

Developing 3D contents for e-learning applications

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DEVELOPING 3D CONTENTS FOR E-LEARNING APPLICATIONS



Motivation for 3D Imaging

3D Imaging can provide:

- Realistic models
- Interactive visualization and manipulation of objects on screen
- Sense of immersion in a 3D world
- Unique opportunity to explore objects and relationships
- Control over how objects are displayed
- A variety of interrogation dialogues as opposed to a fixed script
- Better recall of learning experience from a visual and spatial environment

These lead to enhanced learning experiences





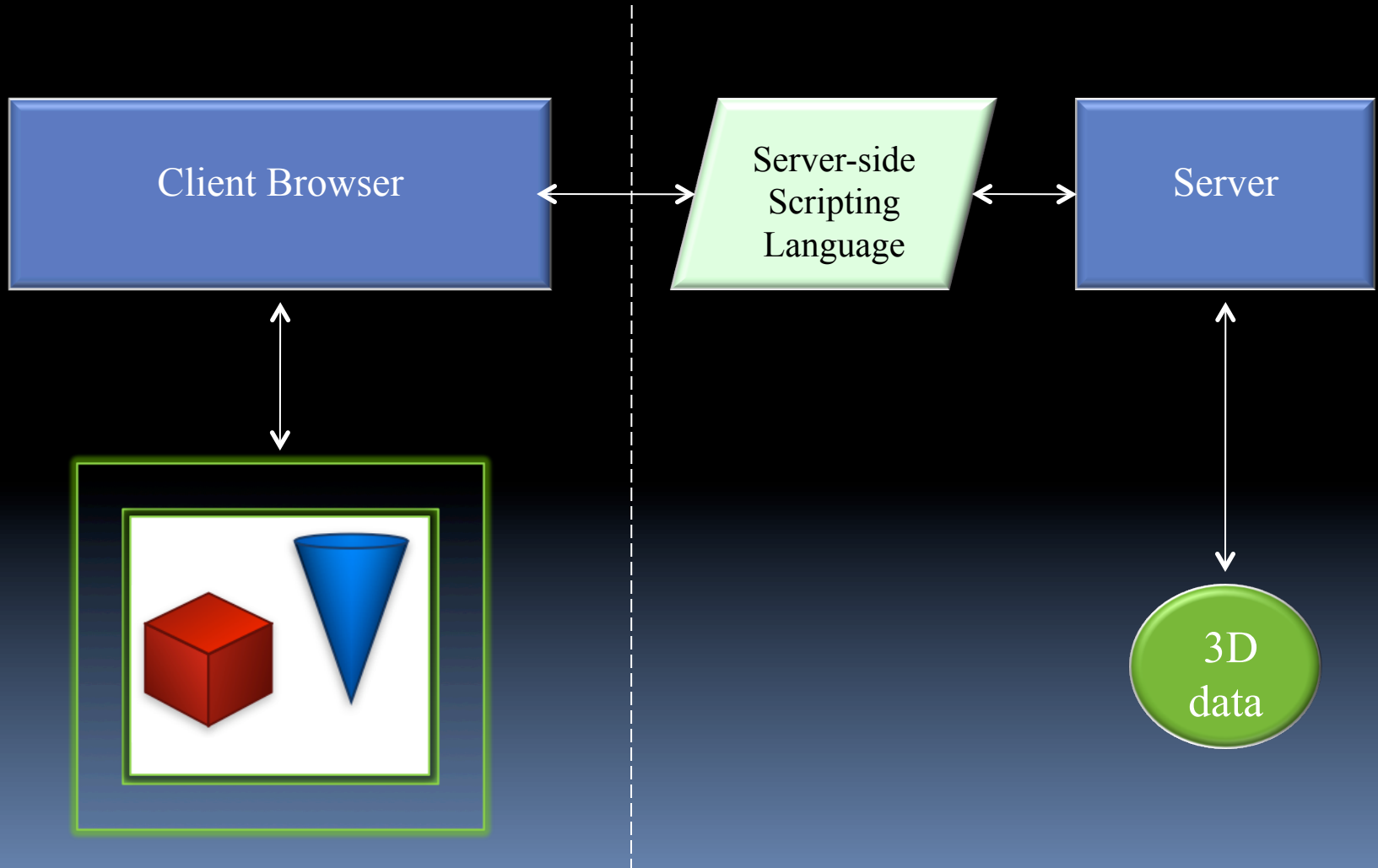
Some Limitations of 3D Imaging

- Web browsers do not understand 3D models
- Current methods are too slow to be used in a realistic scenario within a web browser
- Problems of data representation, compression, processing time
- Need a number of techniques to generate 3D models



Our needs are for real-time, responsive interaction with 3D scenes within a browser

Existing Option

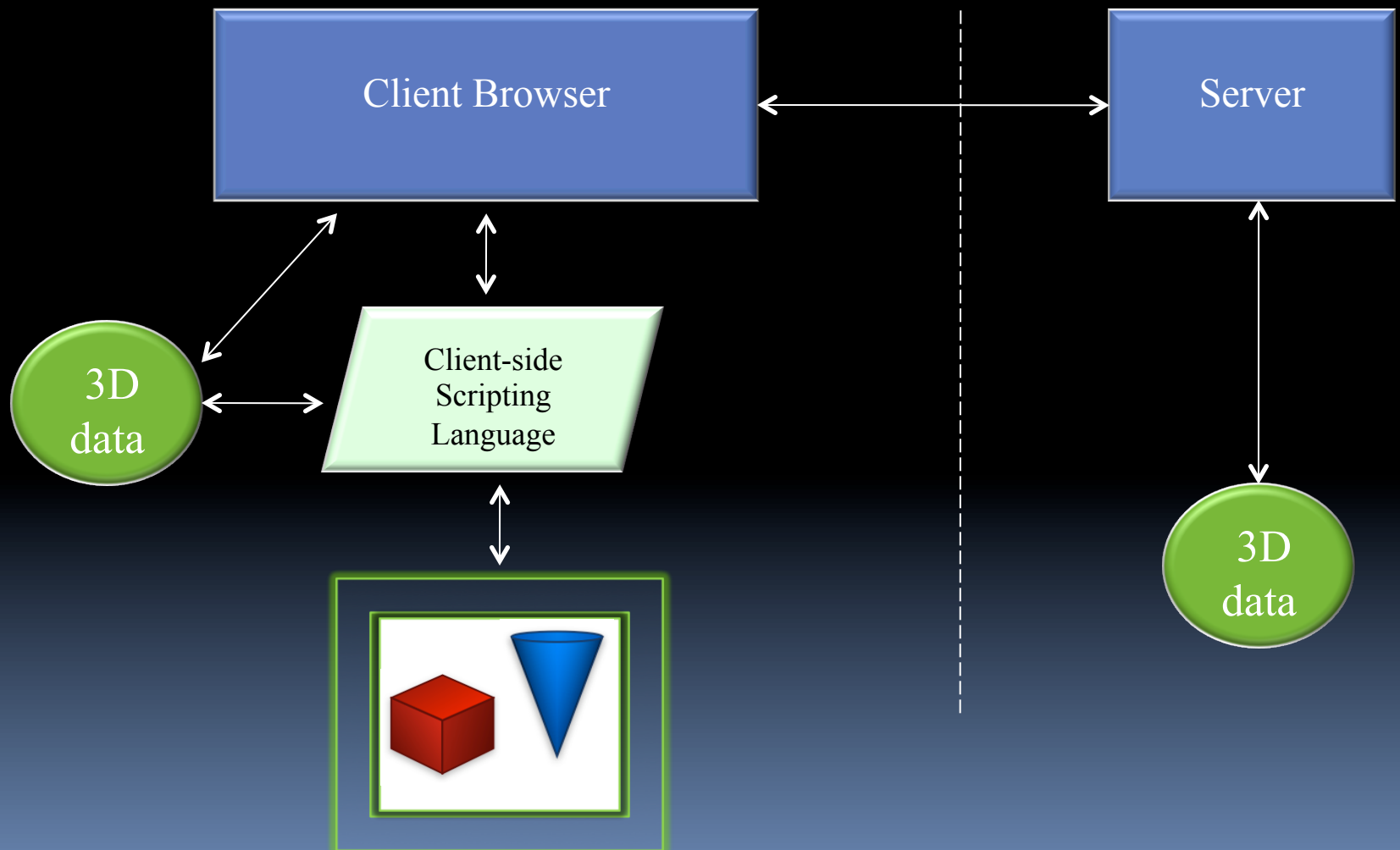


Some Problems with this Approach

- If the scene is to be rotated or translated the server has to calculate new pixel values for the displayed image
- Too much overhead communication between client/server
- The burden is mostly on the server, uneven load (fat server and thin client)
- Works well for 2D images, streaming audio and video, and text data from databases

A workable solution for interactive 3D would be to place the load on the client machine taking advantage of the underlying hardware thus reducing overhead communication

A Workable Solution



The Obvious Options (1)

JavaScript

- Client-side scripting language
- Developed to add dynamic content to web pages
- JavaScript statements are embedded into html code
- Compatible with all browsers
- The most popular scripting language on the Internet

