithm

2.3.1 Procedure

Instead of reducing the number of unknowns, the number of equations can be increased. One way to do this is to photograph the foreground object in front of two known but distinct backgrounds. Let $C_{k1} = [R_{k1}\, G_{k1}\, B_{k1}]$ and $C_{k2} = [R_{k2}\, G_{k2}\, B_{k2}]$ be the two different backing colors, $C_o = [R_o\, G_o\, B_o\, \alpha_o]$ be a foreground and C_1 and C_2 are desired composite images then,

$$C_1 = C_o + (1 - \alpha_o)C_{k1}$$
$$C_2 = C_o + (1 - \alpha_o)C_{k2}$$

If we write the above two equations in terms of their RGB coordinates, we have 6 equations and 4 unknowns $R_o, G_o, B_o and \alpha_o$.The equations are,

$$\begin{aligned} R_1 &= \alpha_o R_o + (1 - \alpha_o)R_{k1} & \quad R_2 &= \alpha_o R_o + (1 - \alpha_o)R_{k2} \\ G_1 &= \alpha_o G_o + (1 - \alpha_o)G_{k1} & \quad G_2 &= \alpha_o G_o + (1 - \alpha_o)G_{k2} \\ B_1 &= \alpha_o B_o + (1 - \alpha_o)B_{k1} & \quad B_2 &= \alpha_o B_o + (1 - \alpha_o)B_{k2} \end{aligned}$$

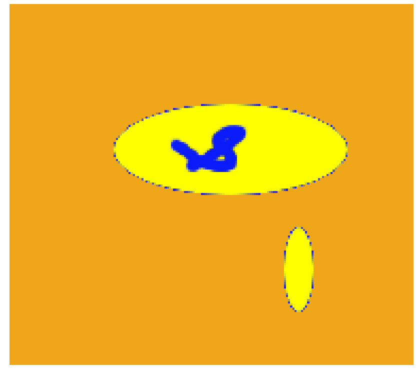
Here now the problem is over specified and it can be solved easily.The alpha value can be given as

$$\alpha_o = 1 - (B_1 - B_2)/(B_{k1} - B_{k2}).$$

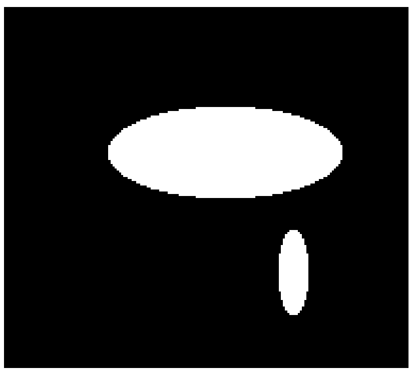
Here each pixel is processed independently, so the backgrounds do not need to be a constant backing color. Triangulation does not have the limitations of Blue Screen Matting but the only drawback is that the foreground object should be shot against two different backgrounds.

2.3.2 Results

(a) Composite Image 1



(b) Composite Image 2



(c) Alpha image

(d) Foregroung image

(e) Composition image

Figure 2.2: a and b are input composite images, c and d are output α and F images, e is output composite image for Triangulation Matting Algorithm respectively.

2.4 Gray image matting Algorithm

Consider the desired composite image C and foreground Co to be gray, which implies that Ro=Go=Bo,all colour components are equal.Then matting equations of RGB channels leaves us with three equations and two unknowns which are alpha value and any colour component.

This gray scale image matting algorithm can effectively handle objects with intricate and vision sensitive boundaries. One of the important applications of gray scale image matting algorithm is to combine with color transferring techniques to achieve object-based colorization, where objects in the same image are colorized independently.

2.5 Variable Background Matting Algorithm

It is our proposed matting algorithm. Blue screen matting and Triangulation matting algorithms are implemented based on some constraints and they are working well for specific colour images. Similarly, variable background matting algorithm also working for specific colour images and it is also implemented based on constraints but it is giving better results over previous algorithms in terms of time and cost.

