# Fast Light for Display, Sensing and Control Applications

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## Abstract

*Digital Micromirror Devices are capable of modulating individual pixels at kilohertz rates. A generically programmable DMD-based projector with a high update rate was created (the Mule). This Multiuse Light Engine was used to develop novel proof-of-concept prototypes with a range of applications including immersive environments, human-computer interfaces, robotic control and machine vision.*

## 1. Introduction

A custom DVI (Digital Video Interface) circuit was developed and interfaced to a 1024 by 768 pixel DMD evaluation card [1]. This design enables a standard PC-based graphics card to act as a high speed image source, capable of refreshing every pixel at frame rates exceeding 1.5kHz. The displayed images are binary. When mechanically integrated with an off-the-shelf projector, a general purpose, high speed programmable light engine is created.

The Mule's ability to rapidly create encoded planes of information was combined with other technologies to create the following proof-of-concept demonstration prototypes.

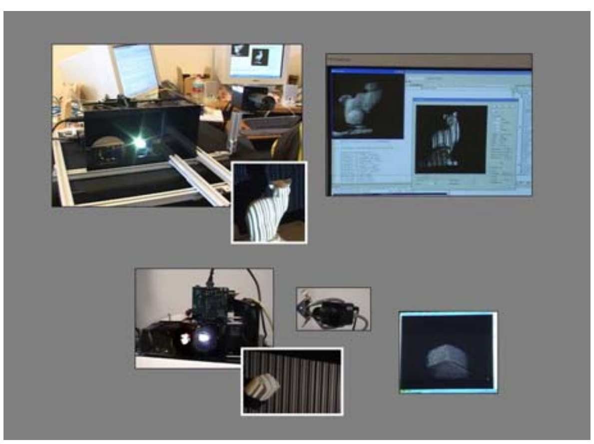

Figure 1: Fast Range Scanning

## 2. Fast Range Scanning

The Mule Projector was integrated with a fast video camera and stripe boundary code algorithms [2]. Because the stripe codes could be refreshed and captured at high speeds, it was possible to create seemingly instantaneous 3D models and time series scans of slowly moving objects.

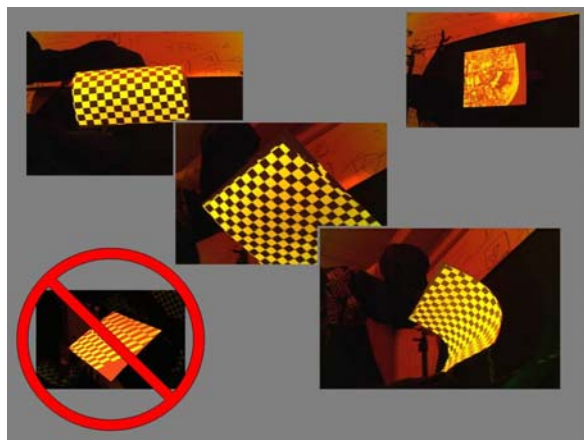

Figure 2: Geometrically Corrected Projection

## 3. Real-time Geometrically Corrected Projection on Deforming Surfaces

This ability to quickly scan and model was integrated with a standard video projector and geometric re-mapping algorithms in collaboration with Guillaume Poncin and David Leib at Stanford University's Graphics Laboratory. This system projected an image upon a dynamically moving and bending surface. The projected image remained undistorted regardless of the user's viewpoint even as the surface was moved and bent.

## 4. Encoded Light for the Tracking, Tagging and Control of a Robotic Swarm

The Mule was programmed to rapidly modulate regions of pixels to time-encode each region with a unique identification sequence. Mobile robots with light sensors were programmed to detect and react to the optical codes as the robots moved through the various regions in the projected light field.

