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3D shape and real-time tracking

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Research team

http://www.eng.cam.ac.uk/~cipolla/people.html

Overview

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1. 3D shape and camera motion recovery:

   Making digital copies of 3D objects from photographs from multiple viewpoints.

2. Novels ways of interaction:

   Realtime detection of hands and faces and gestures.

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Part 1:
3D shape and camera motion recovery

The problem

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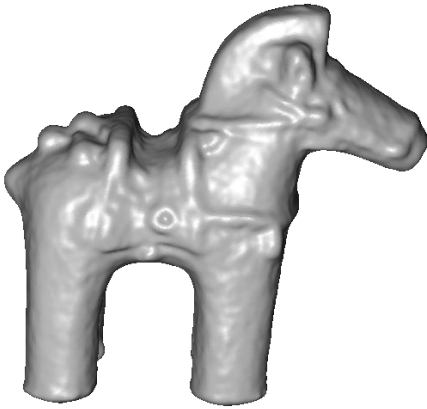


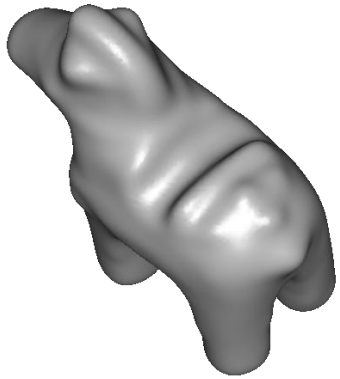
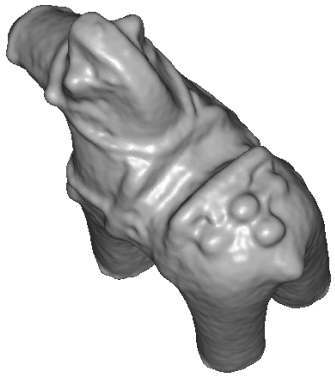

An example – Elgin marbles

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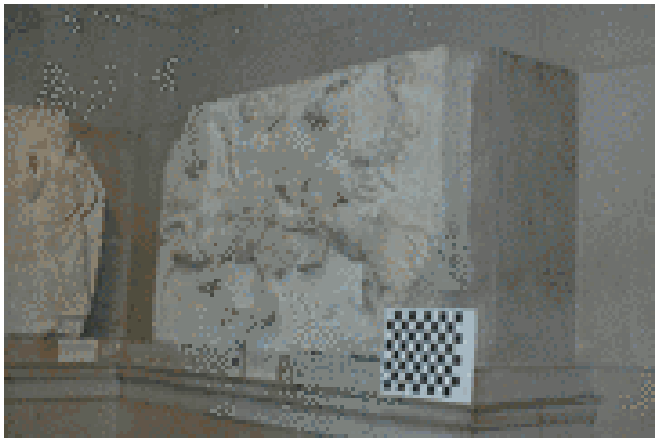

An example – Elgin marbles

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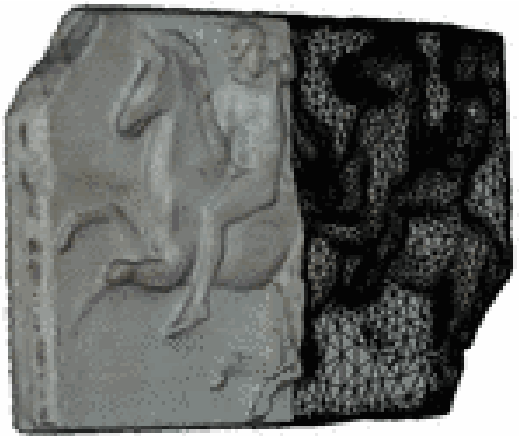

Background - Perspective

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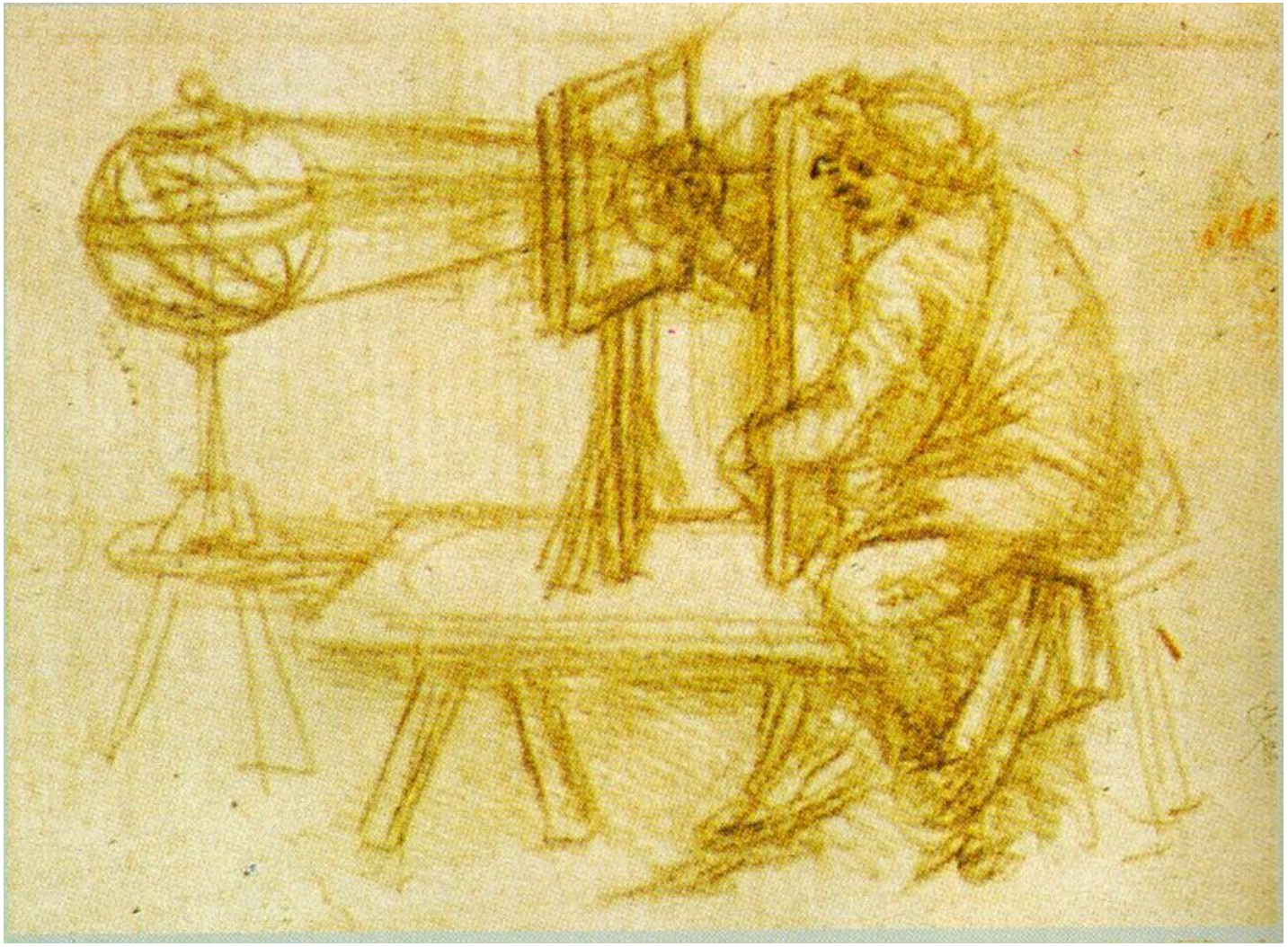

Ambiguity in a single view

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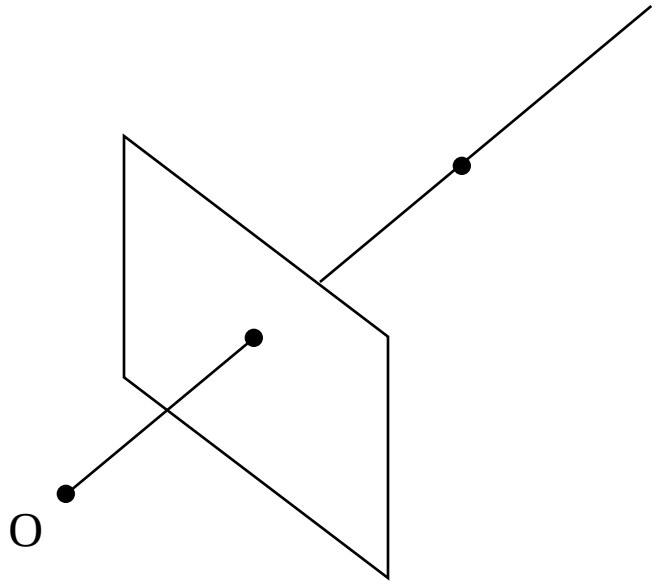