Variable background matting algorithm also uses the same matting equation $C = C_o + (1 - \alpha_o)C_k$. For this algorithm, our constrains are background and foreground component should not have common color components in desired composite image, which is in same as blue screen matting algorithm, and we should know Hue of background in prior. Hue is defined as the dominant colour at the pixel location in an image which is defined and associated with HSV color space in colour image processing.

The flexibility of this algorithm is that background need not be uniform but composite image have slightly variable background.Algorithm do not require two or more image information as input.

2.5.1 Algorithmic Approach

Let C be desired composite image, C_o be foreground component and C_k be backing colour. The algorithm is involved with following steps,

- Find Hue values of each pixel of composite image C.
- Compute the cluster of pixels which are belongs to background using Known background Hue.
- Find the center of Background cluster....$X_o = (R_o\, G_o\, B_o)$.
- Find the standard deviation of background pixels(σ).
  $\sigma = \sqrt{(}\sum_{i=1}^{n}(X_i - Xo)^2/(N-1))$, Where N = Number of pixels in Cluster.
- Find the alpha values and
  $\alpha_o = 1/(1 + [3\sigma/dist(r, g, b)]^{2n})$.
- By using matting equation and compute the output.

The alpha equation is working well for all pixels accurately.Here in equation d(r,g,b) represents distance between image pixel and cluster center X_o.

If $d(r, g, b) = 0$ then $\alpha_o = 0$ which is in case of background pixel,
If $d(r, g, b) = 3\sigma$ then $\alpha_o = 0.5$ which is in case of boundary pixel,
If $d(r, g, b) = \infty$ then $\alpha_o = 1$ which is in case of foreground pixel.

2.5.2 Results

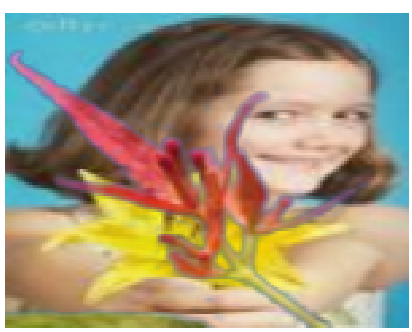
Figure 2.3: a and c are input images, b and d are output α images, e and f are output composite image for for Variable Background Matting algorithm respectively.

(a) Variable background image

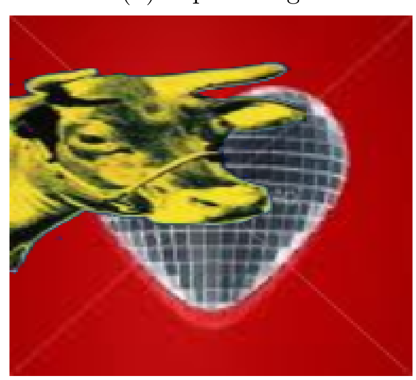
(b) Alpha image

(c) Variable background image

(d) Alpha image



(e) Composite 1



(f) Composite 2

2.6 Comparison of Algorithms

- Blue screen matting algorithm works for an ideal case. It needs two images information as input.

- The scope of Triangulation Matting Algorithm is better than Blue screen matting algorithm because of some flexibility in its approach.The time and space complexity is same as that of Blue screen matting algorithm but it give better results.

- The variable background matting algorithm can also work for specific images. But it need only one image information as input.The time and space complexity is less and give better results compared with Blue screen matting and Triangulation matting algorithms.

Chapter 3

Environment Matting Algorithms

3.1 Introduction

The chapter 2 explains about different approaches of opaque foreground object matting.The results of all those algorithms are not looking to be real and natural. Blue screen matting algorithm, Triangulation matting algorithm and our proposed Variable background matting algorithm could not work if the foreground component in composite image have transparent and reflectance properties.

This chapter introduces a new process, *environment matting*, which captures solid transparent specular foreground object's opacity matte and description of how that object refracts and reflects light, which can be called an *environment matte* .The foreground object can then be placed in a new environment, using environment compositing, where it will refract and reflect light from that scene. Objects captured in this way exhibit not only specular but glossy and translucent effects and scattering of light according to wavelength.Refraction ad Reflection are properties of an object. Refraction is defined as fraction of incident light transmitting through an object.Generally the transparent objects exhibits refraction. Reflection is defined as part of incident flux of light is reflected back by objects which looks shiny.

