# Textured 3D models derived automatically from photographs

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iVEC @UWA

# 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

Beacon Island
WA Museum

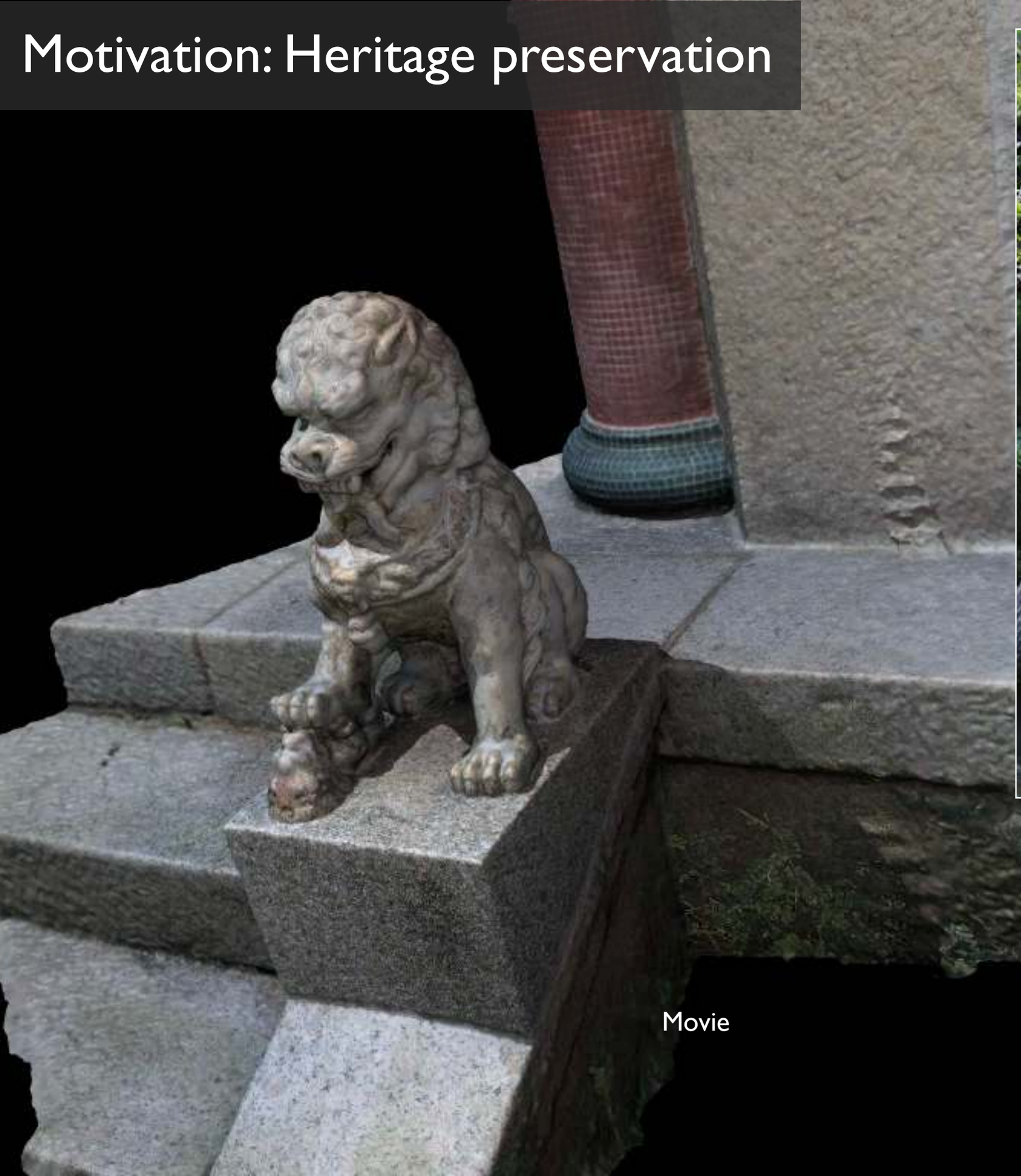
# Motivation: Richer capture in Archaeology

