

# 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



Movie

# 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



Movie

Coolgardie mine site  
HasnainAli Bangash  
Centre for Exploration Targetting, UWA

# Motivation: Artefacts in cultural heritage



Movie

Indigineous headdress

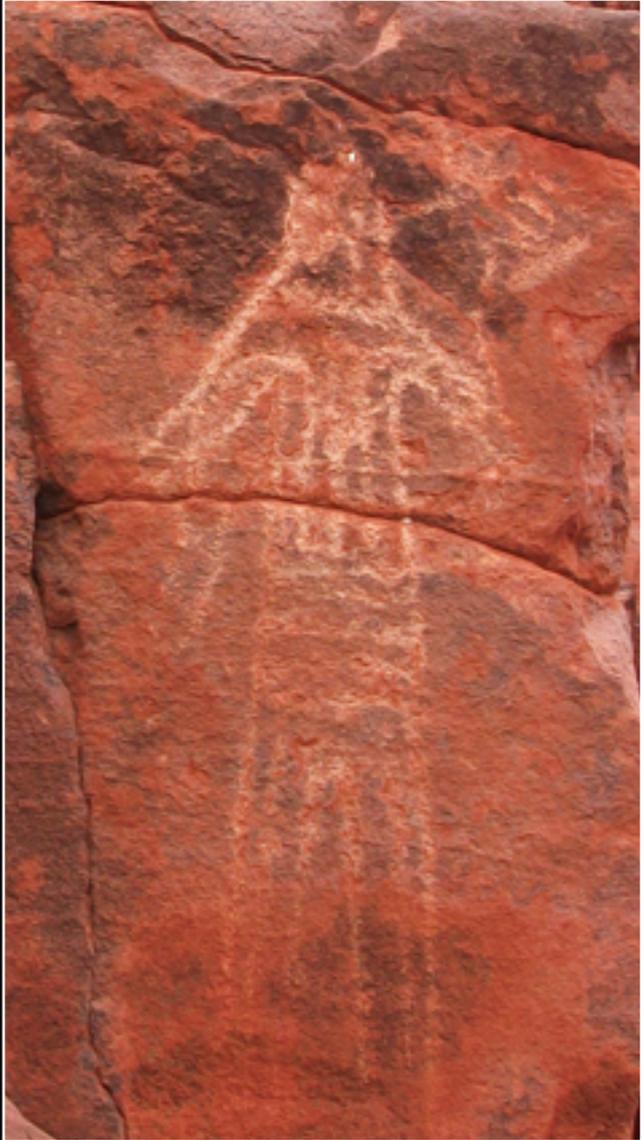
# Motivation: Assets for virtual environments



