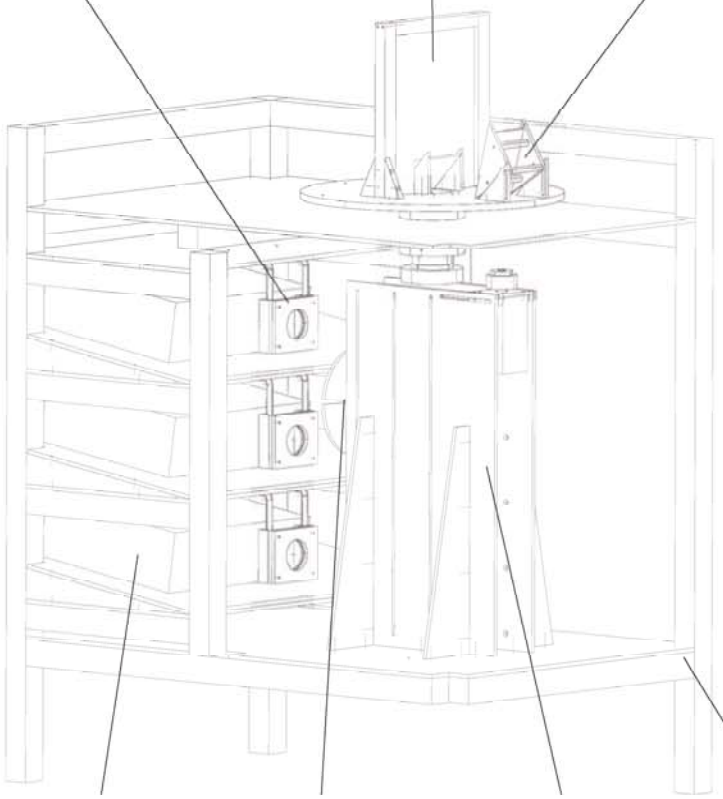
Design and Manufacture of an Interactive Three-Dimensional Swept Volumetric Display



Collimating Optics - undo the diverging effect of the projector lens, providing a near columnar beam of light. This is necessary so that the beam can pass unobstructed through several narrow openings

Rotating Screen - the screen onto which the image is projected rotates at 900rpm

Mirror Array - allows an image to constantly projected onto a moving screen

Projector Stack - to achieve higher frame rates than a single projector is capable of multiple projectors are used

Shutter Mechanism - occludes each projected frame for a portion of the frame projection time

Beamsplitter Array - combines the beams from multiple projectors onto a single path

Framework - an adjustable aluminium framework is used to support the assembly

Introduction

An investigation into three-dimensional dispays was carried out as a joint project with the Computer Science department. The main requirement of the investigation was that a working prototype of a swept volumetric display be built with which to experiment. The swept volumetric display produces a volumetric image by projecting light onto a rotating screen, as shown in the photos.

Optics

In order to produce a clear, focused image on the screen an optical setup was implemented to allow the projector light to pass through a central column (a key part of the rotating section) unobstructed. A three lens setup was installed to produce collimated light which could then be diverged onto a screen whilst retaining its focus. The setup was designed for use with three projectors in order to achieve the very high rate of projection required. A series of beamsplitters allowed the light from the three sources to be combined into a single light beam. To reduce the length of time each projected frame was displayed a mechanical shuttering mechanism was manufactured, allowing a much smaller sweep angle per frame.

Control

Accurate control of the rotating parts in this system was important in order to produce a convincing three dimensional image. A closed loop proportional-integral-derivative (PID) control scheme was used to control the two motors, however a more advanced Iterative Learning controller was designed with the ultimate aim of implmenting this.

Electronics

To automate the controller in the system, an Arduino Mega board was installed with the control schemes loaded onto it. This board took readings from the motor encoder and an optical transistor and produced a pulse-width modulated signal allowing accurate PID control of the rotation rates.

Conclusions

The project was largely a success, however due to budget constraints only one projector was made available for use. Whilst the fundamental operation of the mechanism was successful, the lack of three projectors restricted the projection rate to 120Hz, and hence fewer slices per rotation could be displayed (photo: top right). By adjusting the rotation rate slightly it was possible to fill the volume as shown in the photo (bottom right) however the update frequency of these slices was poor. The Computer Science department are currently using the display tfor research into three dimensional interaction through infra-red refraction in the dome.

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