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Image-Based Localisation

Roberto Cipolla

Duncan Robertson and Ben Tordoff

Department of Engineering

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Background

The goal – where am I?

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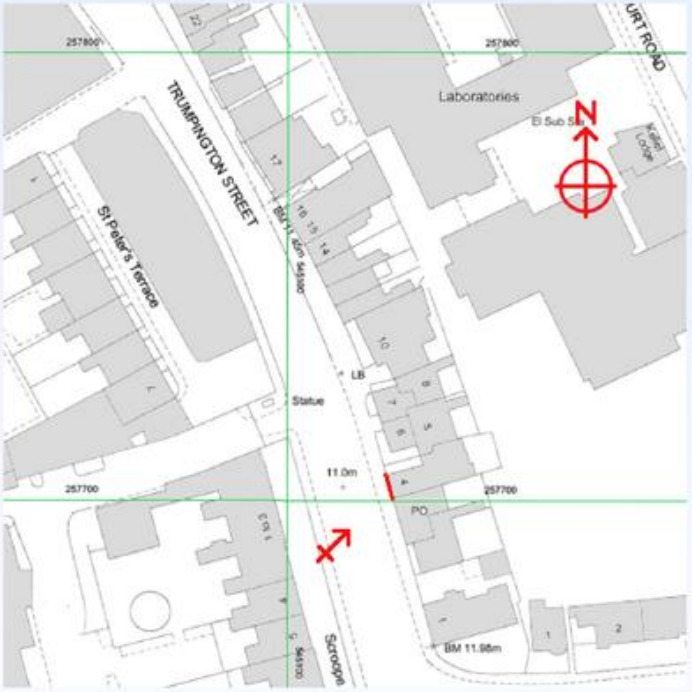
User takes a picture of a nearby building. System tells you what you are looking at and exactly where you are on a map.



The problem

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?

Why difficult?

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Extreme perspective distortion

Differences in colour / lighting conditions

Occlusion

Unconstrained matching

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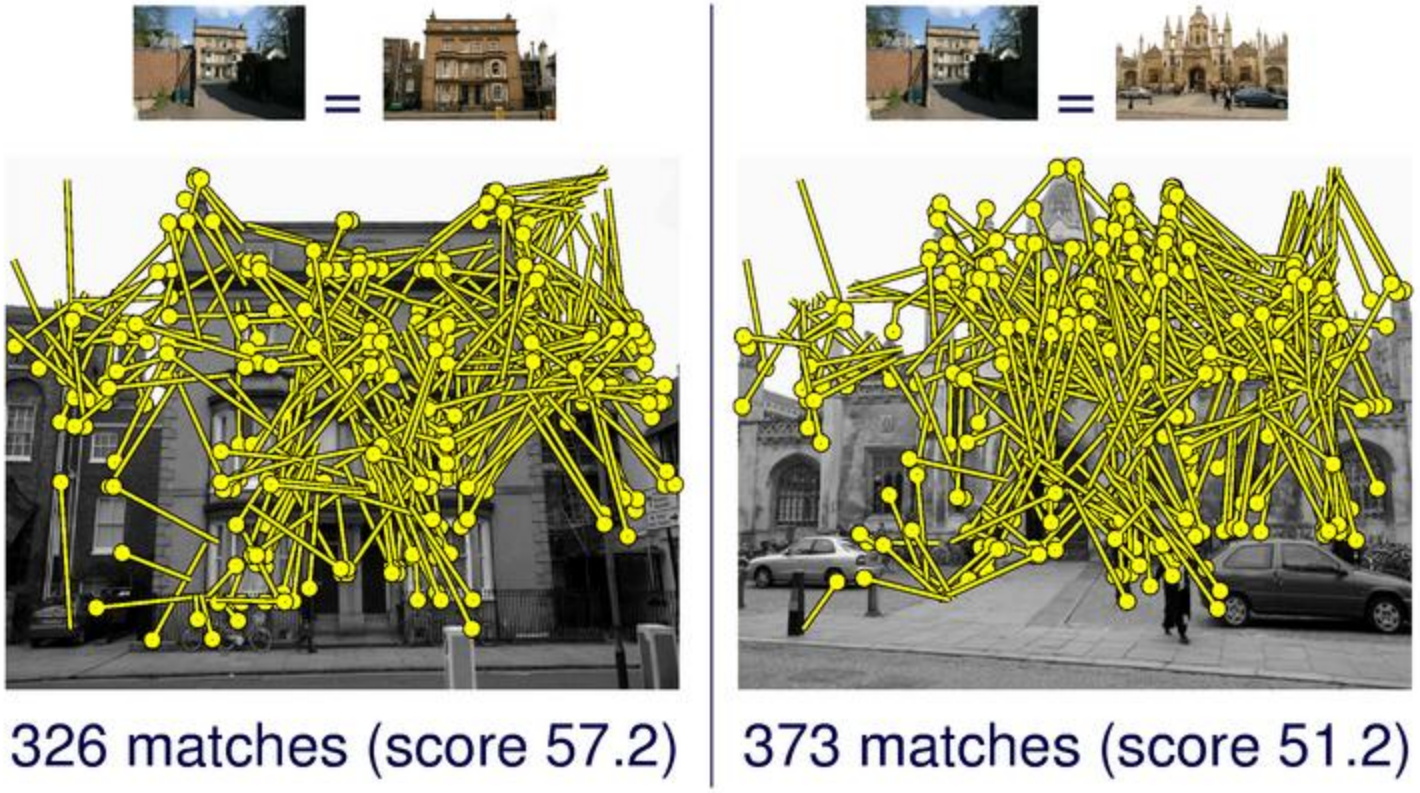

326 matches (score 57.2)

373 matches (score 51.2)

Constrained matching

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- Building façades are roughly planar
- They contain many horizontal and vertical features
- We can use this to get a “front view” (rectified image)
- Front-views are related by translation and scale only

Constrained matching

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Constrained matching

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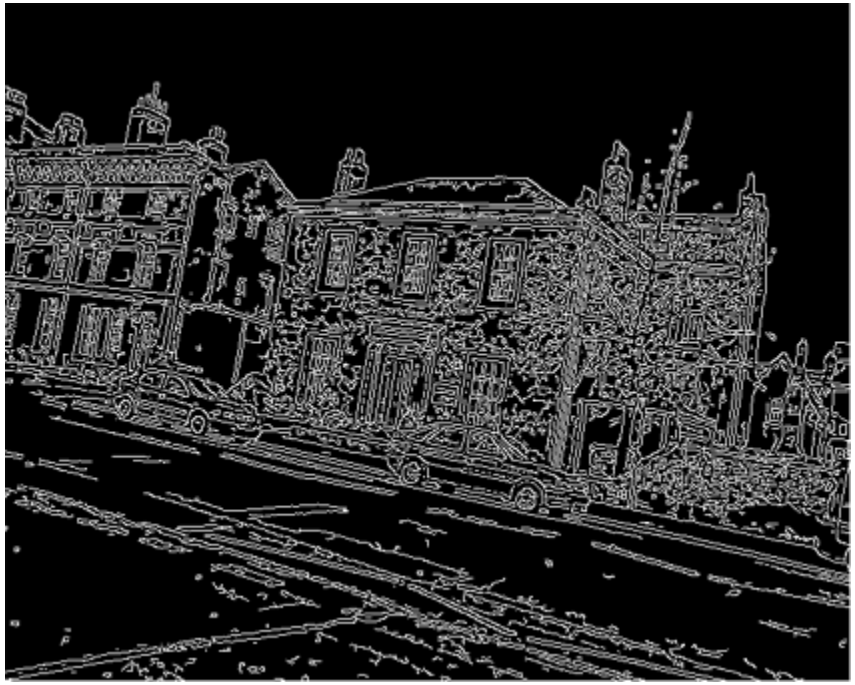

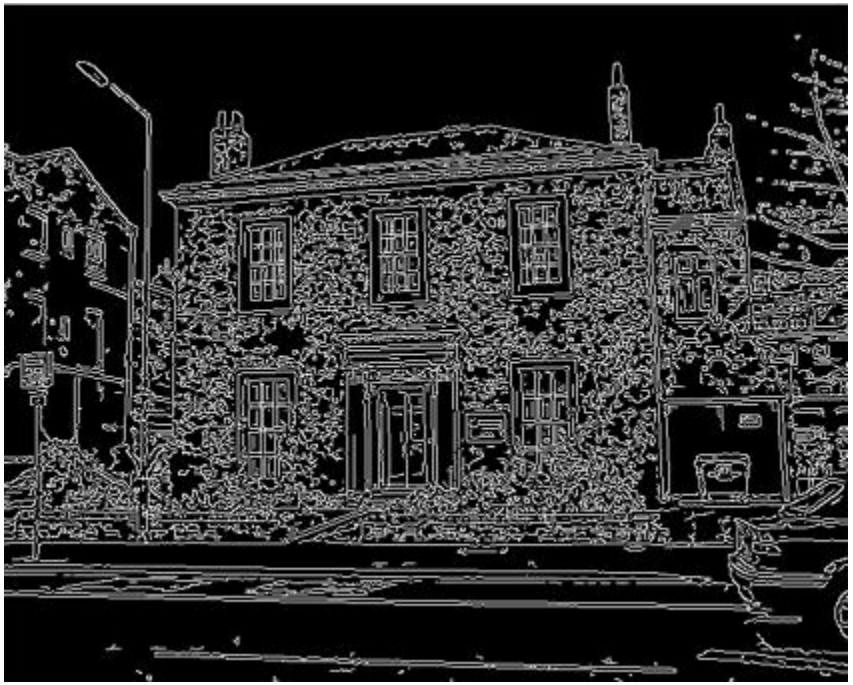

Constrained matching

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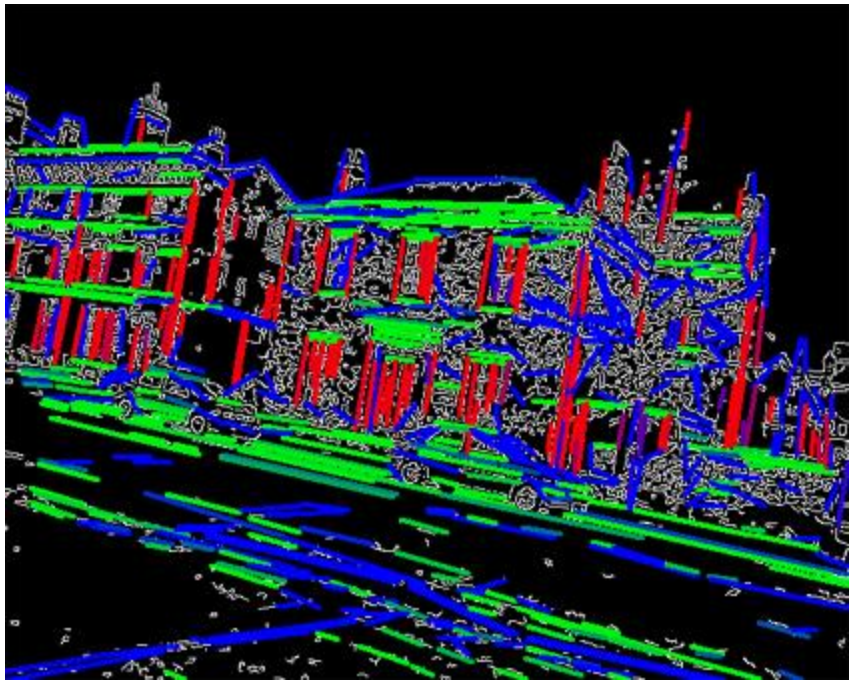