Stereo vision

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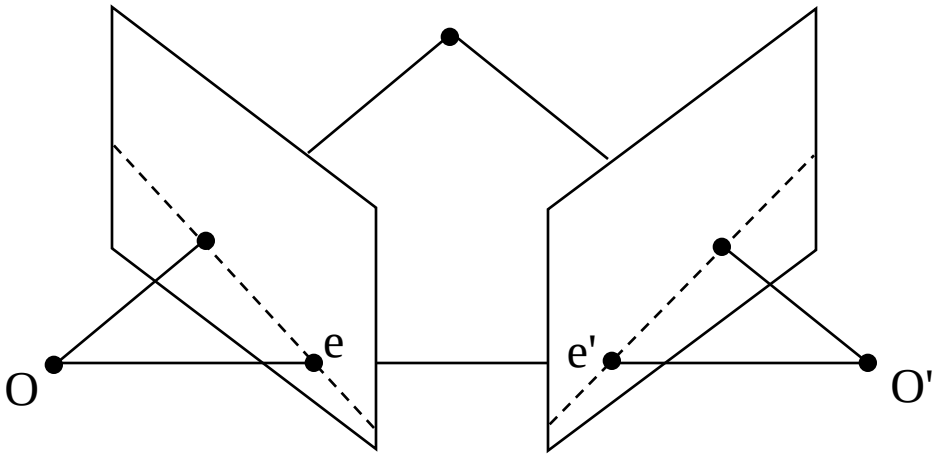

Stereo vision

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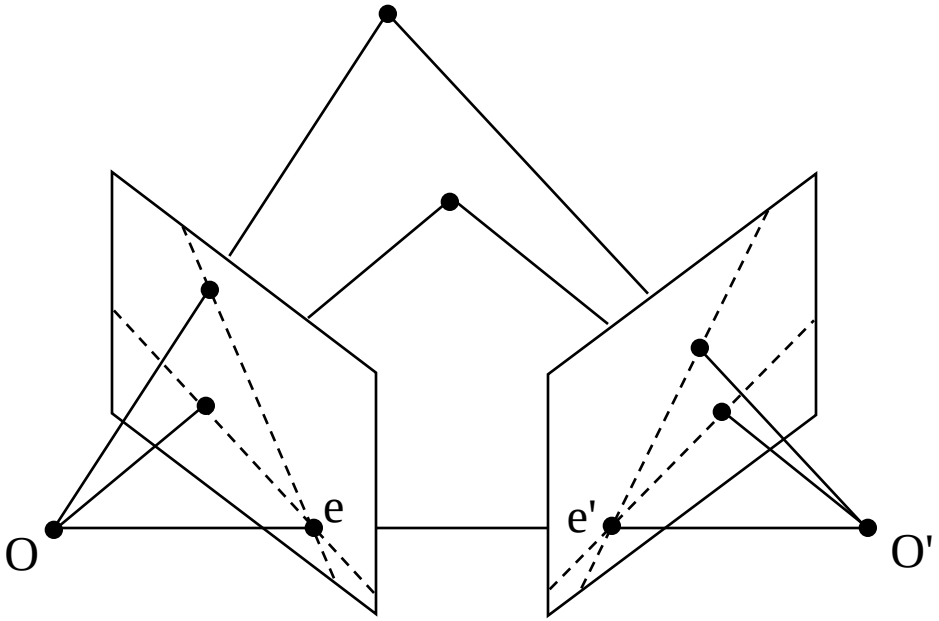

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3D reconstruction of streets

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Trumpington Street Data






















3D reconstruction

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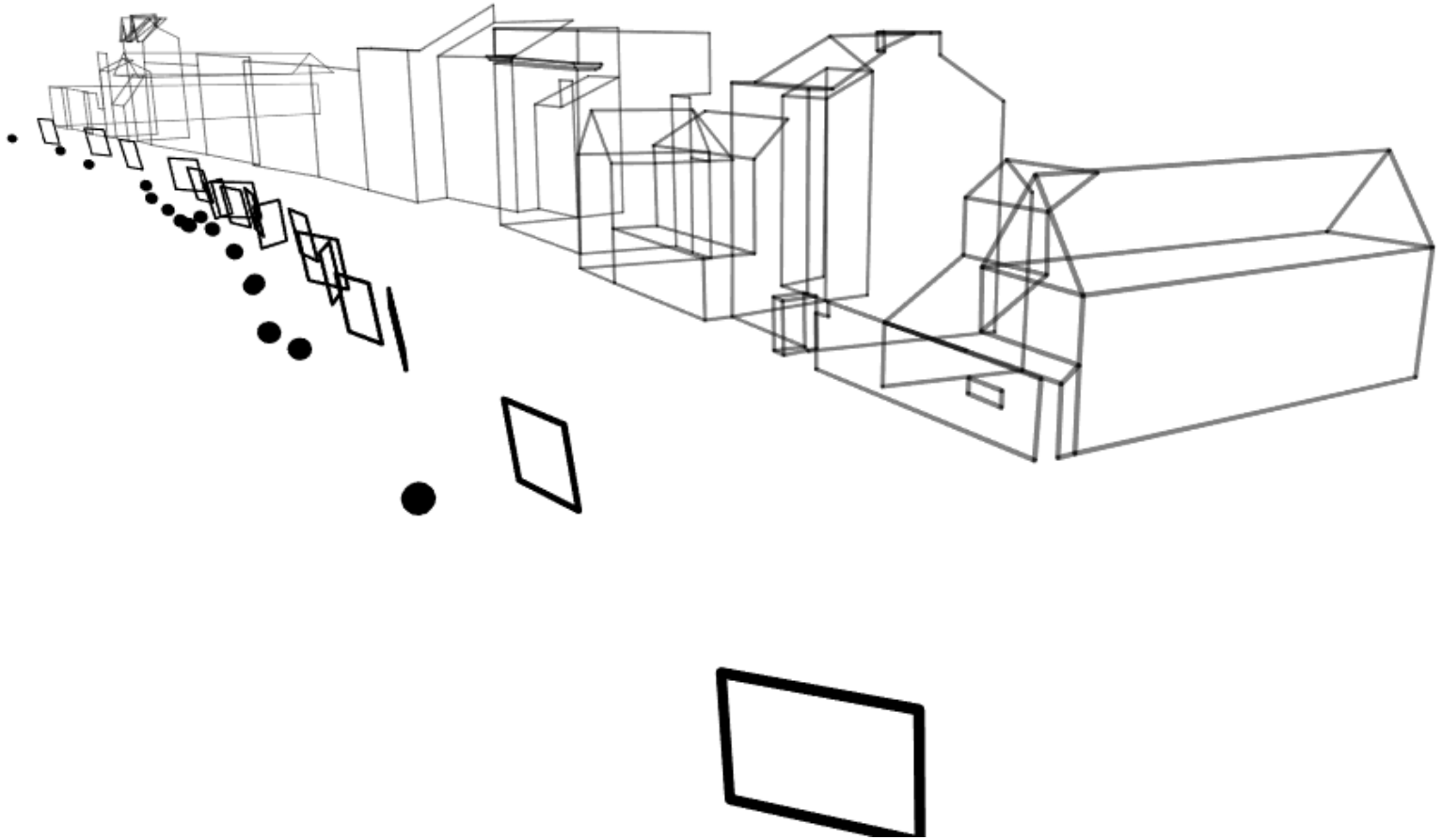

Reconstruction texture mapped

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3D shape recovery from uncalibrated images

Cipolla and Giblin 1999
Mendonca, Wong and Cipolla 1999-2005
Vogiatzis, Favaro and Cipolla 2003-2005
Hernandez and Cipolla 2005

Input images

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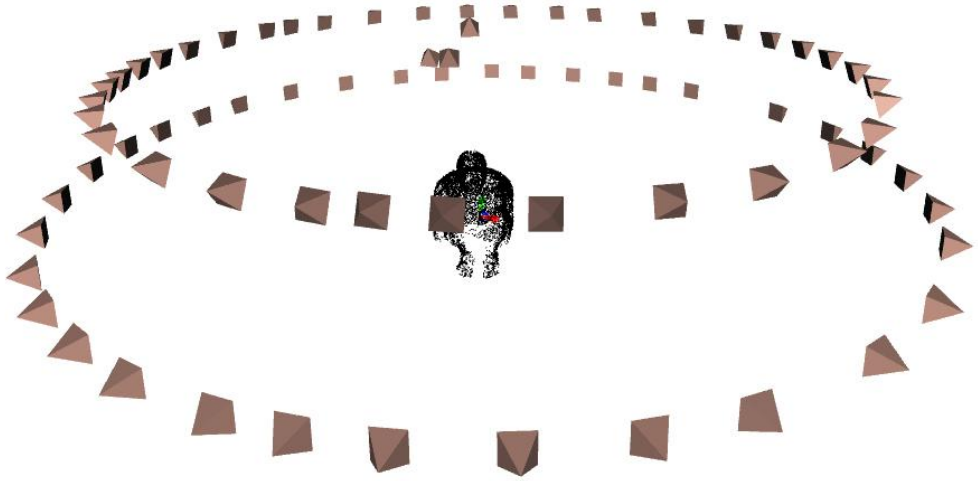
Step 1: Recovery of camera motion



Recovery of camera motion

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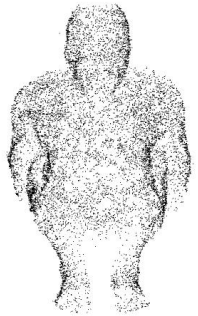
Input images