Movie

# Motivation: Richer capture in Archaeology

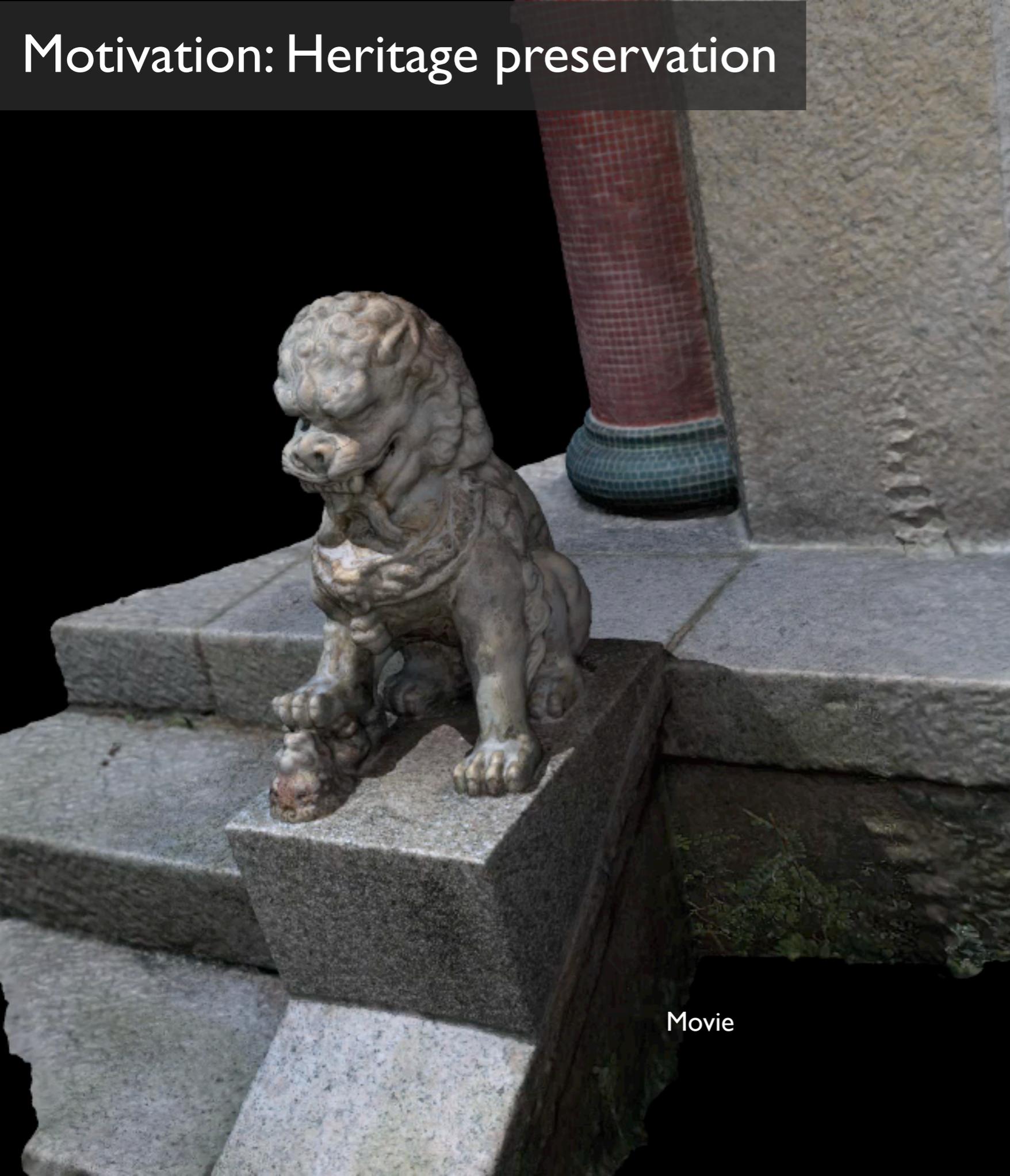
Panel   (512858mE 7714203mN)	
Aspect:	North
Technique:	Pecked
Style:	In filled
Form:	Enigmatic
Clarity:	High
Weathering:	Low
Boulder Size (mm):	590 x 380 x 330
Motif Size (mm):	120 x 110
Location of Panels:	Small rock outcrop (rock pile)
Lithology:	Basalt
Disturbance (%):	10
Erosion:	Low
Rock and Motif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