Thus, potential for easy integration of 3D contents into a web page

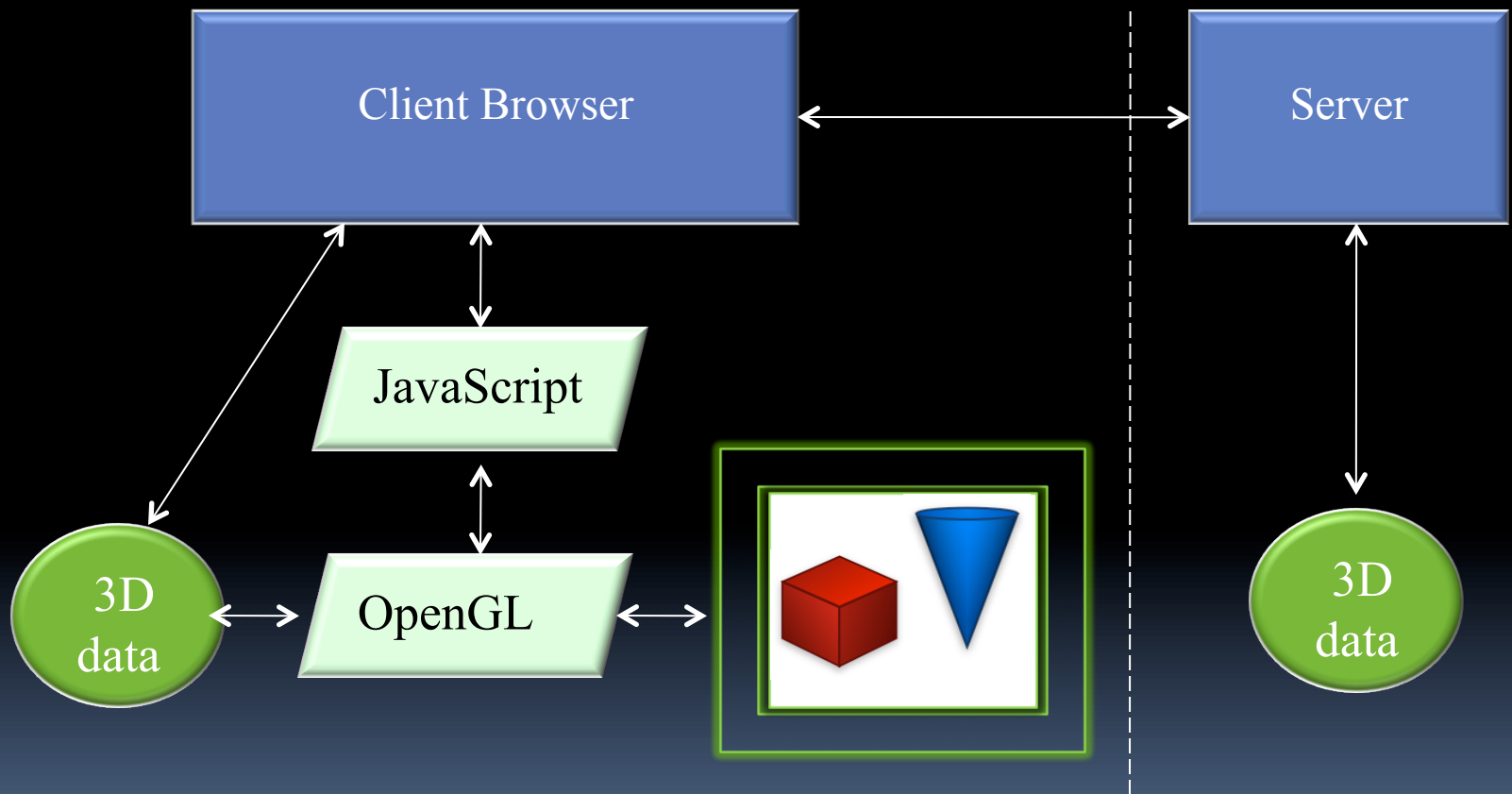
The Obvious Options (2)

OpenGL

- The industry standard for high performance graphics
- Comes pre-installed on all major operating systems (Windows, Mac, Linux, Unix)
- Runs on the client machine taking advantage of graphics hardware
- Developed in C/C++ so it requires some programming knowledge to be able to drive the OpenGL API
- Vast number of tutorials on the web

However, since we just want to include interactive 3D models on the web we may not want to learn OpenGL at all !

THE Solution



The problem at this juncture is that JavaScript does not understand OpenGL

The Mozilla Approach

- The future of the web is augmenting 2D content with the 3rd dimension
- Khronos: a 3D web project seeking to create standards for 3D solutions development
- The aim is for end users to take advantage of those solutions as part of the normal web experience
- Standards are expected to be published by May 2010
- The approach
 - To develop an OpenGL wrapper within JavaScript
 - Effectively, a JavaScript extension
 - The browser will come pre-installed with all necessary plug-ins

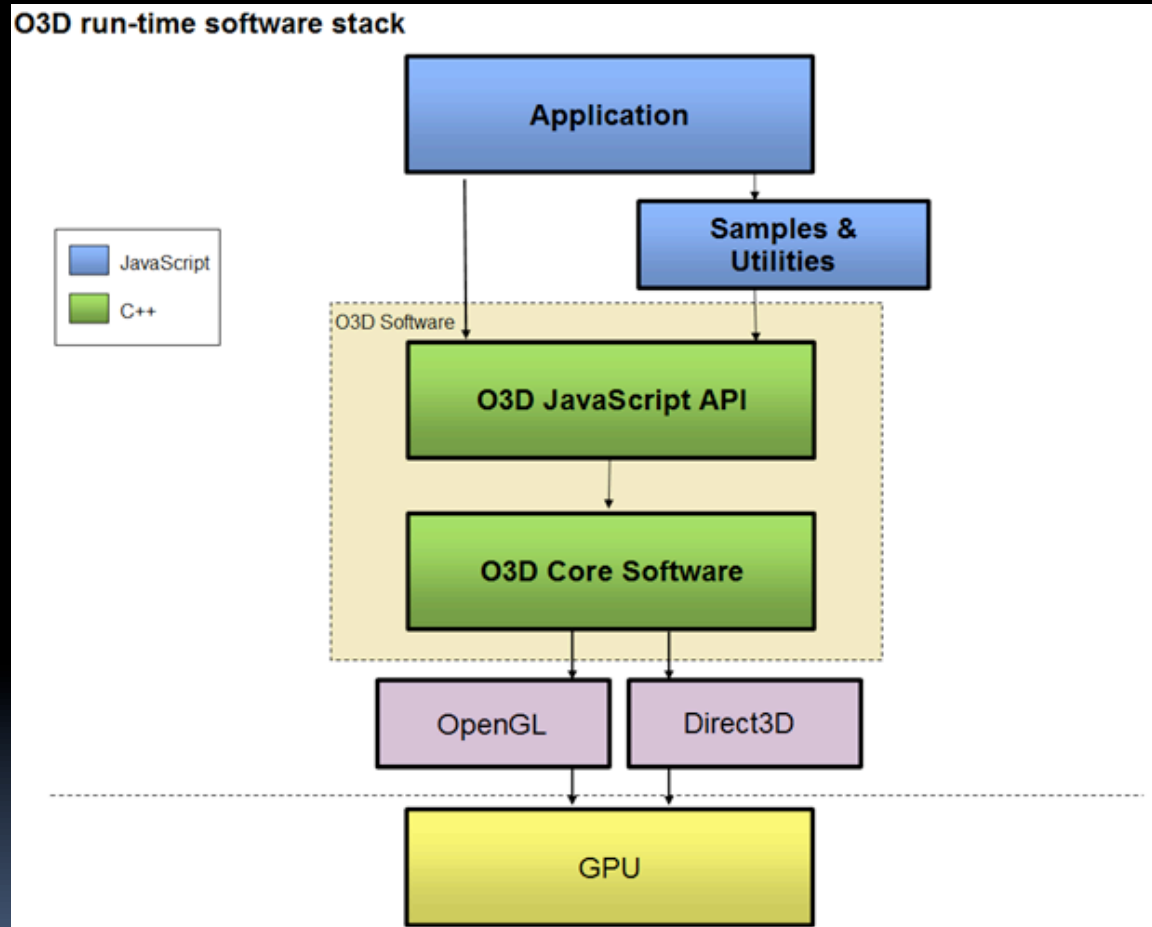
It is not clear which range of 3D formats will be supported

The Google Approach

- Same reasoning and motivation as Mozilla
- Differs in implementation details
- Much further down the line in the development process
- An API is already available with good documentation: O3D
- The approach
 - To develop an OpenGL wrapper within JavaScript
 - Effectively, O3D is a JavaScript extension
 - Plug-ins are required

Google has opted to support the COLLADA format for 3D contents, but this still needs conversion to O3D notation

