

Textured 3D models derived automatically from photographs

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Outline

- Goal of this presentation
 - Provide an overview of the state of the technology
 - Indicate some of the remaining challenges
- Motivation
 - Mine site capture
 - Cultural heritage
 - Asset generation for virtual environments
 - Richer data capture in Archaeology
 - Non-intrusive 3D capture (Medical)
 - Heritage preservation
- Workflow example
- Limitations
 - Movement
 - Shadows
 - Mirror surfaces
- Challenges and future work
 - Real vs apparent detail
 - Database integration and online delivery
 - Geometric form based queries



Introduction

- Goal: Automatically construct high quality 3D geometry and texture based solely upon a number of photographs.
- Photogrammetry is the general term for deriving geometric knowledge from a series of images.
- Big step forward was the development of SfM algorithms: structure from motion.
- Wish to avoid any in-scene markers required by some solutions. Often impractical (access) or not allowed (heritage).
- Need to target fast and automated approaches as much as possible.



Gommateswara, Manipal India

Motivation: Mine site capture



Coolgardie mine site
HasnainAli Bangash
Centre for Exploration Targetting, UWA

Motivation: Artefacts in cultural heritage



Indigineous headdress

Motivation: Assets for virtual environments

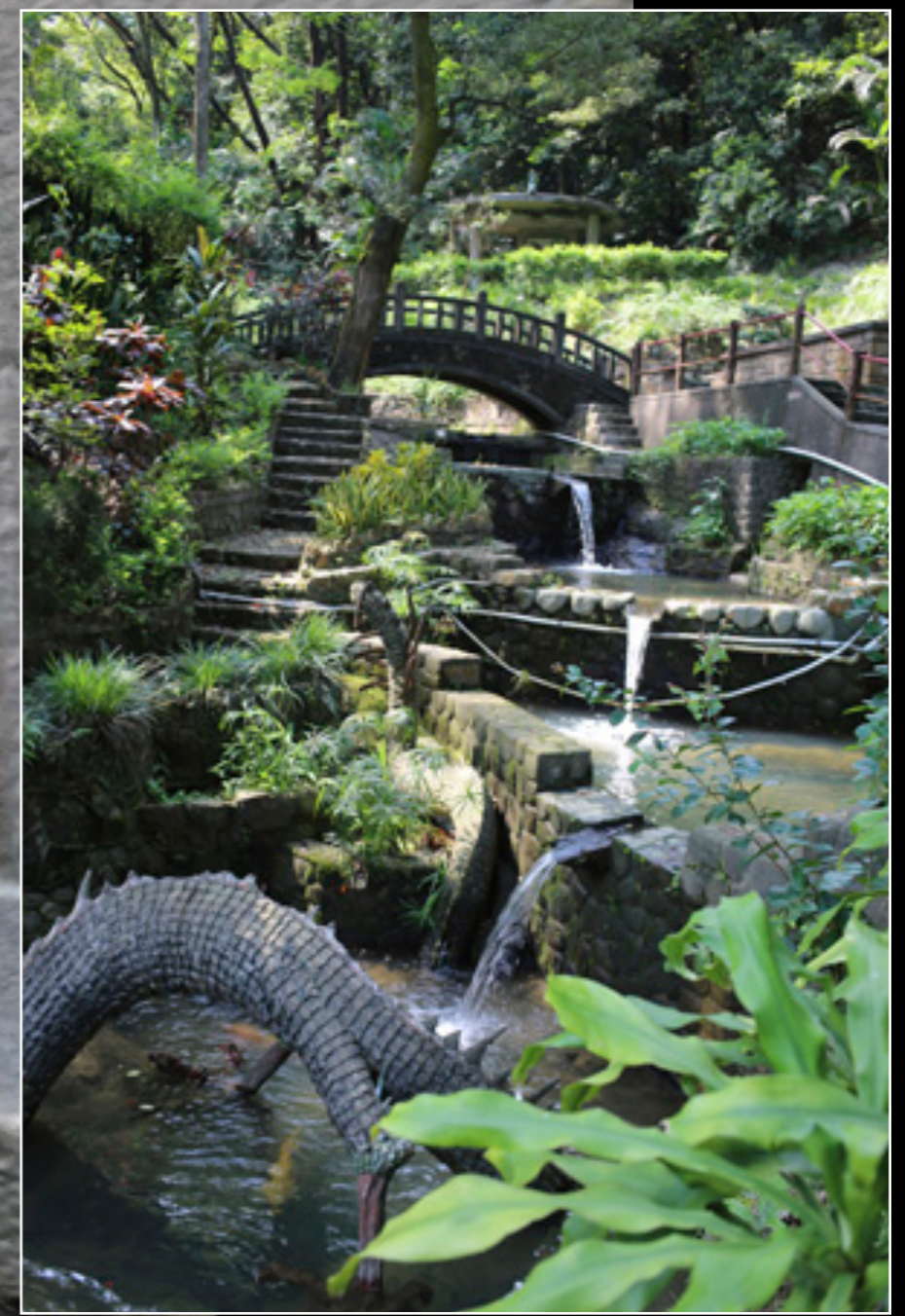


Motivation: Richer capture in Archaeology

Panel (512858mE 7714203mN)	
Aspect:	North
Technique:	Pecked
Style:	In filled
Form:	Enigmatic
Clarity:	High
Weathering:	Low
Boulder Size (mm):	590 x 380 x 330
Motif Size (mm):	120 x 110
Location of Panels:	Small rock outcrop (rock pile)
Lithology:	Basalt
Disturbance (%):	10
Erosion:	Low
Rock and Motif Color:	Brown/Light

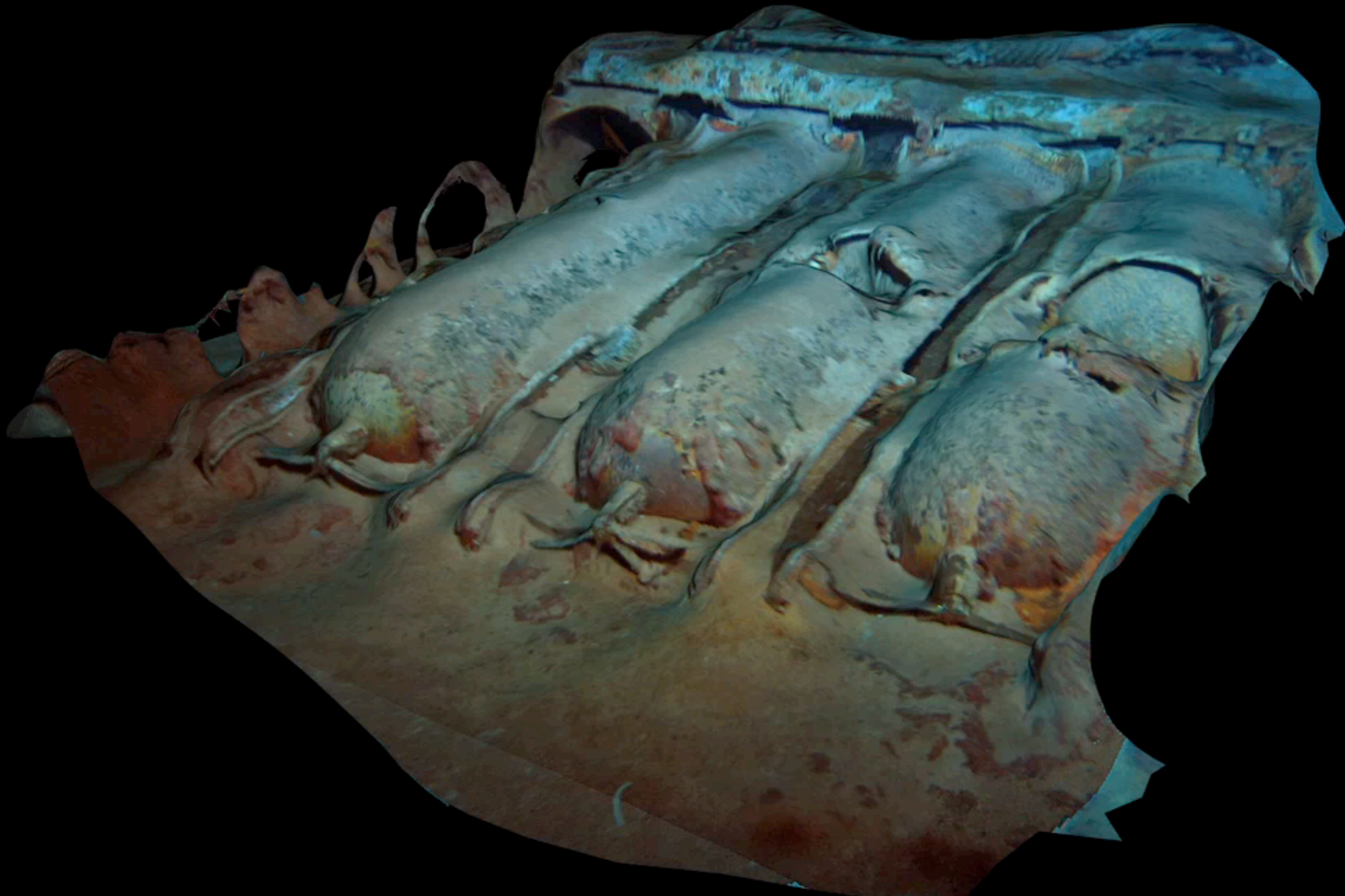


Motivation: Heritage preservation



Dragon Gardens, Hong Kong

Motivation: Marine Archaeology



Workflow: Photography

- Fixed focal lens (Prime lens).
- Most point and click cameras have fixed focal lenses, mobile phones, etc.
- Range of prime lenses for SLR cameras.



