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TOWARDS A REALISTIC MARKER-BASED AUGMENTED REALITY SCENE: ISSUES AND PROSPECTIVE ASPECT

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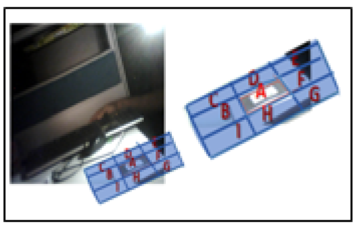
Graphical abstract



Abstract

This paper describes the main problems in realistic Augmented Reality scenes. In order to view the real world with additional computer-generated information in a seamless and realistic integration, there are several research challenges that can be identified; some related to camera tracking, system design, user interaction, and rendering. The focus on each of these aspects was thoroughly explored by several methods and techniques. This study is considered to be an exploration for an Augmented Reality rendering technique. This technique focuses on increasing the realism in the AR scene. Thus, in order to realize the AR scene in a more realistic way, there are four main issues; light source detection, well-designed virtual objects that can have true reflex of the real environment, then integration of a real-time accurate soft shadow.

Keywords: AR, lumination, shadows, detection, realism

1.0 INTRODUCTION

Augmented Reality is a technology that merges the virtual imagery with the real world. Augmented Reality systems aim that the user cannot tell the difference between the reality and the virtual augmentation of it. These systems bring for the user a composite view combined of the real scene and a virtual scene generated by the computer that augments the scene with additional information. With Augmented Reality the user gets to interact with the virtual images using real objects in a seamless way. This generated virtual scene is designed to increase the user's sensory perception of the virtual world that he sees or interacts with. The number of many possible domains such as entertainment industry, military training, engineering design, robotics, manufacturing and other industries, entertainment and education successfully benefit from the use of Augmented Reality technology.

Light Sources detection is an interesting research area in Computer Vision with a large variety of applications especially in Augmented Reality. Researchers have worked on this topic targeting virtual objects to be as realistic as the neighboring in the real environment. This requires the virtual objects to have the same shade in the real environment. To apply the seamless shade for the virtual object, we need to recover the basic attributes of the real light sources such as the positions, directions, intensities, and types.

On the other hand, Lighting in Computer Graphics refers to the process of illuminating a scene in order to give it some effects by placing the lights. Illumination is one of the three key factors of how realistic rendering is; the two other factors are workspace geometry and time. Illumination is important to match the shading of the virtual object with other objects in the scene. It increases the degree of realism in the Augmented Reality scene by applying correctly lit virtual objects as in the real illumination scene.

Multimedia contains different types of lights with different parameters. Most of the experts emphasize on lighting when creating images or animations since Lighting is a very important part of image synthesis. The proper use of lights in a scene is one of the priorities of Computer Graphics; many research works were carried out on lighting issues in photography, film, and real-time video that raised an interest for decades.

Shadows play a significant role in improving the merge of the image appearance in Augmented Reality environment. In any scene with no shadows, the object will appear unreal, like floating in geometry, especially in the case of Augmented Reality. The hard shadow resembles the object, itself making spatial information. On the other hand, Soft shadows are shown in a realistic fading appearance. The algorithms proposed in earlier works varied in trade-off between high computational costs and low costs in terms of real-time applications for the generation of realistic shadow.

In our study further, we intend to explain the steps to locate the real light sources in the real scene and apply the realistic illumination and soft shadow on the virtual objects.

2.0 LIGHT SOURCE DETECTION

2.1 Related Work

The first illumination estimation model was based on a simple point light source without ambient light assuming uniformly colored objects. The distant point light source is defined by an illumination direction [2]. Then, Kanbara [3] used a marker with a mirror ball to resolve geometric and photometric registration. Two methods rely on the illuminated geometry with no requirement for knowledge of a specific calibration object, one method was proposed by Sato from shadows [4] and another from Shading by Wang [5]. Then, Wang [6] integrated the above two methods and proposed a new method for multiple directional source estimation. The model came after had used omni-directional stereo cameras to capture environment illumination and to model the distant parts of the environment [4]. Stumpfel [7] introduced other approach by photographed mirror spheres to capture the illuminants in the scene. This paper discusses another way to realize the illuminants in real scene in real-time.