The O3D Solution



Source: <http://code.google.com/apis/o3d/docs/techoverview.html>




The O3D JavaScript Extension

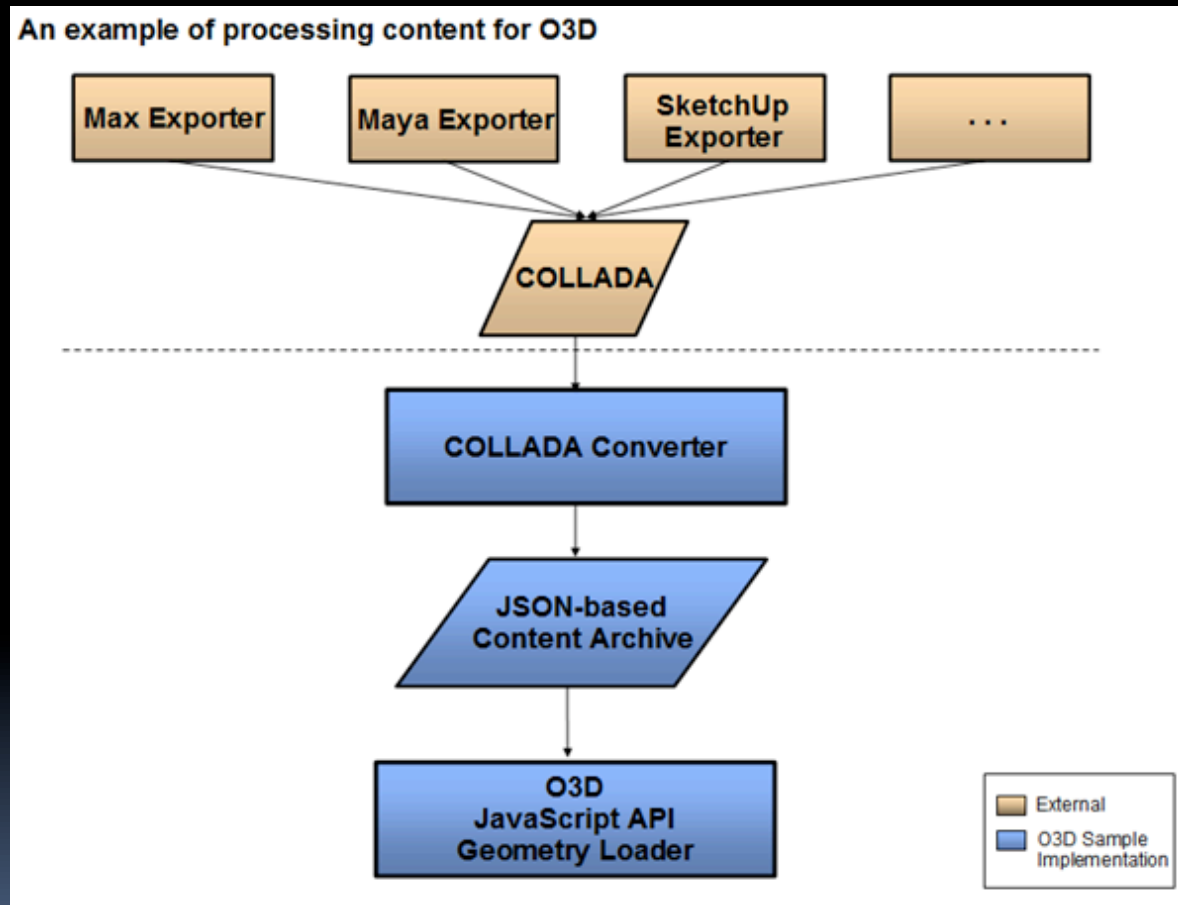
- O3D is an open source JavaScript extension
- The O3D API provides interactive web based applications
- Interfaces with OpenGL
- Harnesses the power of the client machine
- Available for Windows, Mac, Linux



Creating a 3D Scene

- With O₃D we can:
 - Import 3D scene models; or
 - Create *transform graphs* from scratch
 - Transform graphs specify the colour, normals, effects, and the position of objects in 3D space
 - We can also use a combined approach, importing some models and adding others from scratch
- 

Importing 3D Contents to O3D



Source: <http://code.google.com/apis/o3d/docs/techoverview.html>

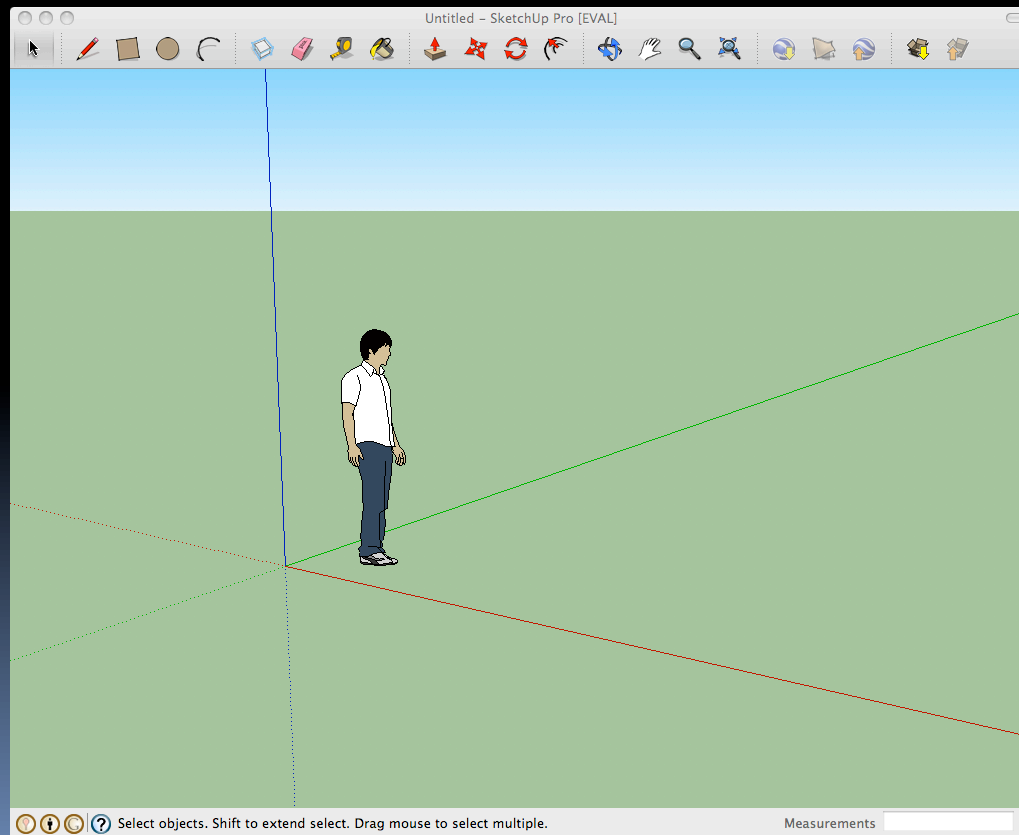


Tools Required

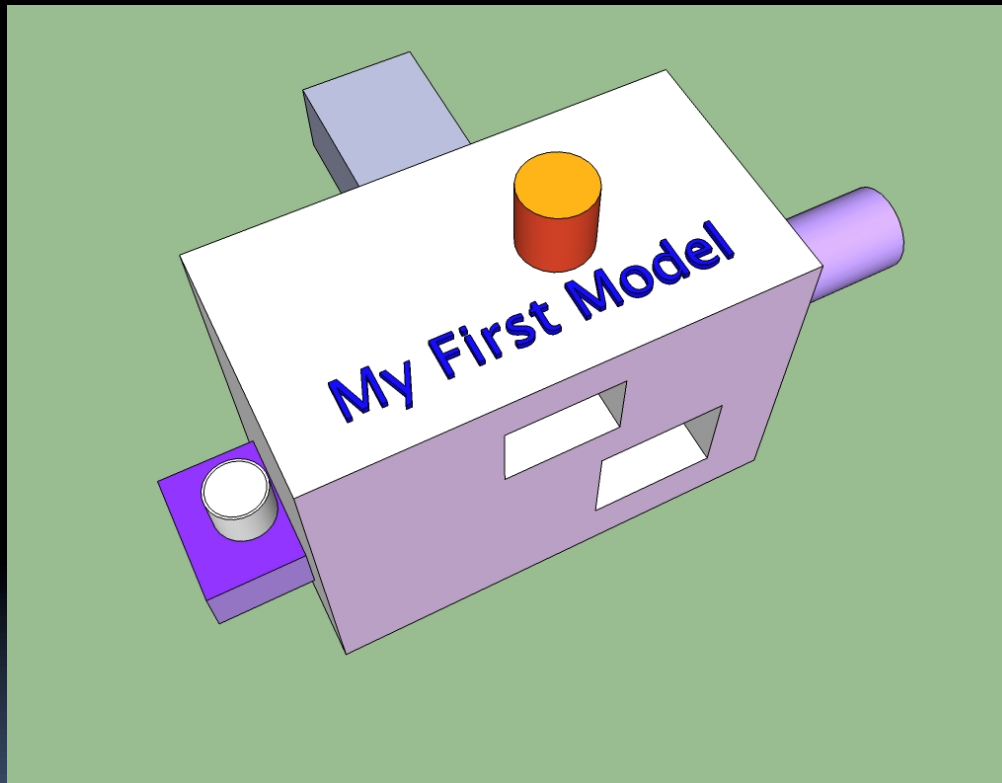
- The O3D plug-in
- A 3D modelling package that can export to COLLADA format
- A COLLADA file converter to *.o3dtgz* (provided by O3D API)
- An html editor to include O3D JavaScript commands to load and display data

