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A Survey on Image Matting Techniques

Jagruti Boda and Dhatri Pandya

***Abstract*—With advanced digital camera, the matting techniques are highly used to create an innovative composite and to facilitate other editing tasks that has gained increasing benefits from both professionals as well as consumers. Image Matting techniques are key step of image and video editing, image translation and in film production to track the object in scene. Image matting methods categories in to three types, sampling based, propagation based, and learning based. A hybrid of sampling based and propagation-based matting uses to improve the result of alpha matte. Various image matting techniques and systems have been proposed to efficiently extract high quality mattes from image. In this paper a comprehensive review of existing image matting techniques along with parametric evaluation of these schemes are discussed.**

***Index Terms*—Deep CNN, Deep learning, Image Matting, Propagation based Matting, Sampling based Matting, Trimap**

I. Introduction

IMAGE matting is a useful tool for film production, image and video editing but is still challenging task in the field of image processing and computer vision. With the blooming of movie industry and image processing, image matting is gaining importance. Matting is usually implemented using foreground (F) of image extracted accurately and pasted onto different background. Specifically, the color I_i of a pixel I in an image can be considered to be foreground color Fi and a background color Bi such that

$$I = \alpha i\, F_i + (1 - \alpha_i)\, B_i \qquad [1]$$

Ms. Jagruti Boda, PG Scholar, Computer Engineering Department SCET, Surat
Prof. Dhatri Pandya, Assistant Professor, ComputerEngineering, Department, SCET, Surat e-mail: jagurtiboda10@gmail.com

Where, α_i called alpha matte, is the opacity value of the foreground pixel and is a value in [0,1]. Pixel value 0 represent the background pixel and 1 represent the foreground pixel [1-16]. The main limitation of matting technique is the equation formulates the matting problem as a linear combination of two colors [4]. The matting techniques mainly classified into three categories: 1) sampling-based matting 2) propagation-based matting (alpha propagation-based matting) 3) Learning-based matting [6][12][15]. The hybrid of sampling based and propagation-based matting is also use to provide the quality result [2] and blue screen matting method that places foreground into the purified background for reduce the complex interference of the background [7][9]. Sampling-based method works on similarity and continuity of image [1]. First, estimate the foreground and background color and then compute the alpha matte. As illustrated in Fig. 1, Sampling based method also classify in two major groups Classical sampling and Optimized sampling [13]. Classical sampling-based methods focus on how to model the relations between the neighboring samples and the alpha parameter [13]. Optimized method collects set of closed foreground and background of each pixel. This accurate selection of pixel used to fit in matting equation. Learning Based method classify local and global matting approach. The local learning-based approach learns the alpha color model from the neighboring pixels of the pixel being estimated. This is suitable for scribble-based matting. The global learning-based approach learns the model from some nearby labelled pixel, and suits better the trimap based matting [15-18]. Recently, more attention has been paid to the optimal selection of good foreground and background samples. Most of the Image matting methods needs a trimap as input.

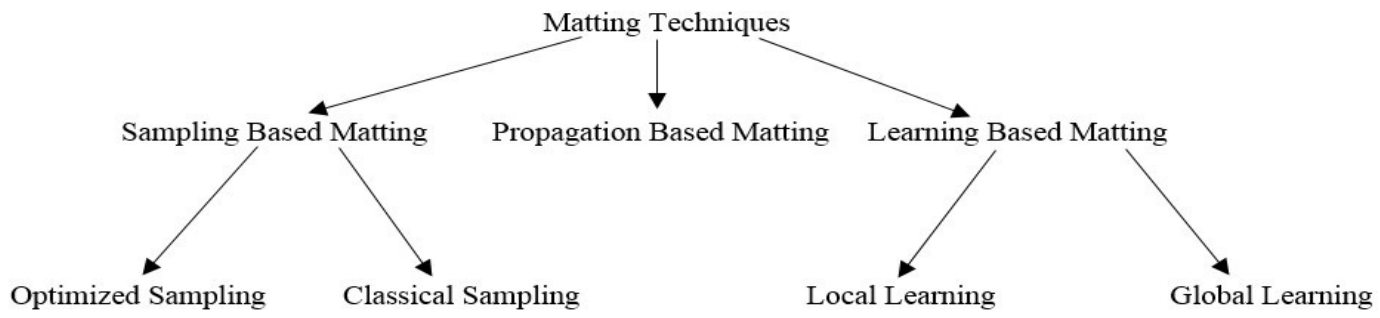

Fig. 1. Image matting methods

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The main purpose is to accurately classify the pixels in unknown area [2]. To solve the image matting problem, User interaction is required to get quality alpha matte. This paper is organized as follows: Section II, summarizes the Related work done in Image Matting. A survey of existing image matting techniques is discussed in section III. Image Matting is based on important attributes such as Matting techniques, User interactive method, segmentation, normalization is discussed along with parametric comparison of matting techniques in section IV. Section V comprises the major issues in image matting. Finally, the decision of image matting technique is concluded in section VI.