2.2 Method

Light source detection problem formulation is based on assumptions like known geometry or analysis of intensity and method. The proposed detection technique is not exactly made to detect the illuminant; the idea is more likely to analyze few segments in the scene and predict some properties of the targeted illuminant like hue, direction, and intensity. Figure 1 shows the first step for this method.

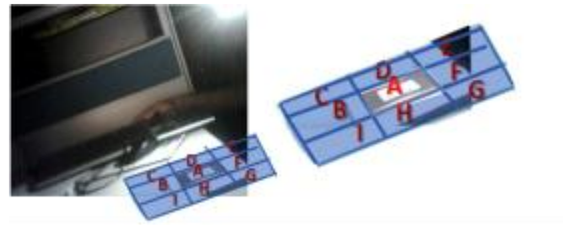


Figure 1 Marker in area A is the base segment to divide the scene into another 8 segments, B to I. Each of the segments around the marker is supposed to be taken as a separate area to predict the light source. Then based on the results from each segment the algorithm will choose the direction, density, and color of the light source

The purpose of segmentation is to minimize the number of system computations in the scene. Without segmentation the system process would not work as a real-time Augmented Reality for number of computations or it will cost high computations. For each segment, there are four dynamic attributes; segments' number, geometry that could be expressed by Equation 1:

$$\alpha_n = < n, G >$$
$$G = < X_0, X_1, Y_1, Y_0 > \quad (1)$$

Where, α_n is the segment, n is the number of the segment, G is the geometry, and X_0, X_1, Y_0, Y_1 are the points which determine the dimensions of the segment.

As for the segments' attributes, it can be determined automatically by computing the size and the position of the virtual object(s) to be merged to the real scene. Obviously, the more segments are there the more factual the detection could be. But for more explicitness, the size of the virtual object sometimes covers the whole scene area whereas sometimes it reigns only small corner of the scene as shown in Figure 2.

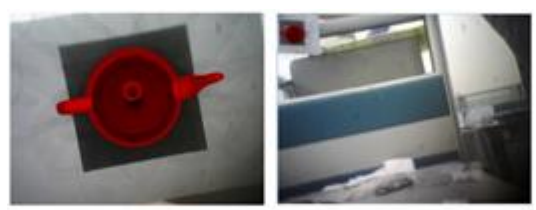


Figure 2 (a) Virtual object covers almost the whole scene. (b) A small virtual object reigns on the top-left corner of the scene

Relatively, the size and position of the virtual object are important for the segmentation of the scene. Also, segments' area should be determined around the object almost as its shadow size, knowing that the length of any shadow cast on the ground is proportional to the cotangent of the light source's elevation angle. For that reason, assumingly, segments' area will be determined as per longest size of the object's shadow. Equation 2 calculates the segments' area.

$S_{area} = 8\sum_{i=1}^{n} \cot O_i$ (2)

Where, S_{area} is the segments' area, is the number of objects, and is the object's vector.

Consecutively, the segmentation in that specific area can be computed. The method used must be at low computation cost, high performance, and could be smart to detect the real scene object features. Area segmentation based on an improved Image Quantization Median Cut theory is adopted to help making the decision of light source detection technique which is the next step. In accordance to Wei-dong [8], the idea of Median-cut algorithm is to make every color at the Color Quantization Table represent approximately the same amount of pixels of original images. The algorithm used is applied on the area as follows:

Calculate the histogram of all occurring colors in the RGB space. Historgram can be calculated using OpenCVfuction as it is described in its documentation.