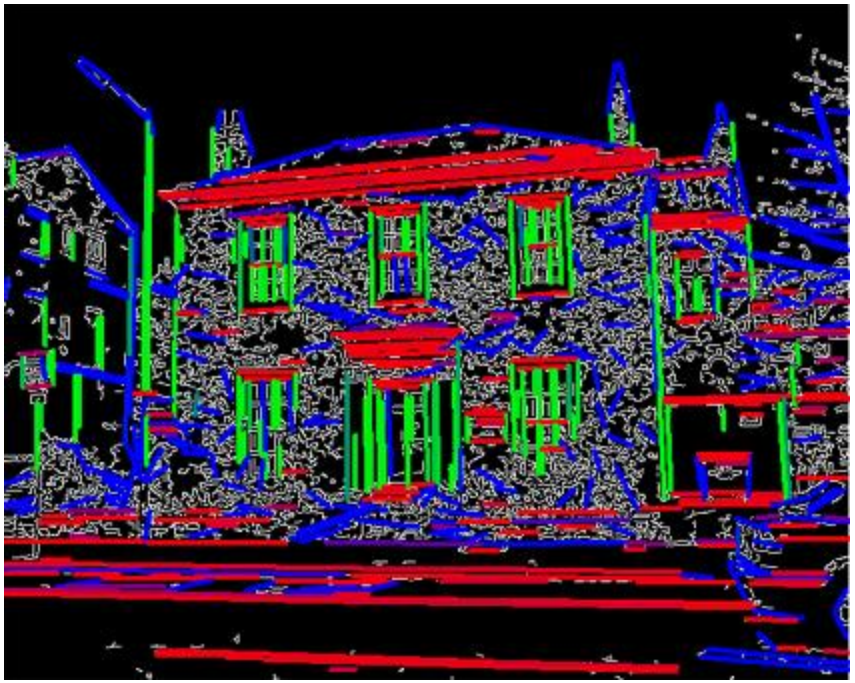

Constrained matching

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Constrained matching

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Overview of solution

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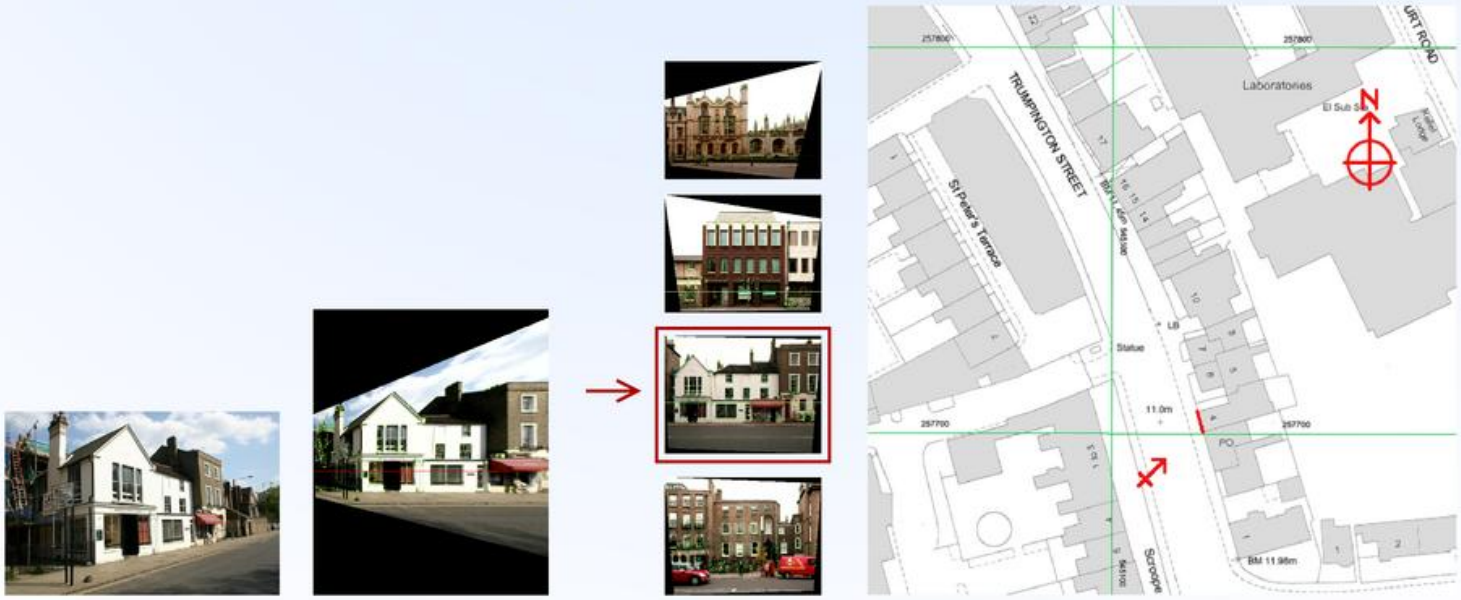
1 vanishing point detection
2 image rectification
3 database search
4 viewpoint determination



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Rectification

Rectification

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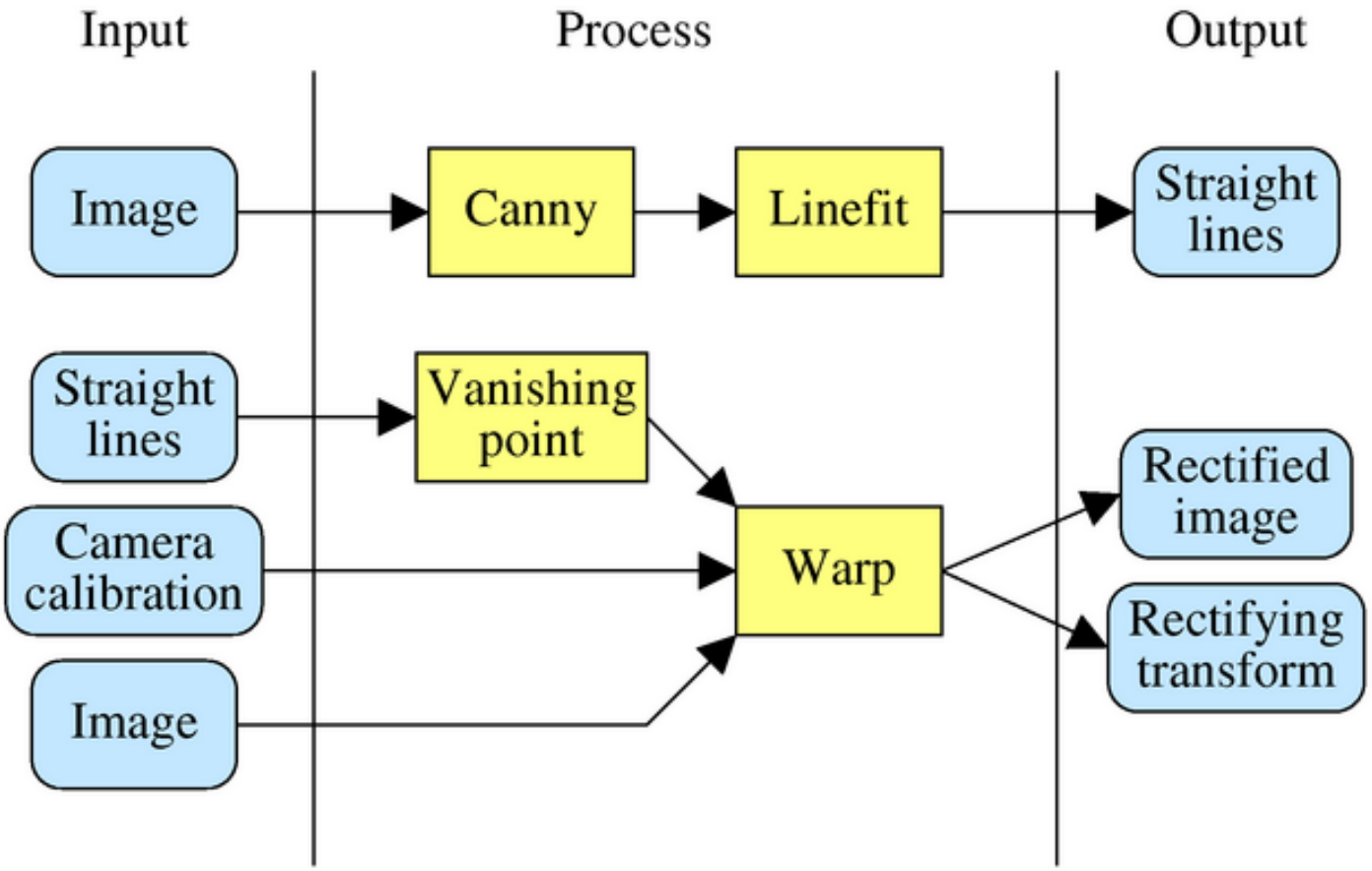