| 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

Wanmanna: Centre for Rock Art Research, UWA

# Motivation: Heritage preservation



Movie

Dragon Gardens, Hong Kong

# Motivation: Marine Archaeology

Movie

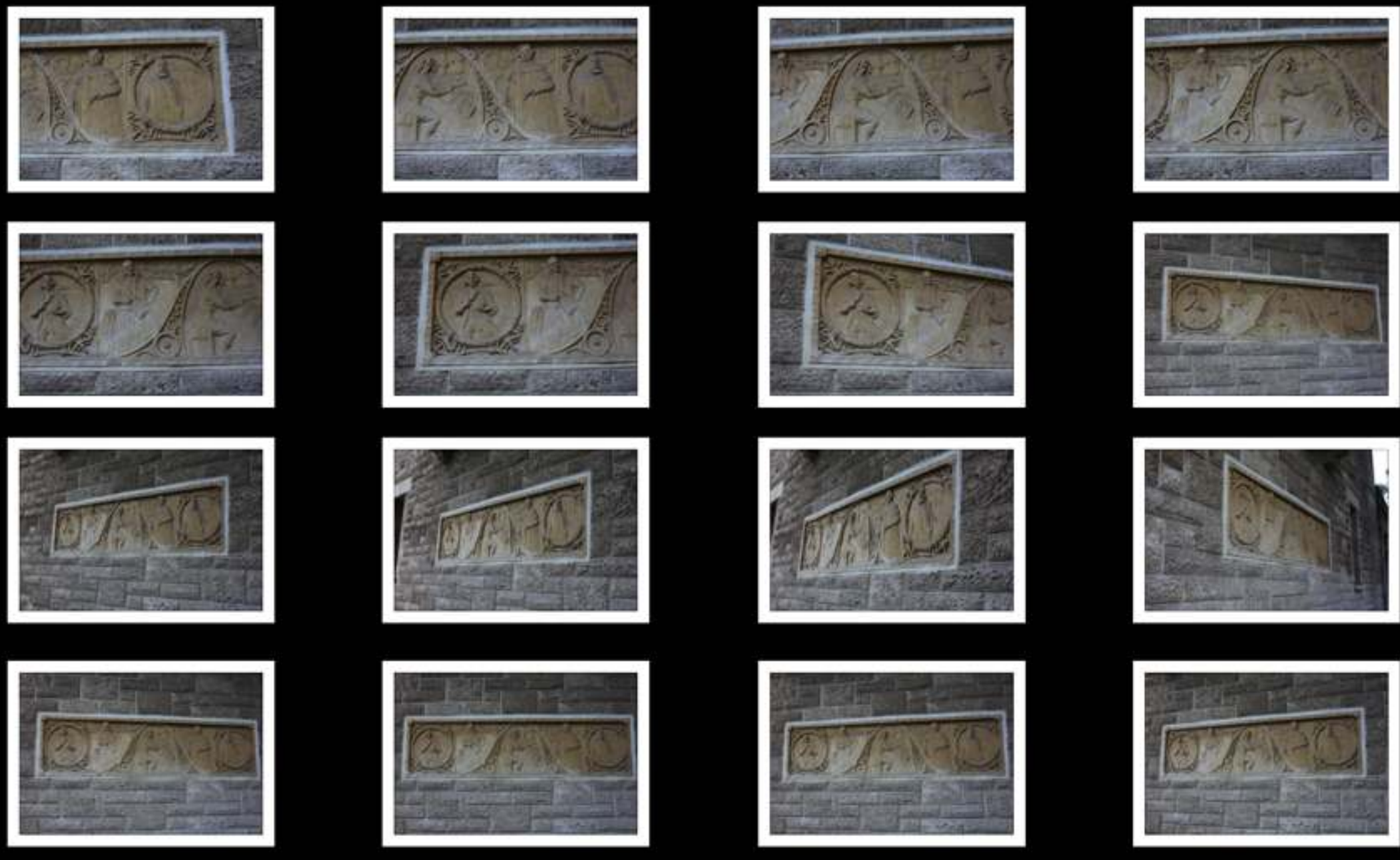
HMAS Sydney

# 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

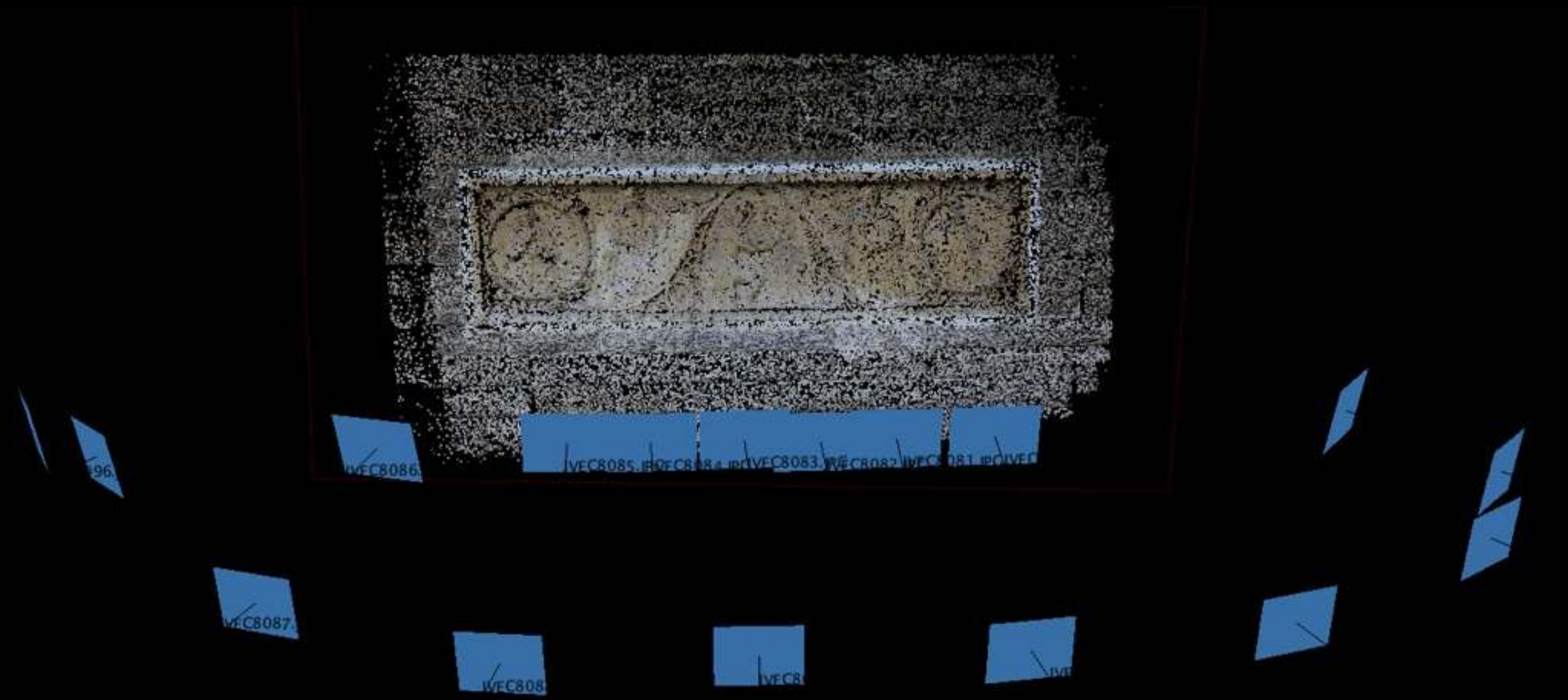
- Don’t take two photos from the same position.