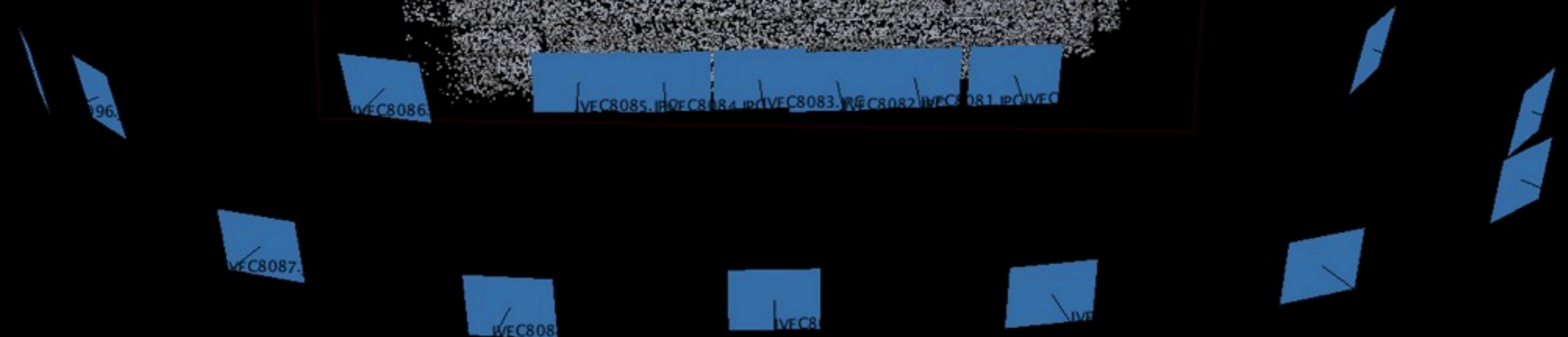
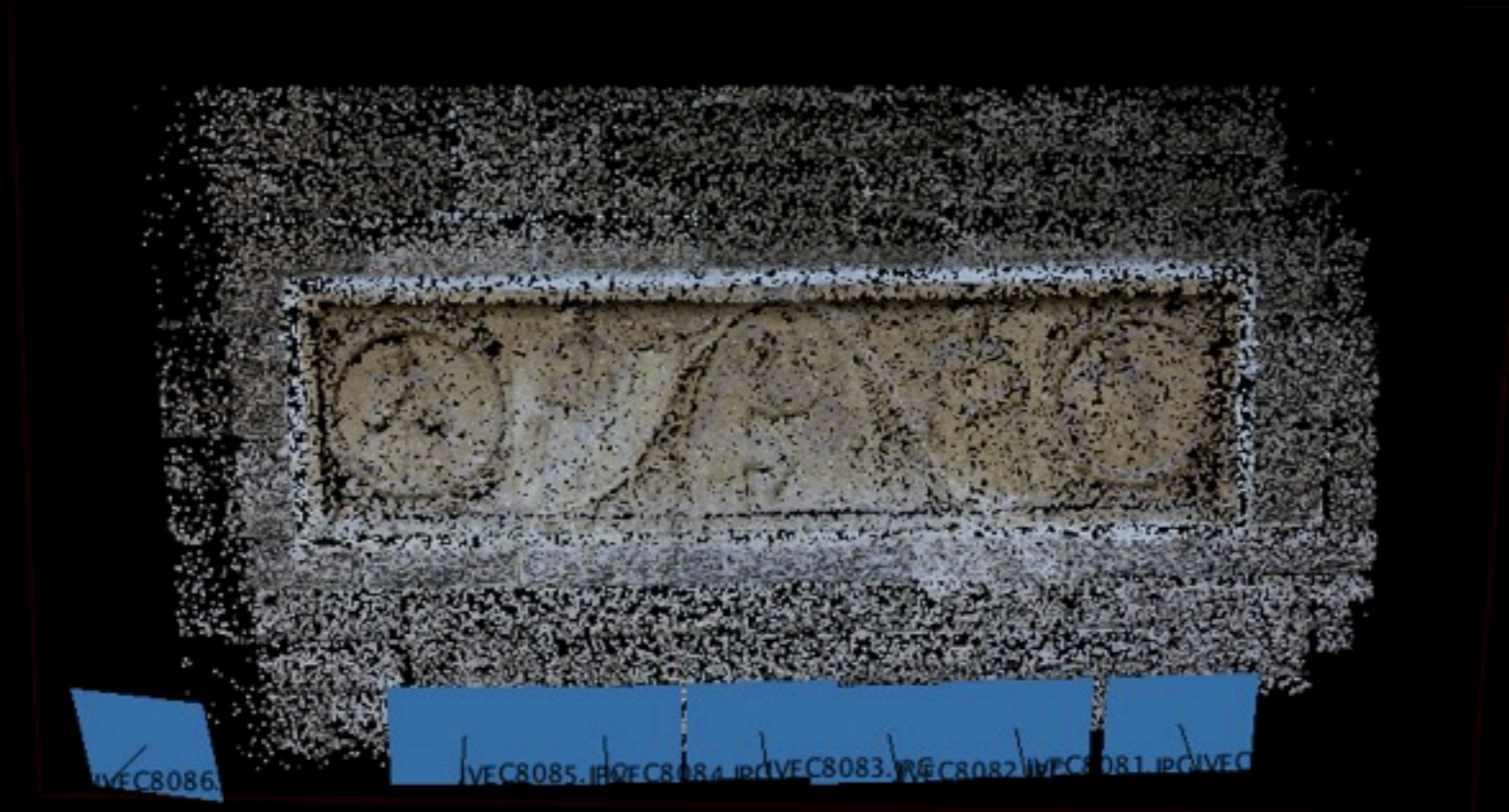
Workflow: Photographs