Detection of straight lines

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Detect straight lines:

Finding vanishing points

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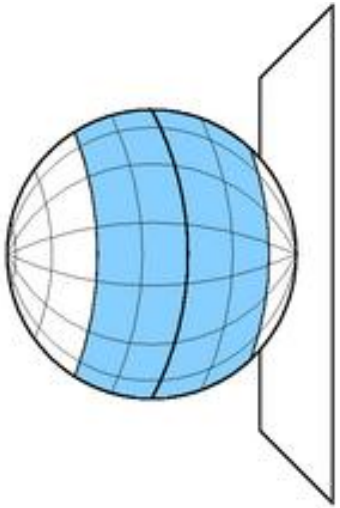

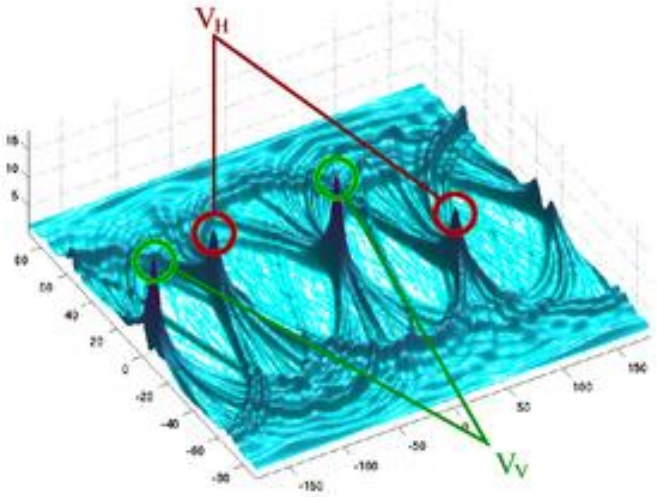

Find vertical and horizontal lines

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Allocate all lines as vertical, horizontal or “clutter”

Rectification by homography

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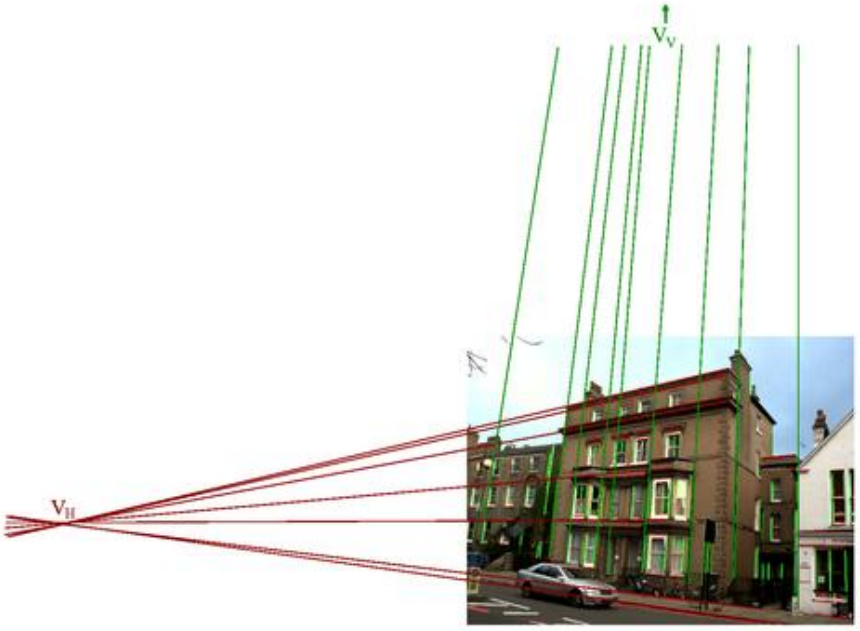

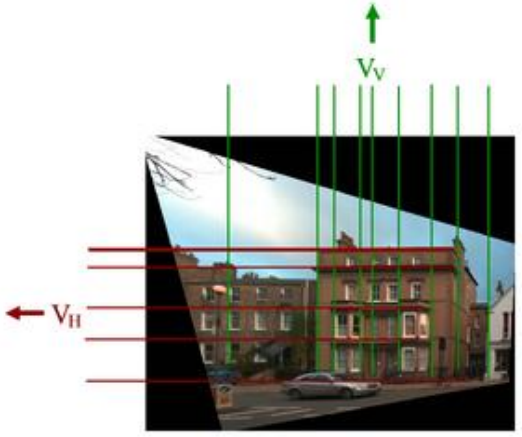

Align horizon

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Only difference is now scale + x translation

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Matching

Matching

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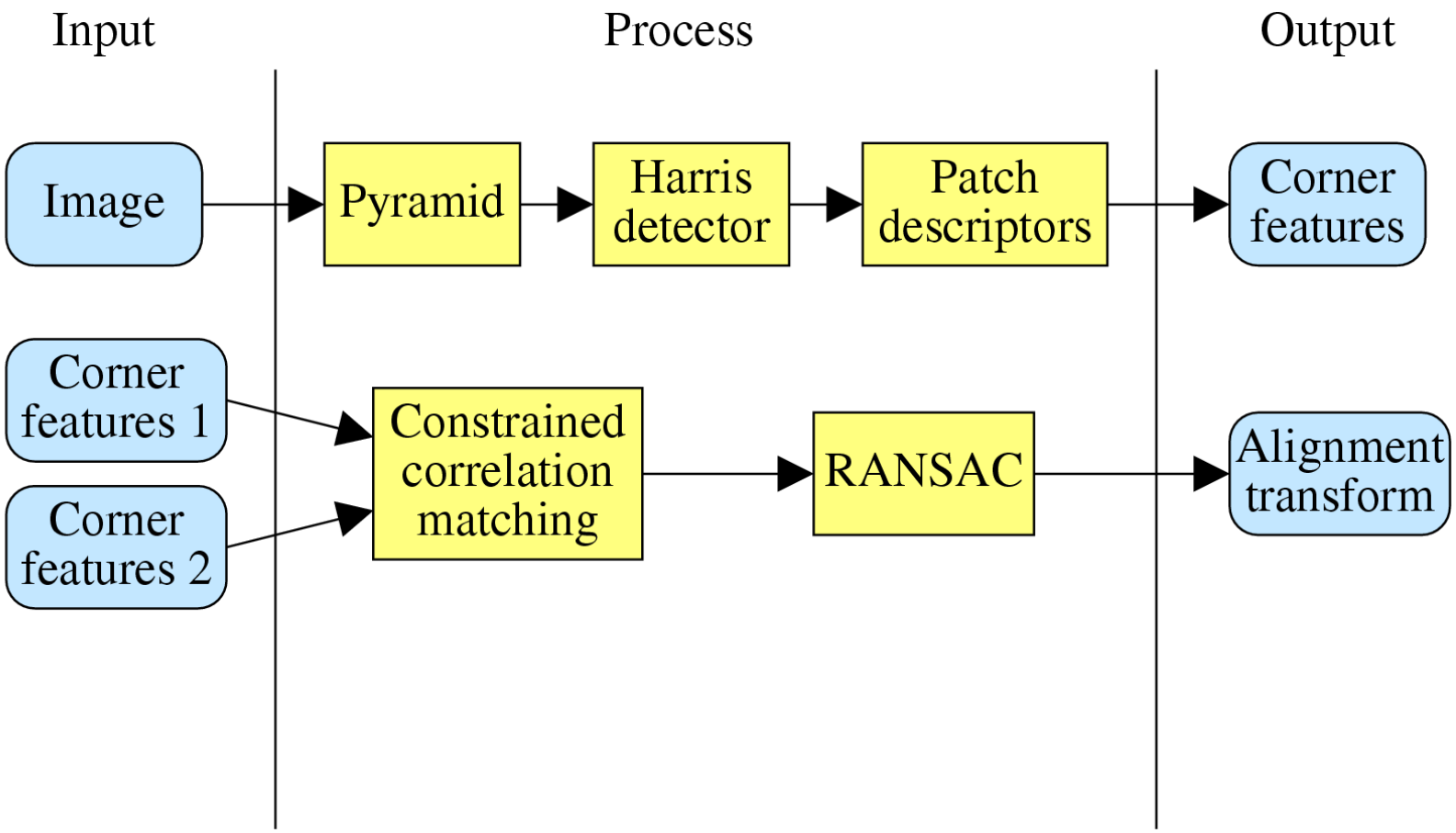

Matching

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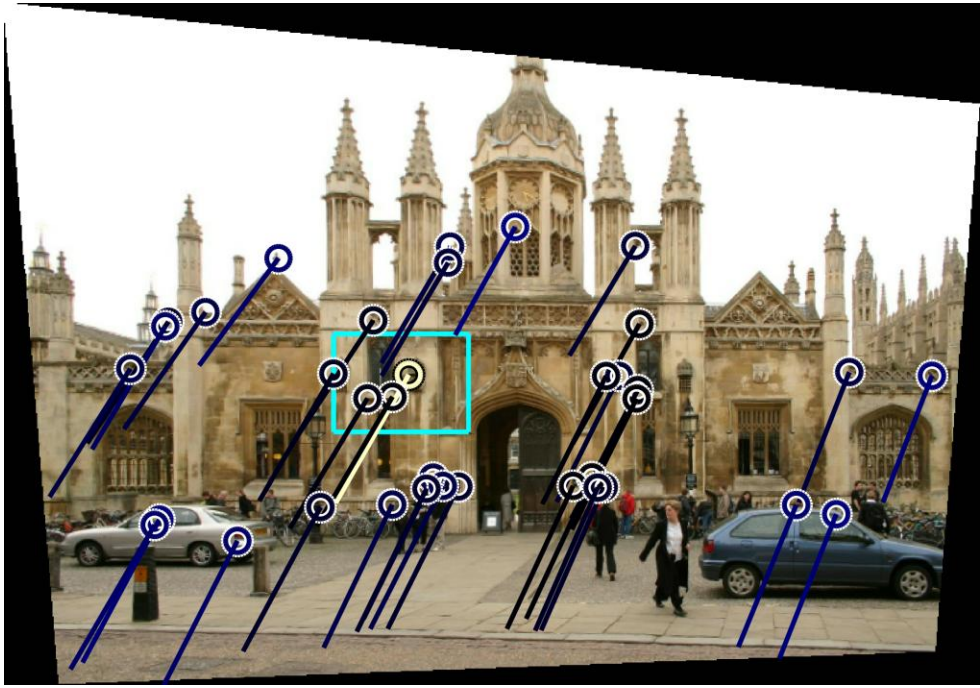