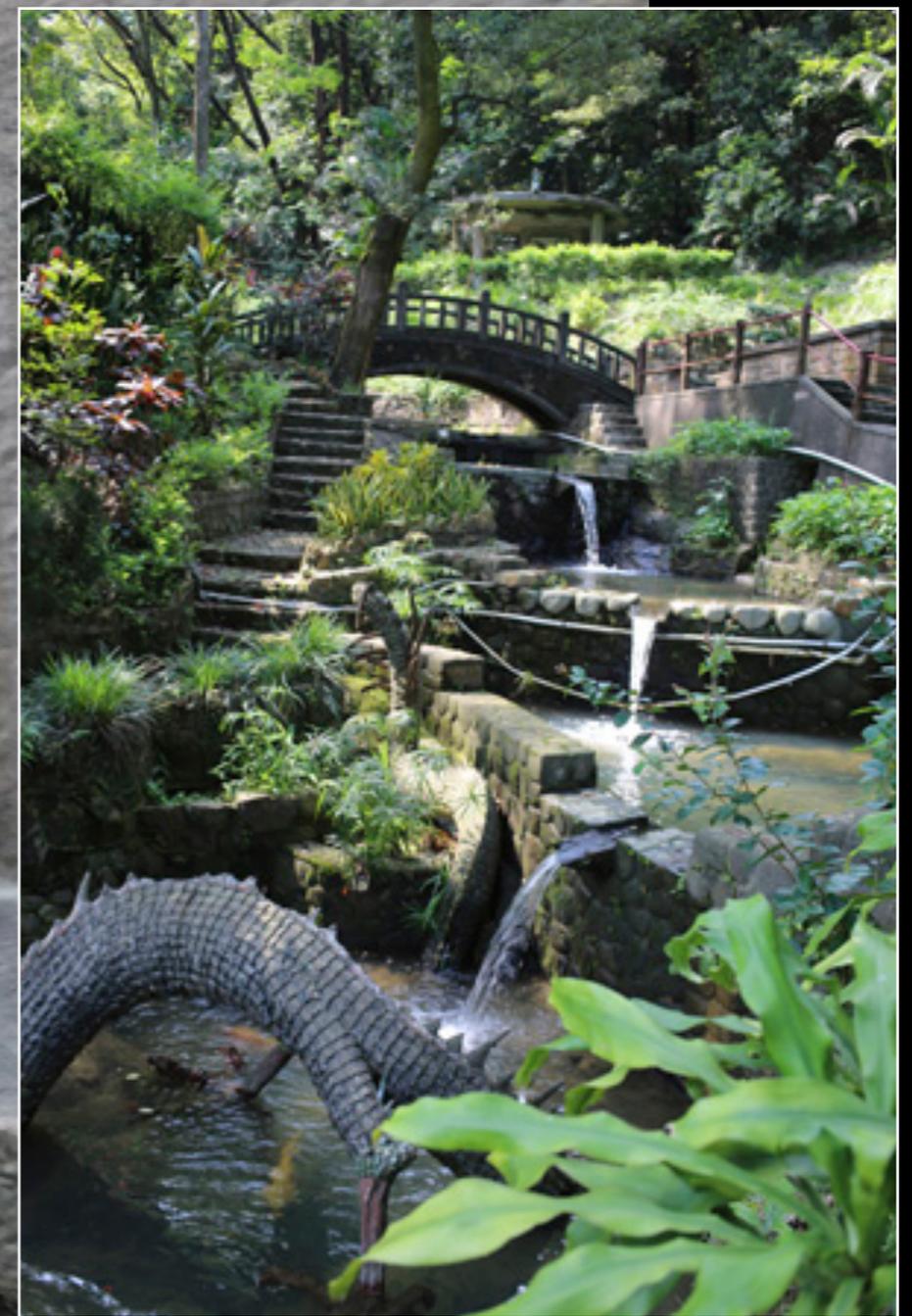
Movie



# Motivation: Heritage preservation

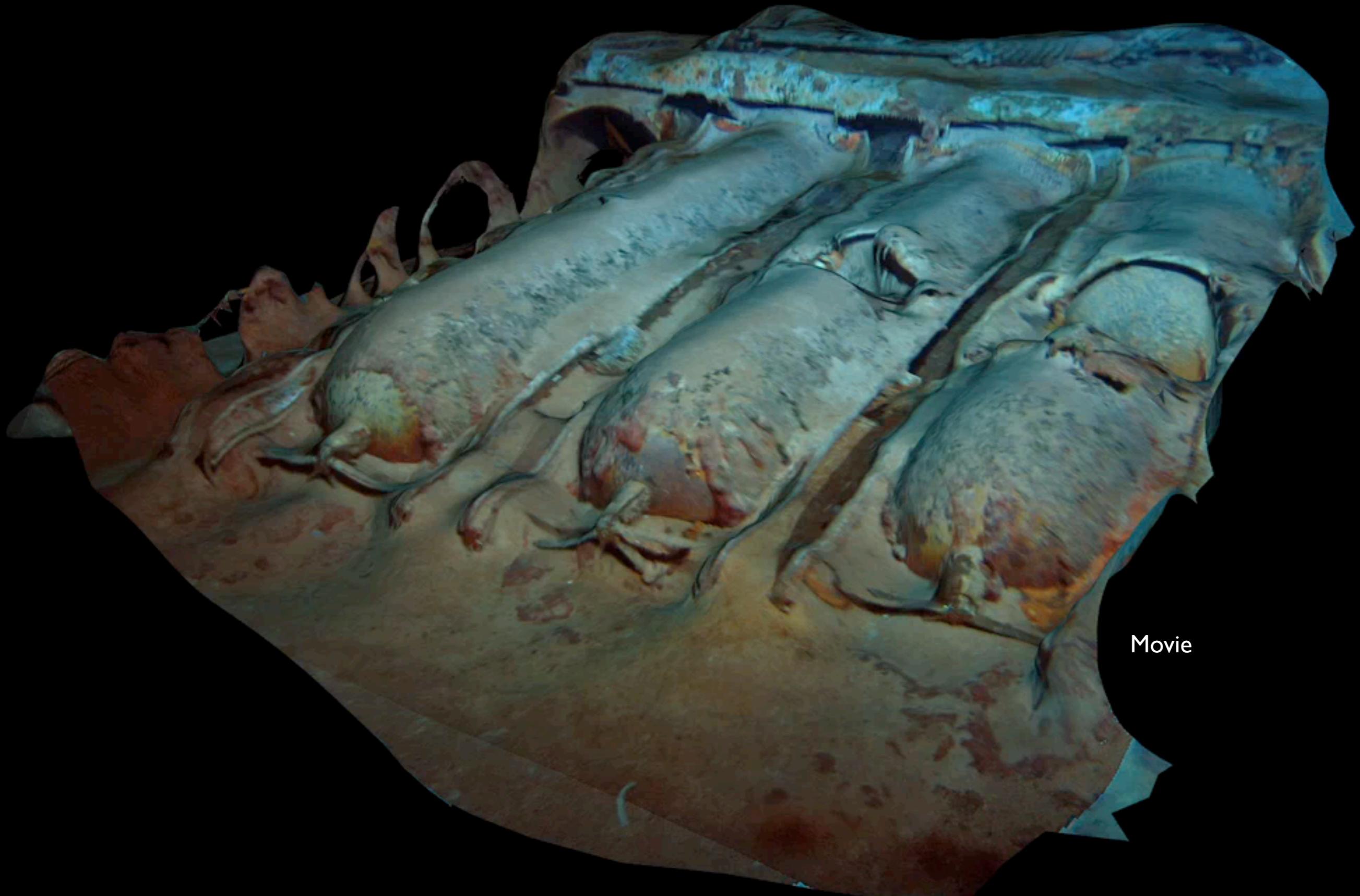


Movie



Dragon Gardens, Hong Kong

# Motivation: Marine Archaeology



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# 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.