- Don't take two photos from the same position.
- Obviously can't reconstruct what is not photographed.
- In general, more is better.



Workflow: Sparse point cloud

- Find matching points between photographs, feature point detection.
SIFT - scale invariant feature transform
- Compute camera positions and other intrinsic camera parameters.
Bundler, SfM - Structure from Motion

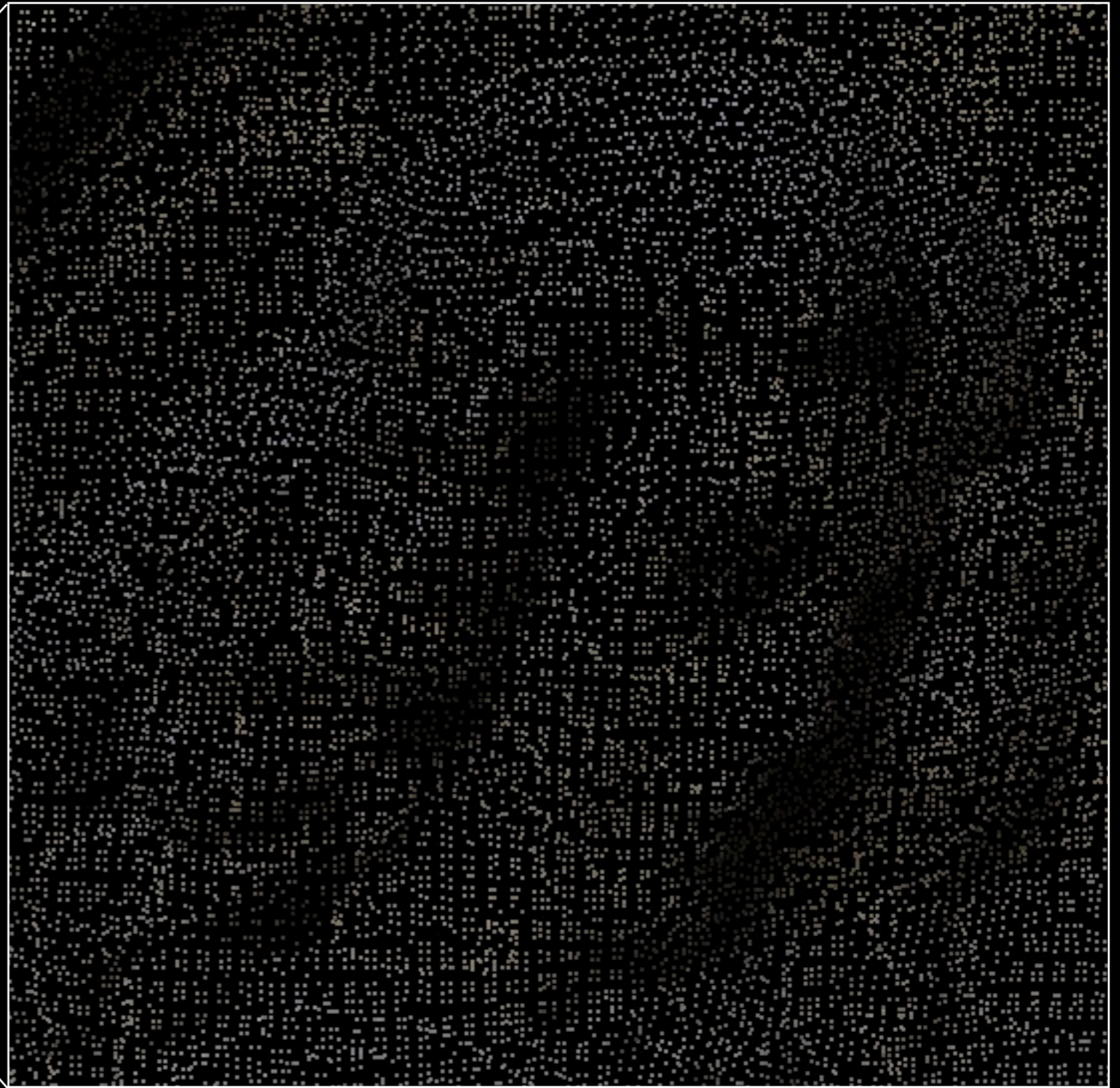