II. Related work

Matting is highly under constrained and difficult program in computer vision so it required user interaction to solve this complex problem. There are two types of interactive matting methods: 1) Trimap based which mainly related to sample matting; 2) Simple stroke based (scribble-based) matting [1] [11], which related to the propagation matting as illustrated in Fig. 2. The widely used technique is Trimap based [16]. Most of the Image matting methods needs a trimap as input. Trimap has three areas: the foreground area, the background area and unknown area as illustrated in Fig. 3. In scribble-based matting no color information is used. Experimental result shows that stroke-based matting achieve good result for tightly trimap.

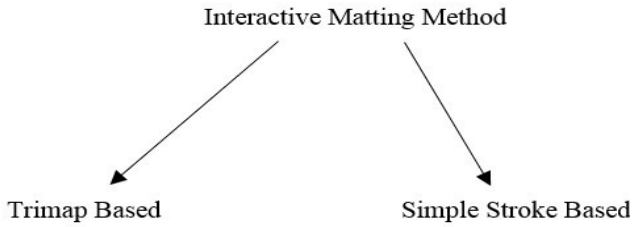

Fig. 2. User interactive matting method

Fig. 3. Image and it's Trimap [18]

In image matting pre-processing plays a major role to extract quality matte. The pre-processing step precisely classify those pure pixels which cannot be easily classified by most of pure matting methods, but also give in effective samples for the subsequent matting process [11] [13-14]. There have been abundant studies done on Image Matting in many years and much work has been done to focus on accurate matting result. Fig. 4 shows general phases of Image matting which includes basic steps to be followed to get accurate output of alpha matte.

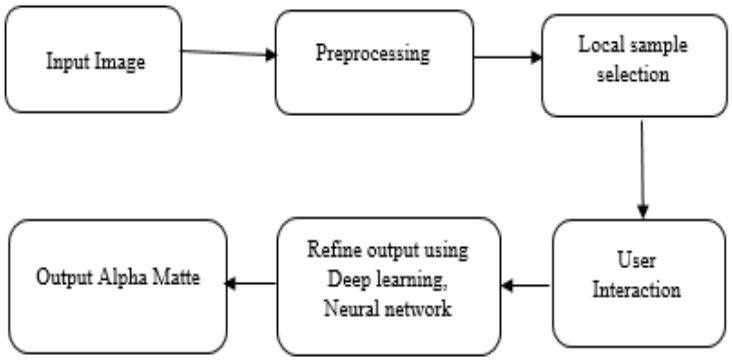

Fig. 4. Phase of Image Matting

III. Existing Image Matting Methods

A. Selective Image Matting

Xian chen et. al. [1] proposed a selective image matting with scalable variance and model rectification. The variance of gaussian distribution describes the dispersion degree of data distribution. Variance is large when texture distribution of image is complex. The theory of information entropy is used to describe the image complexity. Bayesian matting calculate alpha by projection and then select using probability but some error may introduce. Instead of that the Model Rectification by Regularization strategy is used that reduce the error. Selective strategy collects the valid global sample matting result into the matting framework as a supplement to the local sample matting result.

B. Image Matting with normalized weight and semi-supervised learning

Sampling based image matting and Propagation based image matting are used, as well as hybrid image matting is used for robust result. In this matting method [2] normalized weighting parameter use to control the relative relationship between information from sampling and from propagation. The matting accuracy increased using semi-supervised learning iteration. This method involves main three steps. First, the Laplacian matrix is constructed by combing data term and local smooth term with normalized parameter. Second, alpha matte is calculated using spectral clustering optimization. Third, semi-supervise learning is used to refine the trimap. This method iterating many times to achieve accurate resulting matte.