Feature extraction

Feature matching



Bundle adjustment

Refine with profiles

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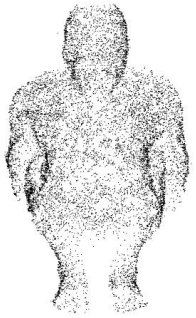
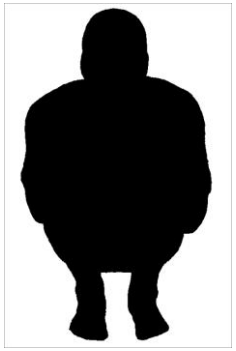
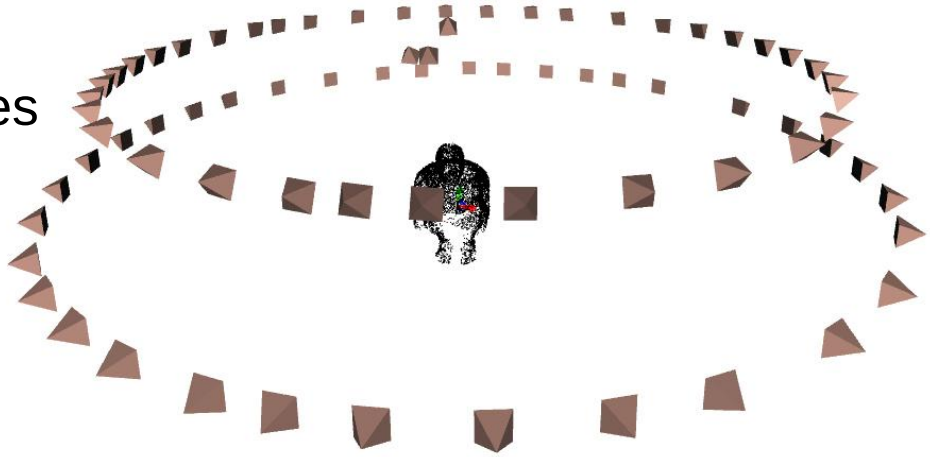


Initialize with features



Refine with profiles



Final camera motion

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Step 2: Recovery of 3D shape

Recovery of surface geometry

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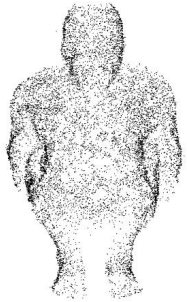
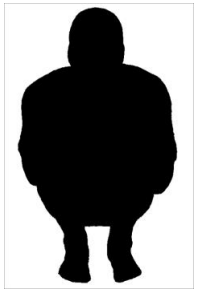
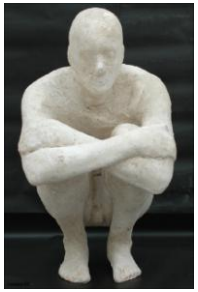
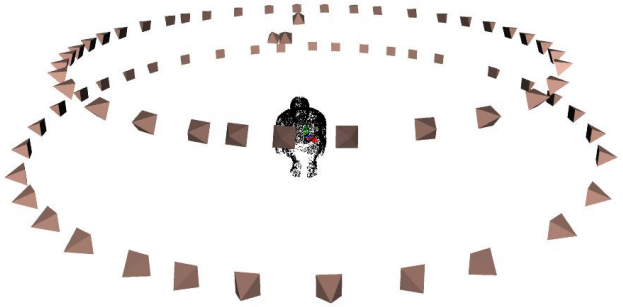
Input data



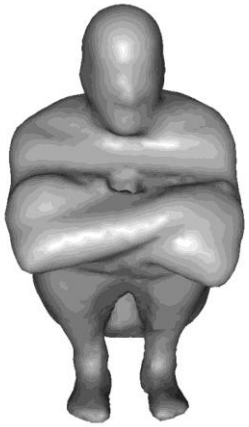




Process



camera motion



visual hull

rough geometry

detailed geometry

texture map

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Step 3: Recovery of material properties and lighting

Non-Lambertian objects

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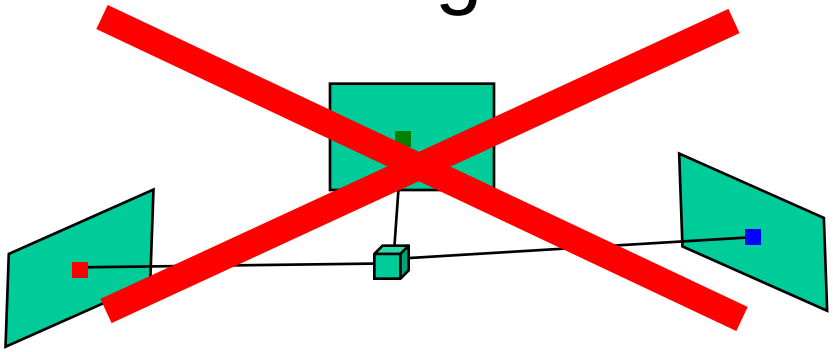
- Shiny surfaces
- Appearance changes with viewpoint



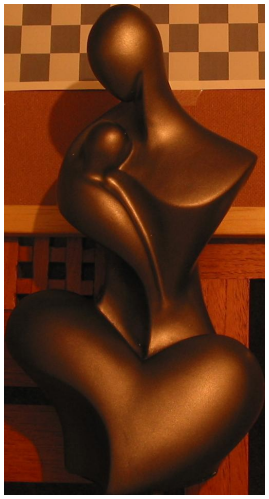


Image formation (BRDF)

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Material properties

Lightfield

Surface normal

$$I(u) = \int \beta(u,v)\, L(v)\, (v \cdot N)\, dv$$

Pixel intensity

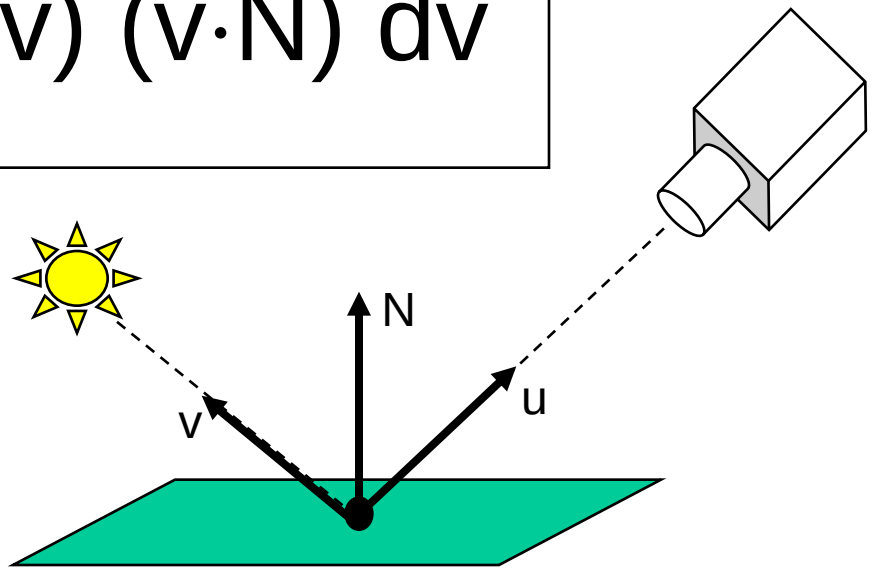

Image formation (BRDF)

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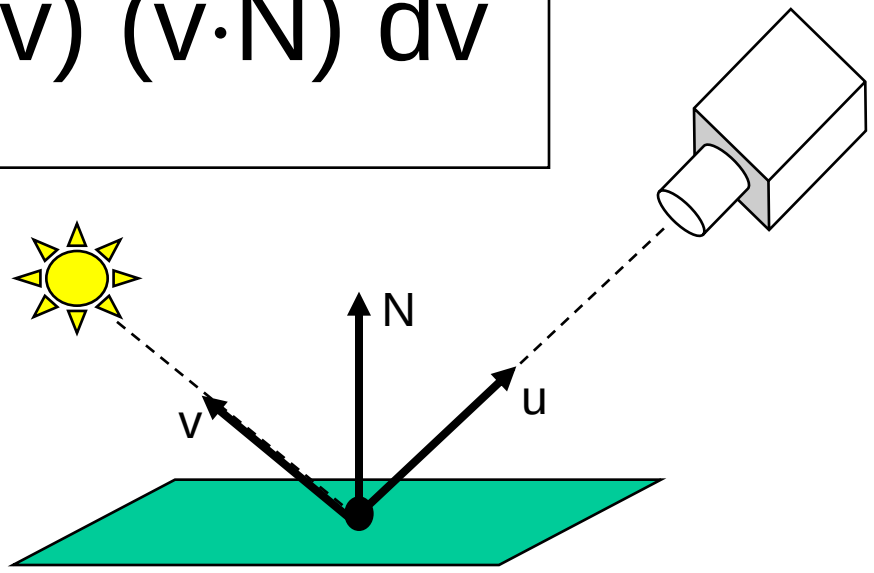
Material properties ?

Lightfield ?