Workflow: Compute dense cloud

- CMVS - Clustering Views for Multi-view Stereo.



Workflow: Compute dense cloud



Workflow: Create mesh

- Various algorithms: Ball pivoting, Poisson Surface Reconstruction, Marching Cubes.
- Optionally simplify mesh (eg: quadratic edge collapse decimation) and fill holes.



Workflow: create textures

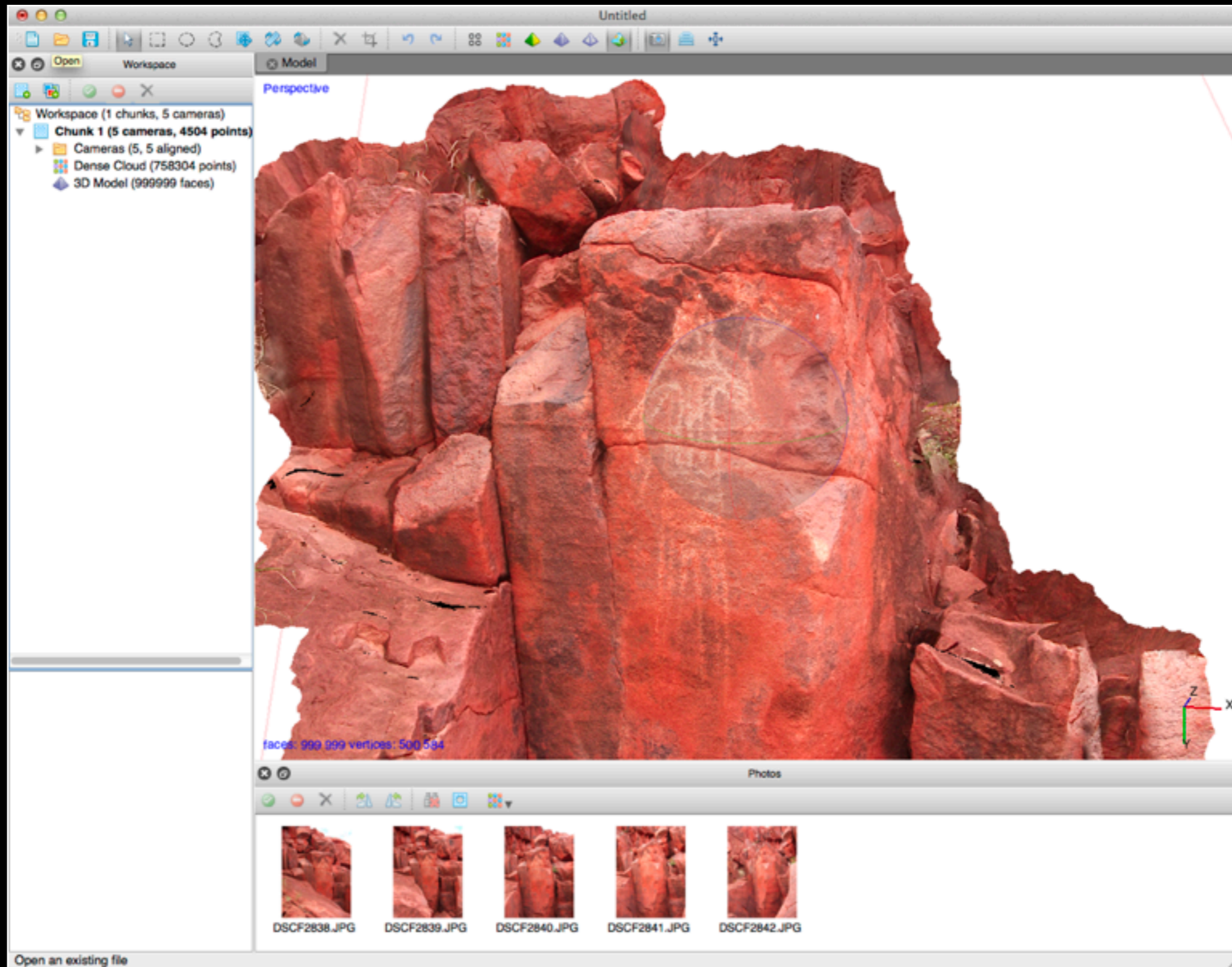
- Re-project photographs from derived camera positions onto mesh.