- Obviously can’t reconstruct what is not photographed.
- In general, more is better.



# Workflow: Sparce point cloud

- Find matching points between photographs, feature point detection.
  SIFT - scale invariant feature transform

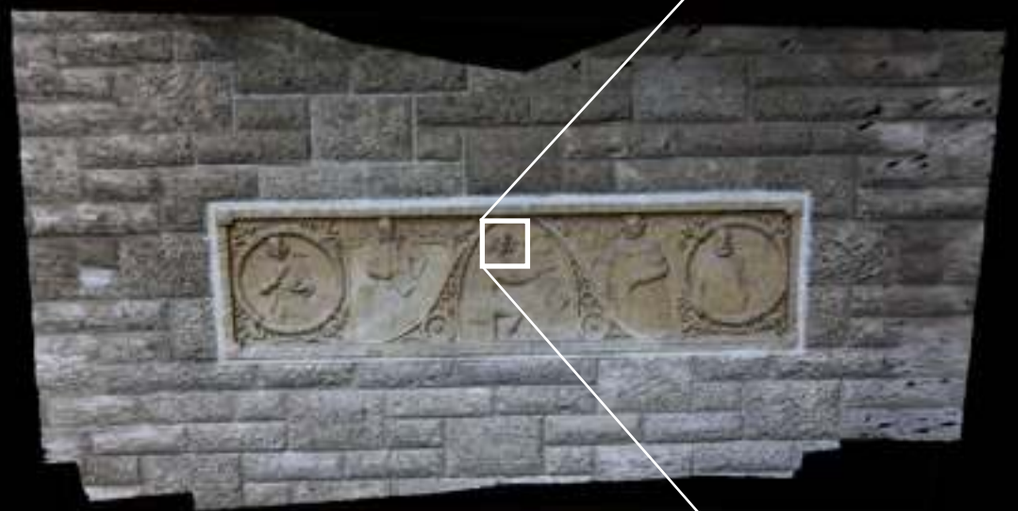
- Compute camera positions and other intrinsic camera parameters.
  Bundler, SfM - Structure from Motion