C. K nearest neighbors (KNN) Matting

KNN is proposed [3] to solve the issues of sampling strategies that depends on foreground and background pixels or learning based strategy where training data is main issue. Other existing methods relay on alpha estimation but KNN is based on layer extraction. After mattes have been estimated using layer extraction the image layer is reconstructed. KNN extract overlapping image layers. It provides fast and better result than nonlocal mating. KNN is not relay on Local color-line model. It does not apply machine learning and regularization. They work on straightforward.

D. Deep Image Matting

The deep learning-based matting method [4] is used to improve the result of matte when similar foreground and background color. Deep model is divide in to two parts. First, deep convolutional encoder-decoder network. The encoder input is transformed into down sampled features maps by subsequent convolutional layers and max pooling layers. The decoder performs reverse the process of encoder that uses subsequent unpooling layers which reverse the max pooling operation and convolutional layers to unsampled the features maps and have the predicate output. Second part refines the alpha matte using small convolutional network. For experiment crate a large-scale image matting dataset including 49300 training images and 1000 testing images.

E. Patch Alignment Manifold Matting

The proposed approach solves the issues of dimensional information redundancy in the alpha space. Xuelong li et. al. [5] proposed a manifold model as illustrated in Fig. 5 of local image patches in color space and attempt to mine the information of the alpha space to compute the alpha value using patch alignment manifold learning. PAMM combines the advantages of sampling base approaches and propagation-based approaches. This matting approach solve the issues of matting method and analyses the confidence of samples. Optimized color model is used to avoid the weak confidences samples. Confidence of each sample is calculated and select the strong confidence samples for alpha matte.

F. Optimized color sampling for Robust matting

The sampling methods estimate foreground and background color for unknown pixels and propagation-based methods avoid the color sampling under weak assumption of image statistics. Robust matting method [6] combines the advantages of sampling base approaches and propagation-based approaches. This matting approach solve the issues of matting method and analyses the confidence of samples. Optimized color model is used to avoid the weak confidences samples. Confidence of each sample is calculated and select the strong confidence samples for alpha matte.

G. Spectral Matting

Spectral matting [7] computes a basic set of fuzzy matting components from smallest eigenvector of a suitably defined Laplacian matrix. It extends the spectral segmentation techniques, whose goal is cover the extra hard segments, to the extraction of soft matting components. The image is segmented to construct high quality foreground mattes as illustrated in Fig. 6. Spectral matting computes the matting components by finding an appropriate linear transformation and applying it to these eigenvectors. Other matting techniques require user interaction for matte extraction process but in spectral matting automatically calculate the matte extraction process and reduce the user effort.

H. Poisson matting

Poisson matting [8] solve the matting problem using poisson equation with the matte gradient field. Matte is reconstructed from continuous matte gradient field. This reduces the error caused by mis-classified of color samples in a complex scene. The poisson matting estimate matte automatically and reconstruct the matte by solving the poisson equation.