Matching

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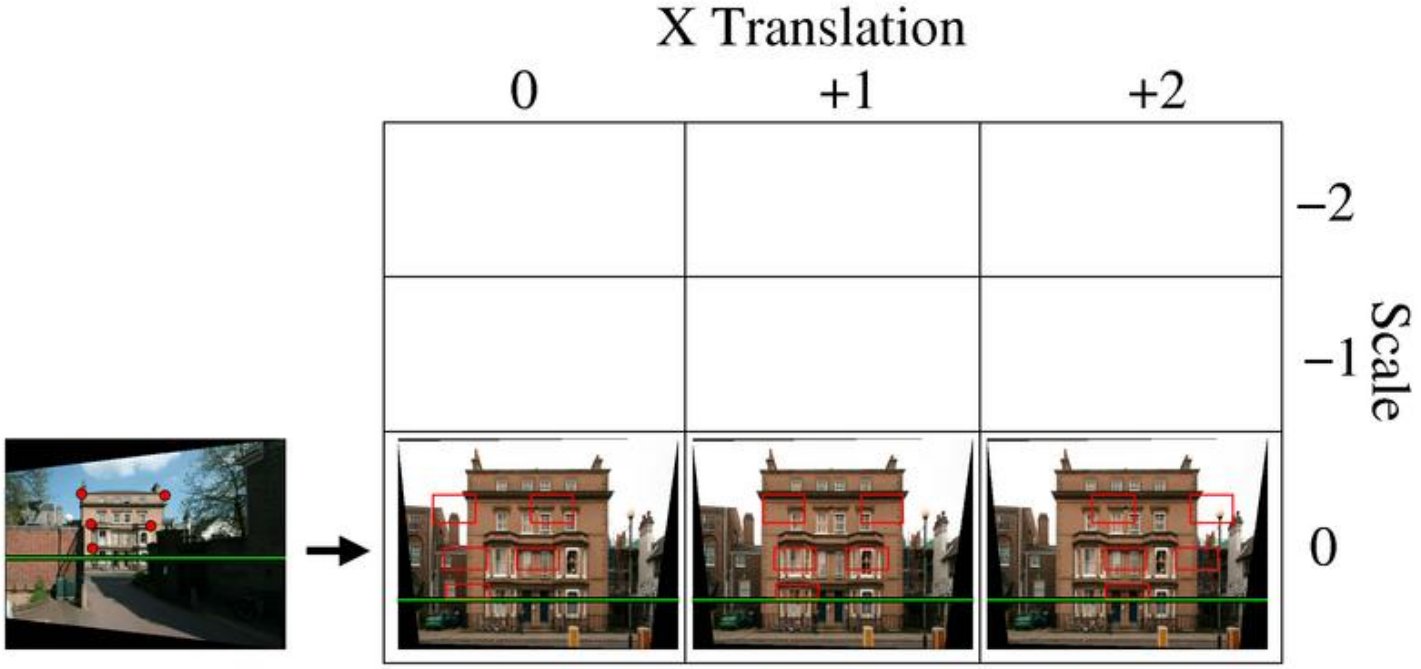
With only 2 params (s,t_x), can search rather than RANSAC.



Matching

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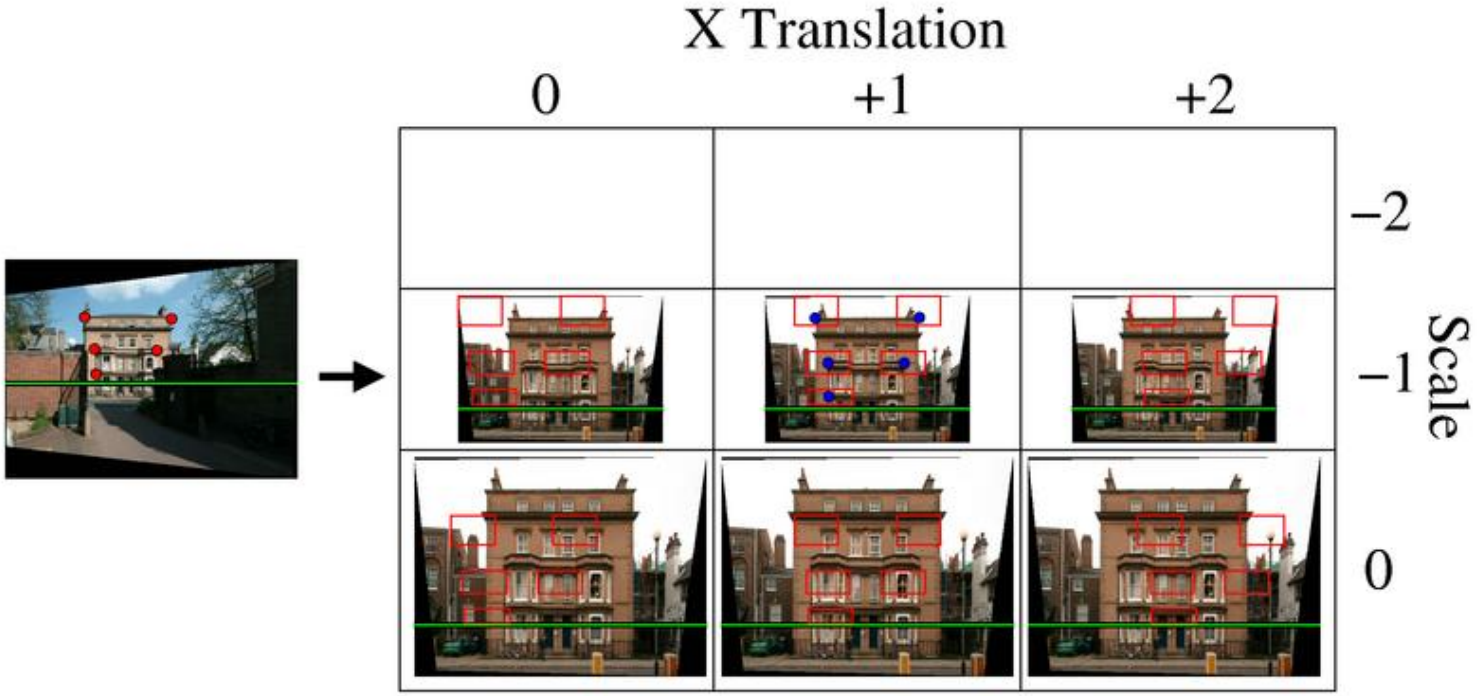

Matching

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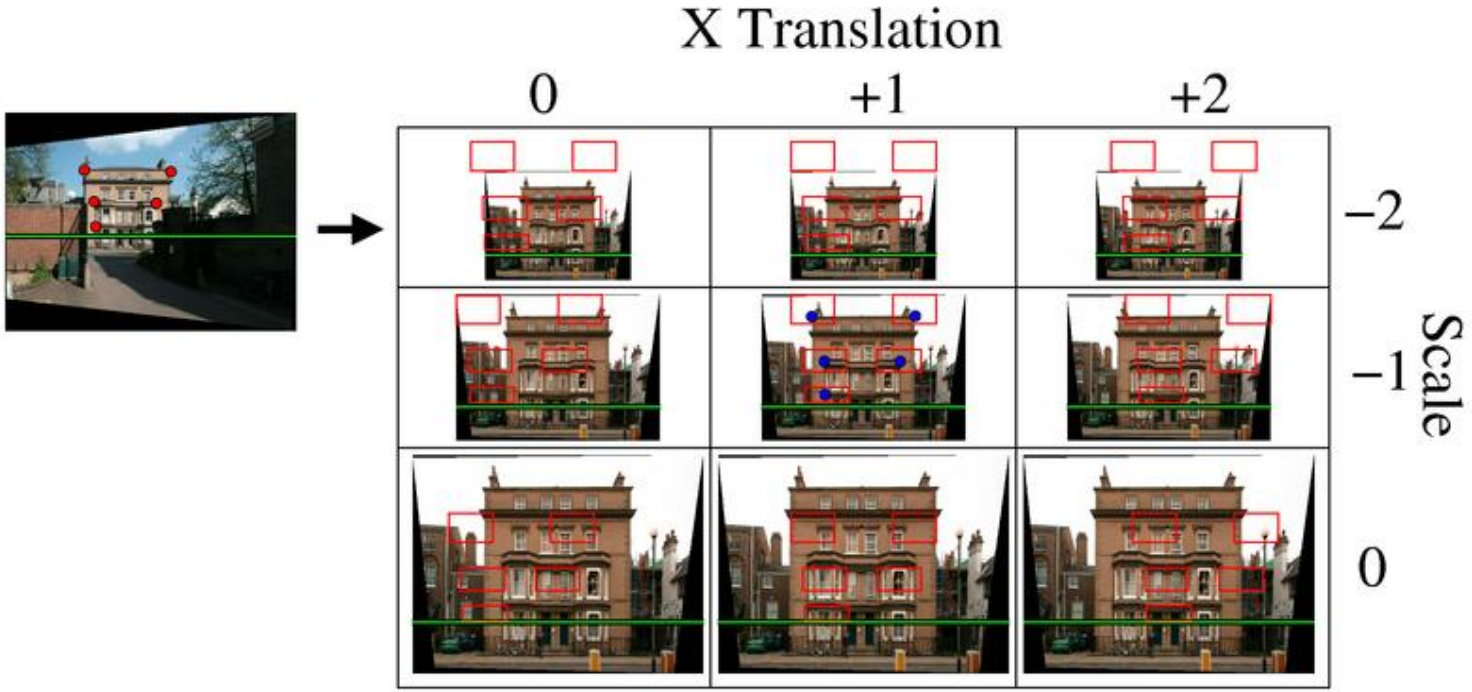