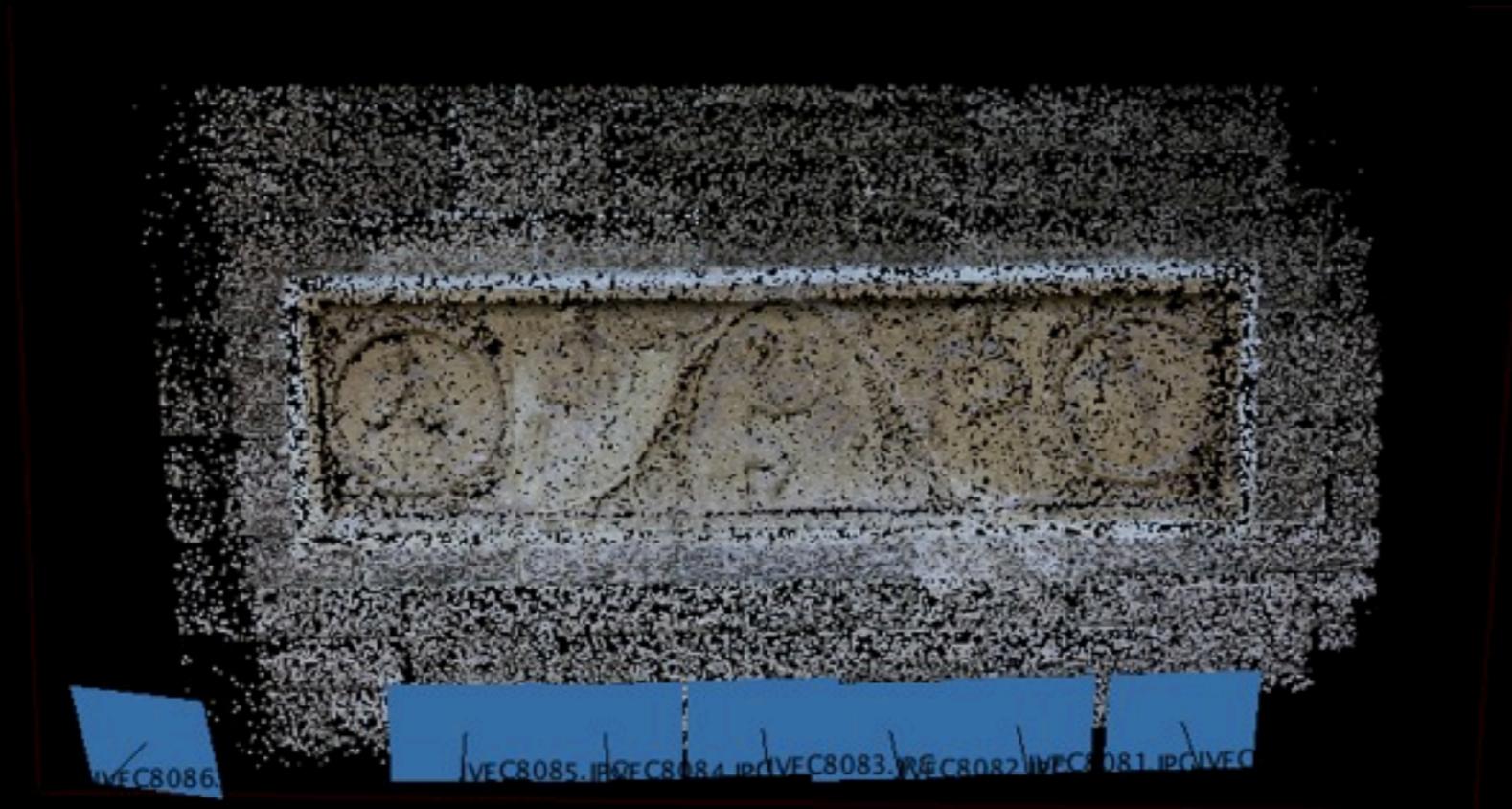
# Workflow: Photographs

- 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



VEC8087

VEC808

VEC8

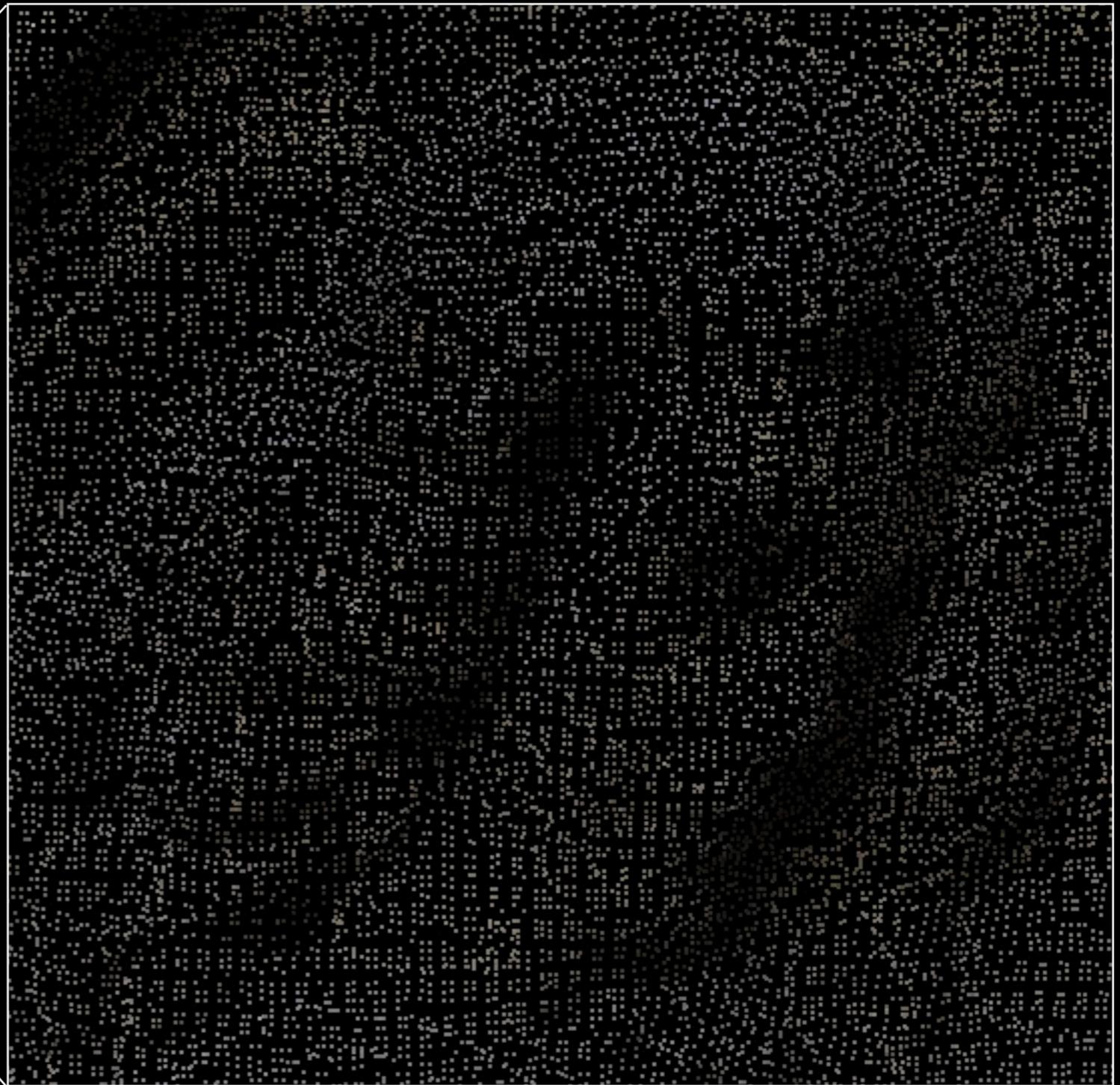
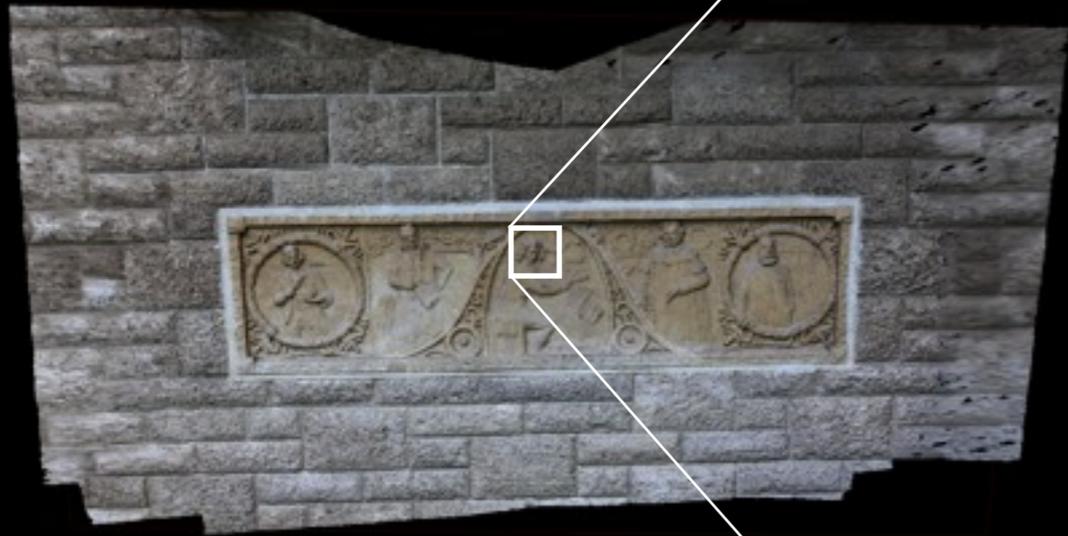
VE

# 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



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# 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 Sydney 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