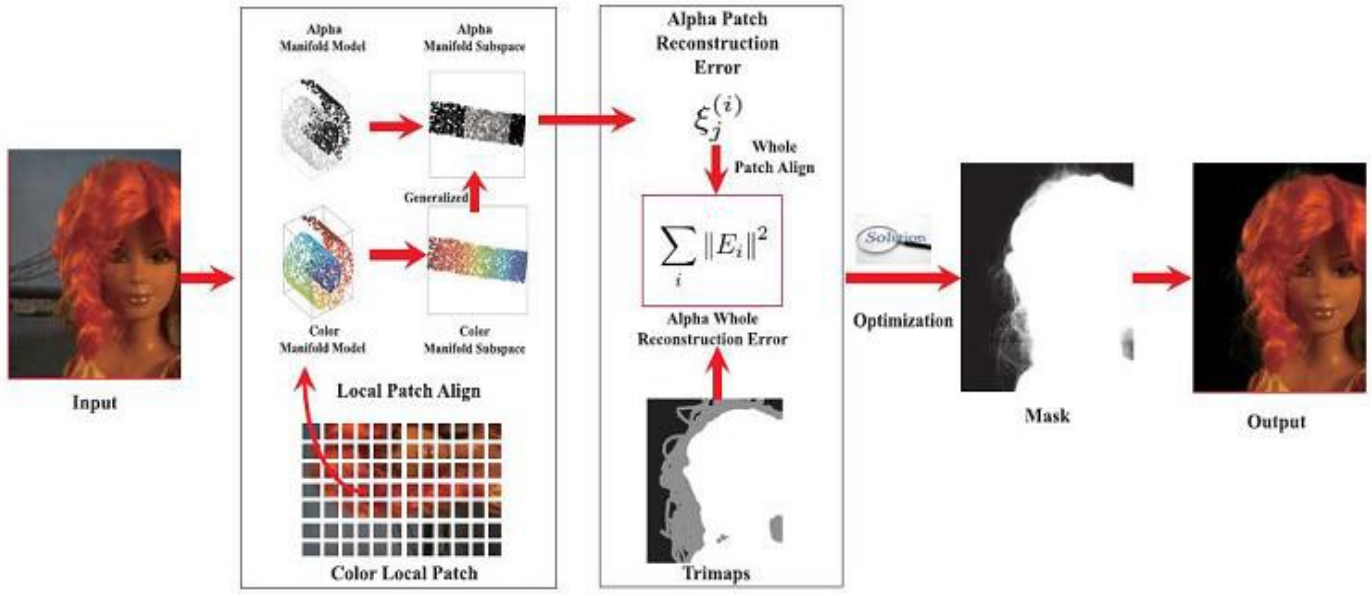

Fig. 5. Flow diagram of PAMM [5]

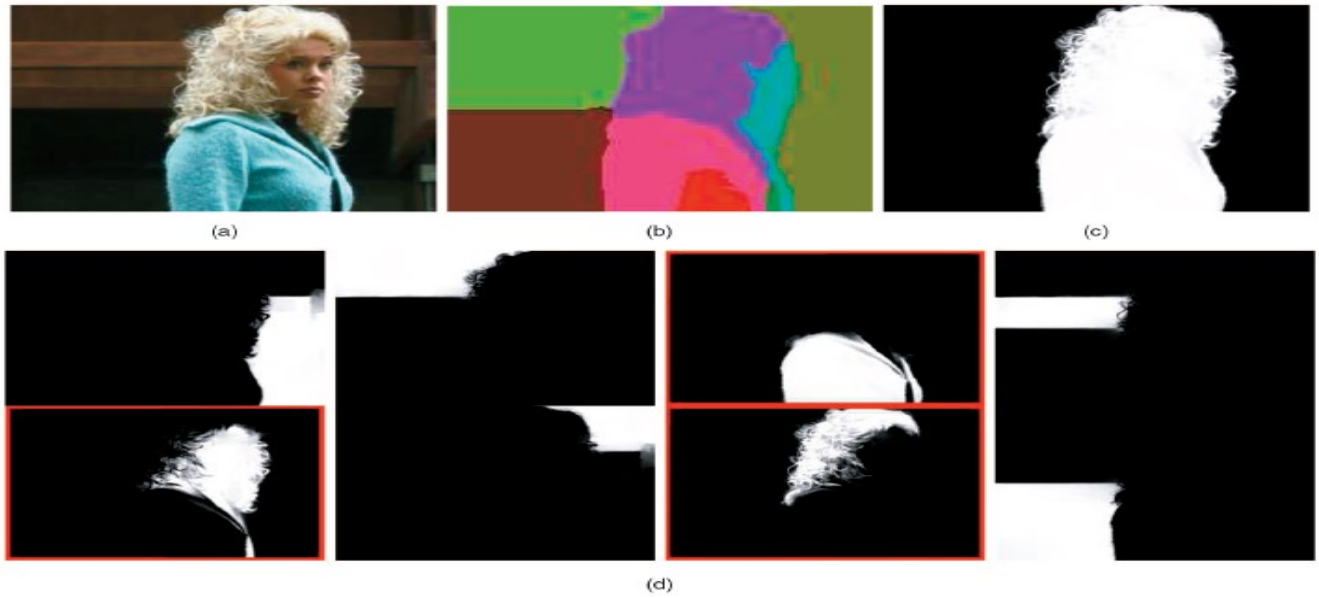

Fig. 6. Spectral matting. (a) Input image. (b) Hard segmentation. (c) Alpha matte (d) Matting components computed by spectral matting [7]

Difficulty is arising when the matte gradient estimated in global poisson matting largely biases the true values, small regions processed for local refinement in local poisson matting. This task may increase the user interaction.

I. Image Matting Method based on Interval-line Sampling

Matting process takes a long time to process the image using existing matting techniques. Wang Hu et. al. [9] proposed an approach to that solves the slow-processing problem of image matting based on interval-line sampling. The sampling is applying to every few lines rather than using the whole picture in matting process. Sampling method calculate every line but this method uses whole picture in matting process. The main aim of this method is lower calculation and increase time efficiency.