In traditional digital compositing, the color C that results from placing a foreground element with color F and matte over a background with color B is given by the matting equation, which is computed at each pixel: $C = F + (1 - A)B$. α represents the foreground and background pixel coverage.The matting equation dose not include lighting effects of object and environment. To deal with environment matting problem, We need to modify the environment matting equation in such a way that the matting equation should be accumulation of lighting effects of image. An image element's color can be thought of as an accumulation of several different components. These include:

- any emissive component that the foreground object may have,
- any reflections coming from light sources in the scene and
- any additional reflections or transmission of light from the rest of the environment in which the foreground object was photographed.

The resulting "Environment Matting Equation", after considering lighting factors, have the following form:

$$C = F + (1 - \alpha)B + \Phi$$

where Φ represents the contribution of any light from the environment that reflects from or refracts through the foreground element.

3.1.1 Environment Matte

This section is the literature survey about the representation of lighting effects of environment matte. To start with an "environment mapping assumption" that the only light reaching the foreground object is light coming from distant parts of the scene. This assumption used[13][14] to create the following simplified model of light transport. There are two or more methods to describe environment matting. Two methods of approach are given bellow.

3.1.1.1 Using Texture Mapping

As in Blinn and Newell's original formulation, it can described an environment as light E(ω), coming from all directions ω. The total amount of light Φ emanating from the portion f of a foreground element that is visible through a given pixel can then be described as an integral over f of all light from the environment that contributes to point p in the pixel, attenuated by some reflectance function $R(\omega)$,and assumed that the reflectance function is actually constant across the covered area of a given pixel,it allowing to write this formula in terms of a reflectance function $R(\omega)$ that is independent of position within the pixel:

$$\Phi = \int R(\omega)E(\omega)d\omega$$

By breaking the integral over the environment into a summation over a set of m texture maps $T_i(x)$, where each texture map represents light coming from a different part of the environment.

$$\Phi = \sum_{i=1}^{m} R_i(x)T_i(x)dx$$

Here, the integral is taken over the entire area of each texture map,and $R_i(x)$ is a new reflectance function, which describes the contribution of light emanating from a point x on texture map T_i to the pixel p. The assumption here is that the contribution from a texture map T_i can be approximated by some constant K_i times the total amount of light emanating from some axis-aligned rectangular region A_i in that texture map.Let $R_i = K_i A_i$. Letting $M(T, A)$ be a texture-mapping operator that returns the average value of an axis-aligned region A of the texture T, we have:

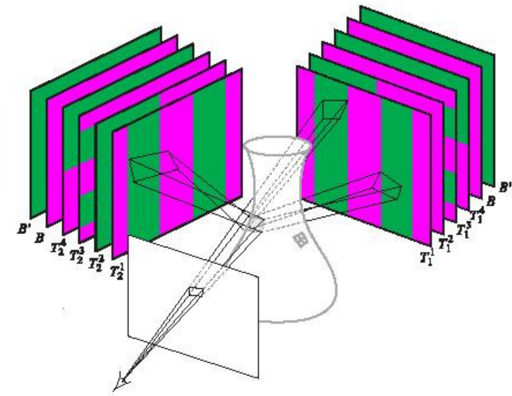
$$\Phi = \sum_{i=1}^{m} K_i \int_{A_i} T_i(x)dx$$

$$\Phi = \sum_{i=1}^{m} K_i(x)A_i M(T_i, A_i)$$

$$\Phi = \sum_{i=1}^{m} R_i(x)M(T_i, A_i)$$

Now overall Environment Matting Equation becomes:

$$C = F + (1-\alpha)B + \sum_{i=1}^{m} R_i M(T_i, A_i)$$



(a) The EM process uses structured textures to capture how light is reflected and refracted from a backdrops and various sidedrops.

3.1.1.2 Using Weighting Function

Consider an object O in a (cubic) environment map B. We can describe an environment as light $E(\omega)$, coming from all directions ω. Thus we have the vector equation,

$$\Phi = \int W(\omega)E(\omega).$$

The weighting function W comprises all means of light transport of environment lighting from all directions ω through a foreground object to the camera.