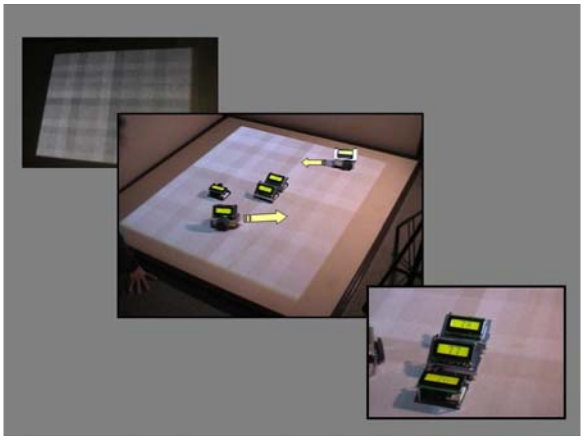

**Figure 3: Control of a Robotic Swarm**

This technique was successfully tested to work through water. In the future, such encoded light could be used to create light-pen interfaces and multiple projectors could be used to experiment with volumetric coding and detection techniques.

## 5. Multiple Coincident Personal Views with Camouflage Layer

Twenty-four images were displayed at a 60 Hz rate to provide multiple, seemingly simultaneous views on a single display surface. Viewers used time-encoded shutter glasses to see person-specific views. This was first tested with multiple stereoscopic views. It was then tested with negative and camouflage images that allowed a view visible without shutter glasses, along with multiple seemingly invisible views. This could be used to create a secure information display.

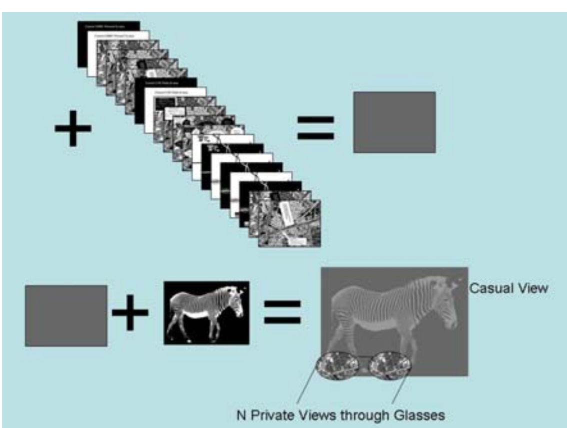


**Figure 4: Multiple View Displays**

## 6. Very High Resolution Display

A shuttered array of lenses may be used to optically produce multiple copies of an image. Each lens in the array can then be shuttered to be synchronized with a sequential series of images projected from the Mule. In this way, a very high resolution image can be produced with a correspondingly reduced bit depth.

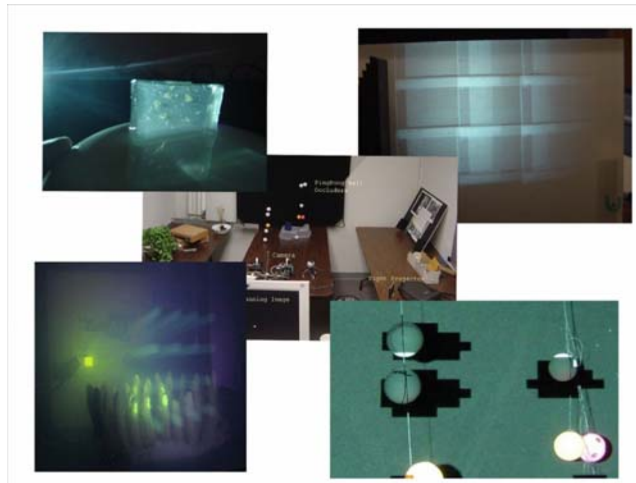

**Figure 5: High Resolution Display and Smart Illumination Applications**

## 7. Real-time Smart Illumination

The high update rates of the Mule projector enable it to provide a smart illumination source for many real-time applications. For example, the Mule and a camera were arranged to selectively light a scene so as to minimize the reflection of unwanted objects. Future work could illuminate a scene with feedback from the camera to always create an equally bright, gray image.

## 8. References

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[1] D. Dudley, W. M. Duncan, J. Slaughter, "Emerging DMD Applications" Proc of SPIE MOEMS Display and Imaging Systems, Ed. H. Urey, Vol. 4985-2

[2] S. Rusinkiewicz, O. Hall-Holt, M. Levoy, "Real-Time 3D Model Acquistion" *Proc. SIGGRAPH 2002*.