J. Image matting using deep convolutional neural network

The novel approach [10] of image matting is applied on image to get robust result. First, it takes the result of closed-form and KNN matting result and reconstructed the alpha mattes. The main benefit is it combine the result of KNN (non-local matting) and closed form matting (local matting) matting effectively to achieve good alpha mattes. At last Deep Convolutional neural network(CNN) is apply to get high quality alpha mattes. Experimental result provides highest accuracy of alpha mattes.

Various parameters for image Matting is explain in next section and based on that prepare a comparison of existing image Matting techniques.

IV. Analysis Of Existing Image Matting Techniques

All the techniques for image Matting have many different weak and strong points as illustrated in TABLE 1. However, the most important requirement is that for an Image matting has to be imperceptible. The various criteria's for judging an image matting algorithm are as follows:

A. Image matting methods: Matting method are mainly categorized into three types:1) sampling-based matting 2) Propagation based 3) learning based

B. Normalization: Normalization is in terms of iterate the process in many steps for more accurate matting result.

C. Segmentation: The image is segmented or not to calculate the alpha matte of an image.

D. Method used for color estimation: The different method is used to estimate the foreground and background color for separate the foreground object.

E. User interactive matting method: To solve the image matting problem, user interaction is required. There are two types of interactive matting methods: (1) Trimap based matting (2) Simple stroke-based matting. Trimap based matting corresponds to the samples matting. Simple stroke-based matting corresponds to the propagation matting.

F. Strategy used for global sample result: The matting process calculated using samples of pixel and at last combine the result of sample for that they use the different strategy.

G. Refine Trimap Generation: Trimap is generate for user interaction but this may be burden on user to generate trimap every time.

TABLE I
PARAMETRIC COMPARISION OF IMAGE MATTING TECHNIQUES

Matting Techniques	Image Matting method	Normalization	Segmentation	Method used for color estimation	User interactive matting method	Strategy used for global sample result	Refine Trimap generation
Selective image matting [1]	Sampling based	Yes	No	Rectification	Trimap based	Selection strategy	Yes
Matting using semi-supervised learning [2]	Sampling + Propagation based	Yes	Yes	-	Trimap based	Normalized weight parameter	No
KNN matting [3]	Propagation based	No	Yes	Color line model	Trimap based	Laplacian formulation	Yes
Deep image matting [4]	Propagation based	Yes	No	-	Trimap based	Convolutional network	Yes
PAMM [5]	sampling based	Yes	Yes	-	Trimap based	Manifold model + Nesterov's algorithm	Yes
Robust matting [6]	Sampling based + Propagation based	Yes	No	Robust color sampling method	Trimap based	Random walk algorithm	Yes
Spectral matting [7]	Unsupervised matting algorithm	No	Yes	-	Stroke based	Laplacian matrix	No
Poisson matting [8]	global poisson matting	Yes	No	-	Trimap based	Filtering tools	Yes
Image matting using Interval-line sampling [9]	Sampling based	No	No	-	Stroke based	Interval-line sampling	-
Deep image matting using deep convolutional neural network [10]	Propagation based	Yes	No	-	Trimap based	KNN matting + Closed form matting	Yes

V. MAJOR ISSUES IN IMAGE MATTING

Listed below are factors that affected in Image Matting when Trimap Generation and Alpha matte calculation is done:

A. Trimap Extraction: Trimap extraction is difficult to generate for high resolution image and the main challenges is user have to supply Trimap to matting method that is so hard working for user and time-consuming task.

B. Training Dataset: The learning-based matting use is increase day to day but it requires large data for training and testing. For experimental result required high resolution image that is quite expensive.

C. Local sample selection: To calculate the matte of an image we required sample pixel of image that selection is complex for accurate result.

D. Color estimation: The main challenges are when same foreground and background color the most of the methods fail in selection of local samples.

E. Speed of Matte calculation: The matting techniques give more effort to acquire robust matte so that it iterates the

process and refine the trimap but this task is more time consuming.

VI. Conclusion

In this paper importance of accurate alpha matte calculation, selection of samples of pixel, and trimap generation has been shown by different image matting techniques. For speed, up the matte calculation interval line-based image matting technique is used. Among existing techniques, learning based matting technique is gaining popularity in this domain. To increase the accuracy of Matte, sampling-based techniques and propagation-based techniques can be combined and apply learning-based matting techniques to refine the result of matte. Various issues such as speed of matte calculation, training dataset, selection of local samples also has been discussed.

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