Generating Long Exposure Effect using Image Sequence

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Abstract: The exposure is the total amount of light reaching the camera sensor and determines the overall quality of the photograph. Therefore, the exposure plays a key role in the process of taking photographs. Long exposure photography is used to acquire some dreamy, yet, mysterious photographs that are different from ordinary fast shutter photographs. However, it is difficult even for professional photographers to take plausible long exposure photographs. Long exposure photography expresses the feeling of movement by blurring the moving objects while the background is sharp. In this study, we present a new algorithm which achieves photographs with long exposure effect using an image sequence of a moving subject. The proposed method works without special equipment or time and space limitation. The algorithm is consisted of three parts: object segmentation, motion estimation and motion blur. The result shows that the proposed method enables even novice photographers to take plausible long exposure photos just by taking a sequence of images at the same spot.

Key words: Long exposure, photography, computational photography, image sequence, image blur, dreamy

INTRODUCTION

Photography is known as the art of light, since, the term "photography" was created from the Greek words phos (light in English) and graph (drawing in English). The total amount of light reaching the camera sensor is defined as the exposure and the exposure determines the overall quality of the photograph (London *et al.*, 2004; Jeong, 2009). Therefore, the exposure plays a key role in the process of taking photographs. Major factors which affect the exposure include the aperture of a lens and the shutter speed. The exposure can be altered by changing any of these factors and they are interrelated.

The aperture of a lens can be defined as an opening through which light travels to the image sensor, so, determines how much light reaches the image sensor. F-number or F-stop is used to express the effective aperture of a lens which is the ratio of focal length to effective aperture diameter.

The shutter speed is the duration of an exposure and typically measured in fractions of a second. A longer shutter speed results in the result image with more amount of light because shutter speed is the amount of time which a camera's shutter is open. The movement of a scene is affected by the shutter speed. Short shutter speed freezes the movement of fast moving objects while long shutter speed blurs motion. Short shutter speed is preferred when taking photographs of fast moving objects but freezing movement decreases the feeling of movement. Therefore, intentional motion blur is used to maximize the feeling of movement in panning shots and long exposure photography.

The main difference between panning shot and long exposure photography is whether background or moving objects are blurred. In the panning shot photography, motion blur is applied on the background by following a moving object and taking a photograph with relatively low shutter speed which exaggerates the feeling of movement. On the other hand, long exposure photography expresses the feeling of movement by blurring the moving objects while the background is sharp. In this study, we present a new algorithm which achieves photographs with long exposure effect using an image sequence of a moving subject.

Literature review: Billions of photographs are taken every day because of the widespread of digital cameras. Related research on digital photography has attracted interest these days, so much research can be found on the field of computer graphics, especially, computational photography (Raskar *et al.*, 2006; Banerjee and Evans, 2004a, b). In this study, we categorize the research field related to long exposure photography by following an explanation of long exposure effect.
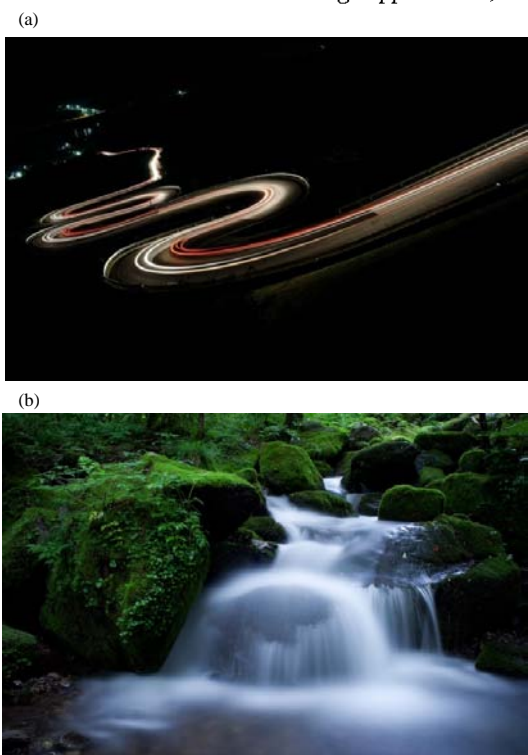
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(a)

(b)

Fig. 1: Examples of long exposure photography: a) at night and b) at daytime

Long exposure photography: Long exposure photography involves a relatively long shutter speed to sharply capture the stationary elements of images while blurring the moving elements which exaggerate the feeling of movement. Long exposure photography captures very unique scenes shown in Fig. 1.