Workflow: Export to favourite 3D environment



Worked example



Limitations: Movement

- Movement in the scene generally destroys fidelity. For example grass blowing in the wind.
- One solution is to create a camera array.



Limitations: Shadows

- Shadows are baked into the textures.
- Possible solutions include HDR textures or clever editing.



HMAS Sydnew memorial, Geraldton

Limitations: Mirror surfaces

- Mirror surfaces obviously provide a reflection of the world that influence the feature point detection.
- Gives rise to a new artform - Photogrammetry that goes wrong in “interesting” ways.

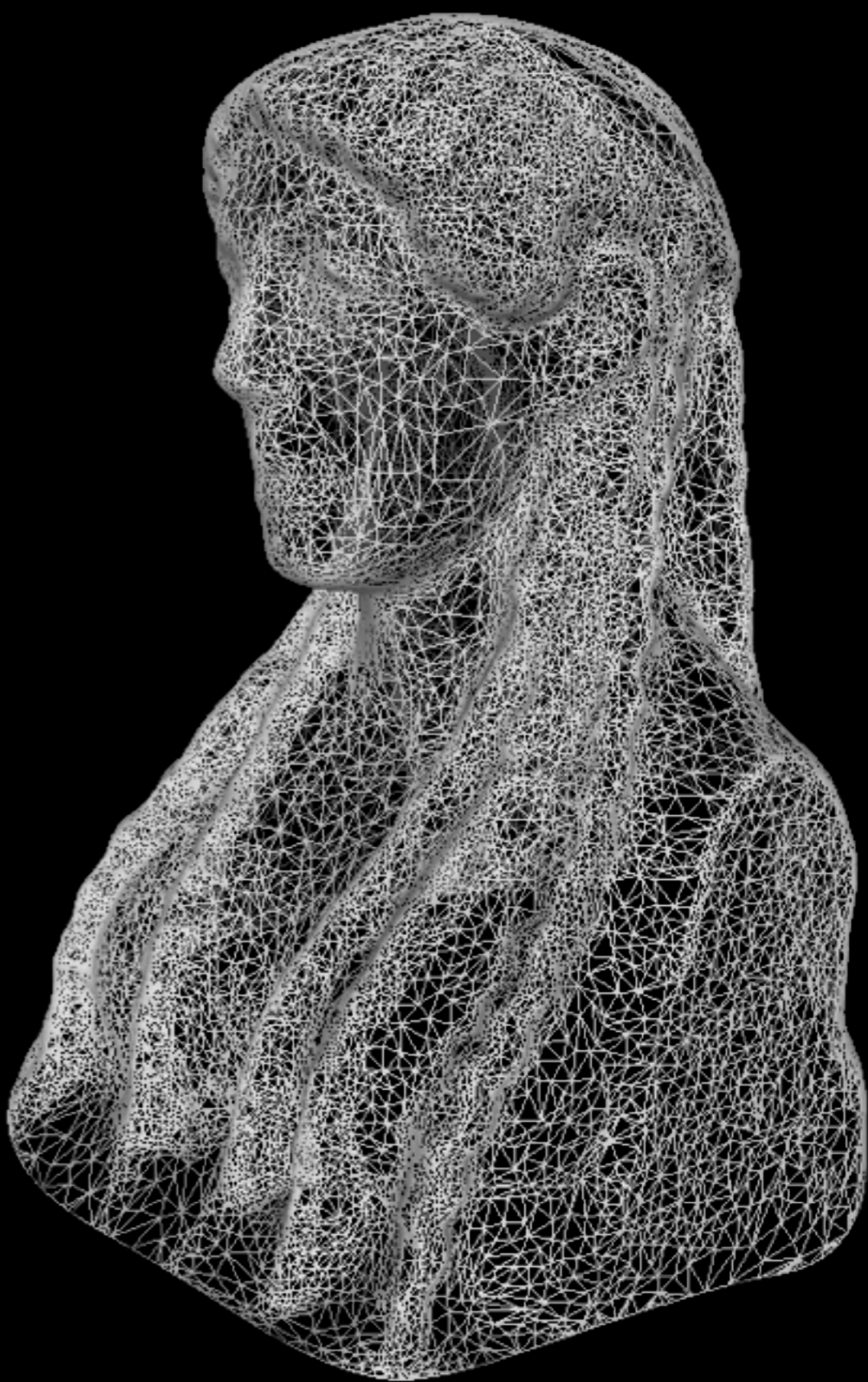


Challenges: Real vs apparent detail

- Geometric detail vs texture detail.
- For realtime environments require low geometric complexity and high texture detail.
- Analysis generally requires high geometric detail.
- As a recording of an object one wants both high resolution geometry and high texture detail.