Example: Creating 3D Contents

- Start your favourite 3D modelling package

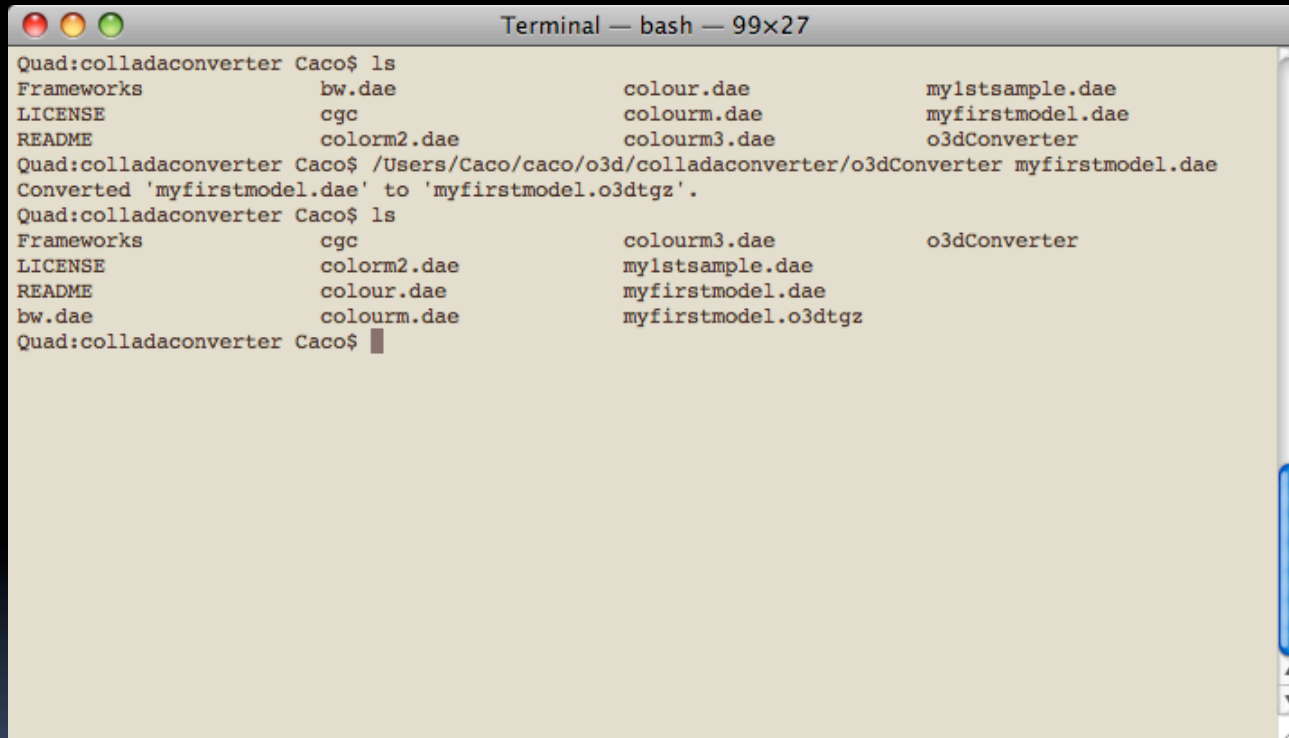


Create a Model and Export to COLLADA Format



The exported file has the extension *.dae* (Digital Asset Exchange)

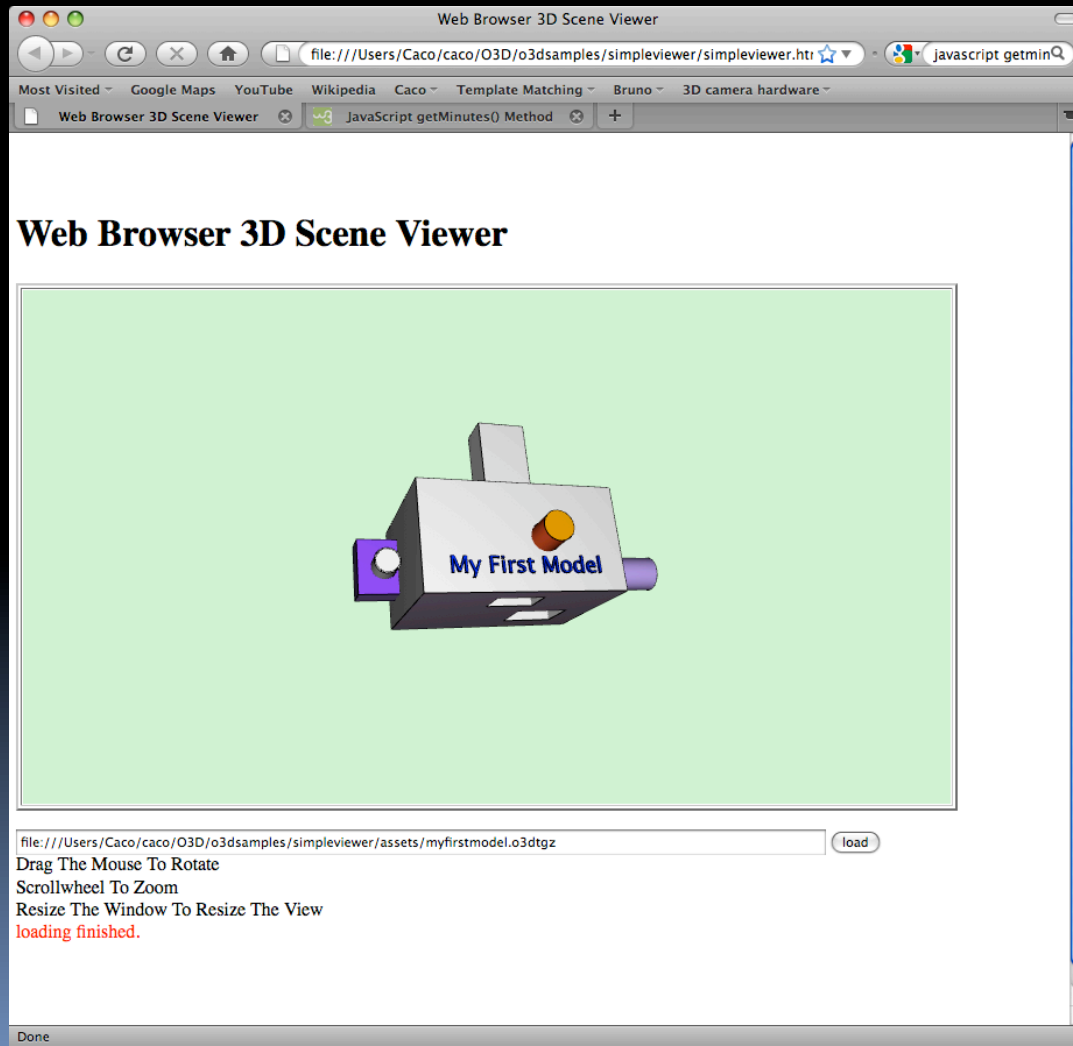
Convert the Model to JSON o3dtgz



```
Terminal — bash — 99x27
Quad:colladaconverter Caco$ ls
Frameworks      bw.dae          colour.dae      my1stsample.dae
LICENSE         cgc             colourm.dae     myfirstmodel.dae
README          colorm2.dae     colourm3.dae   o3dConverter
Quad:colladaconverter Caco$ /Users/Caco/caco/o3d/colladaconverter/o3dConverter myfirstmodel.dae
Converted 'myfirstmodel.dae' to 'myfirstmodel.o3dtgz'.
Quad:colladaconverter Caco$ ls
Frameworks      cgc             colourm3.dae    o3dConverter
LICENSE         colorm2.dae     my1stsample.dae
README          colour.dae      myfirstmodel.dae
bw.dae          colourm.dae     myfirstmodel.o3dtgz
Quad:colladaconverter Caco$
```

The file has now the extension *.o3dtgz* (Tar-Gnu-Zipped) and can then be displayed on the browser

Viewing and Interacting with the Model on a Web Browser



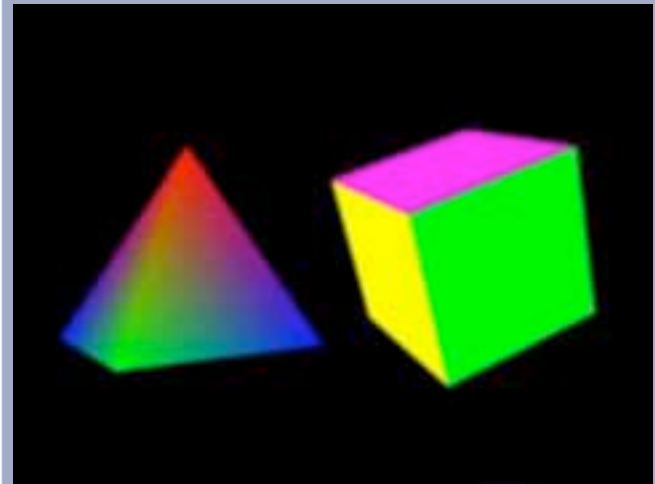
Not a Single OpenGL Low Level Construct is Required

```
glBegin(GL_TRIANGLES);

glColor3f(1.0f,0.0f,0.0f); // Red
glVertex3f( 0.0f, 1.0f, 0.0f); // Top Of Triangle
glColor3f(0.0f,1.0f,0.0f); // Green glVertex3f
(-1.0f,-1.0f, 1.0f); // Left Of Triangle
glColor3f(0.0f,0.0f,1.0f); // Blue glVertex3f
( 1.0f,-1.0f, 1.0f); //Right Of Triangle

.....

glEnd();
```