Surface normal

$$I(u) = \int \beta(u,v)\, L(v)\, (v \cdot N)\, dv$$

Pixel intensity



Material & lighting recovery

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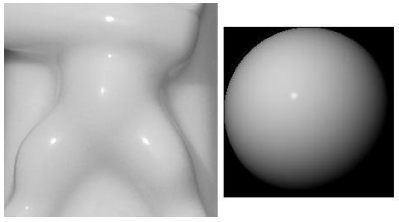
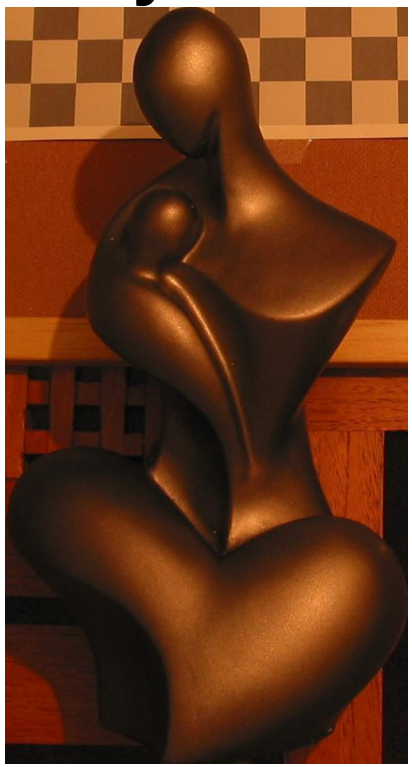
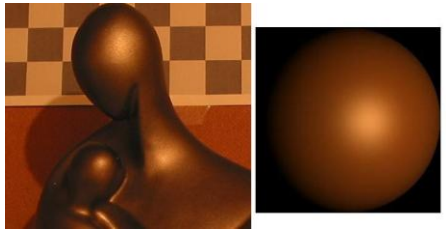
Porcelain



Shiny stone





Summary of shape project

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- Developed technique for recovering shape, material properties and lighting
  - Use digital cameras only ✓
  - Calibration using images for
    - camera pose
    - lighting conditions ✓
  - General & practical algorithm
    - large class of objects ✓
    - Simple, cheap set-up ✓

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Part 2: Interaction

Stenger, Thayananthan, Torr and Cipolla 2003
Williams, Blake and Cipolla 2003 and 2005
Ramanan et al 2005

Real-time hand tracking

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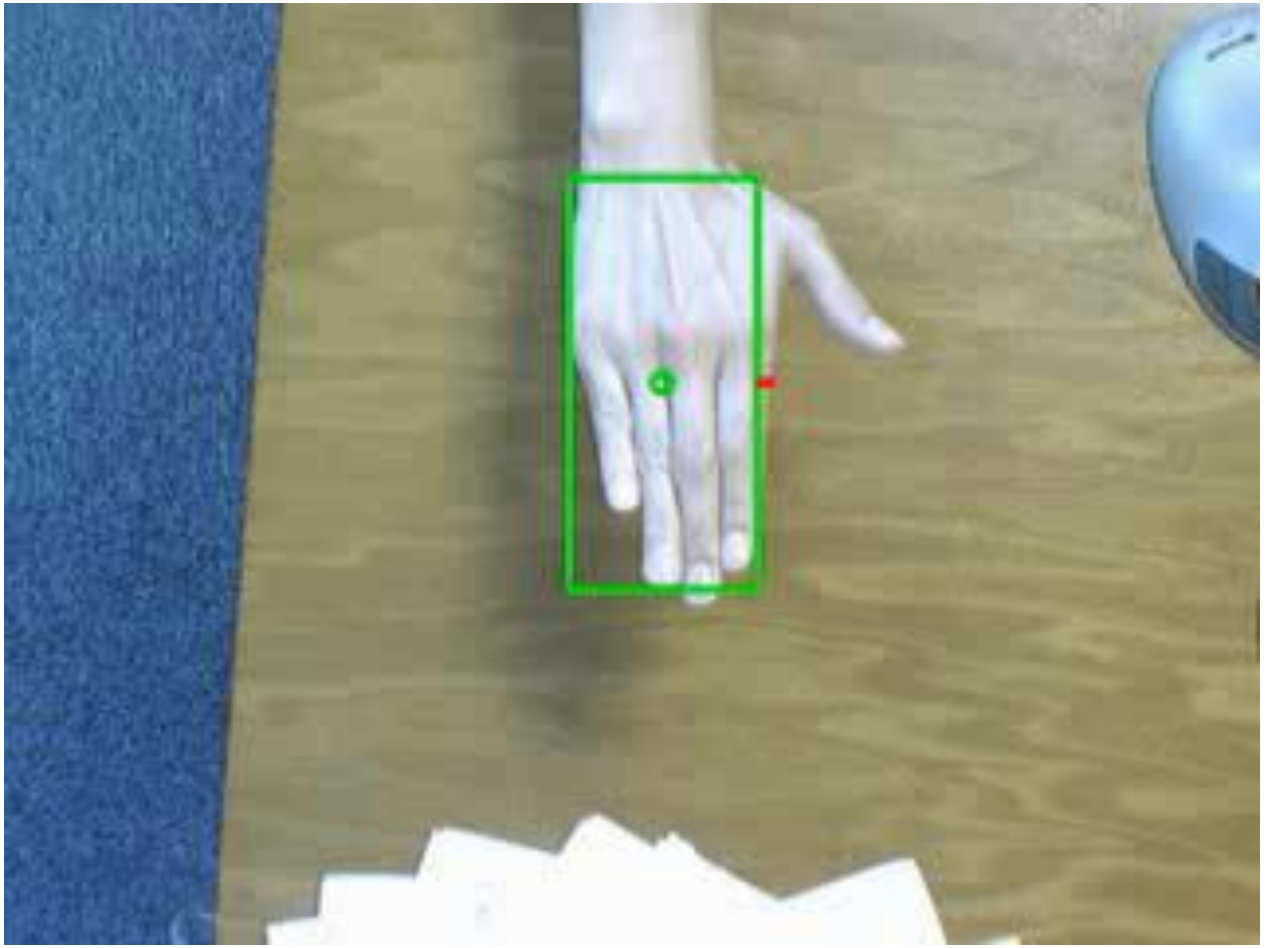

Real-time visual controller for Dasher

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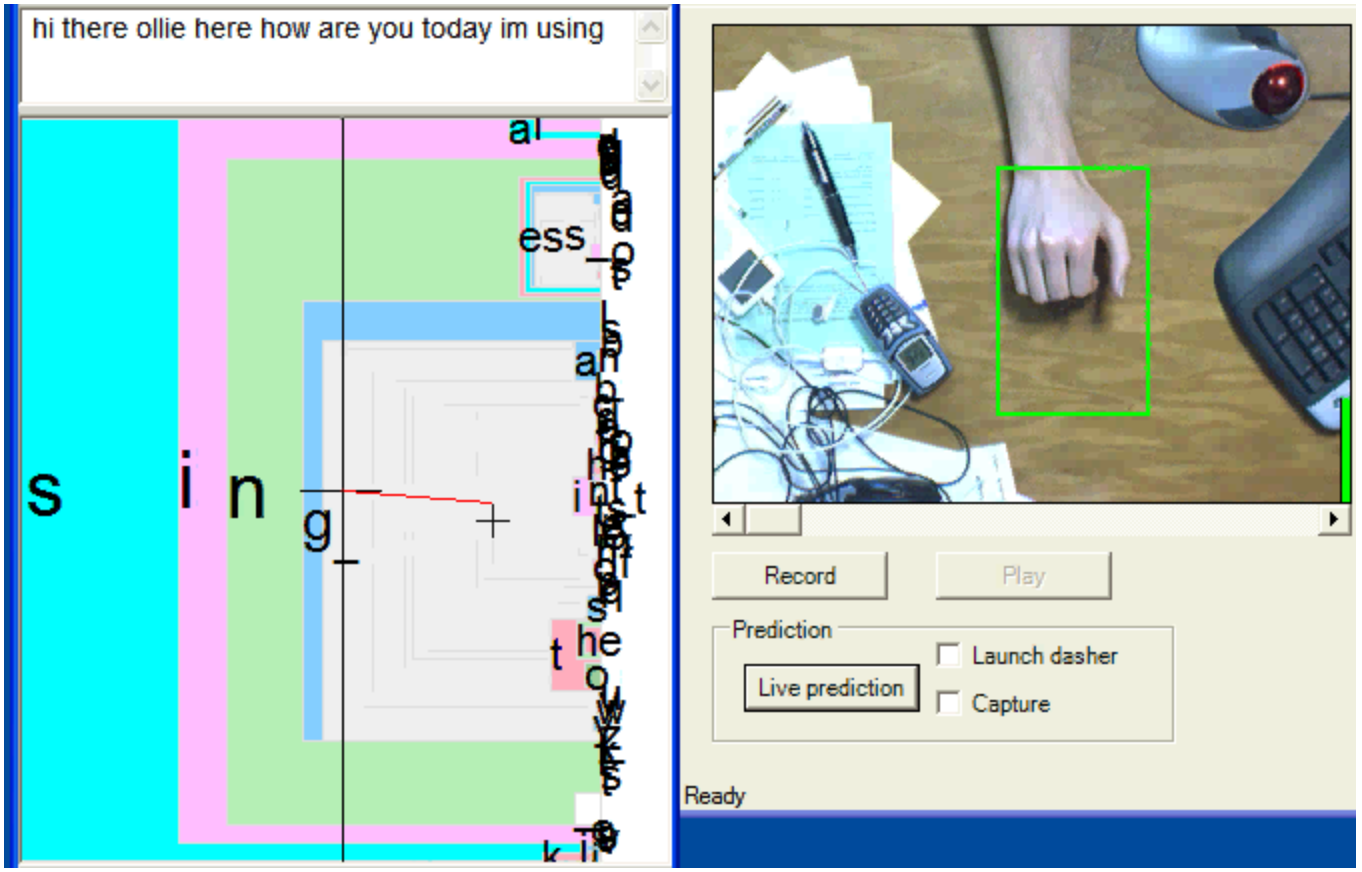