Long exposure refers to the technique of shooting with the shutter open for a long period of time in contrast to a typical handheld shot. For this reason, it is often used to acquire some dreamy yet mysterious photographs that are different from ordinary fast shutter photographs. It is static rather than dynamic and it is a good technique when you want to include a flow rather than a moment.

Generally, long exposure photographs are often used for night photography. At night, because there is a lack of light than during the daytime, there are many situations where photographers have to take long exposure pictures. Because the amount of light is large due to sunlight in the case of daytime if the shutter is opened for a long time, overexposure phenomenon occurs. Therefore, special equipment such as ND (Neutral Density) filter should be used to take long exposure pictures during daytime. The ND filter acts like sunglasses as shown in Fig. 2 which intentionally lowers the amount of light entering the lens, allowing daytime exposure photography.

Fig. 2: ND filters with various densities

Long exposure photographs are by definition, the result of opening the shutter for a long period of time. Therefore, the whole picture will shake and ruined results will be gained unless a tripod is used. To solve the problem, a tripod is essential for long exposure photographs. Long exposure photographs are mysterious because they produce scenes different from what human eyes actually see. Moving people or dark objects tend to disappear in the images with several minute shutter time, since, they are in any one spot for only a fraction of the exposure time. Both stationary and moving subjects exist in a scene, a long exposure photography can cause interesting effects such as light trails as shown in the right of Fig. 1. Amateur photographers are attracted to these mysterious photographs, but they are difficult to challenge because it needs full understanding of exposure and special equipment such as ND filters and long-exposure photographs demands patience. For this reason, research on long exposure photographs could not be found yet (Fig. 3)

Panning shot generation: As shown in Fig. 4, panning in photography is a technique which photographers follow a moving subject and take a photo with a slow shutter speed. It can capture the main subject very sharply while the background blurry. As a result, panning shot dramatically emphasizes the subject's movement which is often used in sports photography. In spite of this unique characteristic, it is not easy for amateur photographers to take plausible panning shots because keeping the subject in the same position of the frame during the relatively long exposure time is not an easy job.

In the previous study by Jeong and Cho (2015), a new digital algorithm was presented which automatically generates panning shots from two photographs taken consecutively in time. With the aid of the presented algorithm, even novice photographers can take plausible panning shots. The algorithm is consisted of three parts: object segmentation, motion estimation and motion blur.