	Geometric resolution	Texture resolution
Gaming	Low	High
Analysis	High	Don't care
Education	Medium	High
Archive/heritage	High	High
Online	Low/Average	Low/average

Challenges: Real vs apparent detail



Aphrodite, UWA

Challenges: Real vs apparent detail



Challenges: Real vs apparent detail

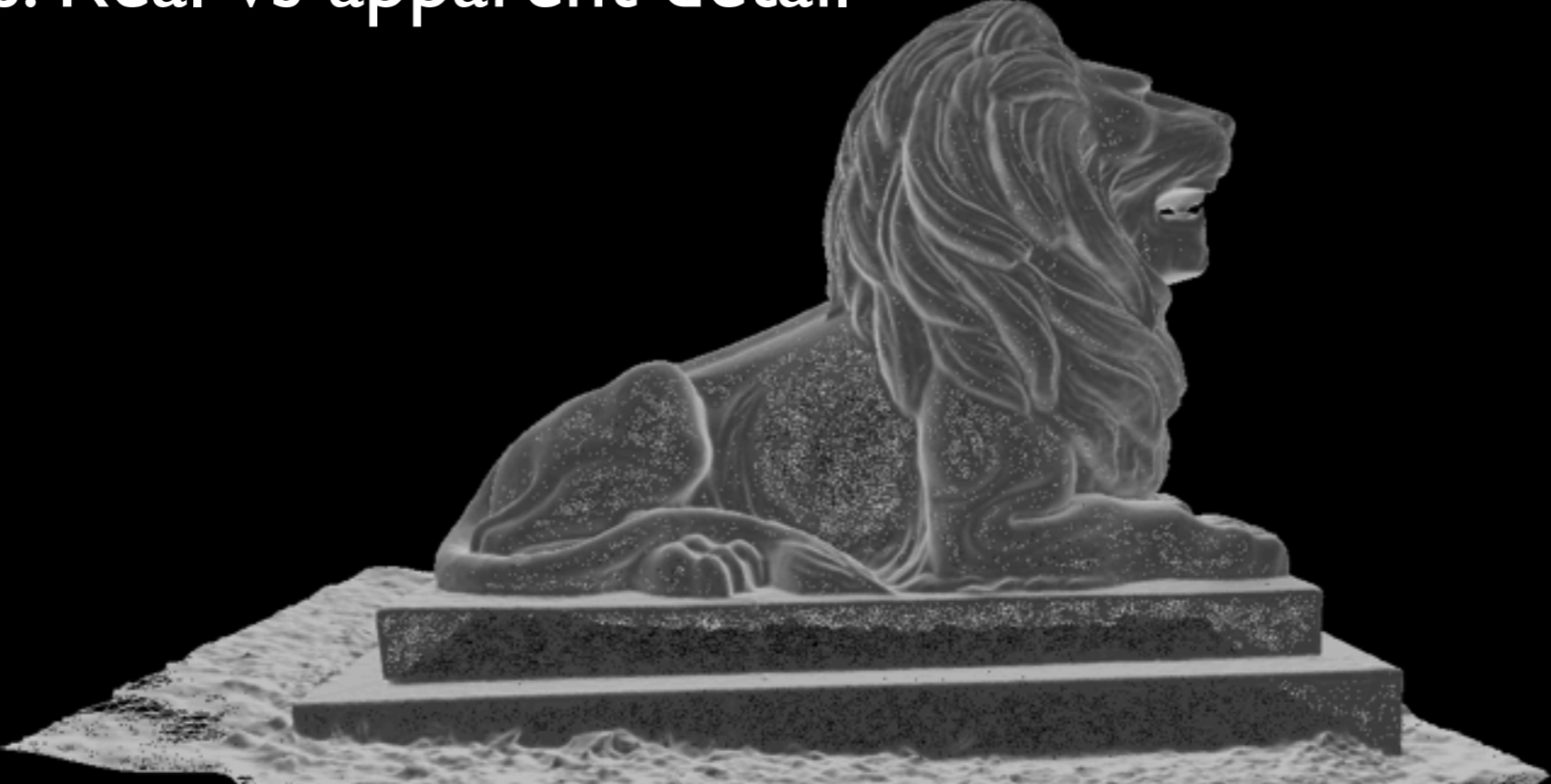


1,000,000 triangles

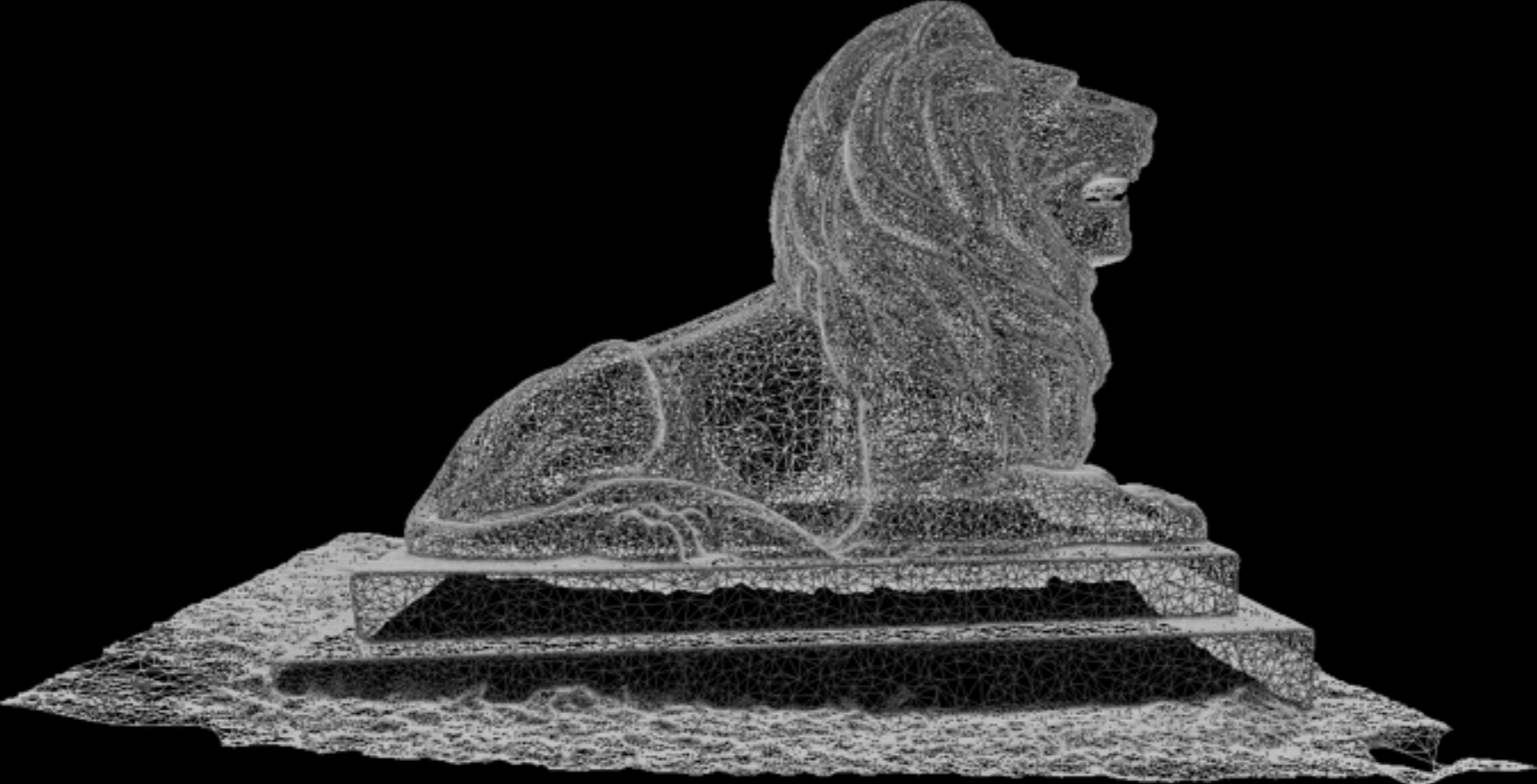


100,00 triangles

Challenges: Real vs apparent detail



1,000,000 triangles



100,00 triangles

Challenges: Database integration and delivery

- Claim that the need to store these higher level forms of data capture will increase.
- Will this replace the need for storing photographic data?
- Surprisingly (depressingly) even after all these years of online delivery there are still no satisfactory ways of distributing 3D data.
- Options
 - VRML, x3d : very poor cross platform support.
 - 3D PDF : dropped by Adobe some years back.
 - WebGL? HTML5 / Canvas?
- Key missing components:
 - progressive texture.
 - progressive geometry.



Gommateswara, Manipal, India

Challenges: Geometric form based queries

- Can we interrogate data besides what is baked in via meta data.
- Form based queries,
 - “Find rock art of emu forms, facing north, on vertical smooth rock face, less than 1m high”.
 - “Find forms looking like this [sketch]”.



Final example: Indigenous rock shelters

- Most challenging are interiors.
- In these examples 200+ photographs.





Questions?

The new digital tourist?

