E90 Project Proposal
Stained-Glass Graphics Filter

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I propose to develop an algorithm for generating physically accurate stained glass images. I will study the chemistry and the optics of stained glass and analyze the optical properties of lead. I will implement a physics-based stained glass modeling algorithm and a distributed ray tracer, which will increase the realism. The output software will be able to generate stained glass images from modeled scenes as well as arbitrary input images. The project requires a solid understanding of optics and significant amount of programming.

Introduction

Stained glass is an art form of medieval period that has not been studied extensively by the computer graphics community. PhotoShop[3] has a stained glass filtering functionality, but it does not take the input content into account when determining the tile size. A Stained Glass Image Filter [1] suggests a stained glass filter that segments the input image based on its content, but it fails to create realistic images.

The goal of this project is to create physically based stained glass software that can generate a medieval-style stained glass version of an input image and create a scene with stained glass objects. This proposal is divided into technical discussion, project plan and milestone, project qualification, project cost, and references.

Technical Discussion

1. The Structure of Stained Glass

Glass, often categorized as an amorphous and inorganic solid, is in fact highly viscous supercooled liquid that failed to crystallize at the freezing point. As the high viscosity of the liquid constrains the molecules from moving around freely, the molecules settle down before they form a crystal. Though these molecules are technically still moving around, these movements are not observed at macroscopic level. Hence, glass appears to be solid. [5]

The main difference between glass and crystal solids is that glass does not have a lattice structure. Instead of having a regular structure with even distribution of molecules, glass has an irregular structure where molecules are distributed randomly. This causes glass to be brittle. As the crystallization of glass is closely related to the speed at which the liquid cooled down, glass that cooled down slowly tends to be stronger than those that cooled down quickly. In case of stained glass, as the glass need to be strong enough to withstand the weather but weak enough to be easy to work with, the precise cooling speed is crucial. [4]

There are several types of glasses, and stained glass falls into the category of soda-lime glass. Soda-lime glass is alkali silicate glass made insoluble in water by adding a small amount of calcium oxide. For stained glass, a small amount of powered metal is added to the ingredients to give color. These metal ions have tendency to separate themselves from the rest of the ingredients, causing inhomogeneous coloring of the glass. [4]

2. The Optical Properties of Stained Glass

Light from a point light source can be modeled as a ray from the light source to the object. According to Snell's law, the angles of incidence and refraction are related to the indices of refraction. In case of homogeneous glass, the transmission light ray that enters the glass from air travels in a straight light until it hits an intersection between glass and air. In case of stained glass, however, as it is heterogeneous, the transmission ray that enters the glass travels in a straight line until it detects heterogeneity. When the ray hits a different medium, it bends just as it does when it reaches the surface of the glass. [2]

3. The Art of Stained Glass

Stained glass is a form of art of assembling various colored glass into a pattern. Its utility and beauty have been admired since ancient Rome, and the art of stained glass reached its peak during the medieval period. Numerous churches and cathedrals decorated their windows using stained glass windows to teach their illiterate believers the message of god. Medieval stained glass windows employed glass painting that adds details to the windows, which consequently clarified the message of bible. [5]

4. The Algorithm

Stained glass will be modeled as layers of transparent sheets with amount of metal, cooling speed, and thickness as input perimeters. A paint layer and an ink layer will be added to the glass to generate more faithful stained glass images. A ray tracer will be implemented to model light rays. A segmentation algorithm, similar to the one suggested by [1], will be implemented to mimic the cartooning process of stained glass.

5. Design Constraints

The main constraints for this project are time and energy. Additional constraints to consider include the waste created by old computers and the cost of trips to museums.