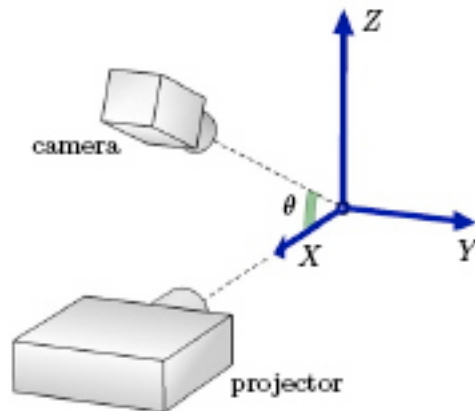
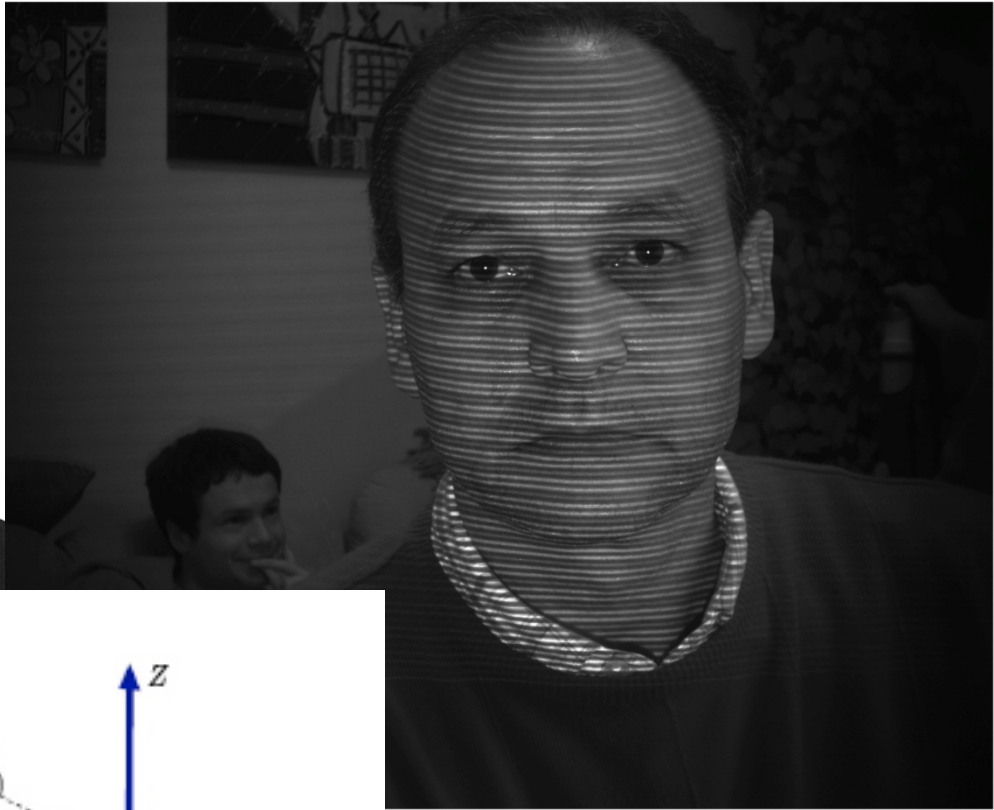
However, O3D provides the equivalent OpenGL constructs (*transform graphs*) as above giving the developer the option for a combined approach

03D Sample Code

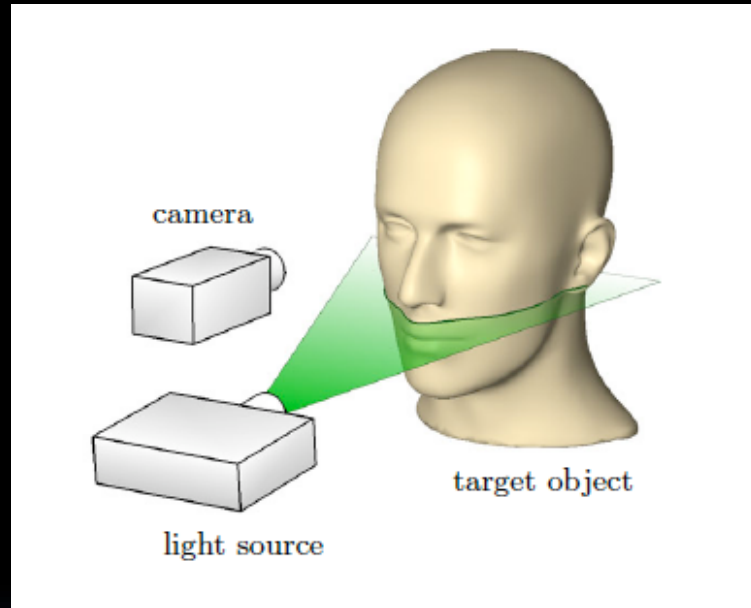
```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN" "http://www.w3.org/TR/html4/loose.dtd">
<html>
<head>
  <title>
    Web Browser 3D Scene Viewer
  </title>
</head>
<body onload="init();" onunload="uninit();">
<script type="text/javascript" src="../o3djs/base.js"></script>
<script type="text/javascript">
... ..
function onRender() {
  g_viewInfo.clearBuffer.clearColor = [ 0.8, 0.95, 0.8, 1 ];
  setClientSize();
}
... ..

function initLoadFile(clientElements) {
  var path = window.location.href;
  var index = path.lastIndexOf('/');
  path = path.substring(0, index+1) + 'assets/myfirstmodel.o3dtgz';
  var url = document.getElementById("url").value = path;
  g_loadingElement = document.getElementById('loading');
  ... ..
}
... ..
</script>
... ..
</body>
</html>
```

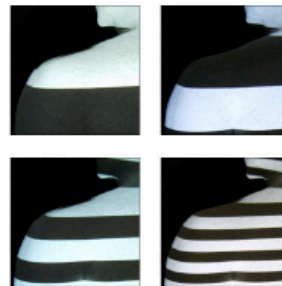
A 3rd Way of Acquiring 3D Models



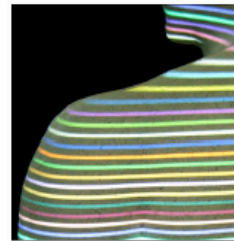
A Number of Alternative Projection Methods Can Be Used



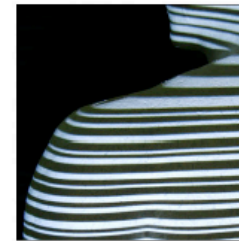
The camera and projector can be parallel or angled, and coding schemes can vary