Photographic recomposition: As shown in Fig. 4, the dictionary definition of composition refers to the texture of shapes, colors and locations in 'art or painting'. Composition is a very important feature in photography
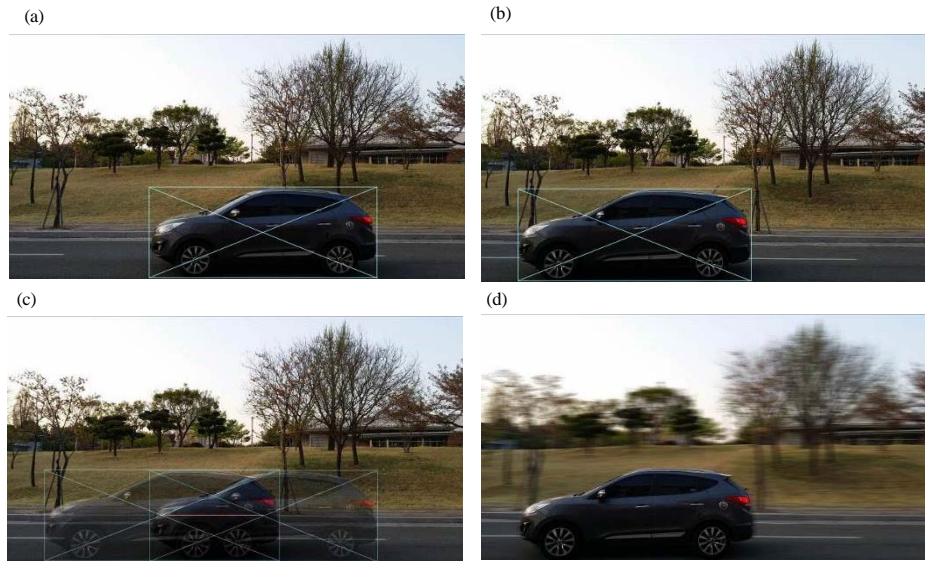
Fig. 3: Panning shot result (Jeong and Cho, 2015): a) 1st input image; b) 2nd input image; c) Estimated motion; d) Panning shot result
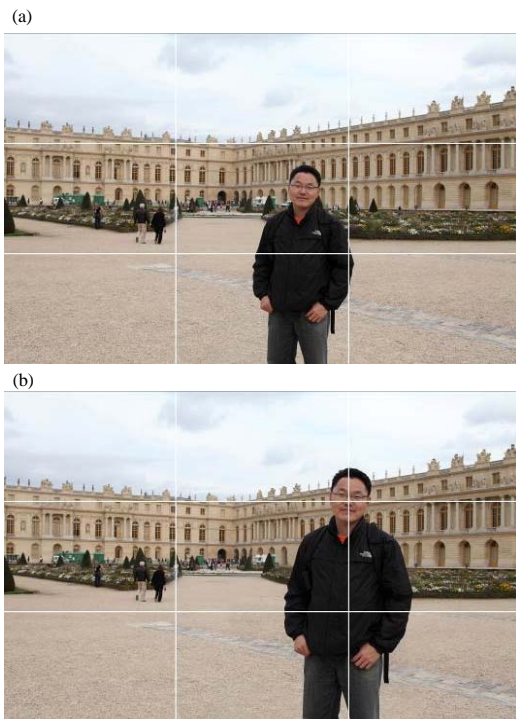

Fig. 4: Photographic recomposition result which obeys rule-of-thirds (Jeong and Cho, 2016)

as well as in painting. A little more photographically speaking, it may be closer to the arrangement and arrangement of the subject in the picture. Even though there is no fixed framework of composition, some rules of composition exist in photography. Some research has been done in the field of photographic recomposition which is based on image transformation (Jeong and Cho, 2016; Chen *et al*., 2003; Tang *et al*., 2011; Banerjee and Evans, 2004) and image cropping (Banerjee and Evans, 2007; Suh *et al*., 2003; Santella *et al*., 2006).

MATERIALS AND METHODS

Long exposure photography is a special shooting technique which results in mysterious photos that cannot be seen by human eyes. Long exposure photos can be obtained by opening a small aperture and lengthening the shutter speed. Because of these charming characteristics, amateur photographers are challenging the long exposure but it is not easy to get satisfactory results compared to other shooting techniques. The reason why it is difficult to take long exposure photographs is as follows. Special equipment (ND filter) is required. Time and space constraints due to prolonged exposure. A complete understanding of exposure.

The third reason is the problem can be overcome through the study of photography which this article does not cover. For more information about understanding of exposure, please refer to the book of London *et al*. (2004). In this study, we propose a new technique to solve the problem of the first and second constraints which makes ordinary photographers easily take pictures of the long exposure effect. The process of presented method is

as follows. If two or more pictures are taken at one location, the algorithm calculates the information of the moving objects from those input pictures and applies the motion blurring effect according to the movement path to obtain the long exposure effect. At this time, if there are many moving objects, individual objects may not be automatically identified between the photographs. In this case, a semi-automatic technique may be needed which takes more pictures or tags objects and recognizes them as the same object.

Long exposure photographs are conceptually very similar to the panning shot technique. Both methods are similar to because they are consist of three steps as follows. Find a moving object; predict a moving direction and apply a motion blur. The main difference of these methods is a background is blurred in a panning shot, whereas a moving object is blurred in long exposure photography. Therefore, the basic algorithm of the proposed method is similar to the panning shot, (Jeong and Cho, 2015).