Examples over wide baselines

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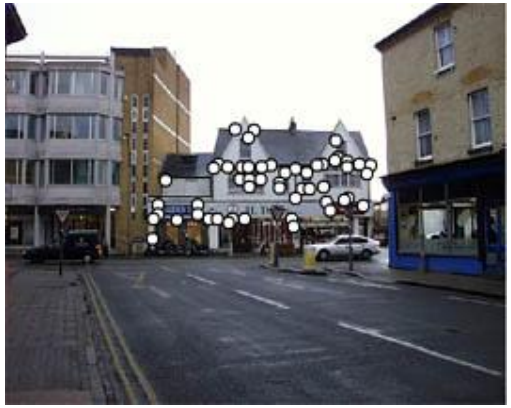

Summary of matching

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Camera pose estimation - localisation

Localisation

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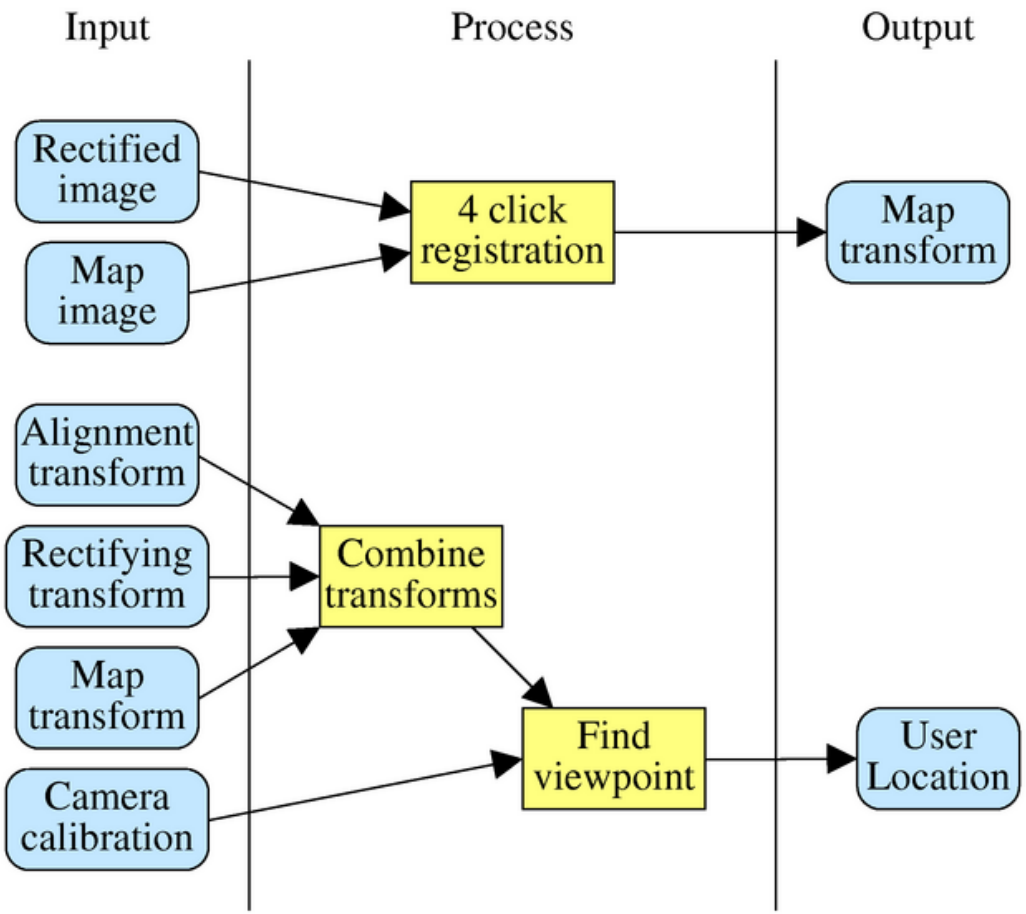

Register database view

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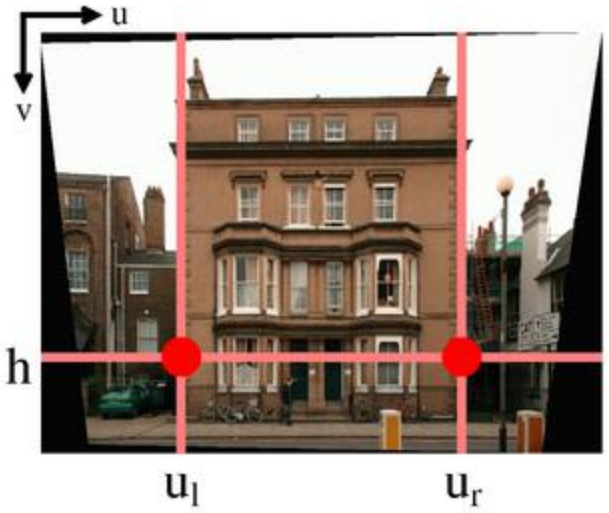
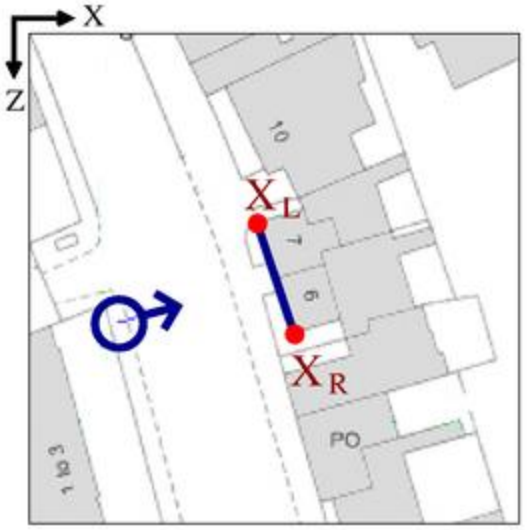
First align database view to map





Localisation

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Knowing the rectifying homography ($H_\perp$), the alignment (H_A), and the database view registration, can work backwards to find user:

Rectifying rotation $R_\perp$ gives the angle from perpendicular and focal length the distance to camera.

Localisation of query view

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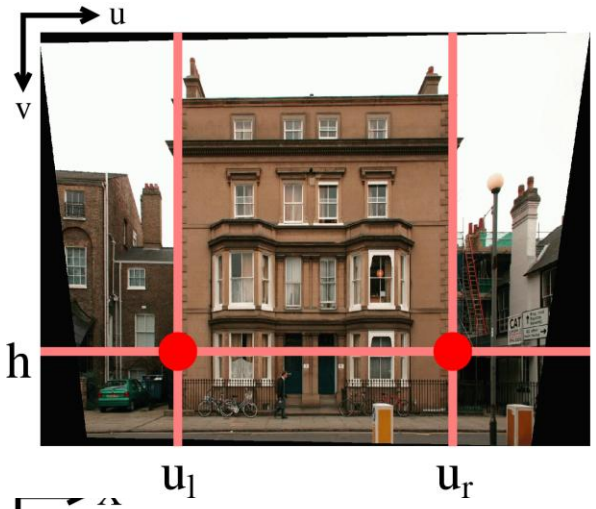

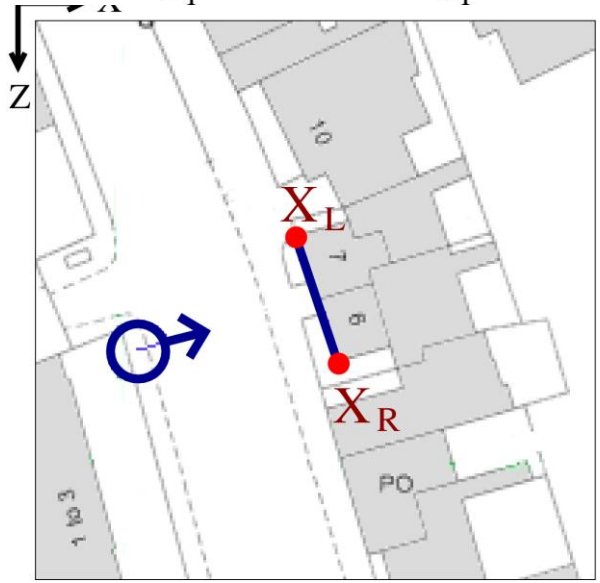

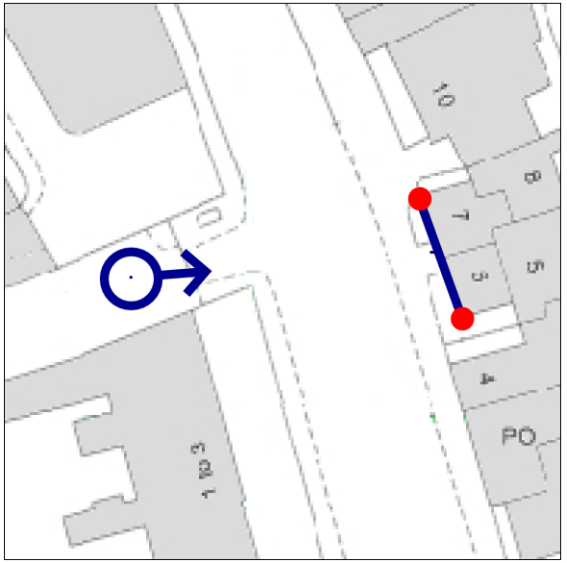

Localisation

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Summary:

- Using geometric information generic matching is reduced to a 2 DOF search problem
- We are also able to find the camera (ie user) position and orientation

