A Framework for Interactive 3D Rendering on Mobile Devices

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ABSTRACT

Although mobile devices have now become an important computing platform, however most of them still lack hardware accelerated graphics. Therefore, interactive 3D rendering on these devices is a difficult task. This paper describes different approaches for 3D rendering on mobile devices and the associated challenges. It then investigates different solutions to resolve these problems and proposes a framework that uses Image Based Rendering (IBR) technique to render interactive 3D graphics on mobile devices. Further, the performance of proposed framework is compared with Geometry Based Rendering (GBR). The experimental results show that the proposed framework performs better than the geometry-based techniques in terms of rendering time, visual quality and memory requirements. The results also show that the rendering time of the proposed framework is independent of the scene complexity. The experiments are performed in Java Platform Micro Edition (JavaME) environment with Sun JavaME Phone emulator.

Keywords: 3D Image Warping, Image Based Rendering, Interactive 3D Rendering on Mobile Devices, JavaME, Phong Shading

1. INTRODUCTION

With the development of technology, it is possible to think of mobile devices as small computers. They are easy to carry and suitable for various work environments. These devices are capable of supporting graphical user interface, audio and video playback, wireless communication etc. However, rendering interactive 3D graphics on these devices is still considered a difficult task due to limited CPU speed, memory and hardware support for graphics. Therefore image-based rendering methods, whose run time depends on the screen resolution is more suitable for these devices. This paper proposes a framework based on IBR technique to perform interactive 3D rendering on mobile devices using JavaME. Such a framework is particularly useful in 3D visualization, 3D navigation systems etc. for mobile/handheld devices. The paper is organized as follows: Section 2 gives an overview of different rendering approaches for mobile devices; Section 3 explores the geometry-based rendering techniques and image-based rendering techniques; Section 4 describes the implementation of the proposed framework for mobile devices using JavaME; Section 5 provides the experimental results and performance comparison with geometry-based rendering in terms of rendering time, visual quality and memory requirements; and Section 6 presents the conclusion.

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2. RENDERING APPROACHES FOR MOBILE DEVICES

Many approaches have been proposed in the literature to render interactive 3D scenes on mobile devices. We can divide these approaches into three main categories (Nadalutti, Chittaro, & Buttussi, 2006):

- Hardware architectures for 3D rendering on mobile device,
- Remote 3D rendering architectures, and
- Software architectures for 3D rendering on mobile devices.

2.1. Hardware Architectures for 3D Rendering on Mobile Devices

For 3D rendering on mobile devices many efficient hardware architectures were proposed (Silpa, Vemuri, & Panda, 2009; Yu et al. 2009; Sohn, Woo, & Yoo, 2004). These architectures aim at producing high performance and low power consumption by exploiting parallelism and multithreaded co-processor concepts. Unfortunately, this approach does not provide flexibility, because new hardware architectures have to be designed for every emerging rendering technique. Moreover, if multiple, diverse applications have to be executed on the same mobile device, adding hardware accelerator for each application results in high hardware cost and more power consumption.

2.2. Remote 3D Rendering Architectures

The most common solution adopted for rendering on mobile devices is remote rendering. In this type of rendering, the process is carried out on a powerful remote computer with graphic acceleration and the results are sent to the mobile device using a wireless network. Thus, the mobile device acts as just a simple client. Chang and Ger (2002) propose a client-server system in which client can produce new images using the depth information and 3D warping without requesting more information from the server.

Further, the works of Bao and Gourlay (2006); Yoo et al. (2010); Banerjee and Agu (2005); Shu et al. (2009) have one aspect in common, they all use the concept of remote rendering over wireless networks. However, a major disadvantage of remote rendering solutions is the need of a reliable and permanent wireless network that is not always available. Moreover, current wireless networks have limited bandwidth and these solutions need complex algorithms to divide processing between server and clients.

2.3. Software Architectures for 3D Rendering on Mobile Devices

Software architectures for 3D rendering carry out the entire rendering process on mobile devices. Generally it has been done using some mobile 3D graphics API such as PocketGL, Mobile 3D Graphics (M3G) etc. Zunino, Lamberti, and Sanna (2003) have adopted this approach to render 3D data completely on the mobile device. This approach provides an inexpensive way to improve the performance of the rendering process.

3. RENDERING METHODS EXPLORED

From the above discussion, it is clear that the hardware architectures for 3D rendering on mobile devices and remote 3D rendering architectures have their own shortcomings, therefore, this paper focuses on the last option i.e. software architectures for 3D rendering process on mobile devices. There are two different models to achieve entire 3D rendering process on mobile devices. These are:

- Geometry Based Rendering (GBR), and
- Image Based Rendering (IBR)

3.1. Geometry-Based Rendering

In geometry-based rendering methods, the scene has to be simulated by applying a shading model on 3D scene descriptions. Two well established geometry based rendering tech-