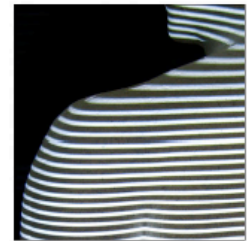
(a) time-multiplexing



(b) colour coding

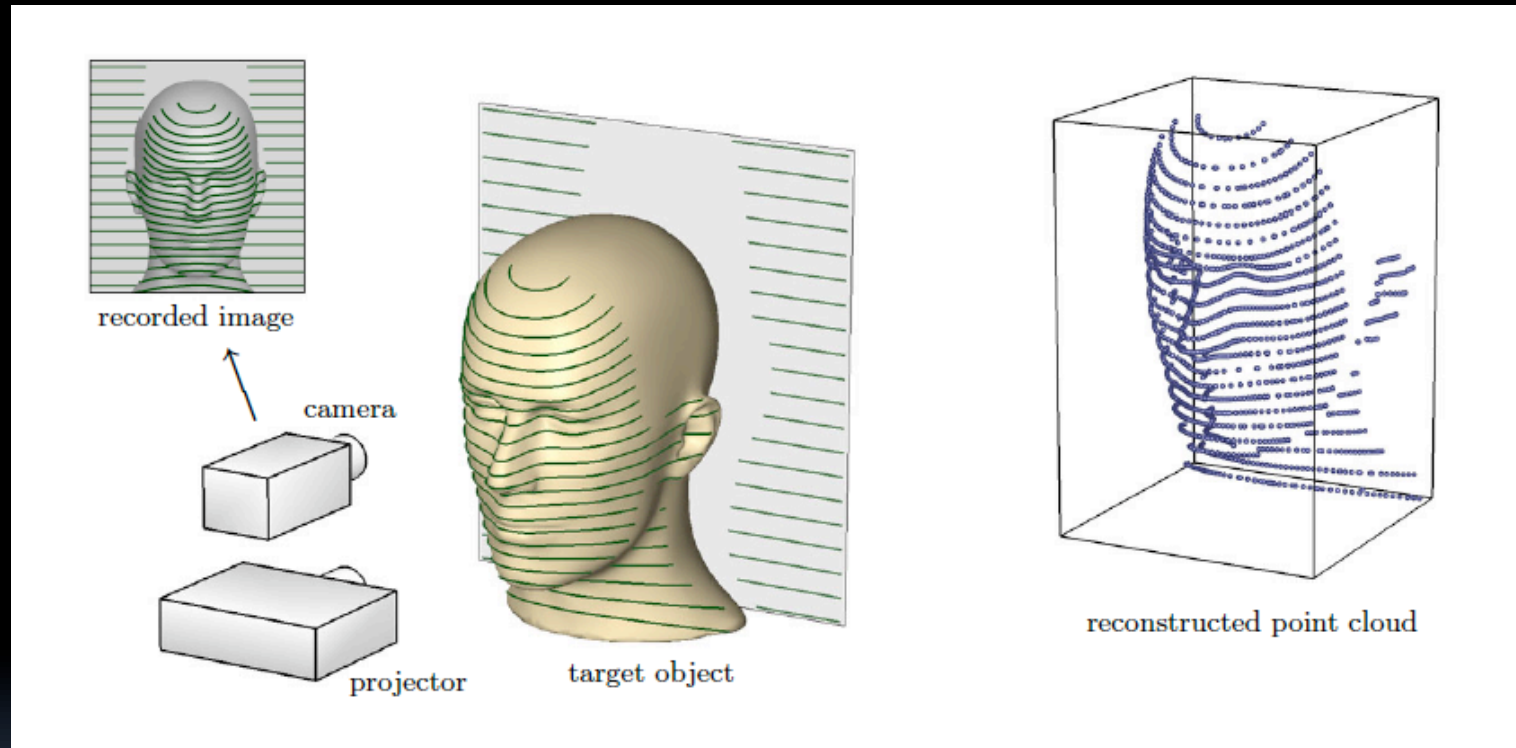


(c) variable width



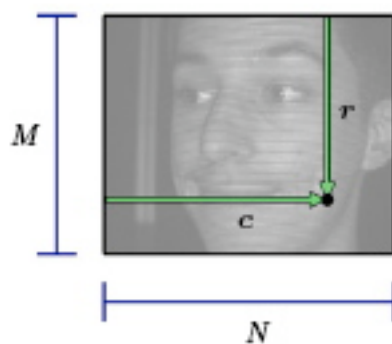
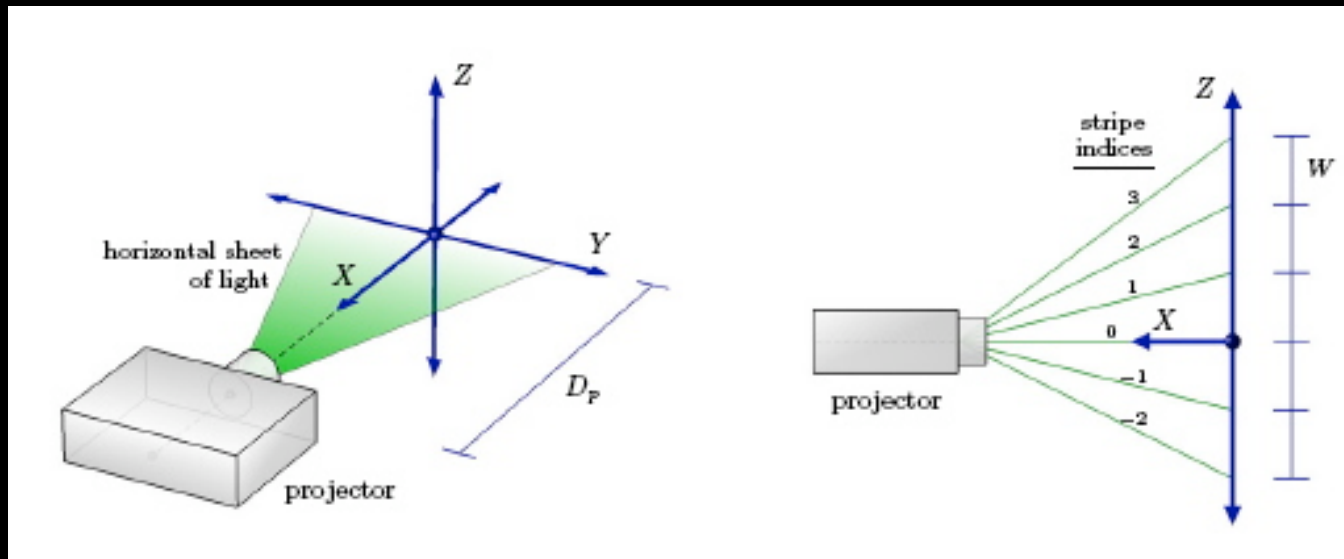
(d) uncoded stripes

Our 3D Striper Method

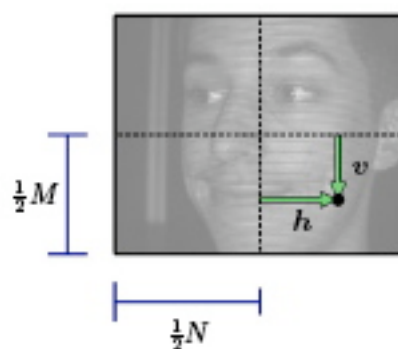


A series of parallel stripes are projected onto a surface of an object.
Stripe information is used to reconstruct a point cloud in 3D space

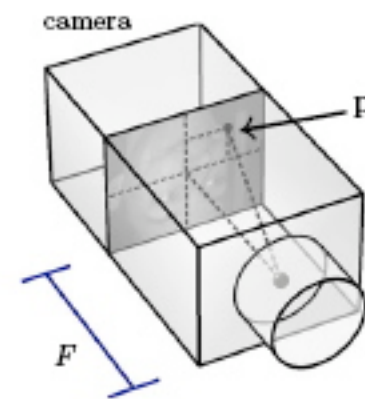
The projector determines the centre of the system



(a) image space

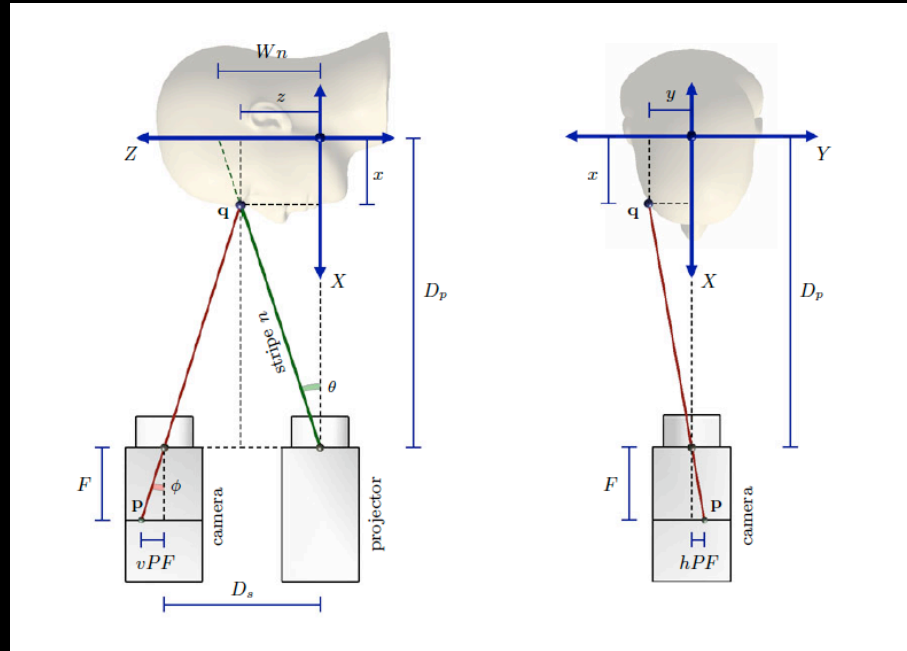


(b) centred



(c) system space

Geometrical Relationships

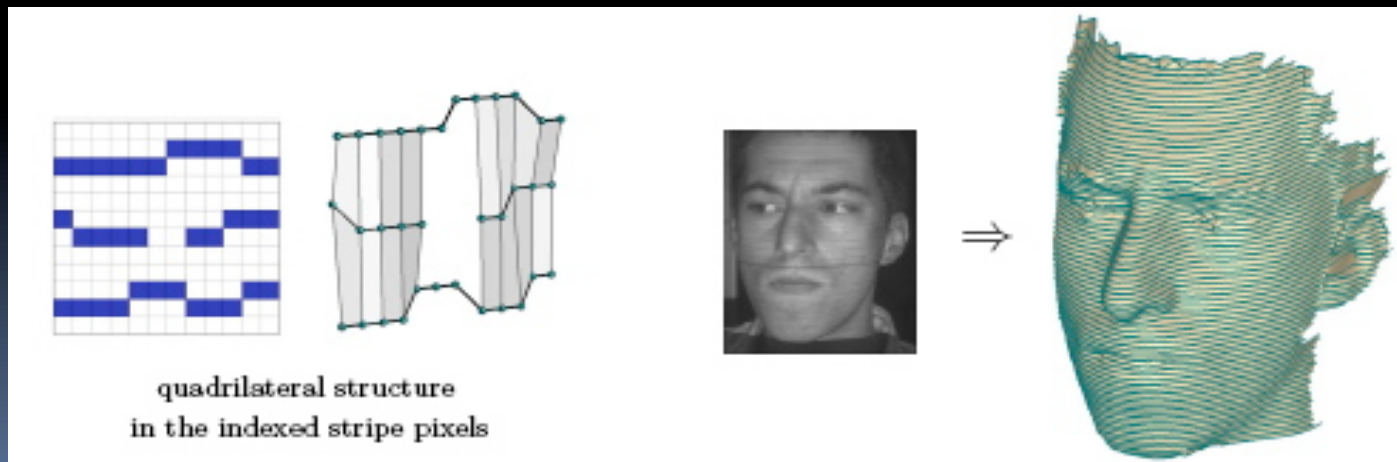
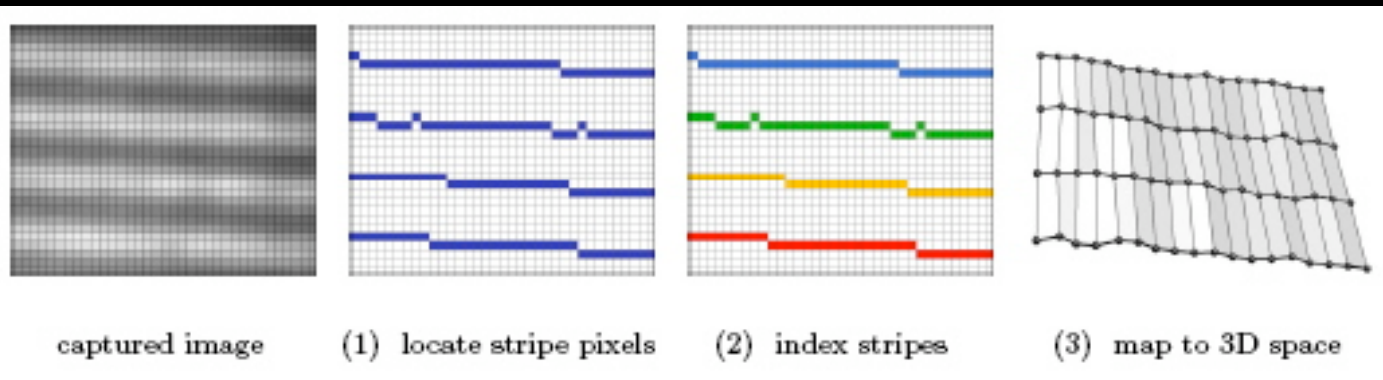