Evaluation

Evaluation

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Evaluation

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Image-based localisation

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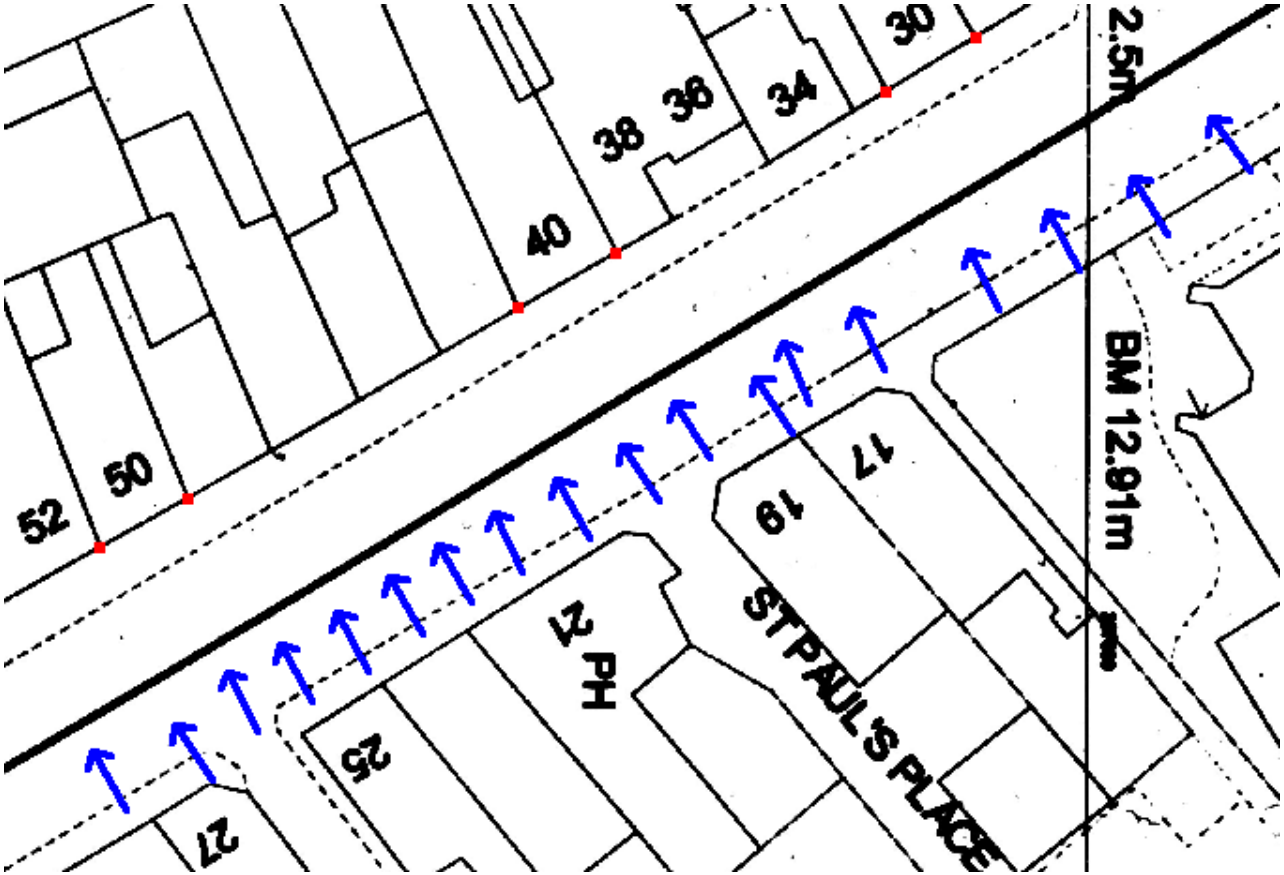

Image-based localisation

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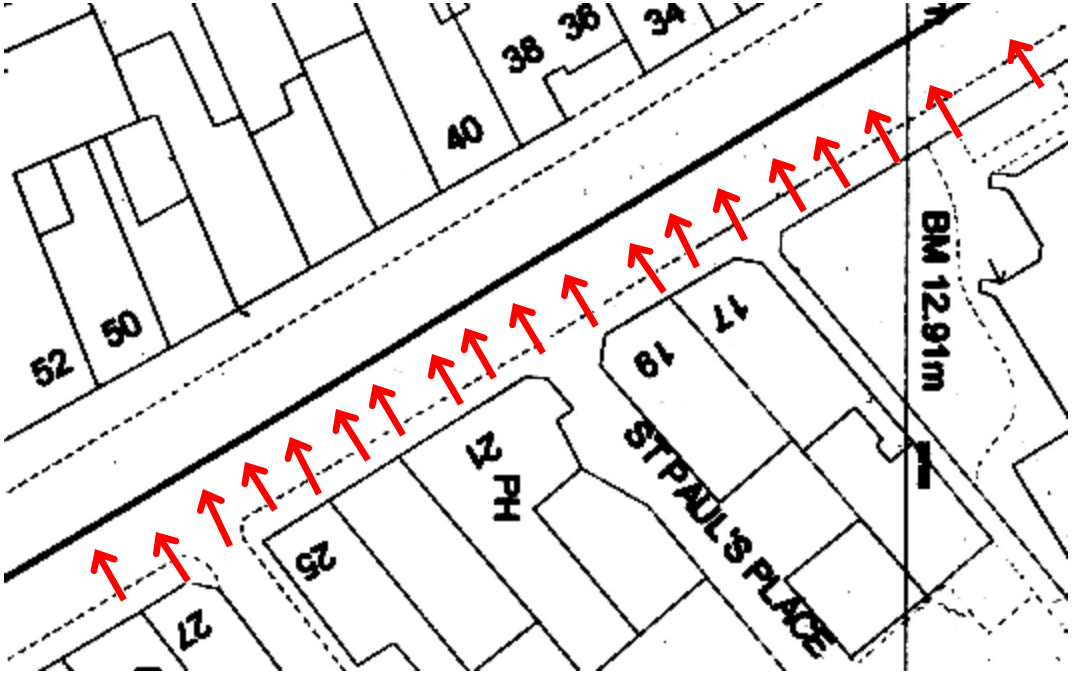

Image-based localisation

UNIVERSITY OF CAMBRIDGE

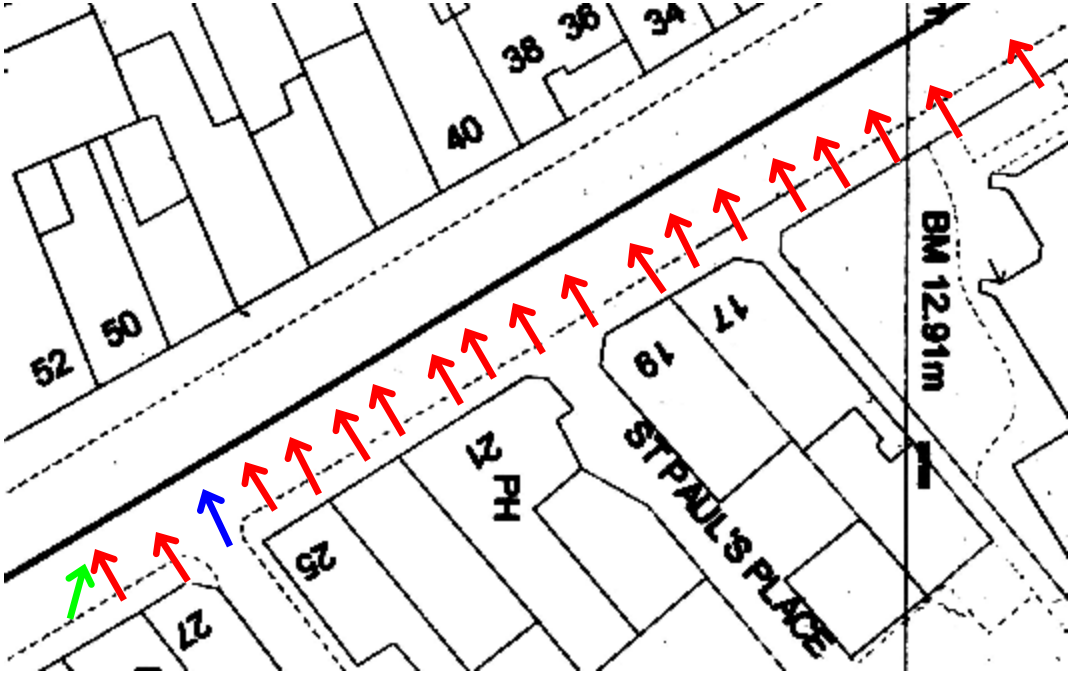

Image-based localisation

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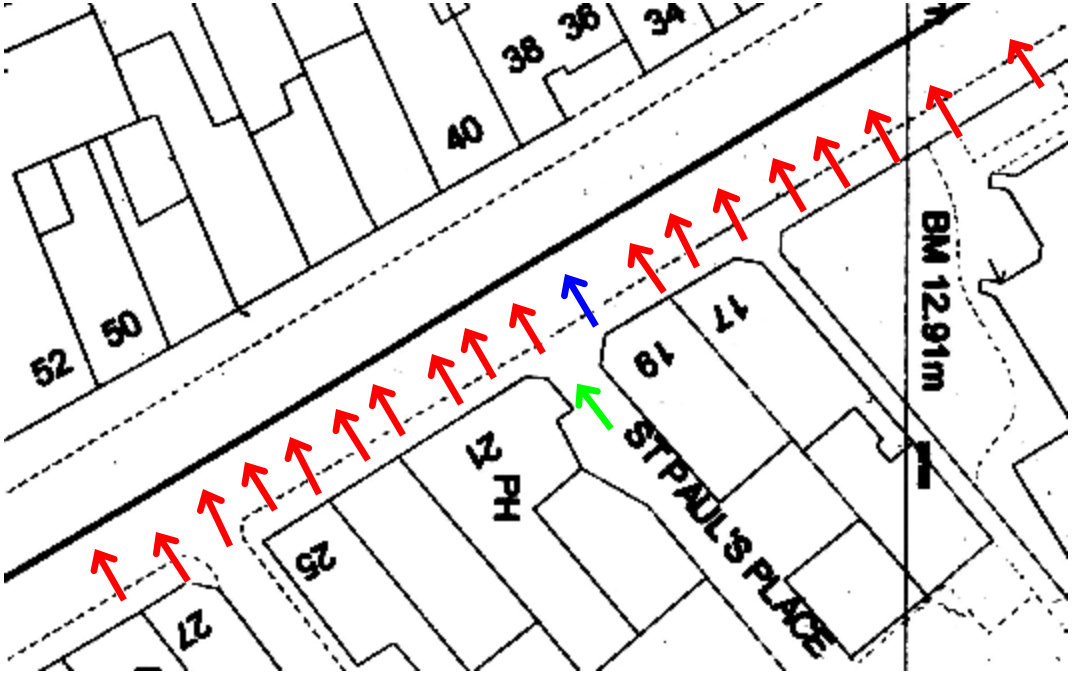