According to Wexler et al. 2002, the weighting function (over a single backdrop) is to abandon the parametric Gaussian, and simply write it as

$$C = F + R \sum_{u,v} W(u,v)B(u,v)$$

which is a pixel based explicit representation of the footprint of pixel p and $\sum_{u,v} W(u,v) = 1$. Footprint of a pixel is the set of backdrop points which are contributing majorly to the transparent foreground pixel. The contribution part is represented with associated weight W and summation of weighting function of foreground pixel over entire backdrop is unity, it should be normalized.

3.2 Types of Environment Matting

3.2.1 Environment Matting and Compositing

D.E.Zongker and Yung-Yu Chuang[5][14] used the texture mapping method in doing environment matting and also used a number of different patterned textures, which are called as backdrops and sidedrops, displayed on monitors behind and to the sides of the foreground object (see Figure 3.1). Each patterned backdrop is photographed both with and without the foreground object in front of it.They called the image of the backdrop alone the reference image, and the image of the foreground object in front of the backdrop the object image and they solved a non-linear optimization problem to determine the set of parameters most consistent with all the image data. They used patterns that vary in only one dimension, thereby decomposing the problem of finding a rectangle into that of finding two one-dimensional intervals. Their method also requires the object photographed against two solid backdrops.

The dimensionality of the Environment Matting problem is quite large: there are three degrees of freedom for the foreground color F and for each reflectance coefficient R_i (one for each color component), four more degrees of freedom for each area A_i , and one more for α. They separate its extraction problem solution into four stages.In the first stage,they used different backdrops to compute a coarse estimate for α. Then then determine F and R_1 for any pixels covered by the foreground element. Next,they solve for A_1 , along with a finer estimate of α along the element's boundary. Once they have found F, α, R_1 , and A_1 ,they determine the R_i and A_i values for other faces of the environment.

They partitioned each pixel of the environment matte into three classes: covered,uncovered and boundary. The uncovered, or background, pixels will be assigned an alpha of 0. The covered pixels which have an alpha of 1 and boundary pixels for which they determined a fractional alpha by refined estimation of coverage.

To refine the alpha values for pixels on the boundary, and to determine the axis-aligned rectangle A_1 of the background that best approximates the reflection and refraction in the scene, they used to minimize an objective function over the series of photographed images for each covered pixel in the scene. The objective function is:

$$E_1 = \sum_{i=1}^{n} ||C^j - F(\alpha) - (1-\alpha)B^j - R_1(\alpha)M(T_1^j, A_1)||^2$$

Here, B^j and C^j are the colors of the pixel in question in the reference image and object image, respectively, when the j-th pattern is displayed as a backdrop. Similarly, the texture map T_1^j is obtained by taking a reference photograph of the j-th pattern, displayed as a backdrop. Finally, the (squared) magnitude is computed as the sum of squared distances between colors in RGB space.

The results obtained by this methods are reasonably accepted. To extract a 512x512 matte, the used 18 stripe images, nine backdrops and nine sidedrops.The extraction process took on the order of 10 to 20 minutes per face of the environment map, running on an Intel Pentium II at 400MHz.

3.2.2 Image-based Environment matting

Environment matting is a powerful technique for modeling the complex light-transport properties of real-world optically active elements. Wexler,Andrew. W. Fitzgibbon and Andrew. Zisserman[13] used weighting function method in environment matting. Estimation of weighting function is their primary goal for them.To calculate optical element's light transport path,they used multiple images of the same optical element over the same background, where the element and background have relative motion.

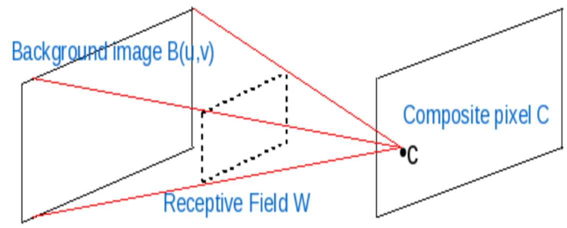
Their idea is each pixel in the composite image C collects light from a blend of pixels in background B. The set of background pixels which contribute to a given output pixel p is called the footprint of p, or ps receptive field. So each source pixel has an associated weight. The value of the output pixel is then computed as a weighted sum over the pixels of B. Thus if we can compute the receptive field for each pixel, we can compute the composite.