$$z = \frac{W_n}{D_p} \left(D_p - D_p + \frac{D_p D_s}{vPD_p + W_n} \right) = \frac{W_n D_s}{vPD_p + W_n}$$

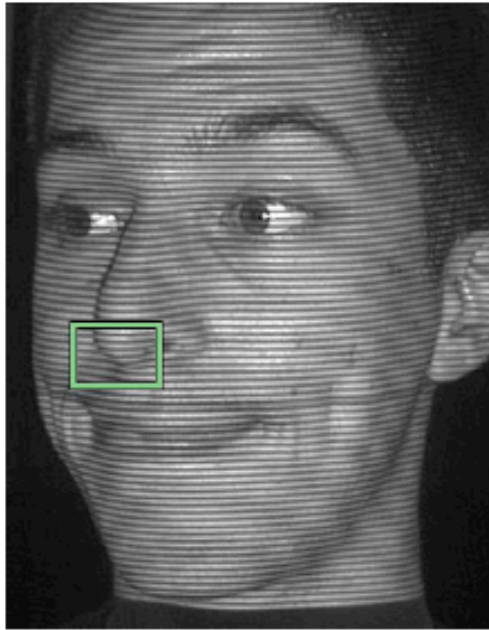
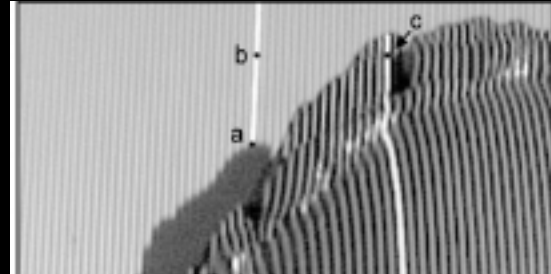
$$\frac{W_n}{D_p} (D_p - x) = D_s - vP (D_p - x) \implies x = D_p - \frac{D_p D_s}{vPD_p + W_n}$$

$$\frac{y}{D_p - x} = \frac{hPF}{F} \implies y = hP (D_p - x) = \frac{hPD_p D_s}{vPD_p + W_n}$$

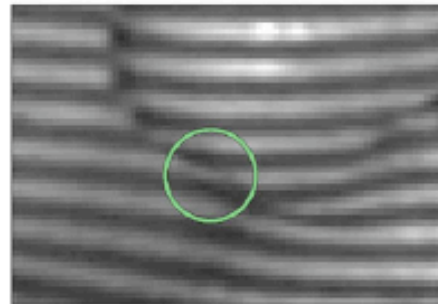
Stripe Indexing and Generation of 3D Data



Problems with Occlusion



(a) captured image



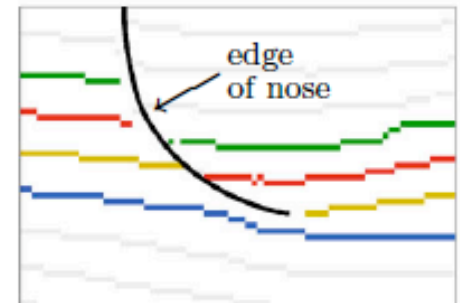
(b) close-up



(c) stripe pixels

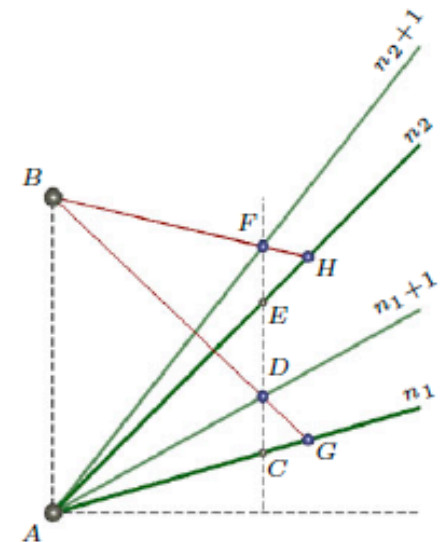
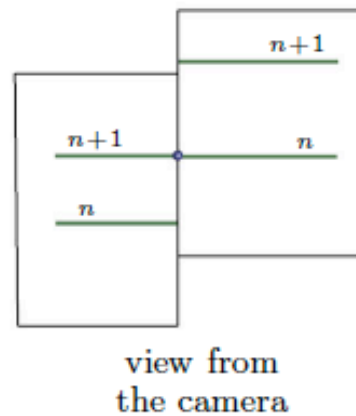
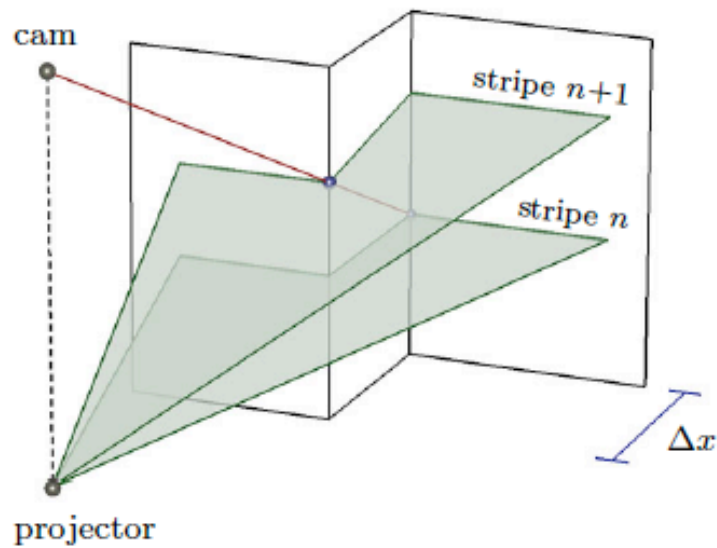


(d) incorrect indexing

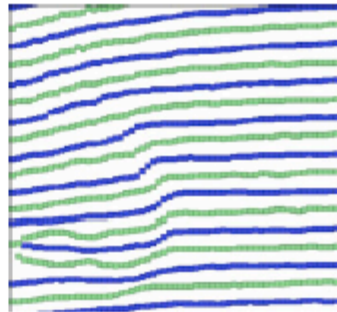
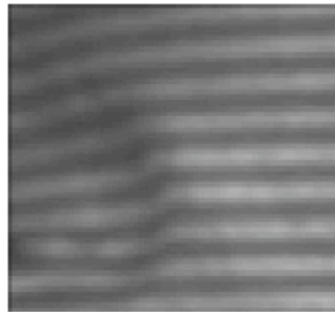
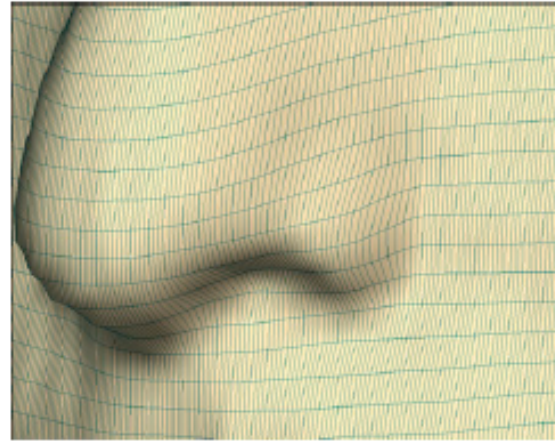
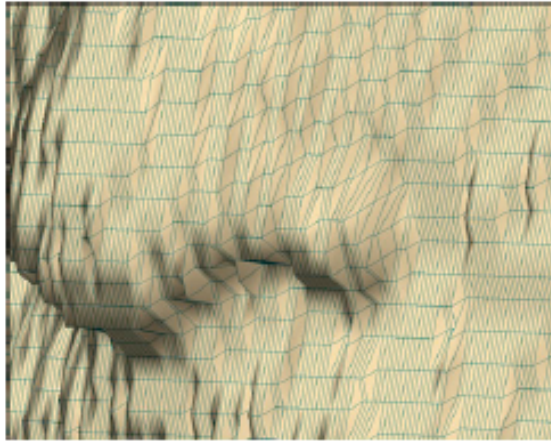