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Semi-supervised Learning

Semi-supervised training examples

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- N Example images

- T “Tags” ($T < N$)

- Exploit unlabelled examples by making 2 assumptions:
  - Similarity
  - Smoothness

Label distribution

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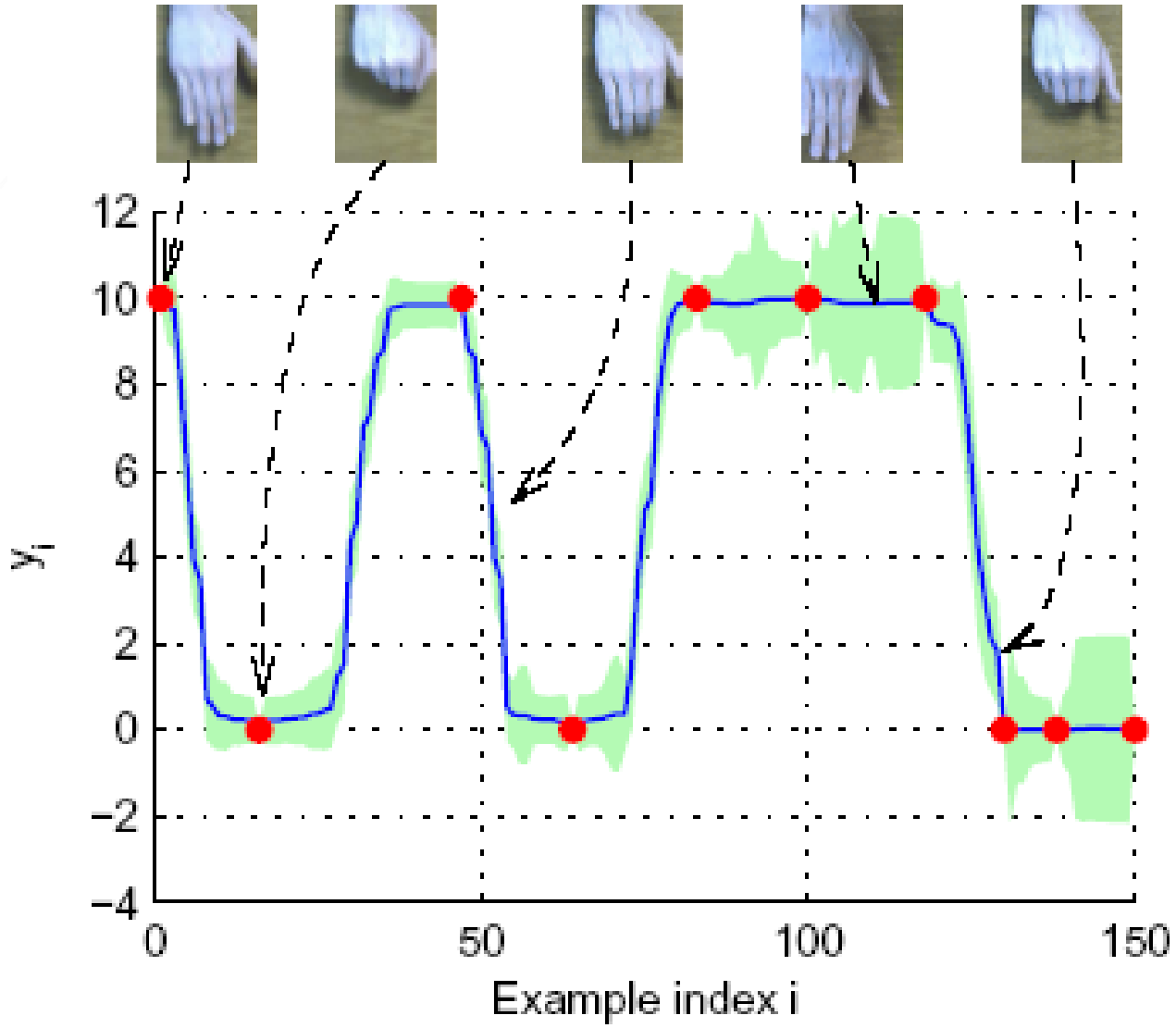

Real-time hand tracking

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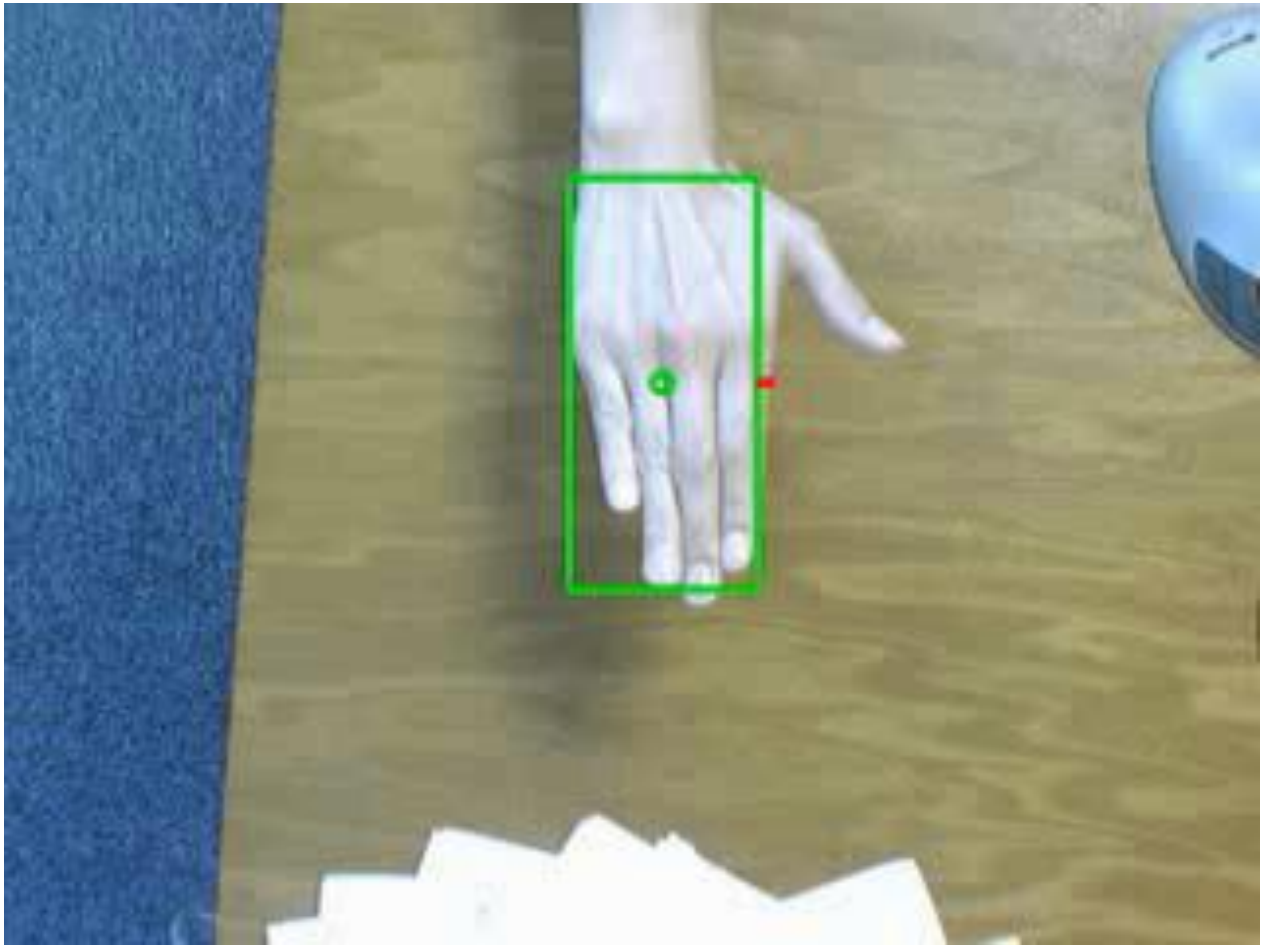

Real-time eye-gaze tracking

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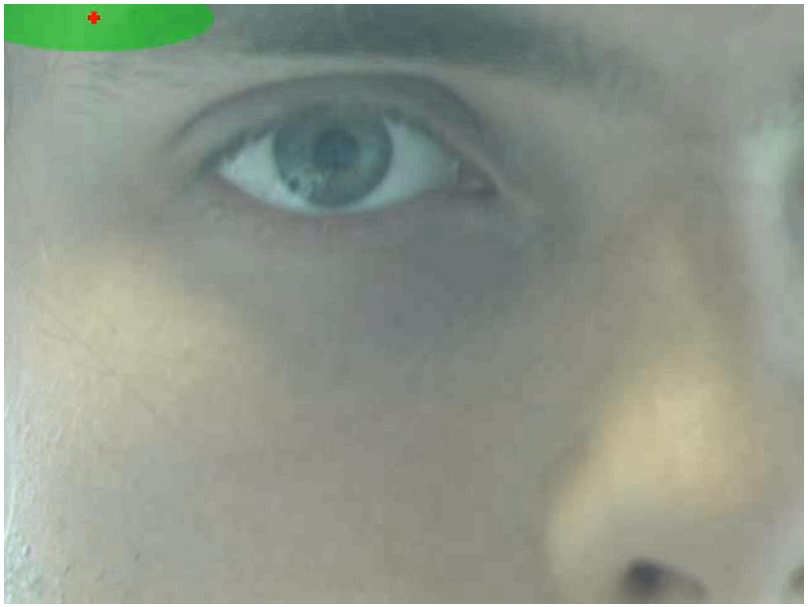