The complete description of the formation of the composite image C as follows:

$$C(x, y) = (1\alpha(x, y))F(x, y) + \alpha(x, y) \sum_{u,v} w(x, y, u, v)B(u, v)$$

where a transparency term α is included to model partial pixel coverage. $w(x, y, u, v)$ is receptive field or weighting function. Acquiring environment mattes from images is a matter of determining W, F and α given examples of C and B.

They used simple matting equation for estimation of F. They used set of images in which background is relative motion with foreground while foreground should be fixed for estimation of α. It is obtained by superimposing all images $I_i = 1..n$ and computing the per pixel mean $m(x, y) = 1/n \sum_i I_i(x, y)$ and variance $\sigma^2(x, y) = 1/(n1) \sum_i (I_i(x, y)m(x, y))$. Because the background is changing,so foreground pixels can have low variance,and the background pixels can have high variance. Where



(a) Formation of a single output pixel C. The pixels receptive field allows each pixel of the background to contribute to the output pixels colour.

$$\alpha = 1/(1 + exp(-\kappa(\sigma^2 - \tau)))$$

yields approximate α matte.The tuning parameters κ, τ are set manually.

In order to compute the receptive field of a given pixel p, it need at least two images: one containing the optically active element C and one containing only the background B. The weighting function is given as

$$W(x, y, u, v) = exp(-\lambda|C(x, y) - B(u, v)|^2)$$

and total weighting function should be normalized. $\sum_{u,v} W(x, y, u, v) = 1$

By this method, the receptive fields were computed over 200x200 regions for each of the 26000 pixels within the lens. For each of these pixels, the cost of building the receptive field was approximately 200 milliseconds (in MAT-LAB on a 1GHz Pentium III). Thus, the time to compute the entire environment matte is of the order of hours.

3.2.3 Our proposed method and Work Done

Environment matting is a complex process because an element's color can be thought of as an accumulation of several different components. We should clearly make some mathematical reputation of exact mapping between background pixel on foreground and lighting and surrounding effects in matting of transparent object.According to our survey,steps involved in matting of transparent objects are:

- Defining an transparency of a foreground,α mapping.For covered pixels $\alpha = 1$, uncovered $\alpha = 0$ and for boundary pixels, $0 < \alpha < 1$.
- Prediction of position of each background pixels where those are mapped on the foreground object. For this problem, we need to form a mathematical solution.
- Finding the color variation of foreground with combination of background i.e. lighting effects.This is harder than first two points.The lighting and color effects at pixel p are include:
  - The contribution of background pixel on foreground,
  - The contribution of foreground on background, and
  - Any additional reflections or transmission of light from the rest of the environment in which the foreground object was photographed.

Wexler and Zongker, the last two environment matting methods did not considered the contribution of foreground on background in computation of environment matte.

For estimating the transparency of foreground, we require two images: one is composite image I_o with optical active foreground object and second one is same image without foreground B_o i.e. background only.Steps in estimation of alpha are:

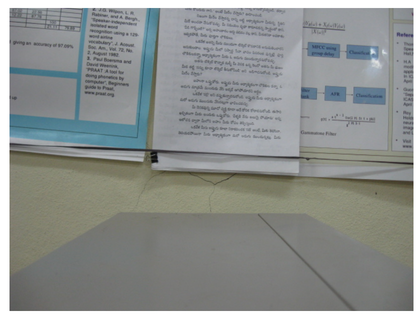
- Calculate the mean pixel value $X_o(R_o\ G_o\ B_o)$ of each and every 9x9 block in background.So, we can get a local mean value of B_o for each block.

- Calculate mean value $X(R\ G\ B)$ in combination with I_o and B_o for corresponding pixels of same 9x9 block in Io and B_o and mean is $X(x,y) = [I_o(x,y) + B_o(x,y)]/2$.