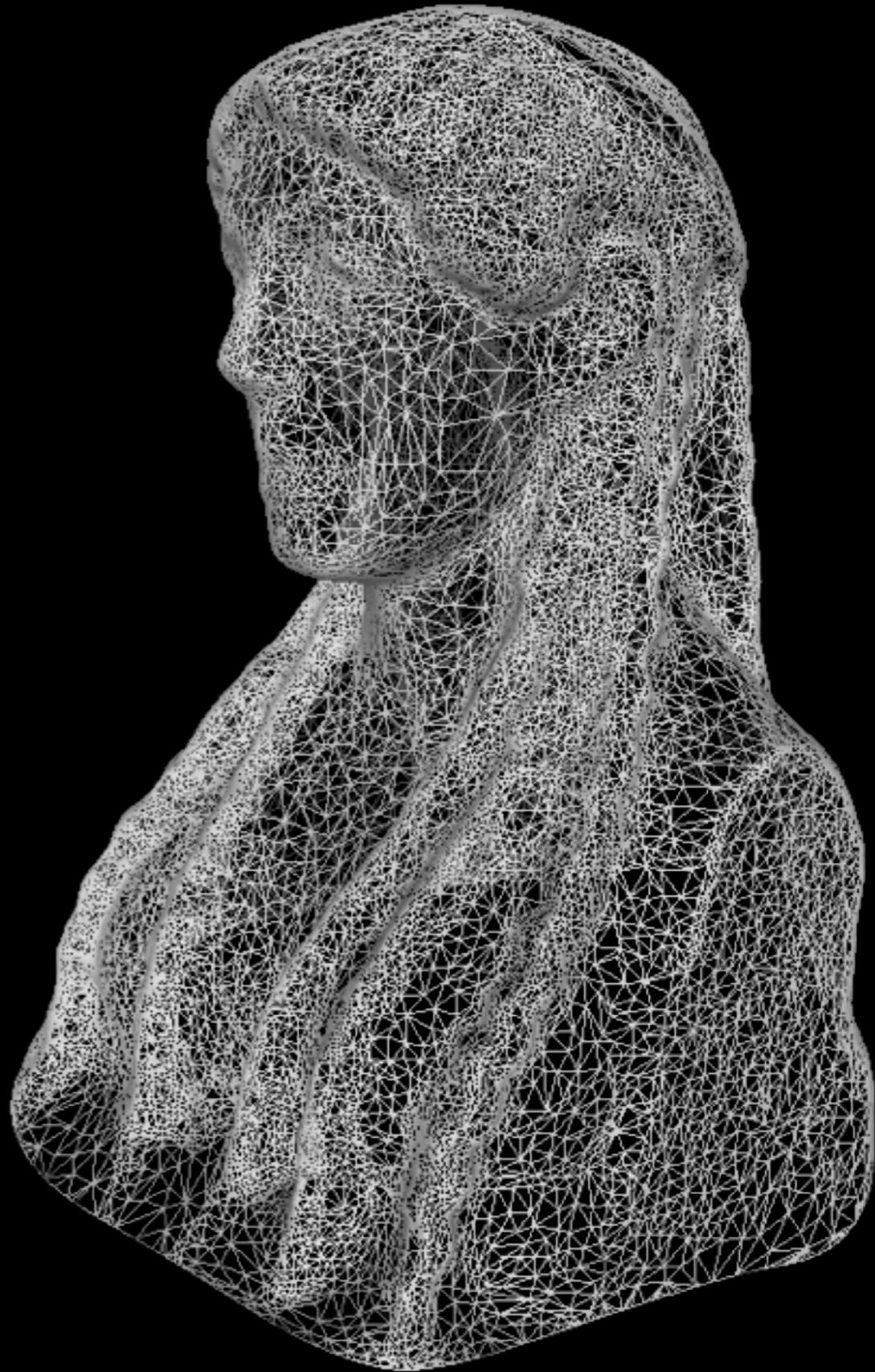
- Geometric detail vs texture detail.
- For realtime environments require low geometric complexity and high texture detail.
- Analysis generally requires high geometric detail.
- As a recording of an object one wants both high resolution geometry and high texture detail.

	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



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Aphrodite, UWA

# 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.

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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]”.



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# Questions?

The new digital tourist?