Image-based localisation

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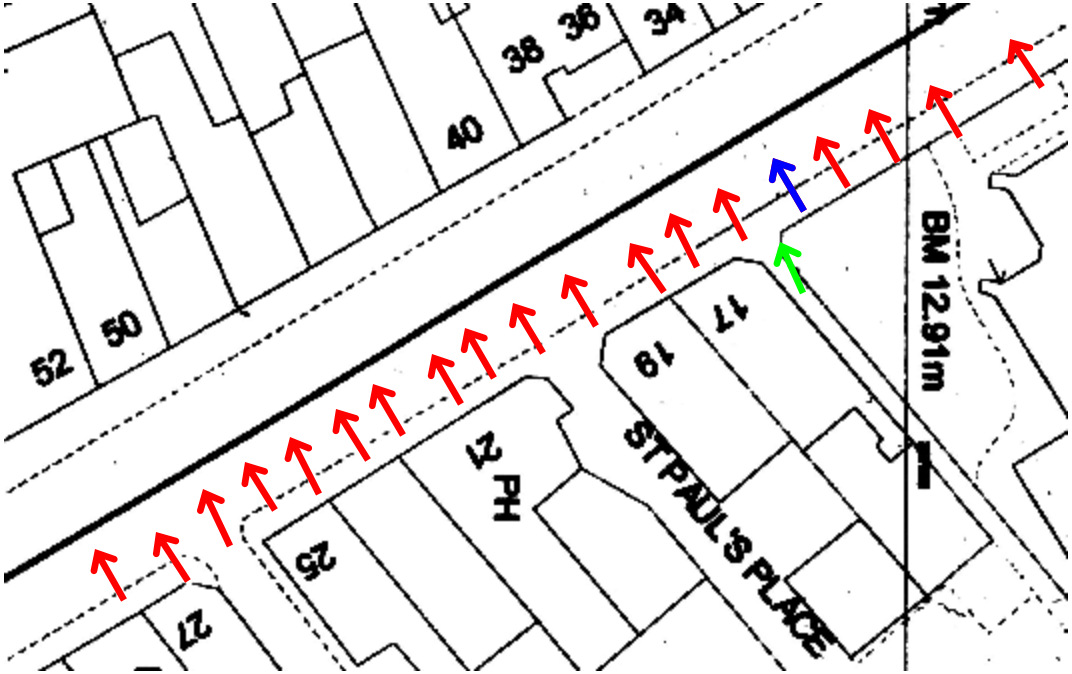

Conclusions

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- Effective wide baseline matching and image registration
- Mobile phone localisation:
  - Where am I?
  - What am I looking at?
- Scaling up to real applications?
- Technology is ripe for adaptation and exploitation

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Perspective projection

Perspective projection

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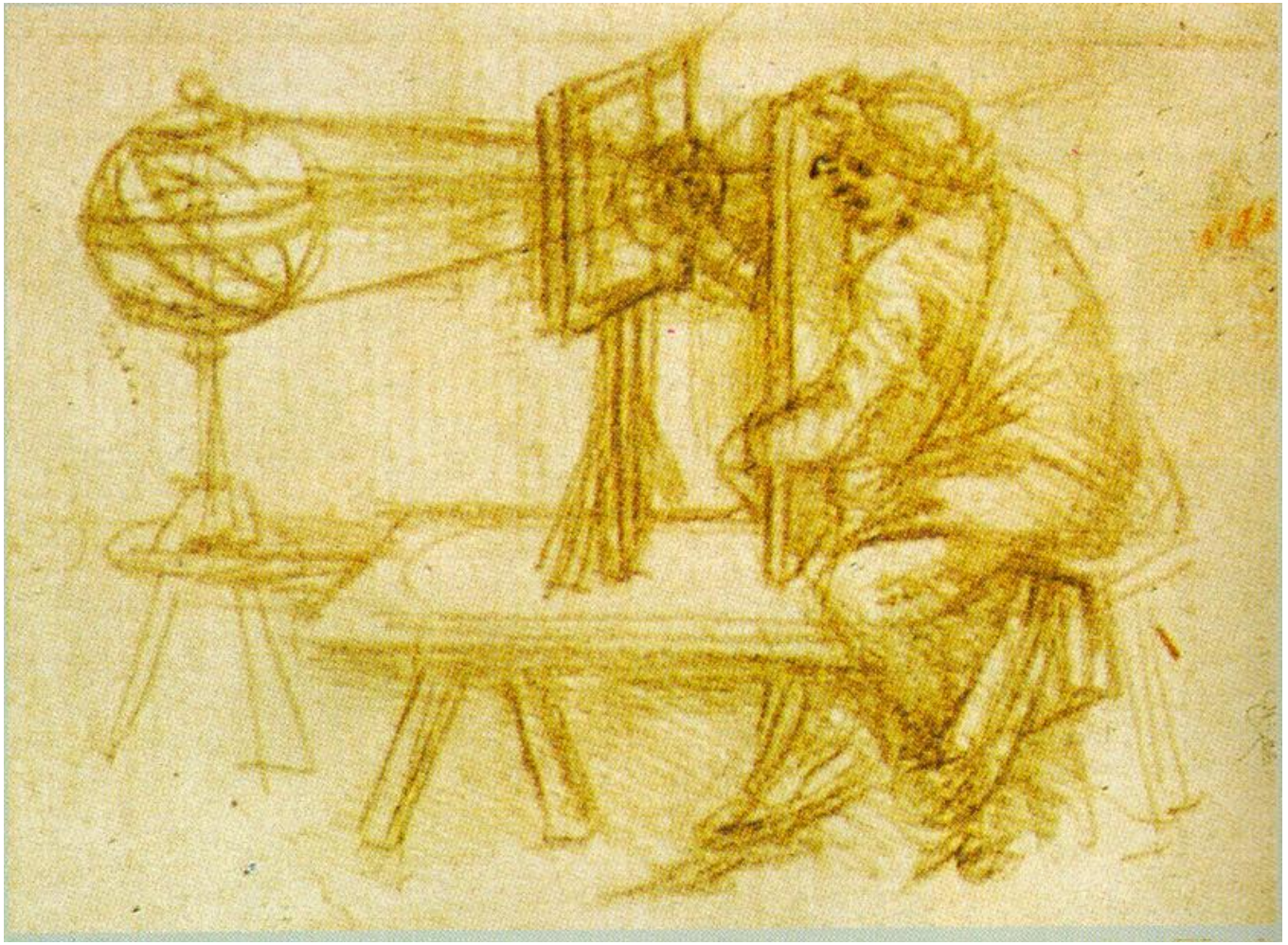

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1. 3D shape from uncalibrated images

3D model acquisition

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Photorealistic models from uncalibrated images of architectural scenes

Ambiguity in a single view

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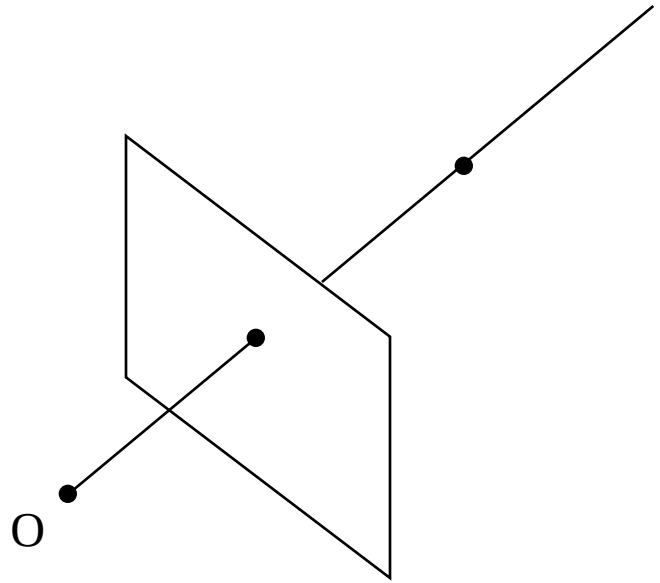

$$\begin{bmatrix} \lambda u \\ \lambda v \\ \lambda \end{bmatrix} = \mathrm{K}\begin{bmatrix} \mathrm{R} & \mathrm{T} \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

Stereo vision

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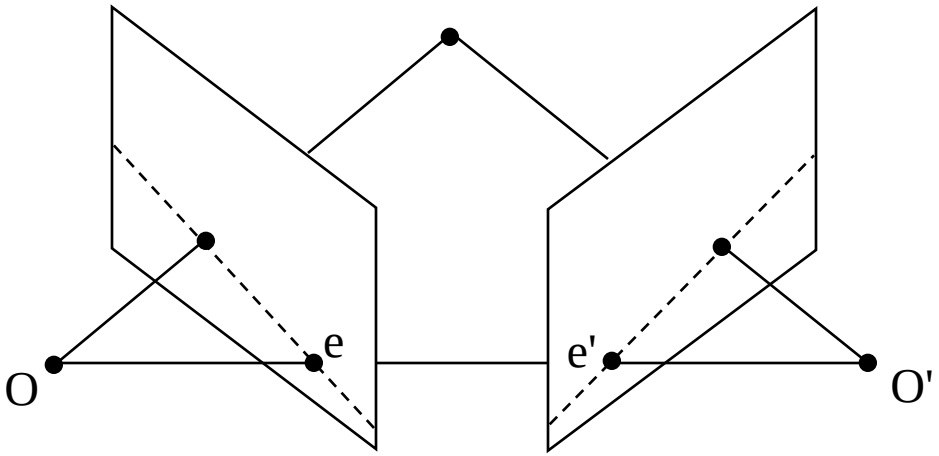

$$\begin{bmatrix} \lambda u \\ \lambda v \\ \lambda \end{bmatrix} = \mathrm{K}\begin{bmatrix} \mathrm{R} & \mathrm{T} \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} \qquad \begin{bmatrix} \lambda u' \\ \lambda v' \\ \lambda \end{bmatrix} = \mathrm{K}'\begin{bmatrix} \mathrm{R}' & \mathrm{T}' \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