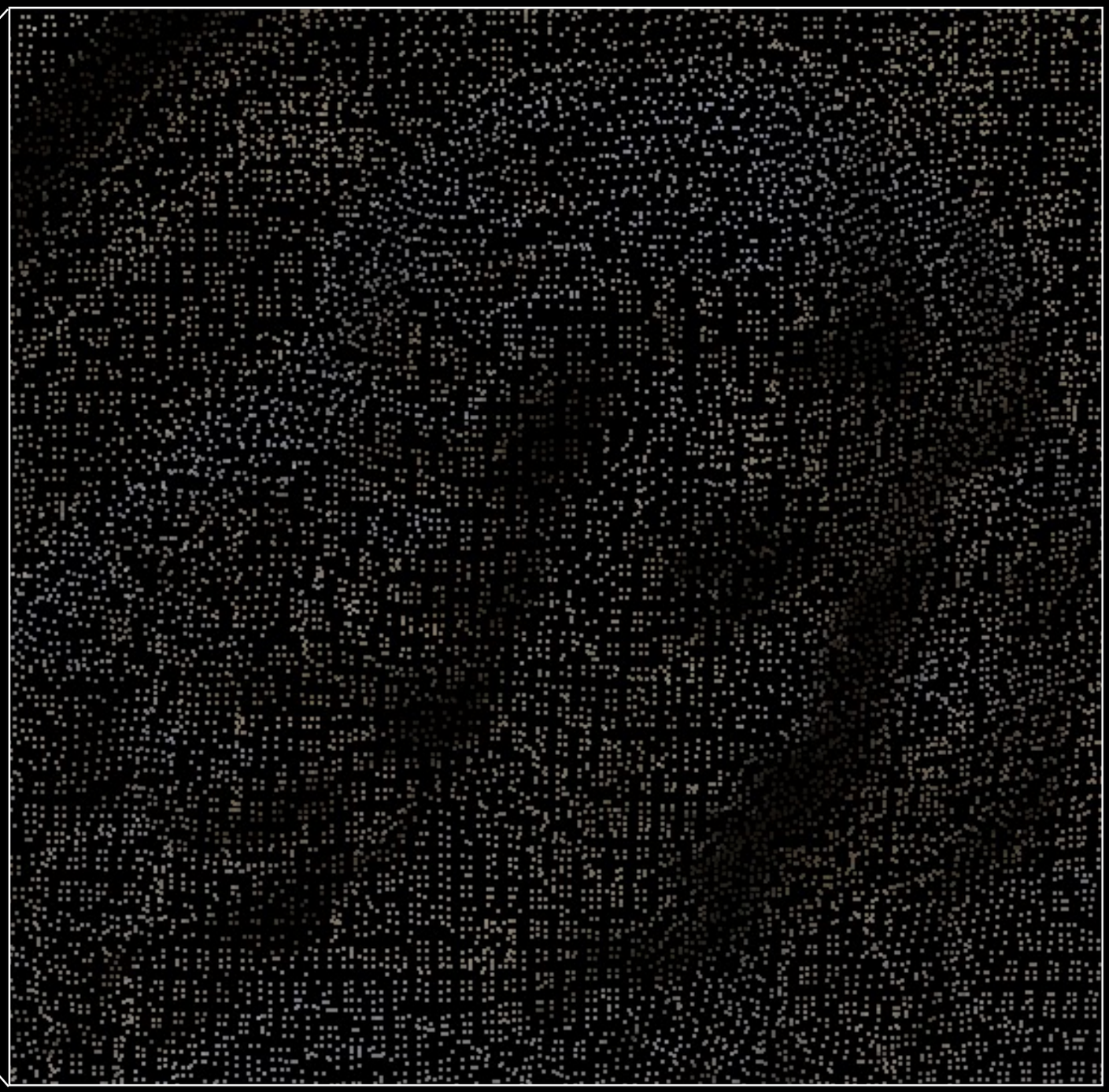


# Workflow: Compute dense cloud

- CMVS - Clustering Views for Multi-view Stereo.