Project Plan

Activities List

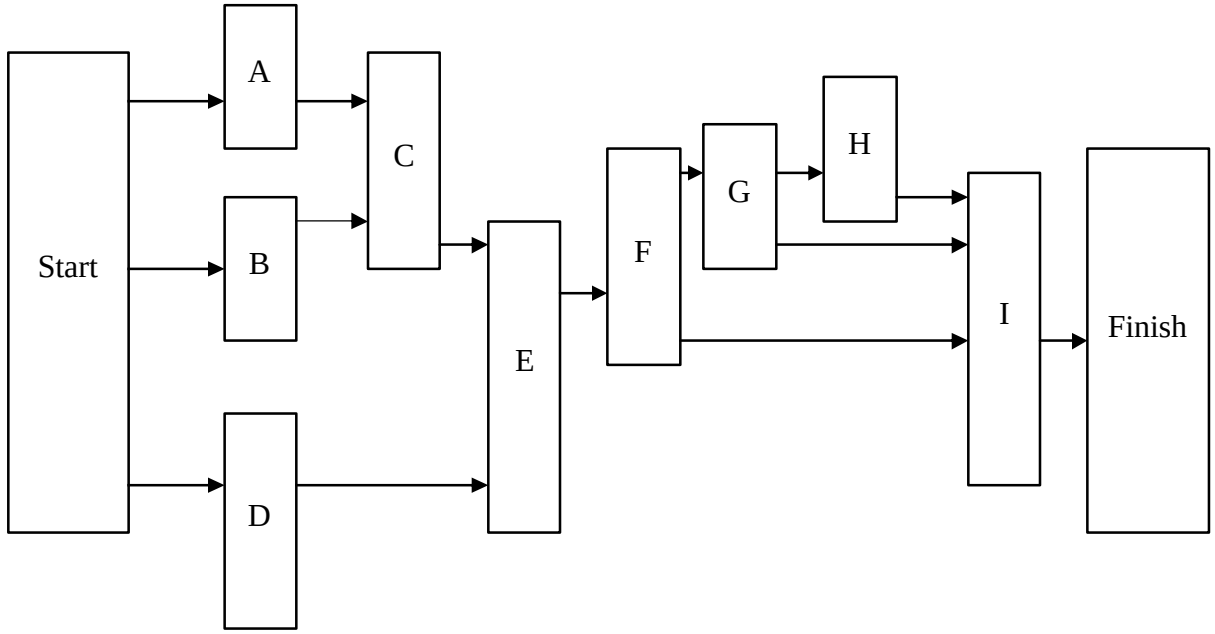
Activity	Action
A	Implement a simple stained glass modeling algorithm
B	Implement a distributed ray tracer
C	Combine ray tracer and glass modeling algorithm and evaluate the performance of the resulting software
D	Implement a cartooning algorithm
E	Add the cartooning algorithm to the program and generate preliminary images
F	Add advanced functionalities such as fluid modeling to the glass algorithm
G	Generate more images
H	Create an animation
I	Write the project report

Table of Activities

Activity	Needs	Feeds	Duration	Effort	Action
A	-	C	2 wks	50 hrs	Implement a simple stained glass modeling algorithm
B	-	C	1-2 wks	30 hrs	Implement a distributed ray tracer
C	A, B	E	1 wk	20 hrs	Combine ray tracer and glass modeling algorithm and evaluate the performance of the resulting software

D	-	E	1-2 wks	30 hrs	Implement a cartooning algorithm
E	C, D	F	1 wk	20 hrs	Add the cartooning algorithm to the program and generate preliminary images
F	E	G	2 wks	50 hrs	Add advanced functionalities such as fluid modeling to the glass algorithm
G	F	I	1 wk	20 hrs	Generate more images
H	G	I	2 wks	50 hrs	Create an animation
I	F, G, H	-	1 wk	20 hrs	Write the project report

Critical Path Method Network Diagram



Project Milestone

task\week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A														
B														
C														
D														
E														
F														
G														
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Project Qualification

I believe I have sufficient experience in computer graphics, necessary analytical skills, and enough creativity to complete this project. In addition to numerous engineering and computer science courses, I have taken Computer Graphics, Advanced Computer Graphics, and an art history course. I have implemented a sumi-e rendering algorithm and a ray-tracer with area lighting, and spent the summer of 2004 doing a tensor visualization research. I am very interested in working on this project, and I believe my enthusiasm will help me finish this project successfully.

Project Cost

The main project costs will be the cost of travel to museums and churches and the admissions to these places. Several trips to various nearby museums will be made throughout the semester to enhance my understanding of stained glass. Other costs include the cost of an ergonomic keyboard, which will decrease the stress on my wrists. The technical assistance required by this project will be provided by Dr. Bruce A. Maxwell, professor of engineering, Dr, Carl Grossman, professor of physics, and Dr. Michael Cothren, professor of art history. Dr. Grossman specializes in optics and will assist me to understand the theory behind stained glass. Dr. Cothren specializes in medieval stained glass and will help me gain a greater understanding of the art of stained glass. There are no costs associated with their assistance.

References

[1] Mould, D. A Stained Glass Image Filter, *Proceedings of the 14th Eurographics workshop on Rendering*, pp. 20-25, June 2003.

[2] Naess, R. *Optics for Technology Students*. Upper Saddle River, NJ: Prentice-Hall, 2001.

[3] O'Quinn, D. *Photoshop 6 Shop Manual.* New Rides Publishing, Indianapolis, 2001.

[4] Paul, A. *Chemistry of Glasses*. London and New York: Chapman and Hall, 1982.

[5] Stained Glass in Medieval Europe. http://www.metmuseum.org/toah/hd/glas/hd_glas.htm

[6] Zallen, R. *The Physics of Amorphous Solids*. New York: Wiley, 1983.