(e) correct indexing

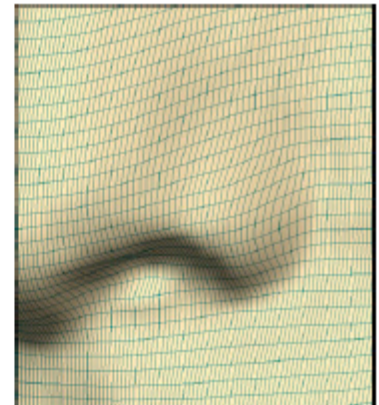
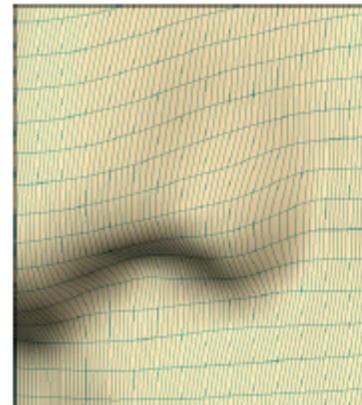
Unsolvable Occlusion Problem



Sub-pixel Estimation

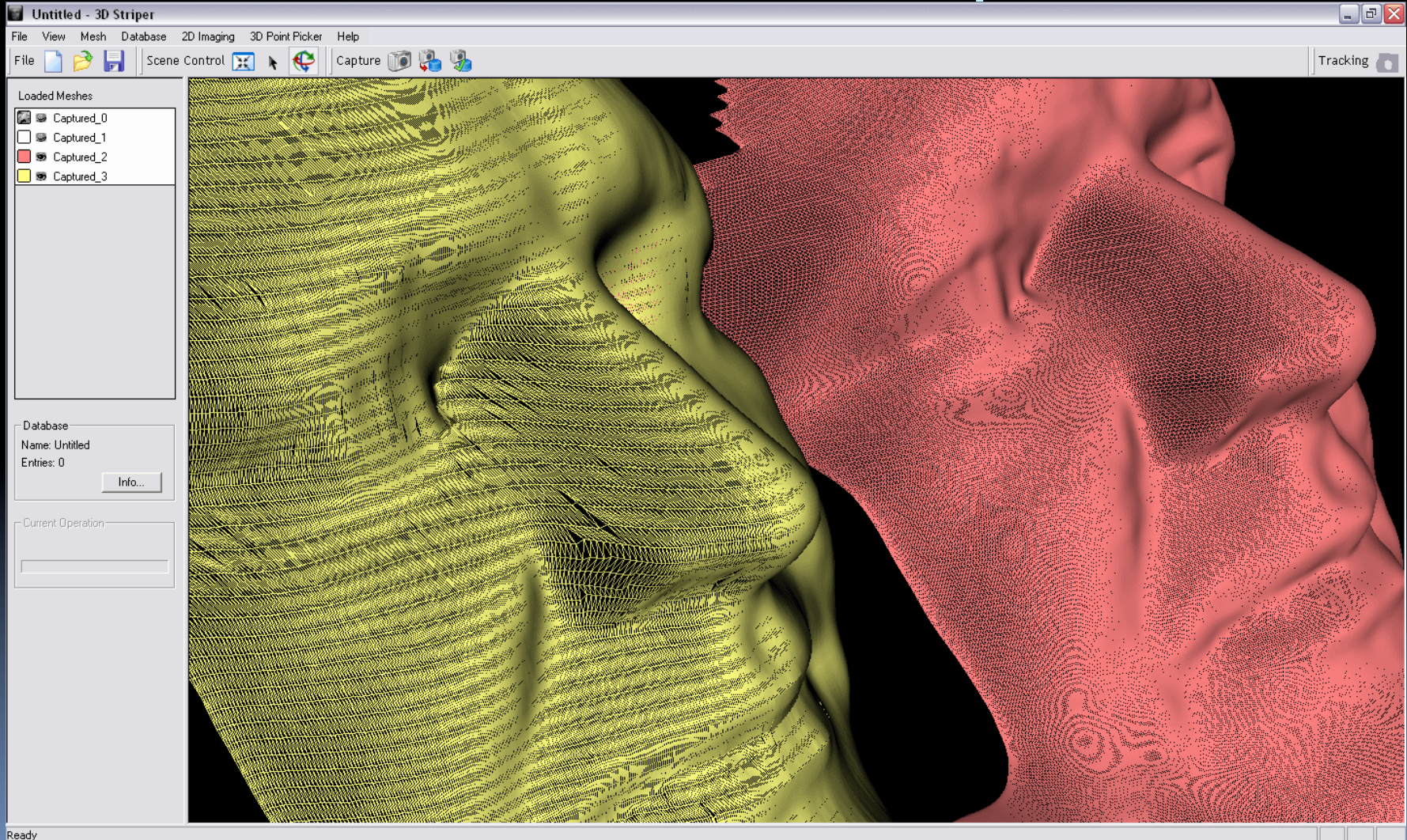


(a) black stripes located between white ones

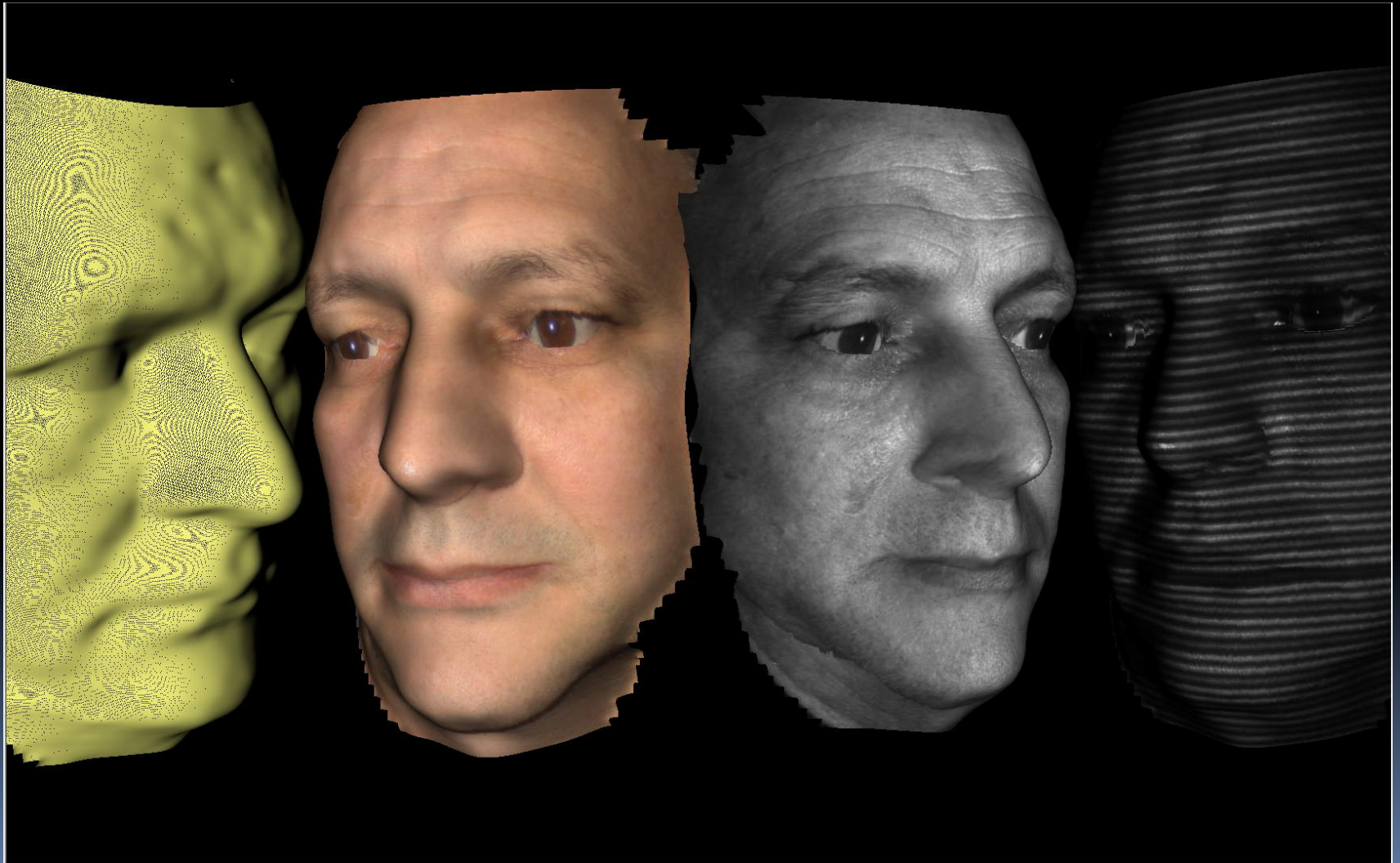


(b) result on the reconstructed surface

The Effects of Computing White and Black Stripes



Texture Mapping




Performance



- 3D reconstruction in 40ms
- Only a single 2D image is required per model
- Can operate at video frame rates
- Also suitable for 3D animation from video frames
- It requires post-processing (hole filling, smoothing, noise removal)
- Sound can be integrated from video footage



Future work

- Hardware issues
 - Embedding the design into DSPs
 - Methods for 3D image compression
 - Built-in exporters
 - 3D data -> COLLADA -> o3dtgz
 - 3D data -> COLLADA
- 

Related work: Feature extraction & recognition

