Hardware-Accelerated Real-Time Rendering for 3D Sumi-e Painting

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Abstract. This paper presents a method for real-time 3D Sumi-e rendering using normal graphics hardware. Sumi-e is one of the traditional oriental painting styles. Most research on Sumi-e paintings has focused on 2D or 2.5D Sumi-e brushwork simulation. On these systems, complicated user's hand drawing is required to generate the image of Sumi-e effects, and it can render the 2D or 2.5D Sumi-e images only. We present an automated rendering system for 3D image of Sumi-e painting. It uses 3D common object as an input data and does not need any additional input of user brushwork. Especially for the real-time rendering, hardware-accelerated algorithm for Sumi-e rendering is newly suggested in our system. It is designed with efficiency for customer level graphics hardware. The results of this paper show that the features of traditional Sumi-e painting are successfully modeled and that 3D Sumi-e painting is rendered in real-time effectively.

1 Introduction

The Sumi-e is the traditional oriental art form of Black ink painting. It is a simple elegant Black ink art on white paper. It is non-photorealistic rendering (NPR) which stands in contrast with to conventional graphics rendering methods of photo-realistic. The recent tendency of NPR system is simulating painting style and natural media, e.g. pen and ink, watercolor, charcoal, pastel, hatching, etc. About the Sumi-e style in NPR, many researches of 2D drawing systems have been shown. In these areas, the delicate simulations of brush, black ink and paper are presented, and a 2D Sumi-e image is generated accepting the hand drawing of the users. In this paper, we present a real-time rendering method for 3D Sumi-e painting. There are three major challenges for Sumi-e painting. First, there is no model for 3D rendering Sumi-e painting. When generating the scene of Sumi-e painting style in 3D games or virtual environment, we can not apply previous 2D rendering methods directly. We need a new concept for 3D rendering technique of Sumi-e painting. Second, 2D drawing work is always required to generate Sumi-e image with previous methods. That leads common users to find difficulties in making it, because they are short of experience. An automated rendering system will enable users to construct Sumi-e scene using 3D arbitrary objects without complicated painting skills. At last, most of previous

2D Sumi-e drawing systems are interested in its quality not processing time. However new 3D system for 3D game and virtual environments must guarantee real-time performance.

The following are the three main contributions of this paper. First, this paper describes the new modeling approach for turning to real-time 3D NPR Sumi-e rendering. We newly modeled 5 features of Sumi-e painting for 3D Sumi-e rendering: *Nong-Dam, Bal-Muk, Brush Stroke, Atmospheric Depth & Inside Omission* and *Paper Effect*. Users will be able to express their emotions efficiently with these representative features. Second, an immediate Sumi-e painting system is suggested using an arbitrary 3D model as an input data. It does not require users' complicated painting input. And it has the feature of supporting various styles of Sumi-e with selectable rendering modules. Third, the real-time rendering is achieved on customer level graphics hardware by using hardware-accelerated rendering algorithms. These are the programmable shading, sphere mapping, shell texturing, and the composition of paper buffer with fiber structure. Our rendering algorithms do not require much processing time for 3D operations. And they are optimized for hardware acceleration for the best real-time performance.

2   Related Work

We implemented real-time rendering system for 3D Sumi-e. There have been number of systems for 2D Sumi-e brushwork and real-time NPR rendering. Early efforts in 2D Sumi-e painting focused on a brush work simulation. Strassmann [9] swept a one dimension texture to show shading tone. Pham [6] modeled brushstrokes based on variable offset approximation of uniform cubic B-splines. Using the theory of elasticity, Lee [3] modeled a brush as a collection of rods with homogenous elasticity along the entire brush. Way [10] presented a method of synthesizing rock texture in Chinese landscape painting. In real-time rendering of NPR, a few recent systems have addressed real-time NPR rendering. Majumder [5] has implemented real-time charcoal rendering applied with CEO (Contrast Enhanced Operators) by using hardware-accelerated bump mapping and Phong shading. Lake [2] presented a method for cartoon rendering suits for programmable pipeline. Praun [7] introduced TAM (Tonal Art Map) representation and showed that it permitted real-time rendering of stroke-based texture for hatching rendering. And he also suggested hardware hatching system with Webb [11] using volume rendering and pixel shading.

3   Feature of Sumi-e

The Sumi-e is one of the traditional arts of Asia (It is called *Su-Muk* in Korean). The essential tools are called the four treasures. These are the brush, Black ink, ink stone and paper. The painter uses Black ink freely with controlled brush strokes. They create beautiful lines and forms by means of brush strokes using a number of techniques and methods to bring life to the subject. The flow and spread of ink on the paper in many shades is an idealization of the form itself.