Epipolar geometry

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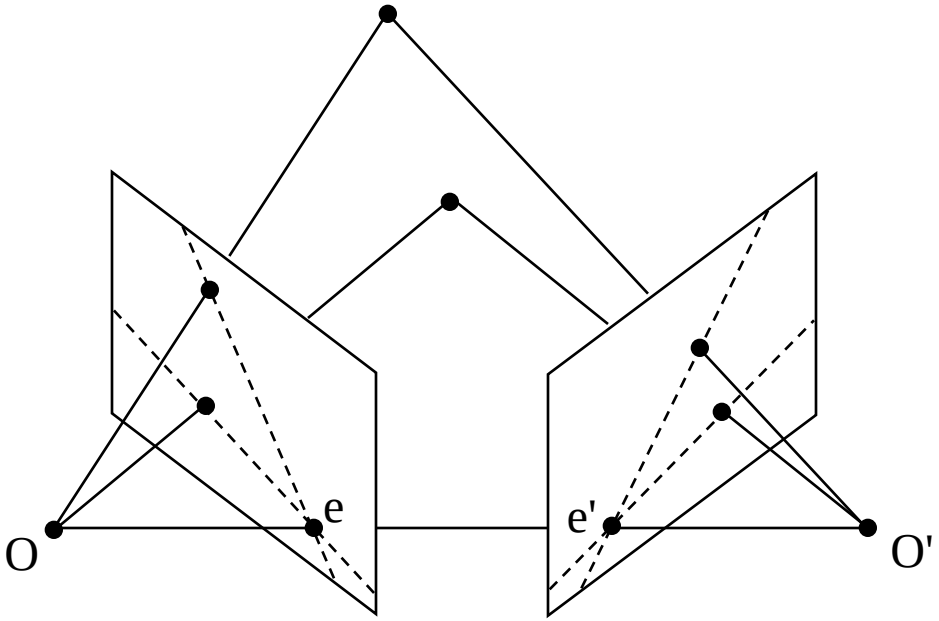

$$\begin{bmatrix} u' & v' & 1 \end{bmatrix} \begin{bmatrix} & \mathrm{F} & \\ & & \end{bmatrix} \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = 0$$

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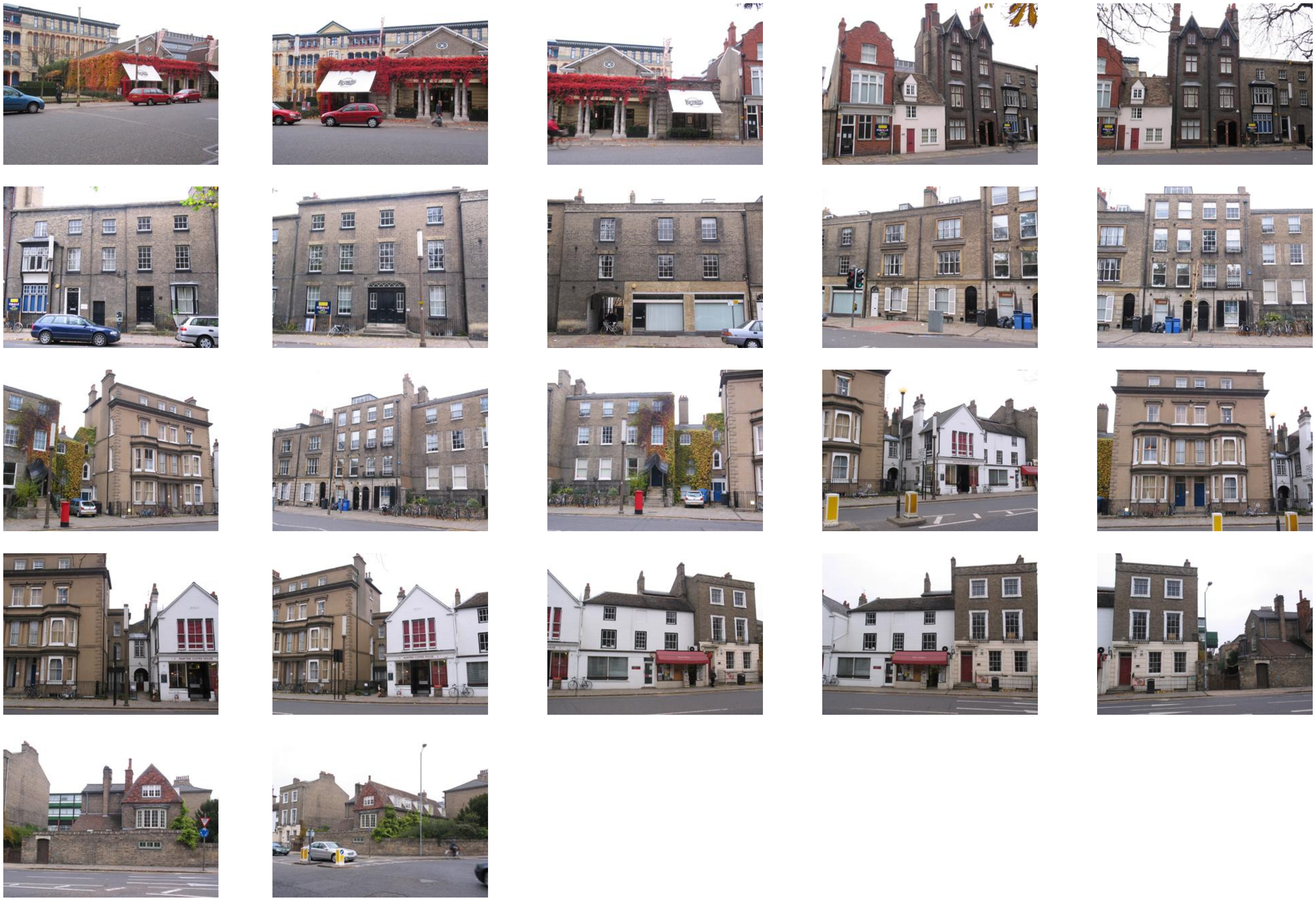
Trumpington Street Data



Camera pose determination

3D reconstruction

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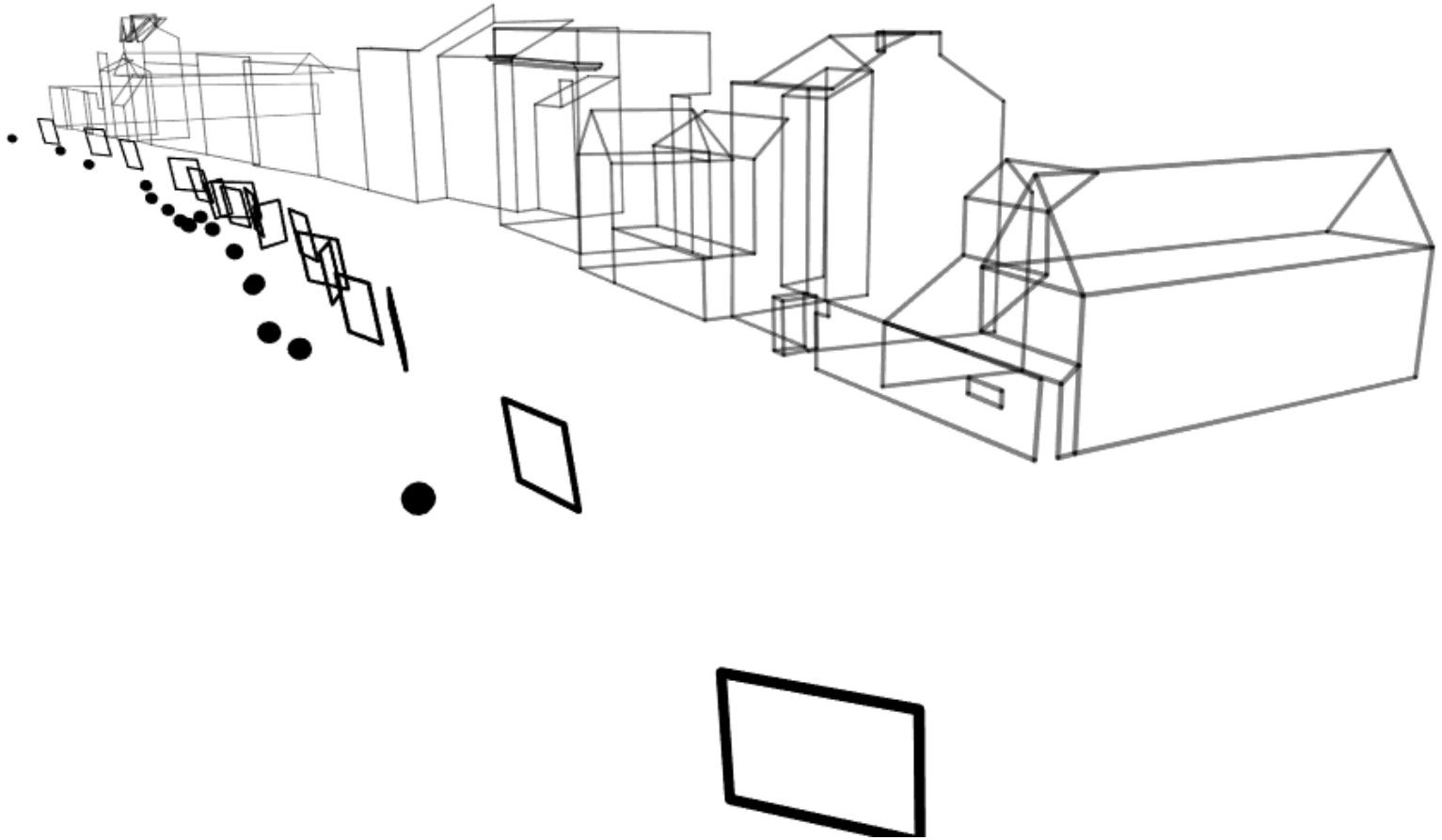

Reconstruction texture mapped

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Conclusions

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- Mobile phone localisation
- Technology is ripe for adaptation and exploitation