SIMULATION OF CAMERA FEATURES

Michal Kučiš
Master Degree Programme (2), FIT BUT
E-mail: xkucis00@stud.fit.vutbr.cz

Supervised by: Pavel Zemčík
E-mail: zemcik@fit.vutbr.cz

Abstract: Computer vision algorithms typically process real world image data acquired by cameras or video cameras. Such image data suffer from imperfections caused by the acquisition process. This paper focuses on simulation of imperfections of the acquisition process in order to enable rendering of images based on a 3D model that are as close as possible to the images acquired by cameras or video cameras.

The paper, besides description of some of the simulated imperfections, also presents results of the simulation software through illustrative figures produced by the software.

Keywords: camera imperfections simulation, depth of field effect, motion blur, distortion, lens flare

1 INTRODUCTION

Computer vision is a field of computer graphics that allows for acquiring, analyzing and understanding images. An input of computer vision algorithms is a set of images which are mainly captured by a camera or a video camera. Input images are not perfect copies of the reality, they are affected by many camera features. This paper describes a method how to simulate a real image from "perfect" images that are generated in computer. Because of the limited space of the article, all simulated effects are not described here. Lens flare effect, distortion, motion blur and depth of field effect are presented, because of their strong influence on the output image.

No complex simulator with all the desired features is known up to the date but there is relatively many publications [1, 2, 3, 4, 5] that describe the camera features and simulation methods for some of the features.

2 DESCRIPTION OF SIMULATION

The proposed simulation consists of several effects, which are applied to the input to modify step-by-step a "perfect" image to the target device like image. All these effects can be adjusted using parameters. Default order of the described effects is shown in the scheme in Figure 1. Order of the effects can be modified to achieve the best possible result.

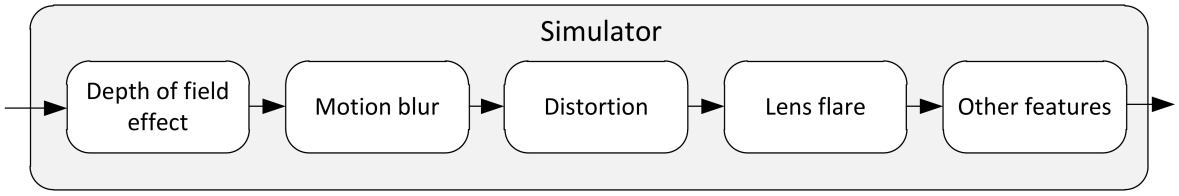

Figure 1: Simulation pipeline

Figure 2: Demonstration of effects; figures are generated by our simulator; top left: depth of field effect; top right: motion blur; bottom left: lens flare; bottom right: distortion

2.1 Depth of field effect

An image in the real world application is formed in an optical system where the light from a point in the scene converges at only one depth behind the lens. The depth is not necessarily that of the sensor depth. The point in the real world appears spread over a region in the image. We use two methods to simulate the depth of field effect. The first method is based on the 2D linear filter and is called "Reverse-mapped Z-buffer depth of field" [1]. The second implemented method is called "The depth of field using simulated diffusion" [2].

2.2 Motion blur

In real world application, when a camera captures an image, a scene is not always stationary. Moving objects are blurred along relative motion. This effect is called motion blur. Motion blur can be also caused by a camera motion.

In computer graphics, images show objects in instant time with no motion blur, even if the objects or the camera are in motion. We implement the algorithm based on full screen motion blur presented in [3]. The implemented method requires the change of the camera's viewport and the positions of image pixels in world coordinates. This approach allows to simulate the camera motion.

2.3 DISTORTION

The most commonly encountered distortion is radial symmetric distortion. Radial distortion model expresses modification distance between a pixel position and a center of the optical system in the input and the output image. [4]

If the distortion is not symmetric, it cannot be simulated by the radial distortion model. In such case, warping via rectangular mesh is used. [5]

In our approach, the distortion simulation uses a Finite Impulse Response filter, namely Lanczos Filter, to remap input pixels to the output pixels.

2.4 LENS FLARE

Lens flare is caused by an unwanted light in lens systems. Flare manifests itself as a haze across the image or as visible artifacts. The visible artifacts can be caused by a reflection on the aperture, inner reflections in the camera lens etc.

A simulation of the lens flare artifacts is shown in Figure 2. We simulate the effect in following way:

$$B = S * K, \tag{1}$$

where B is a output image, S is an input image to this effect, operation $*$ is a convolution and K is a convolution kernel. The convolution kernel is slightly complex, but it can be imagined as a star. This star creates lens flare effect around bright pixels. This behavior was derived from real world images. In Figure 2, it is represented by a bright light added into the image.

3 CONCLUSIONS

This paper presented simulation of camera imperfections applied on computer generated images. The purpose of the simulation is to get computer generated images with features close to the features of images captured by real cameras. Such images can be used for testing of image processing and computer vision applications. Some of the features, such as distortion, can be simulated successfully. On the other hand, some of the others, such as lens flare, are very difficult to simulate since each camera has slightly different lenses that require individual and rather complex model.

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