Object segmentation: Object segmentation (Bai and Sapiro, 2009) is the first step of the presented algorithm, which aims segmenting moving object from background image. In the computer graphics society, much research has been done on object segmentation problem. In this study, one of the most traditional method is applied which discriminates the moving object from background image

based on background subtraction and frame difference technique. Since, only the main object moves, this simple method works well.

Motion estimation: After segmenting moving object from background, motion vectors should be determined which describe the motion path of the moving object. This step is called motion estimation and we use optical flow (Beauchemin and Barron, 1995) which is also used in our previous panning shot research. The main difference a sequence of images is used for long exposure while only two images are used in panning shot. Therefore, the result of motion estimation in this research is motion path vector rather than motion vector.

Motion blur: The final step is to blur the main object by applying motion blur kernel according to the estimated motion path. Gaussian blur kernel is widely used in computer vision applications, but Gaussian blur kernel results in isotropic blurring which cannot express directional blur effect. Therefore, we used directional motion blur kernel in this study.

RESULTS AND DISCUSSION

To show the effectiveness of the proposed method, we use 3 input images as an image sequence as shown in Fig. 5a-c which generate a long exposure result image as shown in Fig. 5d. From the input image sequence, two
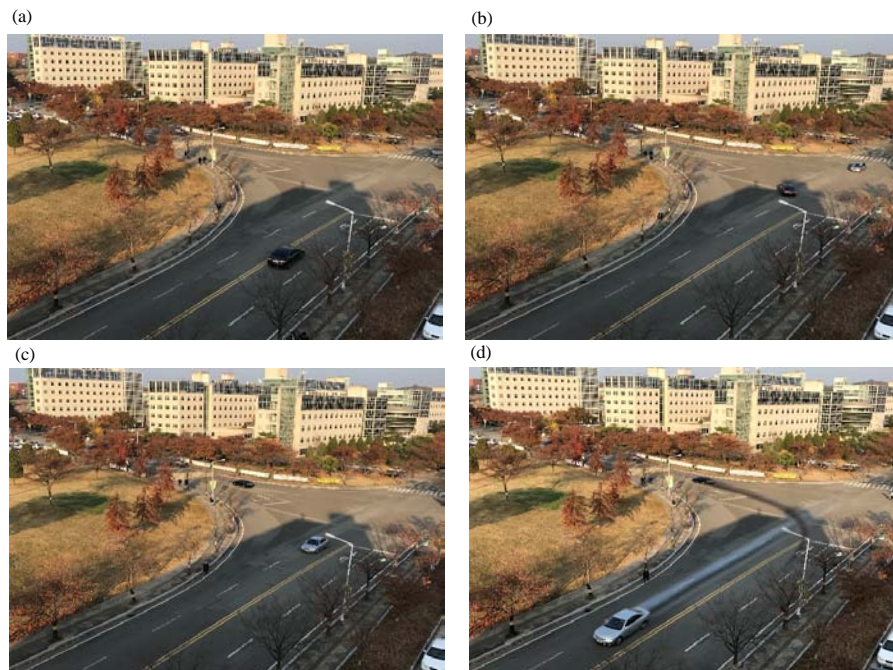

Fig. 5: a) 1st input image; b) 2nd input image; c) 3rd input image and d) Long exposure result image

main objects (a black car and a silver car) are segmented and their paths are calculated. The final result with long exposure effect can be obtained by applying motion blur according to the calculated paths. As shown in the Fig. 5, the algorithm can generate plausible long exposure photographs just by taking a few photos. No ND filters are used. Also there are no time and space constraints due to a long shutter time.

CONCLUSION

In this study, we propose a new method for generating long exposure effect from a image sequence taken consecutively in time. The main algorithm of the presented method is very similar to that of panning shot generator which consists of three parts: object segmentation, motion estimation and motion blur. The result shows that the proposed method can generate very plausible results in theory and practice.

LIMITATIONS

It is very difficult to take plausible long exposure photographs even for professional photographers. However, the proposed method enables even novice photographers to take plausible long exposure photos just by taking a sequence of images at the same spot.

RECOMMENDATIONS

In the experiment, a tripod is used for the convenience of photography but it is expected that input image can be taken without a tripod if image matching technique is adopted in the future. In this case, it is expected that it will be easily implemented in a smartphone and can be conveniently used by many users.

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