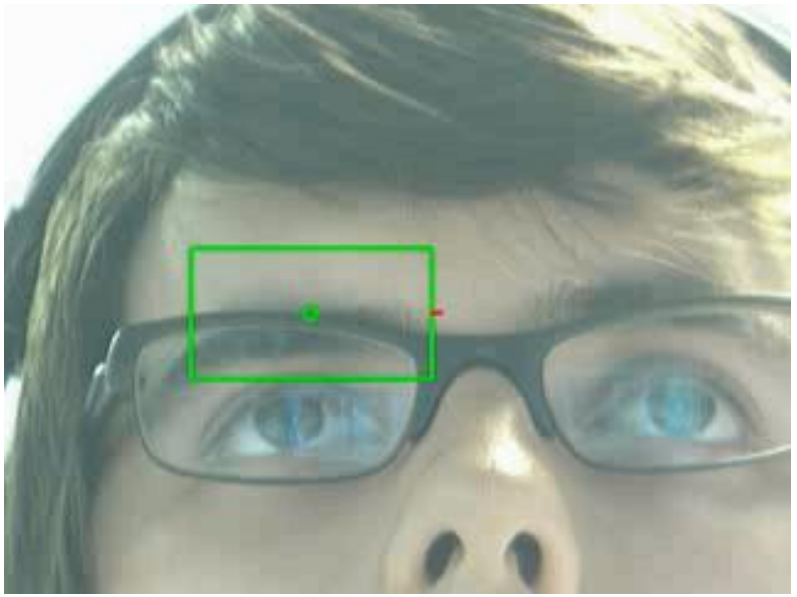

Real-time face detection

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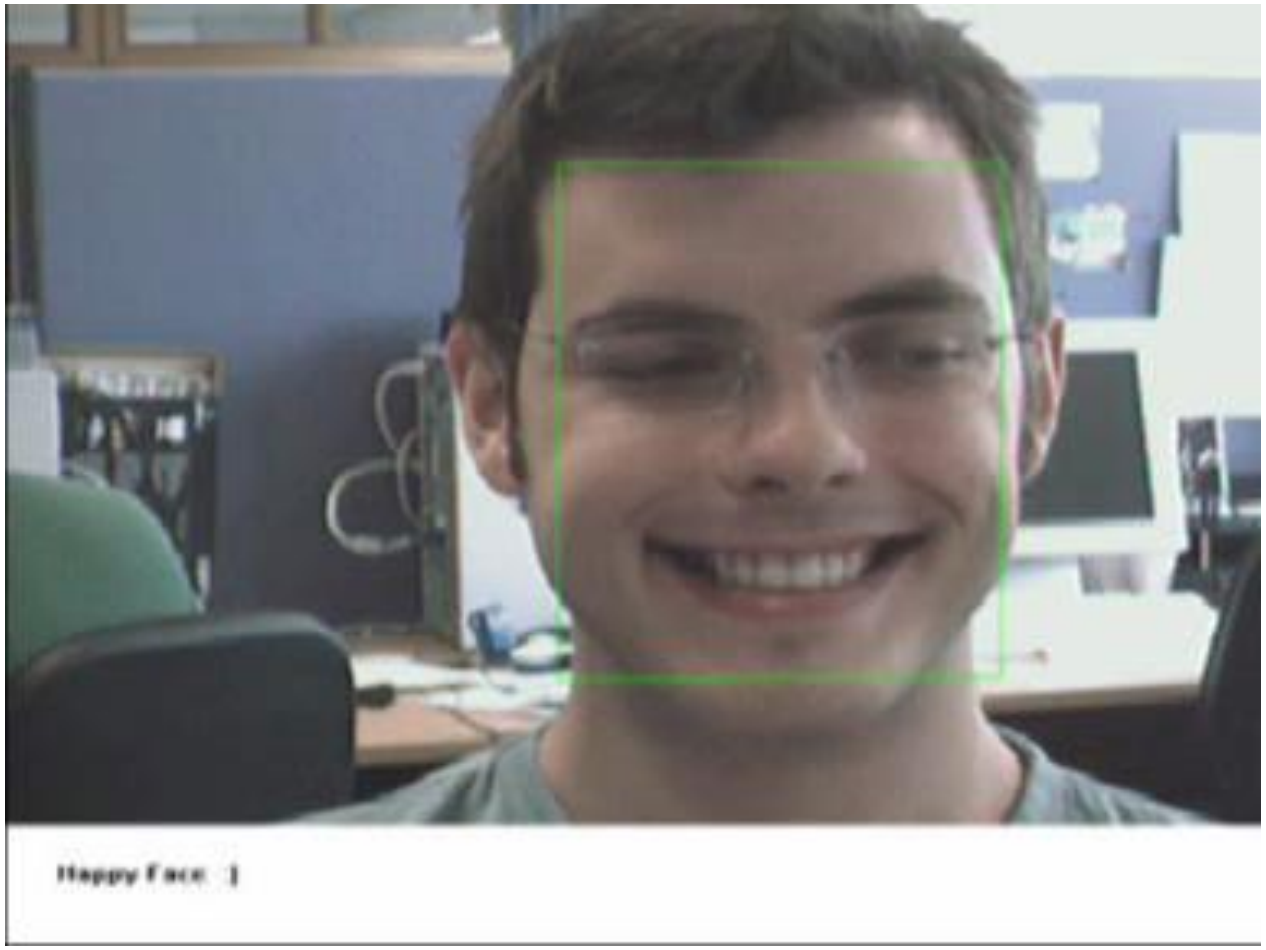

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Template-based detection

Hand detection system

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Tracking - 3D mouse

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Opening and closing

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People and pose detection

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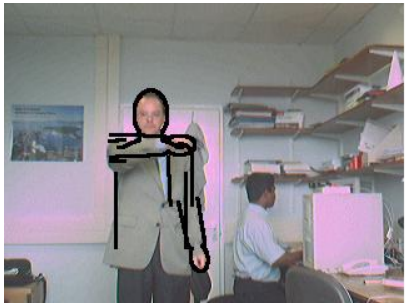
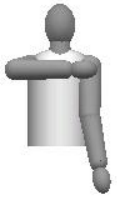
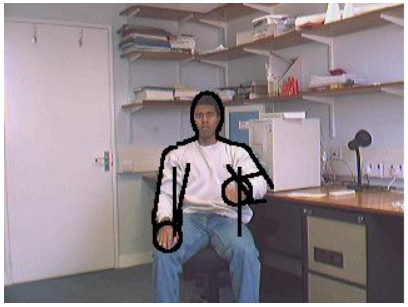

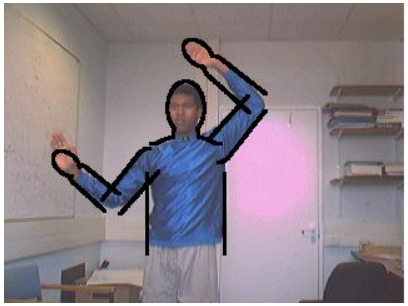


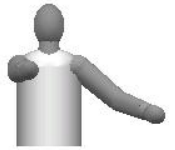
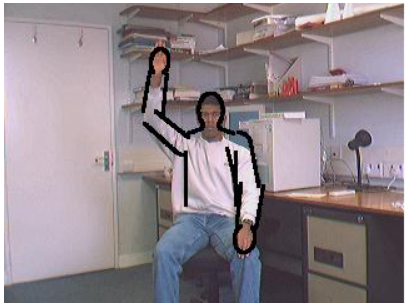

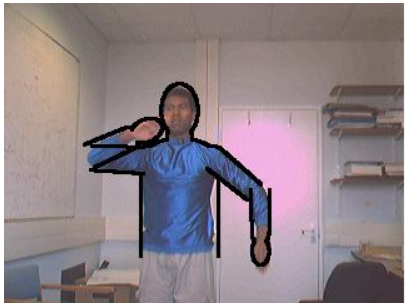


A Tracked Sequence

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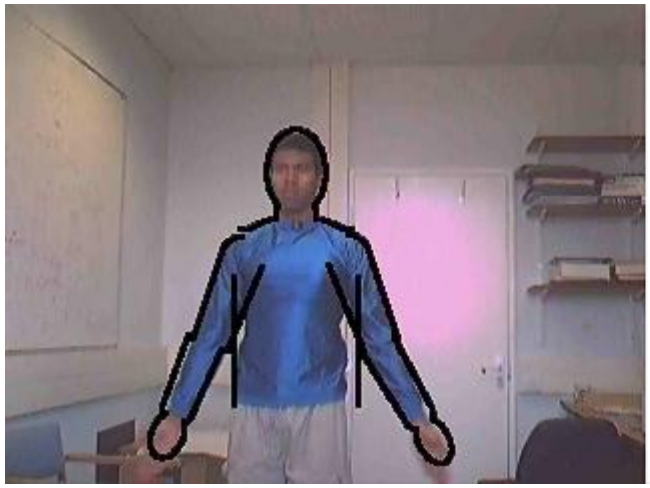

