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A new sampling algorithm for high-quality image matting ☆

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ABSTRACT

Image matting is the extraction of the foreground from an image through the use of provided information. It has been an important technique in the image and video editing field. Current image matting methods estimate the foreground and background, based on information provided regarding the nearby pixels. Color sampling has been an effective means for matting directly, and quite a few methods have achieved high quality matting results based on color sampling. However, there are some drawbacks; for example it is easy to overlook important candidate pixels for matting, and even if the candidate pixels are effectively selected, similar foregrounds and backgrounds will reduce the accuracy of the matting.

In this paper's work, a Weighted-Least Squares (WLS) filter was utilized to sharpen the boundaries between the foregrounds and backgrounds, which facilitated the matting process; and an innovative sampling criterion based on random searching for the matting was then presented. This innovative method could effectively prevent valid samples being overlooked, and could manage the relationships of the nearby and distant pixels. In this process, a new cost function was utilized to evaluate the candidate samples. Experiments utilizing an image database demonstrated that this method significantly improved the matting results.

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1. Introduction

Natural image matting is of great significance in image editing. Candidate image I for matting can be considered to be the composition of a background image B and a foreground image F. The value of each pixel can be represented by a linear combination as follows:

$$I = \alpha F + (1-\alpha)B, \tag{1}$$

where α is the pixel's foreground capacity. In the image matting process, all the quantities on the right-hand side of Eq. (1) are unknown. Thus, there are seven unknowns, and three equations, for a 3 channel color image. Most current methods require a trimap as part of the provided information. The trimap is one image segmented into three regions: the background, the foreground, and the unknown region. Given the trimap, F, B and α are all calculated simultaneously. To obtain more realistic results, the unknown region should be as small as possible. The instance shown in Fig. 1 clearly describes the details of matting. There are three principal matting methods; propagation-based methods, sampling-based methods and a combination of propagation and sampling based methods. A more detailed assessment is in the following (see Fig. 2).

1.1. Sampling-based matting

It can estimate the foreground and background colors of each pixel, and the alpha matte, simultaneously. Spatial, photometric and probabilistic characteristics of one image are combined to find the known samples exactly in order to represent the unknown pixels. This method can be sub-divided into non-parametric and parametric methods. Parametric sampling methods [1–3] usually fit parametric models to known background and foreground samples and then estimate alpha through using the distance of unknown pixels to known background and foreground distributions. Non-parametric methods [4–9] collect set of known samples to calculate the alpha values of unknown pixels. However, the quality of matting largely depends on selected samples. The challenge is to

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Fig. 1. Examples of image matting using the proposed methodology for the; (a) input image, (b) trimap, (c) estimated alpha matte, and (d) composite of the extracted foreground object onto a new background.

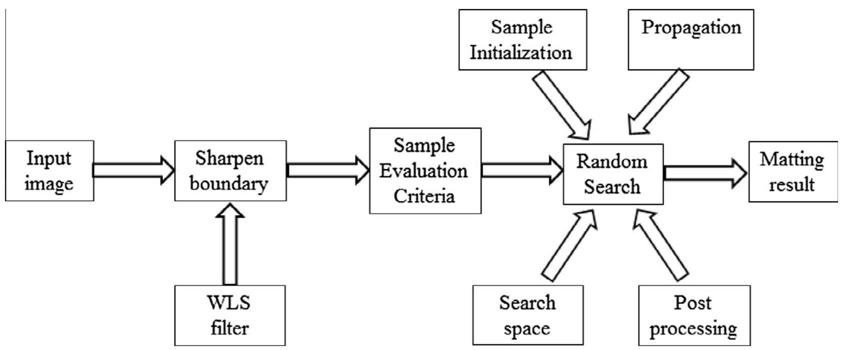

Fig. 2. The flow chart of our method. It shows our algorithm's procedure from input image to matting result.

find the best selected samples. A comprehensive review on matting methods is presented in [10].

The weighted color and texture matting method [9] proposed texture as the feature that can complement color to improve matting results by discriminating between known region with similar colors. The main contribution of color and texture is automatically estimated through analyzing the content of the image. Moreover, the local sampling is combined with a global sampling scheme to prevent true foreground or background samples to be missed in the process of sample collection. An objective function containing texture and color components is optimized to select the best foreground and background pair from a set of candidate pairs.

Robust matting [6] collect samples that are close to unknown pixels. The selection of best known foreground and background samples from candidate set is done with respect to a color fitness parameter. Only good samples explain the observed color of unknown pixels linearly so that the quality is better than knockout system. However, it doesn't work better when the true sample are out of the sets of known samples.

Shared matting [7] divides image plane into disjoint sectors containing equal planar angles and collected samples that lie along rays that are emanated from unknown pixels. Spatial, photometric and probabilistic characteristics of image are combined to find the best samples for unknown pixels. The sampling method is as similar as the weighted color and texture matting if the desired samples for unknown pixels are far from the boundary, the extracted matte will not be exact.

1.2. Affinity-based matting

The process for solving the alpha matte does not depend on the foreground and background colors. Poisson matting [11] made use of image gradient to achieve matting. Random walk matting [12] utilized one random walk algorithm [13] to obtain the alpha value based on the similarities of the neighboring colors. Minimizing a cost function is an effective way to solve the alpha value in closed-form matting [14]. Spectral matting [15] utilized spectral clustering models on the foundations of the closed-form matting. The Laplacian matrix matting combined priors [16], learning based methods [17], or data constraints [6] for the image matting. The k-Nearest Neighbors (k-NN) matting method [18] capitalized on the non-local principle by using the k nearest neighbors for matching non-local neighborhoods, and contributed a simple and fast algorithm giving competitive results with sparse user markups. In other words, k-NN matting has a closed-form solution that could leverage on the preconditioned conjugate gradient method to achieve an efficient implementation.

1.3. Combined sampling and affinity matting

It balances the two classical methods successfully. Some sampling-based matting methods or affinity-based matting methods also draw on the experience of each other. Robust matting [6] was used first to search the candidate samples with a high confidence level, and then the random walk method [13] was utilized to minimize the energy usage. In detail, Robust matting searched several foreground and background pixels near the unknown pixels, to locate candidate pixels; and from the candidate pixels, valid samples were selected by analyzing the confidence levels of those samples. The minimum matting function was used with valid samples to obtain a good alpha matte. Global sampling matting [8] collected the global samples using a random search model derived from Patch Match algorithm [17]. It indicated that all foreground and background pixels around the unknown regions should be treated equally, after which a simple cost function and a random search algorithm were utilized to search the valid sample pairs.

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