As for the chromatic histogram, the color box in the chromatic histogram the index value of the color box will be applied to replace the value of the original chromatic histogram with color index value, thus significantly reduces the amount of the following calculation.

Apply a mathematical expectation on every color in the histogram to get its variance of the full sets of the R, G and B components

$$sum(C_i \times F_i)/sum(F_i) \quad (3)$$

Cutting method:

Choose the cutting box for each division in the area by taking the color palette. This can be done by calculating the variance of the part sets.

Calculate the variance along the R, G and B axes of the color box until it becomes larger than half of that of the full sets, and then take the current R, G and B as the cutting point.

3.0 SCENE ILLUMINATION WITH SOFT SHADOW

Lighting gives an emotional impression to the viewer and can add 3D effect to the objects in the scene. Shadows are created by testing whether a pixel is visible from the light source. Shading is the process for color attributes of the object by applying the light source effect from its position with a darker shade for darker areas, and less densely or with a lighter shade for lighter areas [9].

There are five types of lights in CG; ambient light, diffusive lights that cast unfocused light in all directions, directional lights that cast parallel beams of light in one direction, target spotlights that cast a focused beam of light towards a target, and the free spotlights that cast a focused beam of light in a direction. Diffusive lights and spotlights can be attenuated, but there is no attenuation for ambient of directional lights. The light intensity diminishes linearly between the Start Range and End Range such that it is zero at the End Range [10].

Objects can be excluded from lights, that is to say, the excluded objects will not be illuminated by that light, but may be illuminated by other lights [10].

Light source effects are the light reflections, transparency (refraction), surface texture, and shadows. Whenever an object is lit, it surely has specific properties to explain its emission synthesis; the position which is a vector defining the location of the light object defined from the origin to the specified x-, y-, and z-coordinates, the shape which modifies the illumination of the scene by, Emission Direction determined by directional lights and spotlights, and is described with a vector, Intensity of Color keeping in mind that one light source may have one or different Colors in different directions, and Reflectivity Properties (if the light source has light-reflective surface) are the light source properties [10].

In computer graphics, single object-light interaction is approximated through local illumination models. Basic model used is the Phongmodel which breaks local illumination into 3 components: Ambient reflection, Diffuse reflection, and Specular reflection. For every point, or small surface area, of an object, we want to calculate the light due to these three components [11].

Local illumination refers to direct interaction between one light source and one object surface. Global illumination refers to the interaction of light between all surfaces in a scene (Responsible for shading, Reflection between surfaces, Refraction of surfaces) [11].

Figure 3 (a) Describing an image with different hues. (b) Brightness with depth (underwater photo as an example) (c) An image with low saturation (left) and normal saturation (right). (d) Hue, Brightness, and Saturation for single color (blue)

It is important to know, when we view a source of light, our eyes respond to the Hue (or color of the light), Brightness (Luminance) of the light which corresponds to the total light energy, and the Saturation (or purity) of the light which describes how close a light appears to be a pure spectral color (ex. Pastel and pale colors). And the term Chromacity, refers to describing the characteristic of the hue and saturation of an object [11].