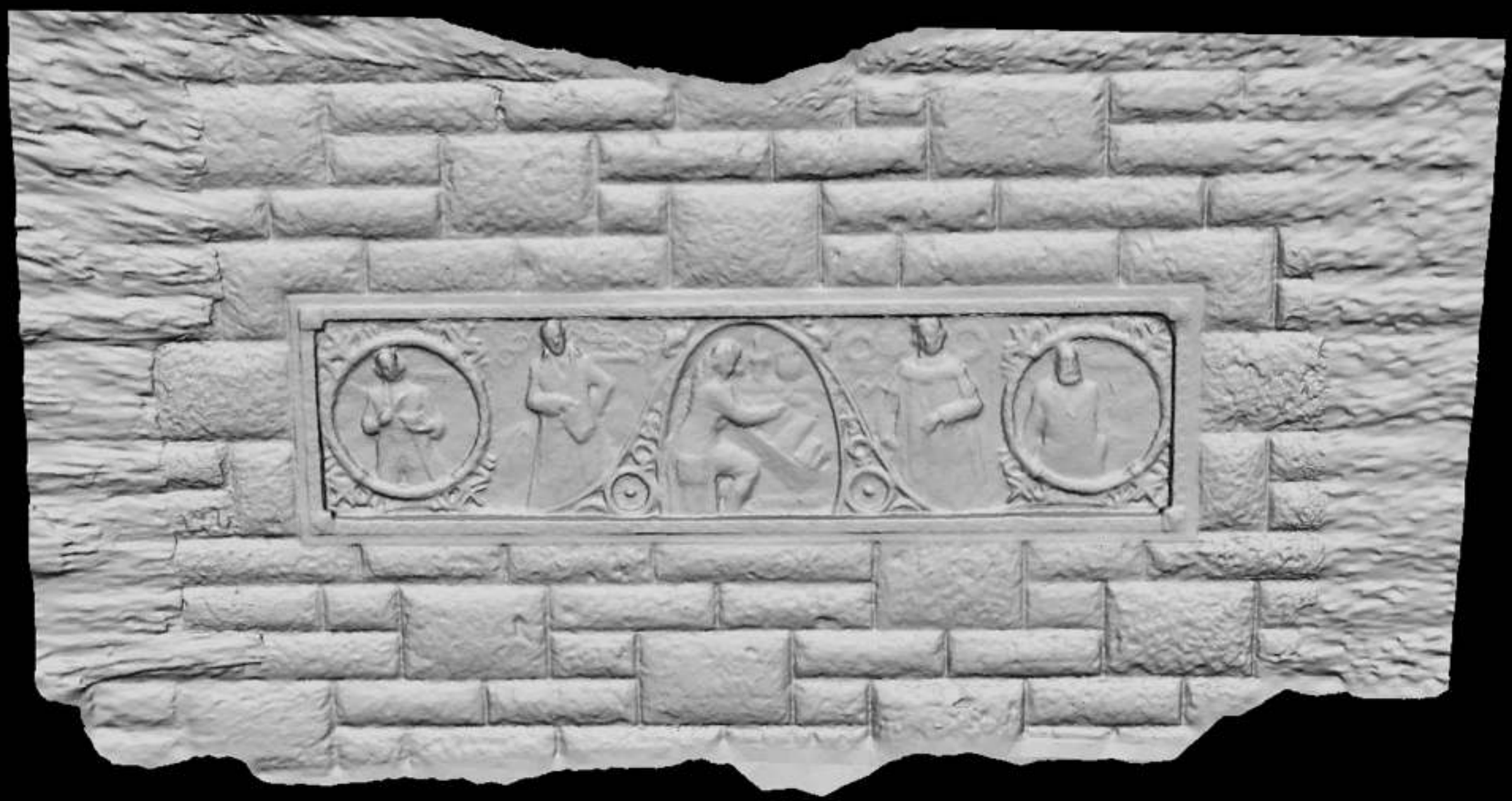
# Workflow: Compute dense cloud





# 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

Movie

UWA Geography Building

# Limitations: Movement

- Movement in the scene generally destroys fidelity.
  For example grass blowing in the wind.