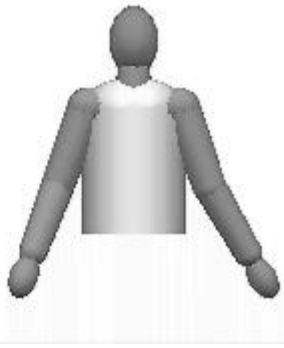

Tracking people in crowds

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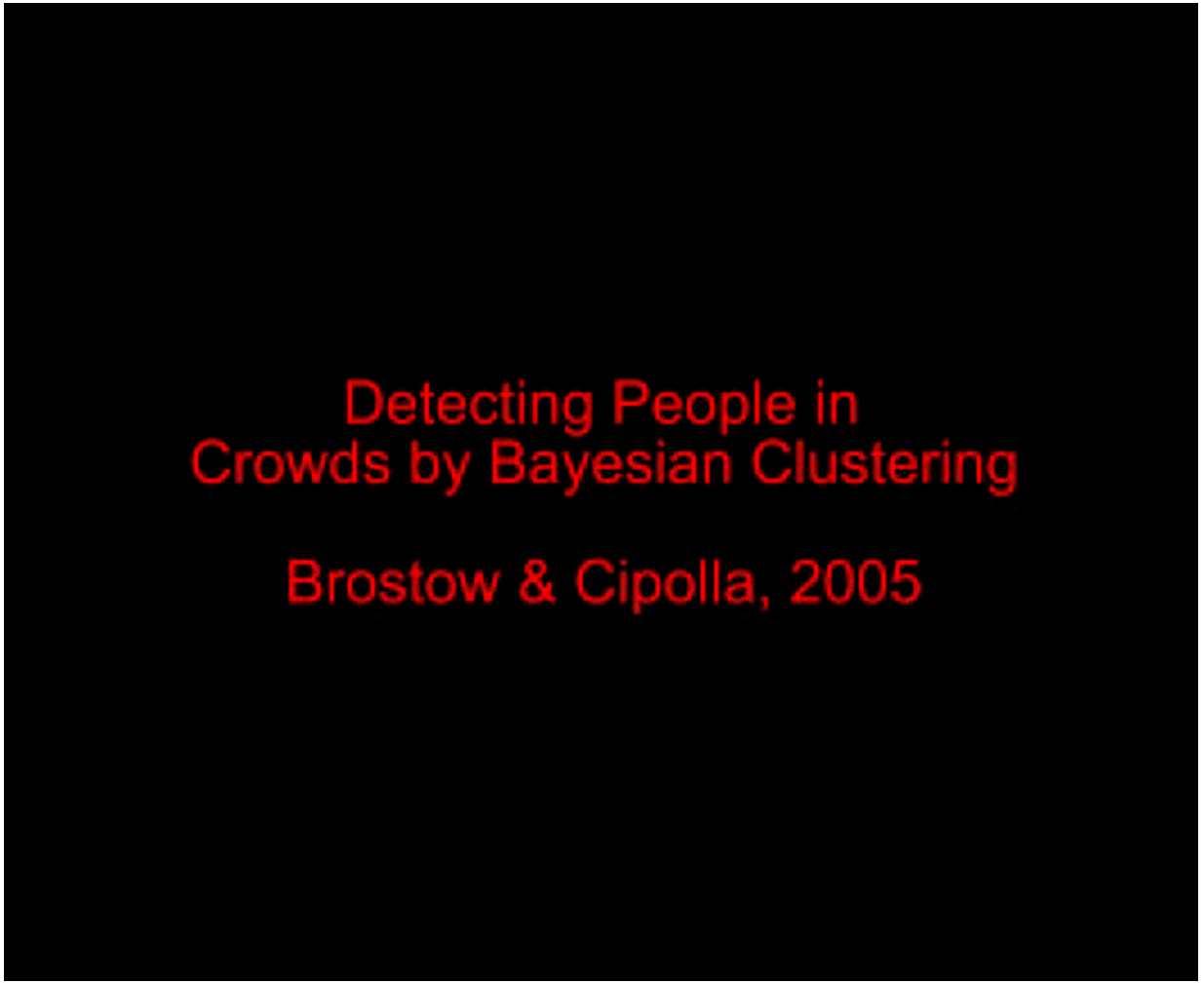

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Part 3:
Object detection and matching images

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Image-Based Localisation
Where am I?

Johansson and Cipolla 2002
Cipolla, Tordoff and Robertson 2004

The goal – where am I?

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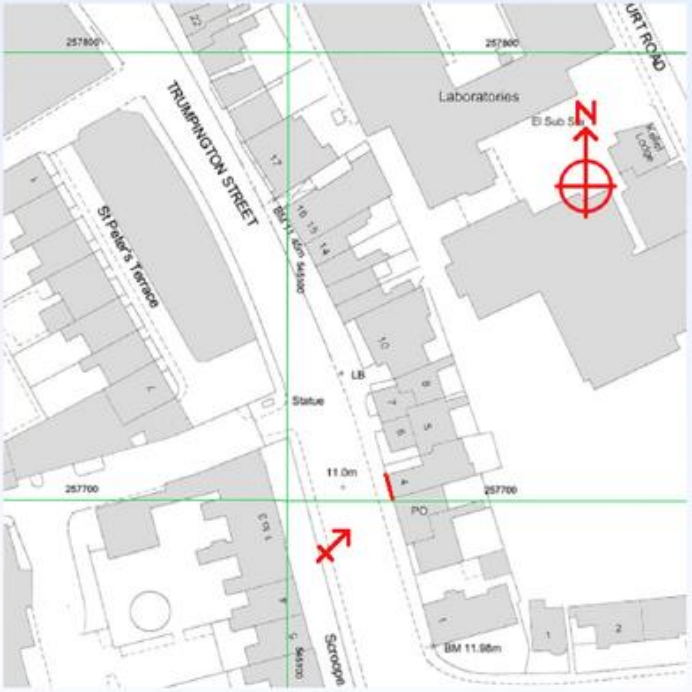
User takes a picture of a nearby building. System tells you what you are looking at and exactly where you are on a map.



The problem

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?

Constrained matching

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Constrained matching

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Localisation of query view

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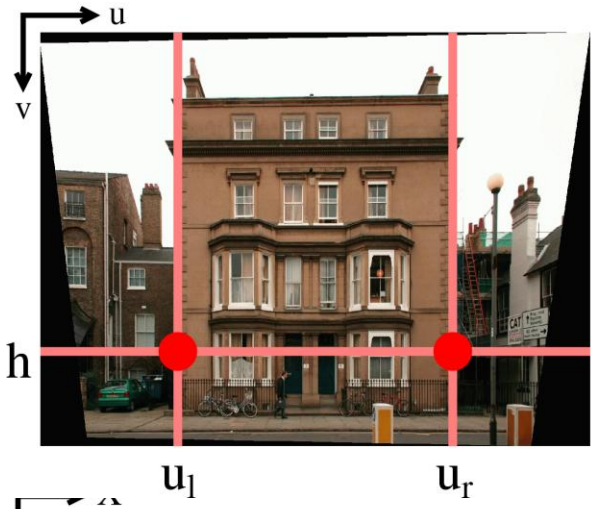