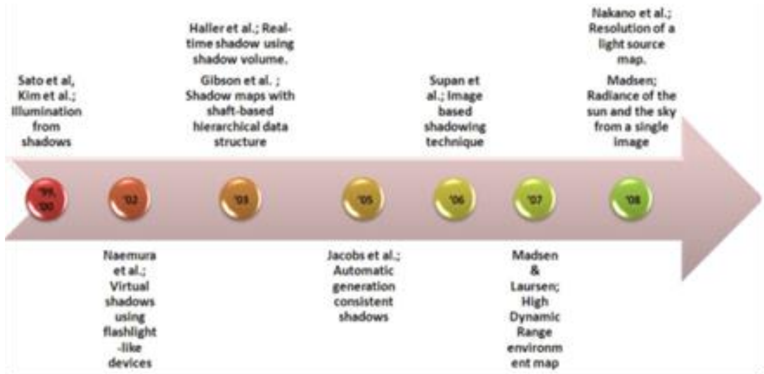


Figure 4 Real-time Shadow timeline. A courtesy of Zakiah Noh [21]

```
LEGACYINSERTION(img, USER)
Model geometry (Sec 4.1), auto-estimate materials (Sec 4.2)
    geometry ← DETECTBOUNDARIES(img)
    geometry ← USER('Correct boundaries')
    geometry ← USER('Annotate/add additional geometry')
    geometry_mat ← ESTMATERIALS(img, geometry) [Eq 3]
Refine initial lights and estimate shafts (Sec 3.2)
    lights ← USER('Annotate lights/shaft bounding boxes')
    lights ← REFINELIGHTS(img, geometry) [Eq 1]
    lights ← DETECTSHAFTS(img)
Insert objects, render and composite (Sec 3.3)
    scene ← CREATESCENE(geometry, lights)
    scene ← USER('Add synthetic objects')
    return COMPOSITE(img, RENDER(scene)) [Eq 4]
```

Figure 5 Karsch et al Pseudo codeshowing steps to achieve realistic scene relighting.

Figure 6 Karsch Algorithm for inserted synthetic objects into existing photographs without requiring access to the scene or any additional scene measurements with illumination and reflectance using the scene geometry, annotating lights, and auto-refining 3D scene. [19]

The work done on seamlessly unitingthe dynamic virtual Illumination with Augmented Reality scene is not quite enough to satisfy the user. J Stauder [12] introduced a method using ellipsoidal models for compositing synthetic object and video broadcast industry application [13]. Agustano [13] then presented seamless integration of virtual objects in an Augmented Reality environment using image based lighting techniques and environment illumination maps. Bimber *et al*. postulate in [14] a consistent lighting situation between the real and the virtual objects to achieve a convincing augmented reality application.Pun-Mo Ho [15] proposed a method based on Principal Component Analysis (PCA) as a compression tool that effectively reduces the data volume while maintaining the real-time relighting capability. A survey on image-based relighting techniques was introduced by Choudhury[16]. Then in 2007, Choudhury again proposed an image-based relighting two steps technique [17] Recently, Grosch [18] has proposed a method to solve indirect illumination in real-time using clustered visibility.

Apart from real-time, research on scene relighting and augmenting virtual objects in the scene in still image was thoroughly given concern; Karsch *et al*. [19] inserted synthetic objects into existing photographs without requiring access to the scene or any additional scene measurements with illumination and reflectance using the scene geometry, annotating lights, and auto-refining 3D scene. Figure 6 is shown to describe Karsch's scene.

Shadows are also important for photorealistic rendering [20], this topic is widely explored in Augmented Reality that researchers have reached promising results. With the increasing of development computer graphics technologies and the demand for more realistic image particularly in our case in Augmented Reality systems, the research about shadow generation growth is rapid. This shows that shadows became one of the most important elements in Augmented Reality environment to achieve photorealistic rendering. Figure 4 shows the timeline of shadow techniques [21]. The photorealistic Augmented Reality environment can be enhanced with adding shadow to the environment. Computing this lighting effect for interactive applications is difficult because of the complex dependence of soft shadows on light sources and scene geometry.

The method which will be proposed enables an augmented reality system to create a realistic lighting of virtual objects in the image of real environments where predictable and unpredictable light changes occur. The shading is based on estimated local illumination parameters, which are converted reflecting the newest lightchanges in the scene. This gives the system the ability to update the image based lighting of a virtual augmented object real-time.

4.0 CONCLUSION

The material presented in this paper showed the work on how to implement an photorealistic rendering in real-time. Four main aspects should be thoroughly covered; light source detection, well-designed virtual objects that can have true reflex of the real environment, and the method to integrate accurate soft shadows for that object.

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