- One solution is to create a camera array.

Movie

Rio Tinto - Cape Dampier

# 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.

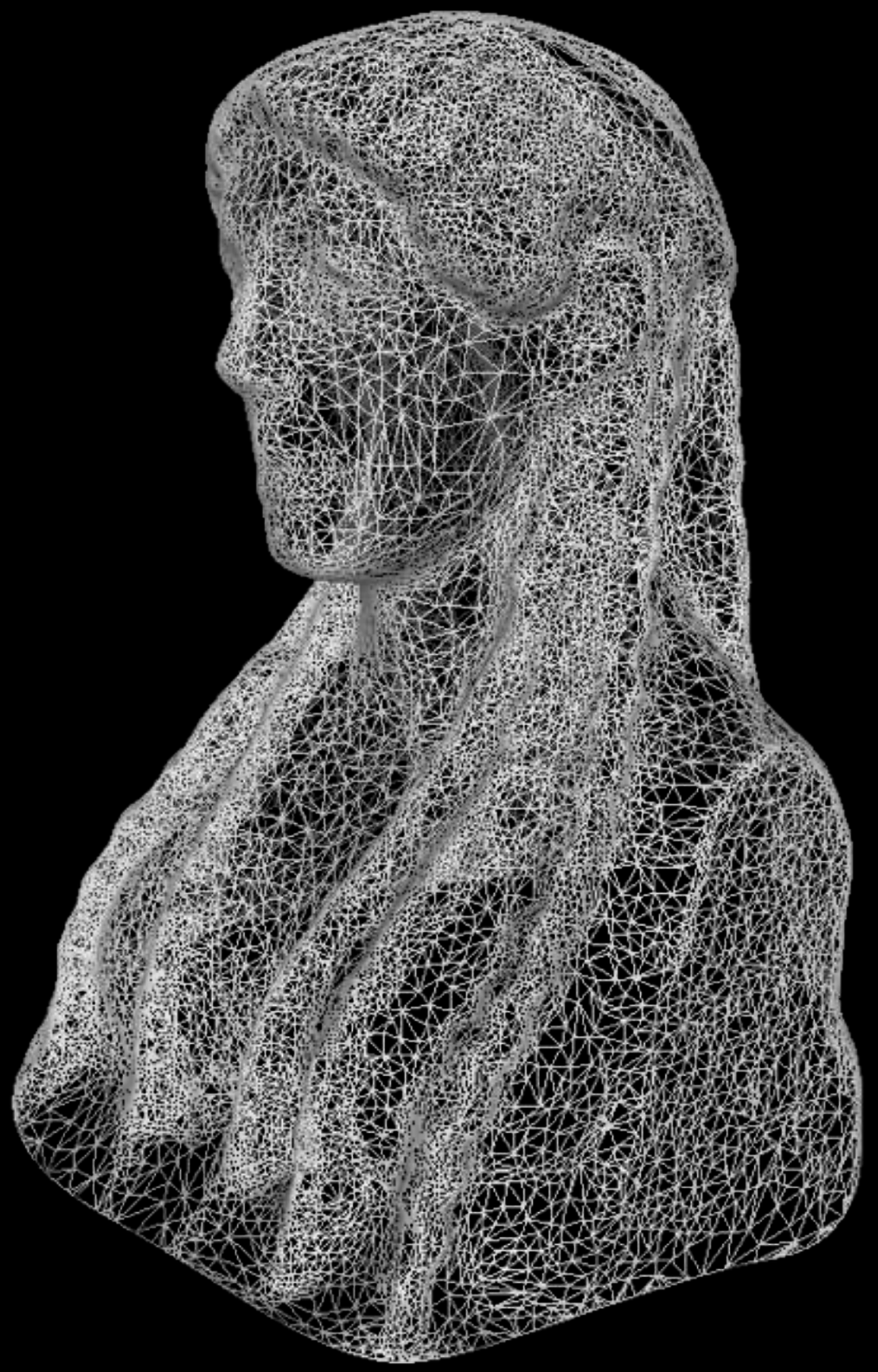
# Challenges: Real vs apparent detail

- 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

Movie



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.

Movie

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]".

Movie

Wanmanna, Western Australia

# Questions?

The new digital tourist?