- The alpha can be best approximated by $\alpha = 1/[1 + exp(-\kappa(X - Xo))]$. Where κ is tuning parameter.we expect here that foreground pixels will have non-zero alpha value and the background pixels will have zero alpha values. This process is done for entire image.

The results are shown bellow:

(a) Composite image



(b) Background image

(c) Input image for Composition

(d) Output image

Figure 3.1: (a) and (b) are input images for Environment Matting and (c) is new image given for composition and (d) is partial output.

We implemented only the alpha estimation part of our problem and results are also not accurate. We need to do the remaining part of problem as we mentioned above.

Chapter 4

Image Composition

4.1 Introduction

As we know that matting and compositing are fundamental operations in graphics. Matting is a reverse process of compositng and vise-verse.In the matting process, a foreground element of arbitrary shape is extracted from a background image. In the compositing process, the foreground element is placed over a new background image, using the matte to hold out those parts of the new background that the foreground element will be.Matting and compositing were originally developed for film and video production, where they are often used, for instance, to place the image of an actor, photographed in a studio in front of a controlled backdrop, into another environment. This chapter explains about image composition.

4.2 Composition Process

Composition is a process of superimposing two or more images one over other and resulting a single desired image. The composition process should be flexible enough in such a way that, it could be easily superimpose one image on another different size image at specified location in background image.

We can use the basic matting equation in image composition process. C be composite image, F be foreground and B be background image then the matting Equation is $C = \alpha F + (1 - \alpha)B$. Where α is opacity of a pixel which can be taken 0 for background image pixel and 1 for foreground image pixel. Let us consider I_o and I_1 are two different or same size images. If we want one image C_{1o} which is resultant of superimposition of I_1 on I_o,considered I_1 as foreground and I_o as background. Then the composition equation can be written as:

$$C_{1o} = \alpha I_1 + (1 - \alpha) I_o.$$

where opacity factor α can be taken as 0 for I_o image and 1 for I_1 image pixels. Otherwise we can use α values achieved by applying any of the Blue screen matting algorithm or Triangulation matting algorithm or Variable background matting algorithm which are discussed in chapter 2.

The results are shown bellow for image composition. Here we print background pixel on resultant image until user specified location from where the foreground image want to matte.This needs the consideration of size of background, foreground and the location, where the foreground is superimpose on background.

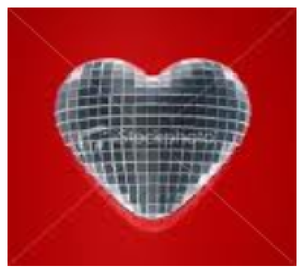
4.3 Image Composition Results

(a) Foreground image

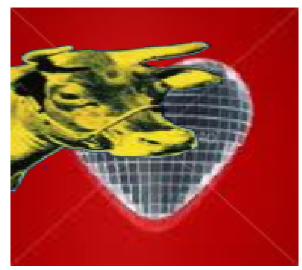
(b) Background Image

(c) Composition output

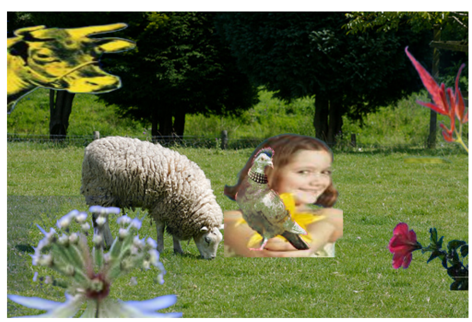
(a) Foreground image



(b) Background Image



(c) Composition output



(a) Composition output

Chapter 5

Conclusion and Future Work

In this thesis, we have given the basic concepts of opaque and transparent foreground object matting which explains how to extract an object from a composite image and also explains problems in environment matting. The implementation of Blue screen matting, Triangulation Matting and Variable background matting algorithms are successful as evident from the results shown in chapter 2.Our proposed variable background matting algorithm, works well, shows low time and space complexity than Blue screen and Triangulation matting algorithm. But Triangulation matting is preferable over others in case of opaque foreground object matting because it involved with less constraints and gives better results.

