Computers & Graphics 59 (2016) 93–106

Contents lists available at ScienceDirect

Computers & Graphics

journal homepage: www.elsevier.com/locate/cag

Technical Section

A novel approach to multi-scale blending based on saliency mapping for multimedia image compositing applications ☆

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ARTICLE INFO

Article history:
Received 23 August 2015
Received in revised form
27 May 2016
Accepted 7 June 2016
Available online 23 June 2016

Keywords:
Image mosaicing
Compositing
Blending
Pyramid
Saliency
Visual attention

ABSTRACT

In multimedia applications, compositing is an inevitable step for creating special visual effects from entertainment to education. It is often desirable to merge two regions or an object from one image over background of another image to get a completely new image. However, compositing multiple images with different textures and colors results in the creation of visual artifacts along the boundaries. A multi-scale seamless image compositing method is proposed to minimize these artifacts in order to generate visually appealing and natural looking composites. Unlike existing compositing techniques, the proposed method automatically detects the visually salient objects from the source image for merging it over a destination image background. Novel facets of the algorithm are: (1) use of a novel salient object detection method for automatic mask generation, (2) formulation of a novel 2-D exponentially weighted Savitzky–Golay (2-D EWS–G) filter, which is an extension of 2-D S-G filter, for multi-scale pyramid based blending with edge preserving blurring property. Experiments performed over different datasets are compared with the state-of-the-art methods to justify the effectiveness of the proposed methodology. Despite smoothing the seams, our algorithm retains the sharpness of the image features, effectively reduces noise, and is robust to change in window size of the proposed filter. Thus, the proposed algorithm exhibits a considerable improvement in image compositing and hence it could be quite useful for multimedia applications.

1. Introduction

Multimedia has been attracting increasing attention in recent years for all sorts of editing and compositing operations to create spectacular visual effects. With the introduction of low-cost multimedia devices, anyone having such device can perform image editing operations. The camera quality of these multimedia devices is improving with increase in memory and computation capabilities. Many applications, such as augmented reality [1,2], image matching, panorama creation and recognition [3] which earlier worked only on computers have now been implemented on these devices. The application domain has extended from the generation of panoramic photographs with increased field-of-view (FOV) to the seamless compositing for digital image editing. The composition of a new image from a collection of two or more image regions has become one of the most exciting and fun applications recently. Cutting a foreground object from one image and placing it over a different background image is desirable in many applications requiring photo-editing or visual effect [4]. In film production and television, it is used for compositing a live actor in front of some new computer-generated background scenery or 3-D virtual character [5,6]. However, in these applications, the success of the problem depends on the creation of seamless boundary between the object inserted from the source image and the background region of the destination image. The problem becomes challenging when this boundary is non-homogeneous. Moreover, the presence of noise can change the texture of the images and pose greater problem in the creation of seamless image composites. Therefore, there is a great requirement of an automatic seamless image compositing technique which could overcome these limitations.

Although, present compositing techniques generate seamless composites, the drawbacks with these approaches are the following: user intervention for trimap or mask generation, color bleeding, and the presence of noise/artifacts in images. In this work, an exhaustive review of the recent related works is described mainly in the context of image compositing and an automated

☆This article was recommended for publication by John Collomosse.

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http://dx.doi.org/10.1016/j.cag.2016.06.003

system for natural image compositing is proposed. The contribution of the compositing algorithm is twofold.

1. A new multi-scale saliency mapping is used to detect the objects automatically and to generate mask based on image dependent adaptive thresholding (IDAT).
2. A blending technique incorporating pyramid and 2-D exponentially weighted Savitzky–Golay (2-D EWS–G) filter is proposed to allow smooth blending and facilitate quality composition.

This method is simple to implement and the comparative analyses over different datasets show its efficacy for multimedia applications.

The paper is organized as follows: existing blending techniques with a brief outline of their strengths and shortcomings is reviewed in Section 2. The motivation behind the proposed work is described in Section 3. The proposed compositing framework and formulation of the blending algorithm are presented in Section 4. Section 5 details the implementation of the algorithm for saliency as well as compositing along with the comparative analyses. This section also provides the limitations of the proposed method. Finally, the work is concluded in Section 6.

