Chapter 8
UbiWave:
A Novel Energy-Efficient End-to-End Solution for Mobile 3D Graphics

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ABSTRACT

Advances in ubiquitous displays and wireless communications have fueled the emergence of exciting mobile graphics applications including 3D virtual product catalogs, 3D maps, security monitoring systems and mobile games. Current trends that use cameras to capture geometry, material reflectance and other graphics elements mean that very high resolution inputs are accessible to render extremely photorealistic scenes. However, captured graphics content can be many gigabytes in size, and must be simplified before they can be used on small mobile devices, which have limited resources, such as memory, screen size and battery energy. Scaling and converting graphics content to a suitable rendering format involves running several software tools, and selecting the best resolution for target mobile device is often done by trial and error, which all takes time. Wireless errors can also affect transmitted content and aggressive compression is needed for low-bandwidth wireless networks. Most rendering algorithms are currently optimized for visual realism and speed, but are not resource or energy efficient on a mobile device. This chapter focuses on the improvement of rendering performance by reducing the impacts of these problems with UbiWave, an end-to-end framework to enable real time mobile access to high resolution graphics using wavelets. The framework tackles the issues including simplification, transmission, and resource efficient rendering of graphics content on mobile device based on wavelets by utilizing 1) a Perceptual Error Metric (PoI) for automatically computing the best resolution of graphics

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content for a given mobile display to eliminate guesswork and save resources, 2) Unequal Error Protection (UEP) to improve the resilience to wireless errors, 3) an Energy-efficient Adaptive Real-time Rendering (EARR) heuristic to balance energy consumption, rendering speed and image quality and 4) an Energy-efficient Streaming Technique. The results facilitate a new class of mobile graphics application which can gracefully adapt the lowest acceptable rendering resolution to the wireless network conditions and the availability of resources and battery energy on mobile device adaptively.

INTRODUCTION

Motivations

Computer graphics is an exciting and rapidly growing field. It has influenced many aspects of our daily life, such as games, movies, advertisements, and education. Traditionally, 3D computer graphics can only be achieved on high performance computers with dedicated graphics hardware. This limits their applications. Recently, two major technology developments have made mobile graphics become possible. One catalyst is the wide adoption of high-bandwidth wireless networks in universities, hospitals, hotels, and other working environments. A second catalyst is the emergence of affordable graphics hardware. Driven by the multi-billion computer game market, graphics hardware has become more and more powerful, cheap, and portable. As a result, many mobile devices are now equipped with dedicated graphics hardware and graphics on mobile devices is becoming popular because untethered computing is convenient and increases the productivity of workers. The following scenario demonstrates how mobile graphics applications can be used.

Motivating real estate mobile graphics use scenario: Ann is an architect who works for Ulo corporation. Ulo corporation is a multi-national architectural film with clients and workers in 50 countries across the world. Ulo maintains a large database of high-resolution 3D architectural drawing of various types of buildings. In order to accommodate workers with PDAs, laptops and cell phones with graphics capability, different teams of architects work on different projects that are maintained in Ulo's database. Initially, an Ulo team visits a client and after preliminary discussions, retrieves possible design solutions and shows them to the client. These serve as starting points of the design process. After the client selects a viable option and requests modifications, the architects annotate the diagrams and return to Ulo's office to make necessary amendments. Periodically, the architects return to the client to show progress and seek more feedback, towards a mutually agreeable design. Some of Ulo's clients are not connected to the Internet. In such cases, Internet hotspots can serve as valuable affordable meeting locations.

In the scenario above, mobility in the home viewing software allowed teams to retrieve new architectural designs for clients on the spot after the client rejected the first one and it was convenient to avoid driving back to their office with clients. Although videos of the homes could have been used in this scenario, graphics allows teams to modify the drawings to answer clients' what if questions. Clients could also interact with the homes and take a closer look at aspects that were important to clients. Indeed, mobile graphics is exploding and new applications are emerging. Computers can reduce boredom on long commutes by playing mobile versions of their favorite games during commutes. Other mobile graphics applications include telesurgery, security monitoring systems, 3D maps, and educational animations. Mobile graphics applications offer a new commercial opportunity especially considering that the total number of mobile devices sold annually