As we Know that Environment Matting should capture the effects of reflection, refraction, transparency and glossiness of an object which we want to extract. Douglas E. Zongker and Yonatan Wexler were given a different mathematical formation, the idea was adopted from Blinn and Newells, of acquiring lighting effects of an object. The results of them are good but their algorithms do not successful in capturing all lighting effects effectively.In chapter 3, we explained the factors should be consider in environment matting in our proposed method and I implemented first step of environment matting in our proposed method which is estimation of transparency, α

matte, of optically active element. The results are shown, but those are not accurate.

This research leads to many areas for future work. First, we have more work to do to formulate the background pixel maps on foreground and estimation of lighting effects accurately without omitting any effecting factors.Till now, any environment algorithm in literature needs set of images as input to processing of environment matte and their computation time for matting is normally in the order of hours. So, we would like to explore ways of reducing the number of images required to capture an environment matte and time complexity.

References

[1] J. F. Blinn and M. E. Newell. Texture and reflection in computer generated images. *Commun. ACM*, 19(10):542–547, 1976.

[2] T. Chen, Y. Wang, V. Schillings, and C. Meinel. Grayscale image matting and colorization. In *IN PROCEEDINGS OF ASIAN CONFERENCE ON COMPUTER VISION (ACCV 2004*, pages 1164–1169, 2004.

[3] B. Choudhury, A. Pandey, and S. Chandran. Efficient image updates using light fields. *Pattern Recogn. Lett.*, 28(3):375–383, 2007.

[4] B. Choudhury, D. Singla, and S. Chandran. Fast color-space decomposition based environment matting. In *I3D '08: Proceedings of the 2008 symposium on Interactive 3D graphics and games*, pages 1–1, New York, NY, USA, 2008. ACM.

[5] Y.-Y. Chuang, D. E. Zongker, J. Hindorff, B. Curless, D. H. Salesin, and R. Szeliski. Environment matting extensions: towards higher accuracy and real-time capture. In *SIGGRAPH '00: Proceedings of the 27th annual conference on Computer graphics and interactive techniques*, pages 121–130, New York, NY, USA, 2000. ACM Press/Addison-Wesley Publishing Co.

[6] R. L. Cook, T. Porter, and L. Carpenter. Distributed ray tracing. *SIGGRAPH Comput. Graph.*, 18(3):137–145, 1984.

[7] F. C. Crow. Summed-area tables for texture mapping. In *SIGGRAPH '84: Proceedings of the 11th annual conference on Computer graphics and interactive techniques*, pages 207–212, New York, NY, USA, 1984. ACM.

[8] J. S. Jamie Gault. Blue screen image processing without a blue screen. Digipen Institute of Technology,5001 - 150th Ave, NE, Redmond, Washington,USA.

[9] W. Matusik, H. Pfister, R. Ziegler, A. Ngan, and L. McMillan. Acquisition and rendering of transparent and refractive objects. In *EGRW '02: Proceedings of the 13th Eurographics workshop on Rendering*, pages 267–278, Aire-la-Ville, Switzerland, Switzerland, 2002. Eurographics Association.

[10] A. S. Nadig. Triangulation and environment matting. 2003-05.

[11] A. R. Smith and J. F. Blinn. Blue screen matting. In *SIGGRAPH '96: Proceedings of the 23rd annual conference on Computer graphics and interactive techniques*, pages 259–268, New York, NY, USA, 1996. ACM.

[12] J. Sun, J. Jia, C.-K. Tang, and H.-Y. Shum. Poisson matting. In *SIGGRAPH '04: ACM SIGGRAPH 2004 Papers*, pages 315–321, New York, NY, USA, 2004. ACM.

[13] Y. Wexler, A. W. Fitzgibbon, and A. Zisserman. Image-based environment matting. In *EGRW '02: Proceedings of the 13th Eurographics workshop on Rendering*, pages 279–290, Aire-la-Ville, Switzerland, Switzerland, 2002. Eurographics Association.

[14] D. E. Zongker, D. M. Werner, B. Curless, and D. H. Salesin. Environment matting and compositing. In *SIGGRAPH '99: Proceedings of the 26th annual conference on Computer graphics and interactive techniques*, pages 205–214, New York, NY, USA, 1999. ACM Press/Addison-Wesley Publishing Co.