2. Literature review

Blending has been used extensively in image mosaicing and editing applications. The basic framework for image blending was established decades ago i.e. in 1975 [7] which subsequently led to the generation of a variety of blending concepts for different application areas. A number of algorithms have been introduced in the past to solve the blending problems.

2.1. In the context of application to image mosaicing

In the context of specific application or purpose of the image mosaic, these methods can be grouped as panoramic imaging [8,9], aerial or terrestrial [10], medical applications [11], underwater optical mapping [12], face recognition [13], and image compositing [14–16].

2.2. In the context of blending strategy employed

Blending approaches can be divided into three classes: transition smoothing methods, optimal seam finding techniques, and hybrid techniques. A brief explanation of these categories is given as follows:

1. *Transition smoothing approach*: In these methods, the weighted combination of each input image is used for smoothing the transition region. One of the simplest yet popularly used transition smoothing approaches is alpha blending [17], but the presence of moving objects and small registration errors cause blurring as well as ghosting.
   Image spline [18] and pyramid blending [19] are also used for reducing the misalignment errors. The authors in [20] have integrated pyramid and Savitzky–Golay (S–G) filter for mosaicing of two non-overlapping images. To avoid the undesirable effects of Laplacian pyramid, the idea was further extended in wavelet domain [21].
   Perez et al. in [22] introduced a generic framework based on Poisson partial differential equation with Dirichlet boundary conditions. The main focus of this work was on image composition, but it is often used for blending in different mosaicing applications.
2. *Optimal seam finding approach*: Here, the seam is placed in the region where photometric difference between the two regions is minimum. Unlike transition smoothing, these methods [7,23,24] consider the information content of the images in the overlapping portion to deal with moving objects or parallax problem. These approaches perform well only with similar source and destination images.
3. *Hybrid approach*: It is a combination of transition smoothing and optimal seam finding technique. In general, these methods employ transition smoothing on a selected region around the optimally computed seam resulting in greater reduction of artifacts [25,26]. The shortcomings of each contributing method such as double contouring and blurring in case of transition smoothing, and exposure differences in optimal seam finding method can be overcome by using hybrid approaches [27,28]. However, these methods result in high computational cost due to the incorporation of the two methods.

2.3. In the specific context of image compositing

The compositing techniques can be classified into following four groups:

1. Matting based.
2. Poisson equation based method and its variants.
3. Image inpainting and image completion based methods.
4. Content aware image synthesis.

2.3.1. Matting based

The estimation of an accurate foreground in images and videos is referred as *matting*. It is a key component in the present day image editing and film making applications. Matting equation [29] consists of too many unknowns making the user intervention essential for obtaining good composite using matte.

In *natural image matting* (e.g. Bayesian matting [30]) the user provides a trimap that categorizes the image into three portions: foreground, background, and an unknown region.

In *blue-screen matting* [4], user inclusion is a key requirement for determining a correct matte.

Poisson matting [29] minimizes the error due to color adjustments in complex scenes. It is a semi-automatic method as user intervention is required for generation of satisfactory composites.

Difference matting [31] requires two images: one with foreground and the other without foreground. Mapping of the difference of these two images results in a matte.

Video matting [32] is an extension of [30] in which a bi-directional optical flow algorithm is used to interpolate trimap in video frames from the key sequences provided by the users.

2.3.2. Poisson equation based method and its variants

In these methods, images are manipulated by modifying the gradient field of the images and are recovered by solving Poisson equations. *Poisson image editing* [22] demonstrates an effective solution to seamless image composition. The colors along the source and destination image boundary are changed smoothly without visible discontinuities. However, during solving Poisson equation for user-specified boundary conditions, the interpolation is inwards leading to color inconsistency i.e. changed color of the source object in the image, also known as *color bleeding*. It is an undesirable effect since the contents of source image are blended and changed preventing the effective generation of image composition.

Several methods have been proposed to improve Poisson image editing. Many of them [16,33] work fine when the boundary is suitable and interior is smooth. An alpha interpolation technique suggested by Leventhal and Sibley [34] successfully removes color