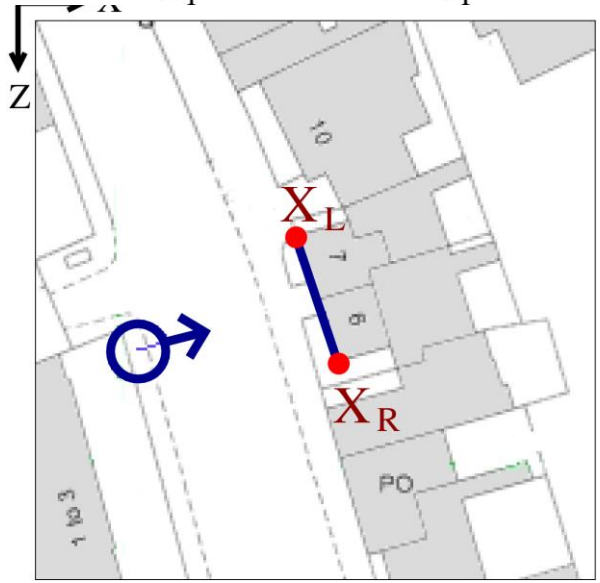

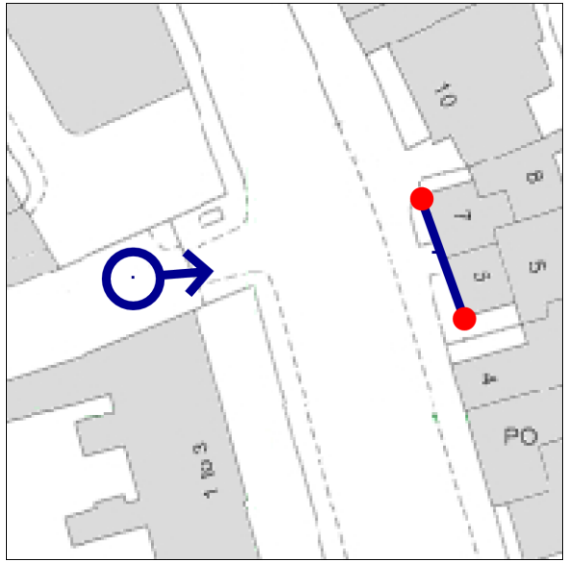

Image-based localisation

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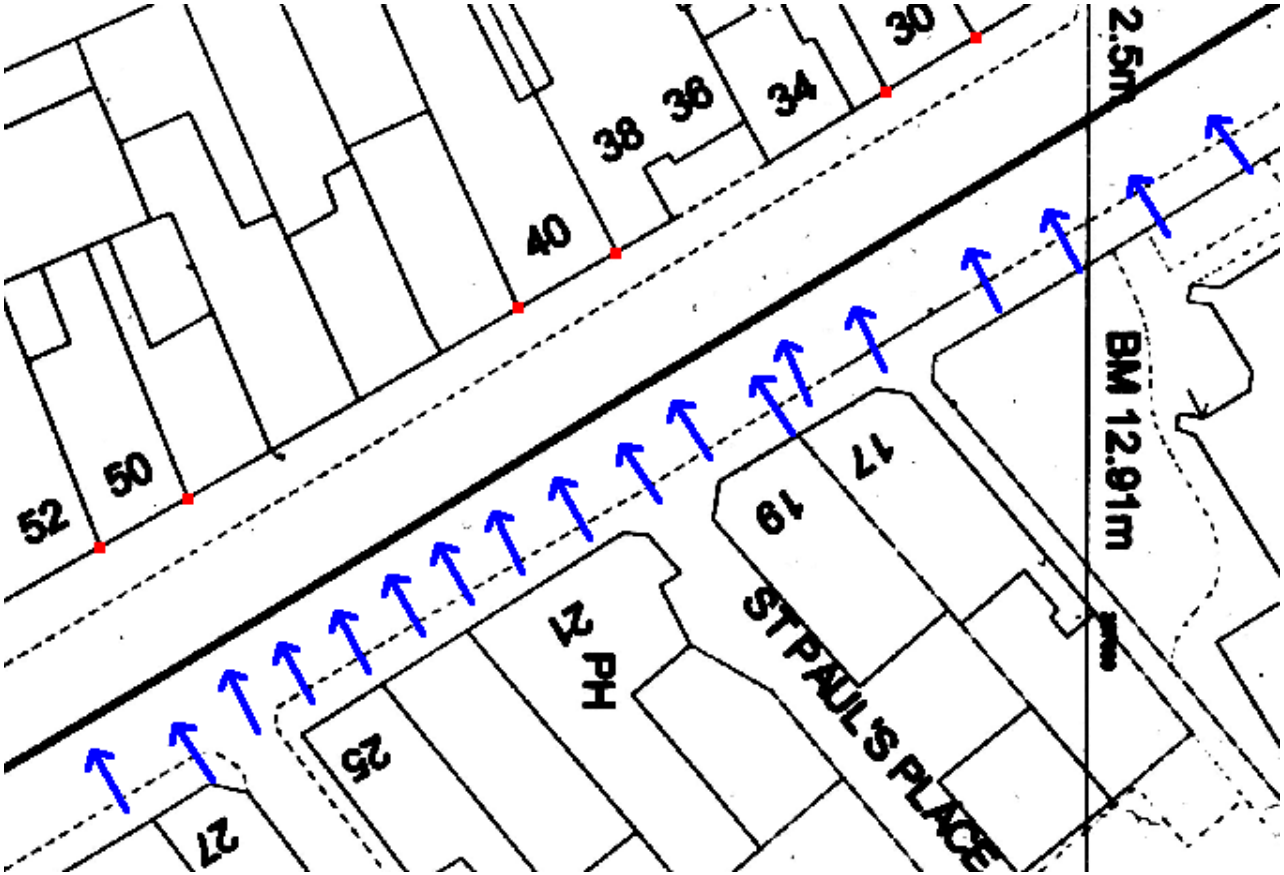

Image-based localisation

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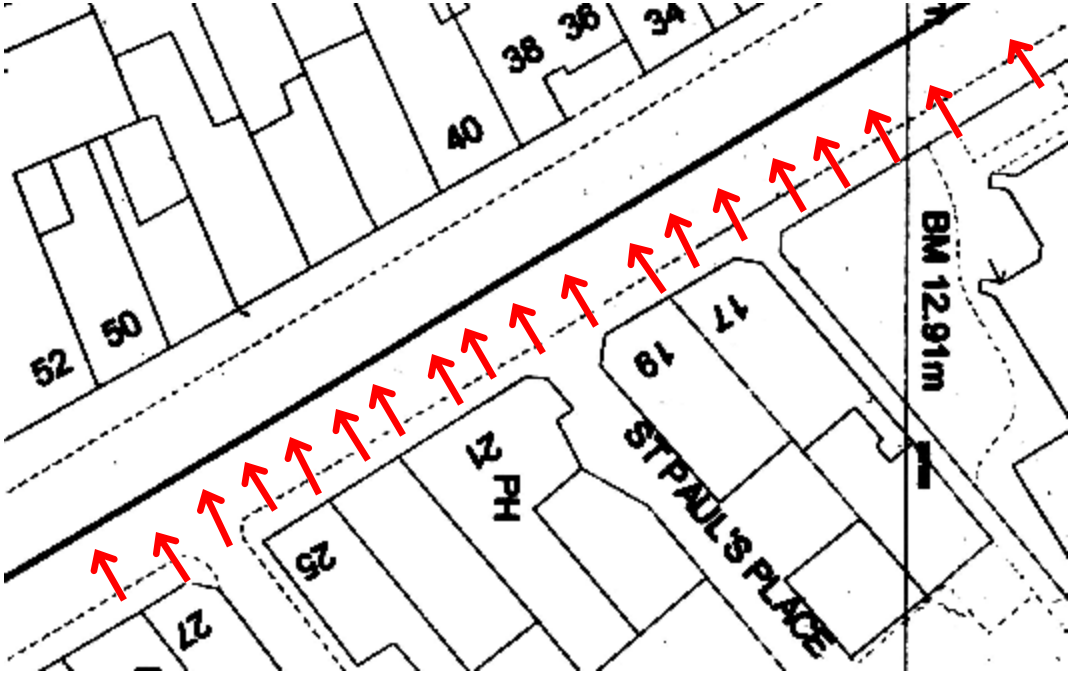

Image-based localisation

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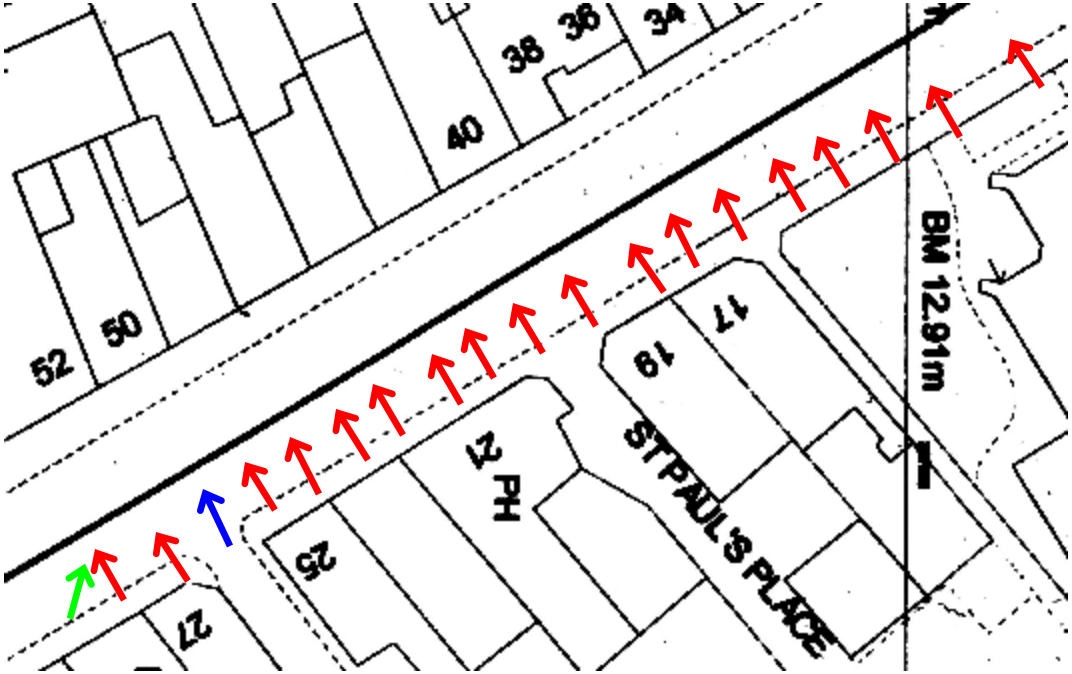

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Demos: Realtime mosaicing and smart erase

Overview

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1. 3D shape and camera motion recovery:

   Making digital copies of 3D objects from photographs from multiple viewpoints.

2. Novels ways of interaction:

   Realtime detection of hands and faces and gestures.

3. Image matching and object detection: