3D Model Acquisition from Uncalibrated Images

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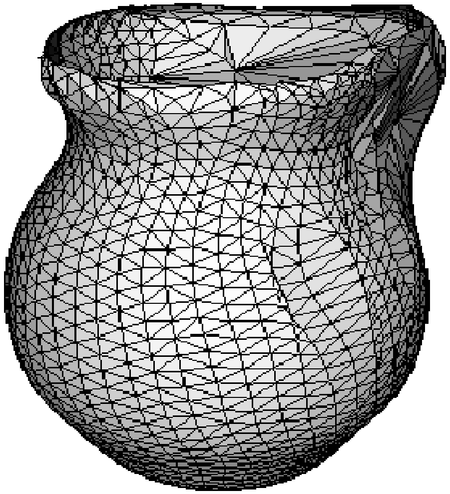
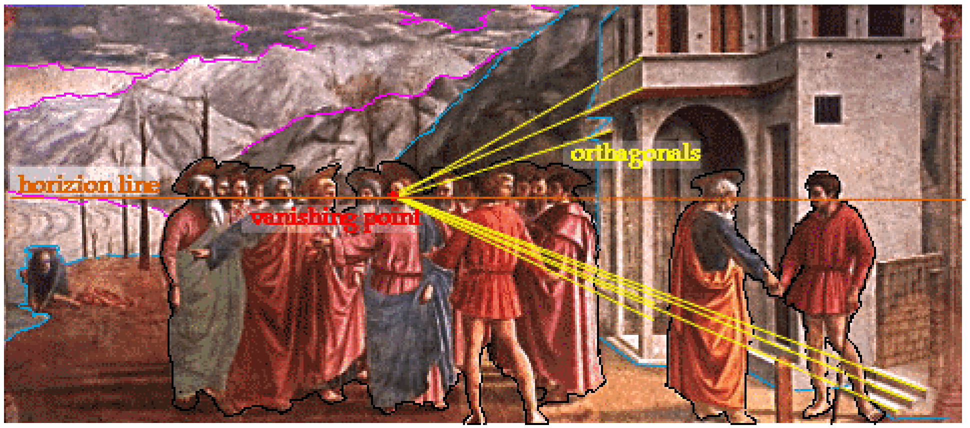
Aim

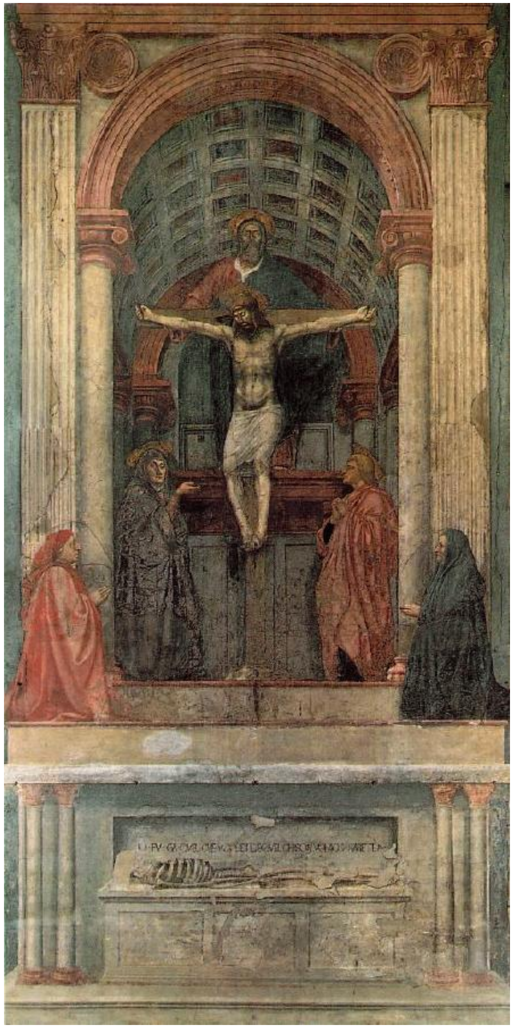
Photorealistic models from uncalibrated images of architectural scenes

Model acquisition under circular motion

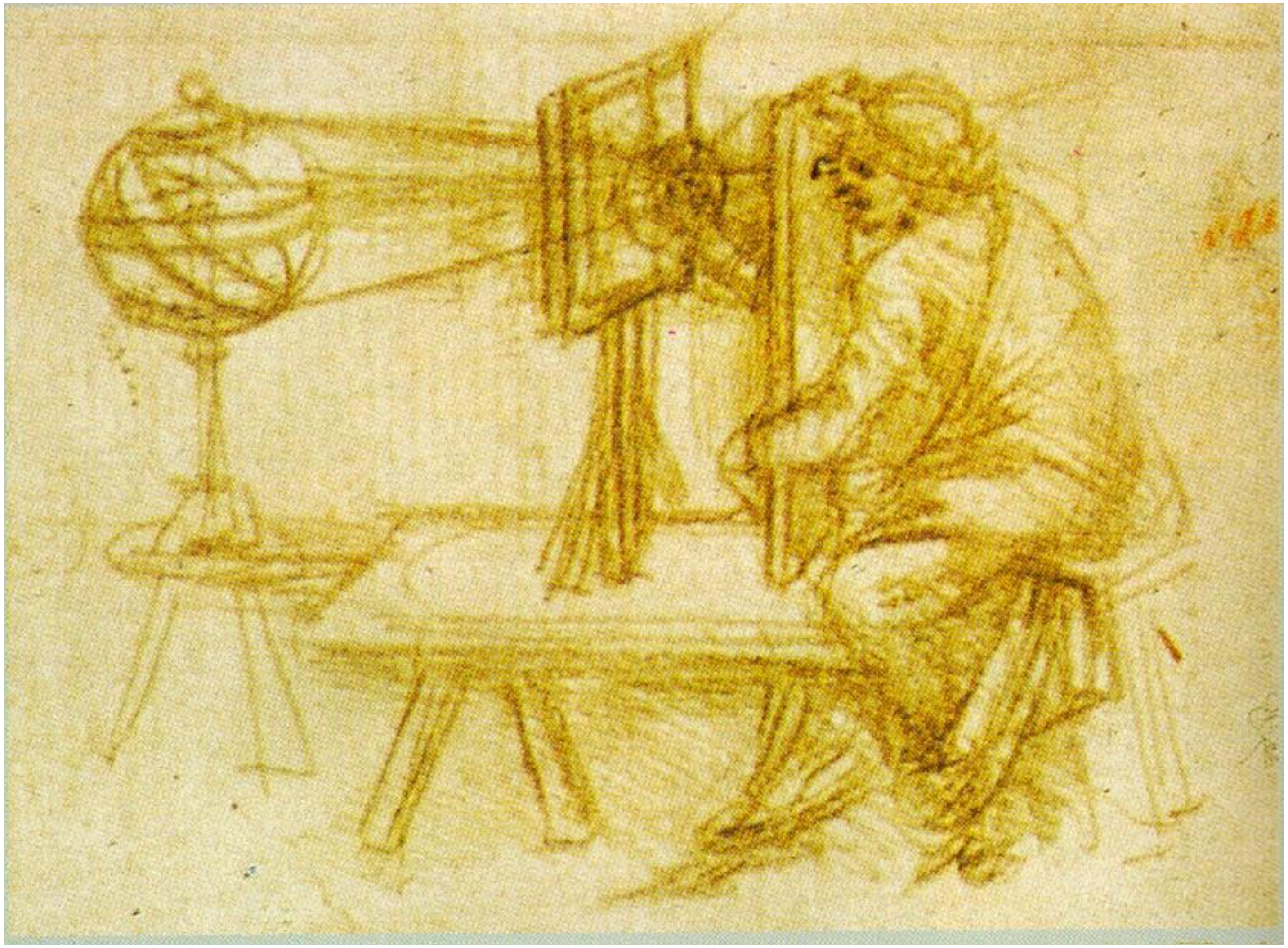



orthagonals
horizion line
vanishing point

Vanishing points



Shape from profile



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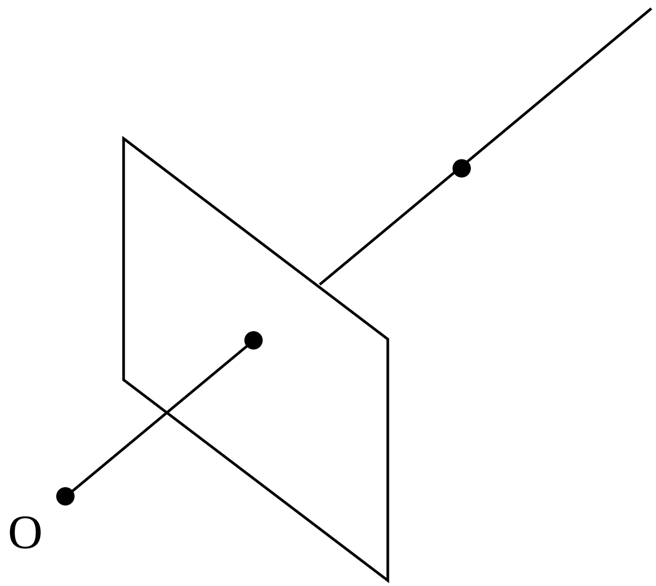
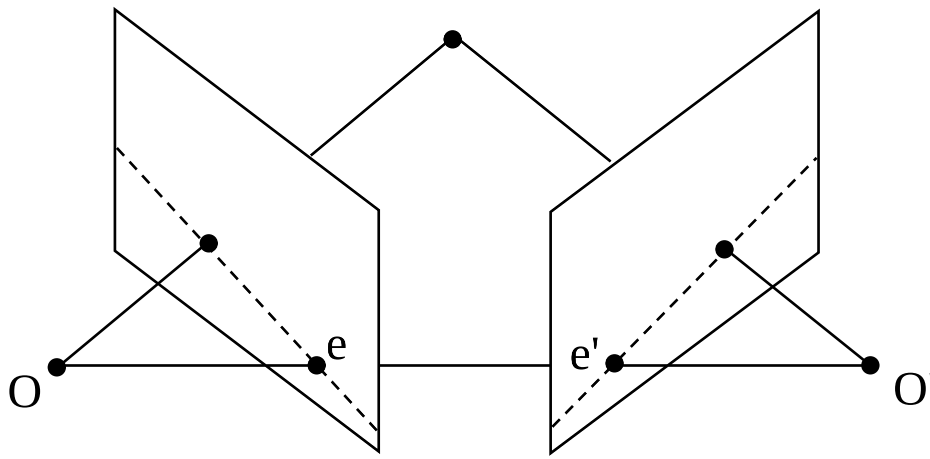
Review: Projection matrix



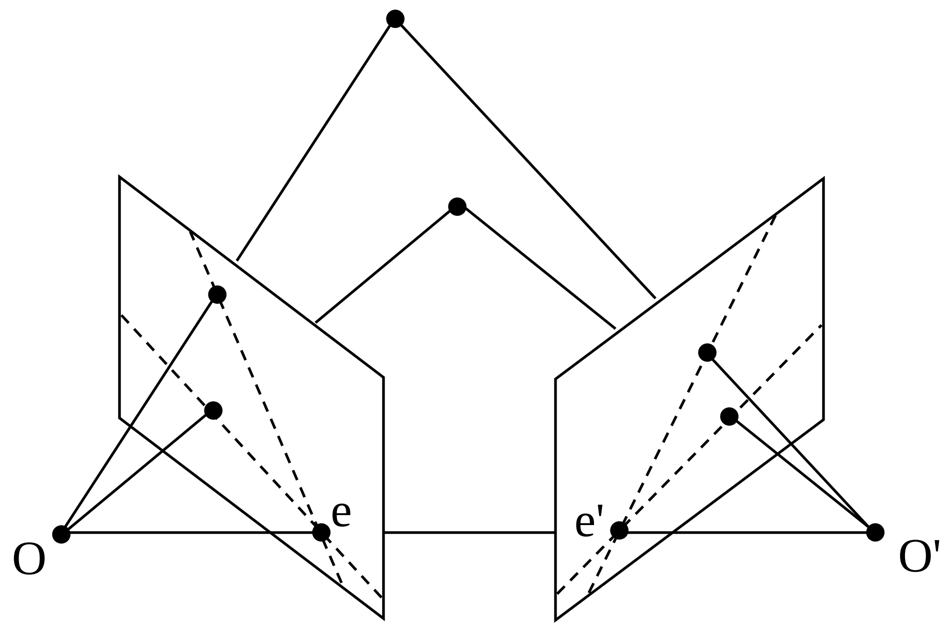
$$\begin{bmatrix} \lambda u \\ \lambda v \\ \lambda \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ p_{31} & p_{32} & p_{33} & p_{34} \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} = \begin{bmatrix} k_u & 0 & u_0 \\ 0 & k_v & v_0 \\ 0 & 0 & 1 \end{bmatrix} \left[\begin{array}{c|c} R & T \end{array} \right] \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

Review: Stereo vision and triangulation



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

Review: Fundamental Matrix and Epipolar Geometry



$$\begin{bmatrix} u & v & 1 \end{bmatrix} \begin{bmatrix} & & \\ & F & \\ & & \end{bmatrix} \begin{bmatrix} u' \\ v' \\ 1 \end{bmatrix} = 0 \quad \textbf{where} \quad F = C^{-T} E C'^{-1}$$

Review: Self-calibration experiments

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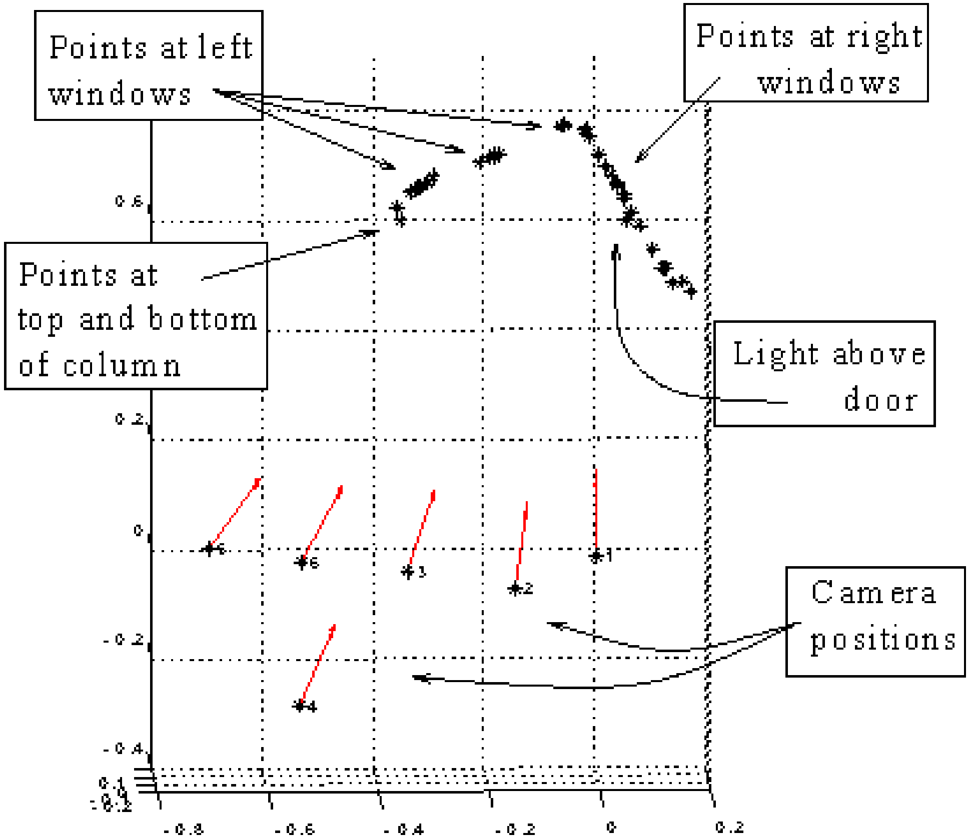
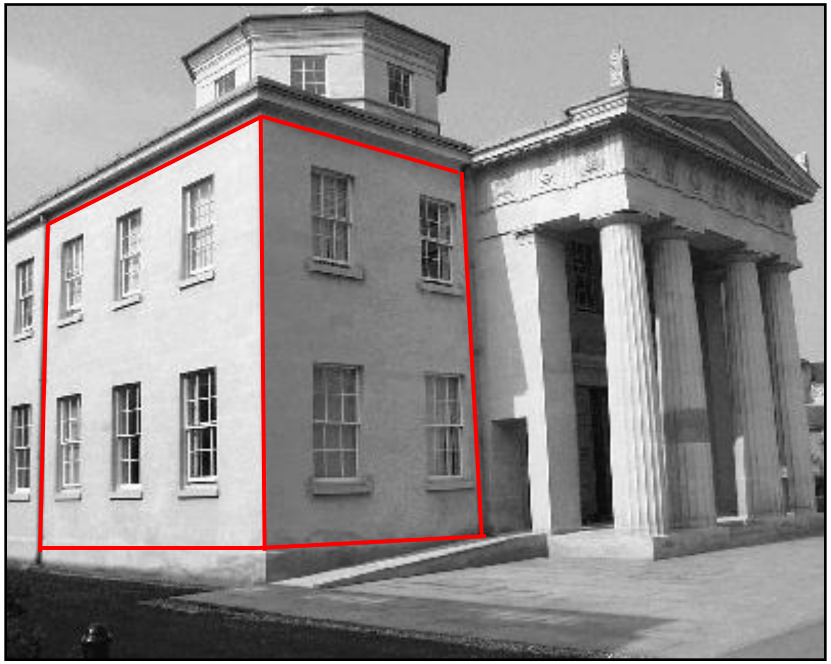
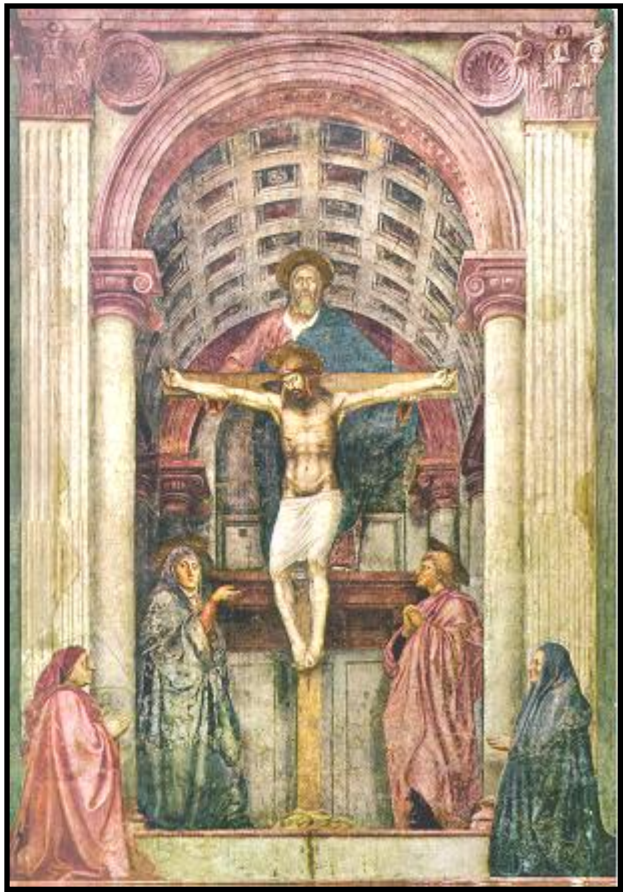


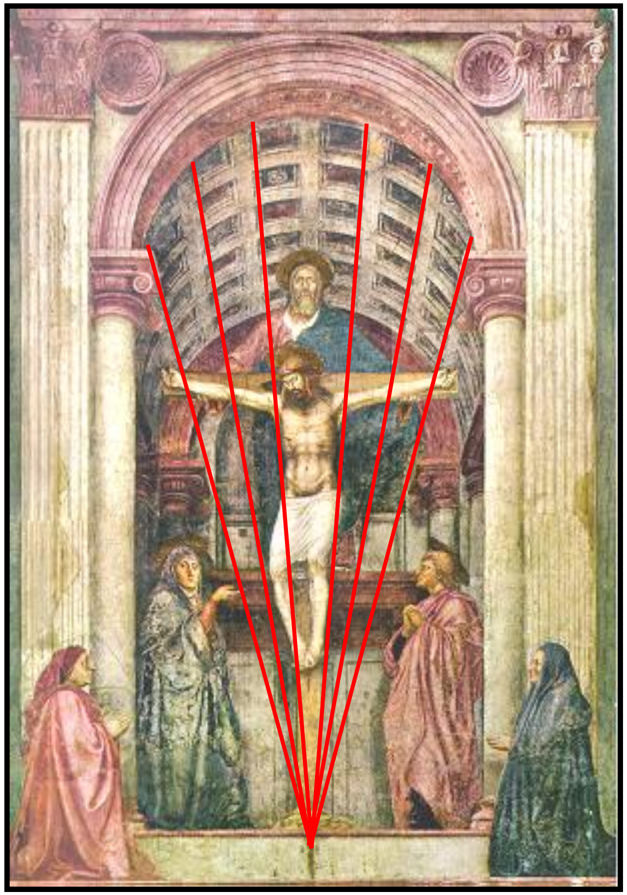
Parallelism and orthogonality constraints



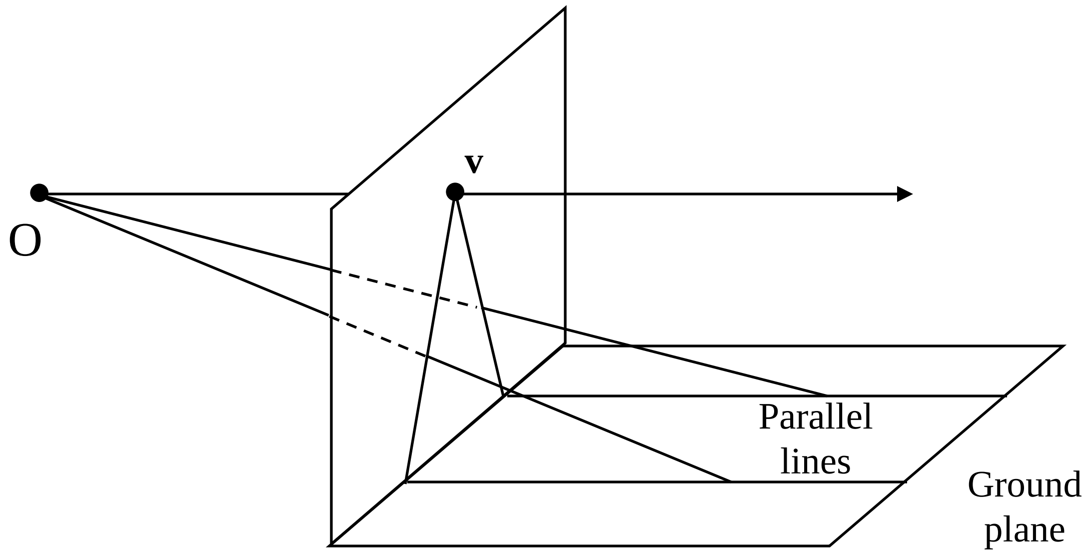
Vanishing Points



Vanishing Points



Vanishing Points



Projection Matrix from vanishing points

$$\begin{bmatrix} \lambda_1 u_1 \\ \lambda_1 v_1 \\ \lambda_1 \end{bmatrix} = \begin{bmatrix} & & P & & \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Projection Matrix from vanishing points

$$\begin{bmatrix} \lambda_1 u_1 & \lambda_2 u_2 \\ \lambda_1 v_1 & \lambda_2 v_2 \\ \lambda_1 & \lambda_2 \end{bmatrix} = \begin{bmatrix} & & & \\ & & P & \\ & & & \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$$

Projection Matrix from vanishing points

$$\begin{bmatrix} \lambda_1 u_1 & \lambda_2 u_2 & \lambda_3 u_3 \\ \lambda_1 v_1 & \lambda_2 v_2 & \lambda_3 v_3 \\ \lambda_1 & \lambda_2 & \lambda_3 \end{bmatrix} = \begin{bmatrix} & & & \\ & & P & \\ & & & \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}$$

The camera position

$$\begin{bmatrix} \lambda_1 u_1 & \lambda_2 u_2 & \lambda_3 u_3 & \lambda_4 u_4 \\ \lambda_1 v_1 & \lambda_2 v_2 & \lambda_3 v_3 & \lambda_4 v_4 \\ \lambda_1 & \lambda_2 & \lambda_3 & \lambda_4 \end{bmatrix} = \begin{bmatrix} & & \\ & P & \\ & & \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Calibration

$$\begin{bmatrix} u_1 & u_2 & u_3 \\ v_1 & v_2 & v_3 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} \lambda_1 & 0 & 0 \\ 0 & \lambda_2 & 0 \\ 0 & 0 & \lambda_3 \end{bmatrix} = C[R]$$

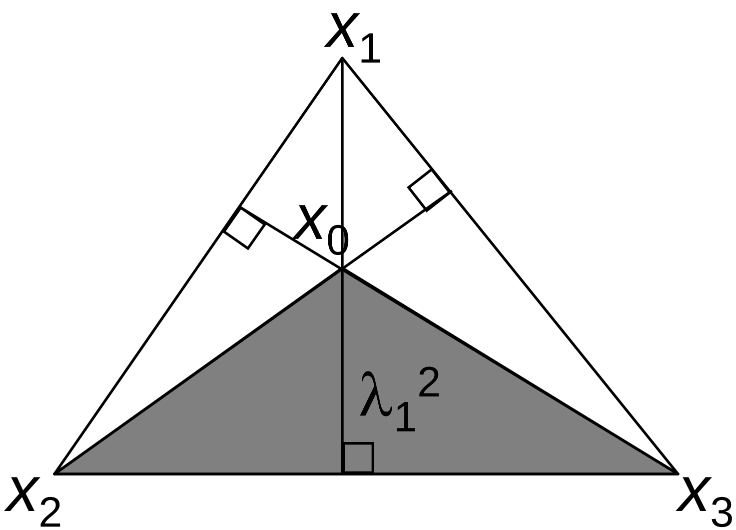
$$\begin{bmatrix} u_1 & u_2 & u_3 \\ v_1 & v_2 & v_3 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} \lambda_1{}^2 & 0 & 0 \\ 0 & \lambda_2{}^2 & 0 \\ 0 & 0 & \lambda_3{}^2 \end{bmatrix} \begin{bmatrix} u_1 & u_2 & u_3 \\ v_1 & v_2 & v_3 \\ 1 & 1 & 1 \end{bmatrix}^T = CC^T$$

Computing the optical centre

$$x_i = \begin{pmatrix} u_i \\ v_i \end{pmatrix}$$

Column orthonormality: $$(x_1 - x_0)\cdot(x_3 - x_2) = 0$$

Row orthonormality: $$\lambda_1^2 = \frac{(x_2 - x_3)\times(x_0 - x_3)}{(x_2 - x_3)\times(x_1 - x_3)}$$



x_0 is ortho-centre

$\lambda_1{}^2$ is normalised shaded area

Fixing the camera positions and epipoles

$$\begin{bmatrix} & & \\ & P & \\ & & \end{bmatrix} = \begin{bmatrix} \lambda_1 u_1 & \lambda_2 u_2 & \lambda_3 u_3 & \lambda_4 u_4 \\ \lambda_1 v_1 & \lambda_2 v_2 & \lambda_3 v_3 & \lambda_4 v_4 \\ \lambda_1 & \lambda_2 & \lambda_3 & \lambda_4 \end{bmatrix}$$

Original uncalibrated images

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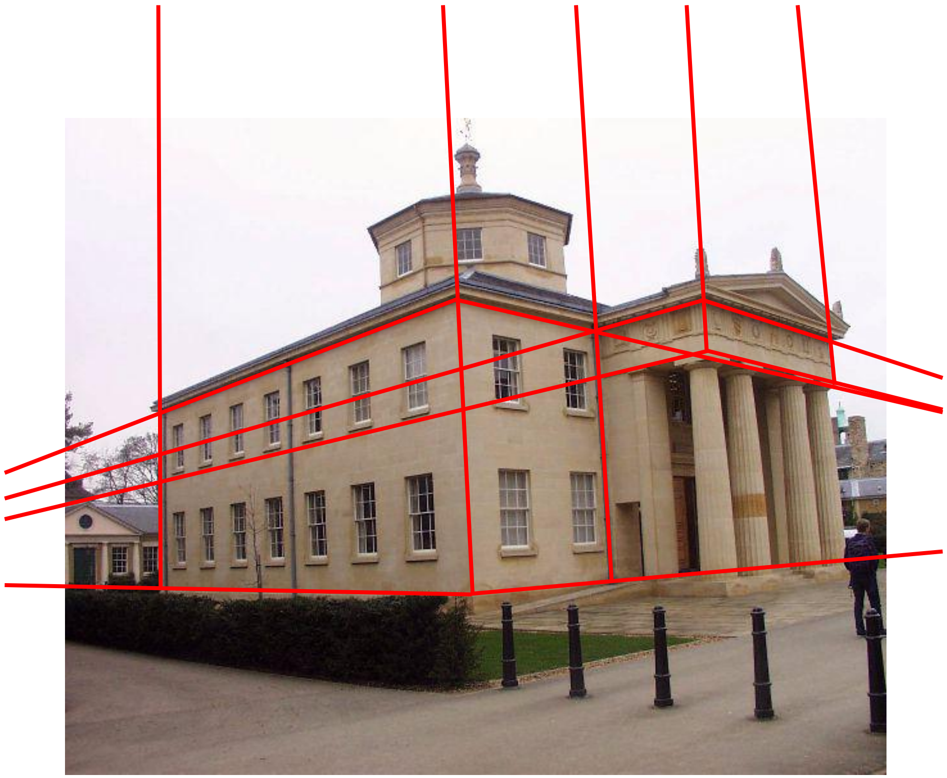
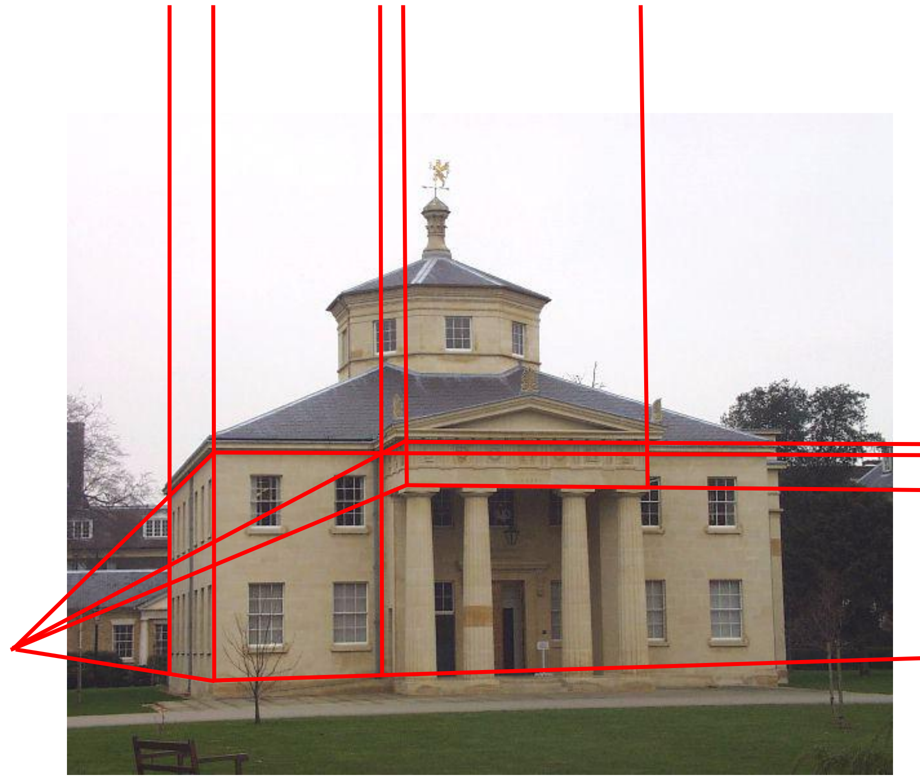
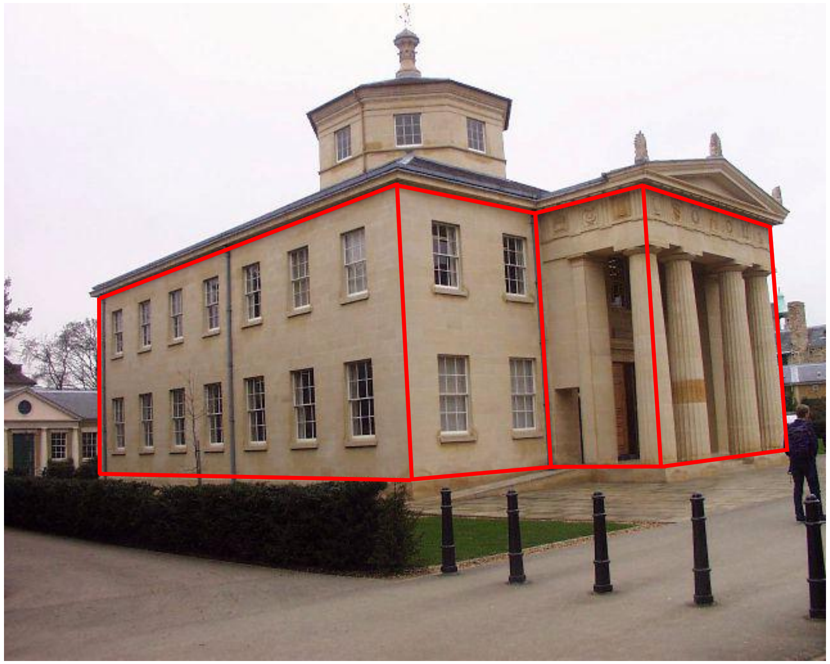
Primitive definition and localisation

Vanishing point location

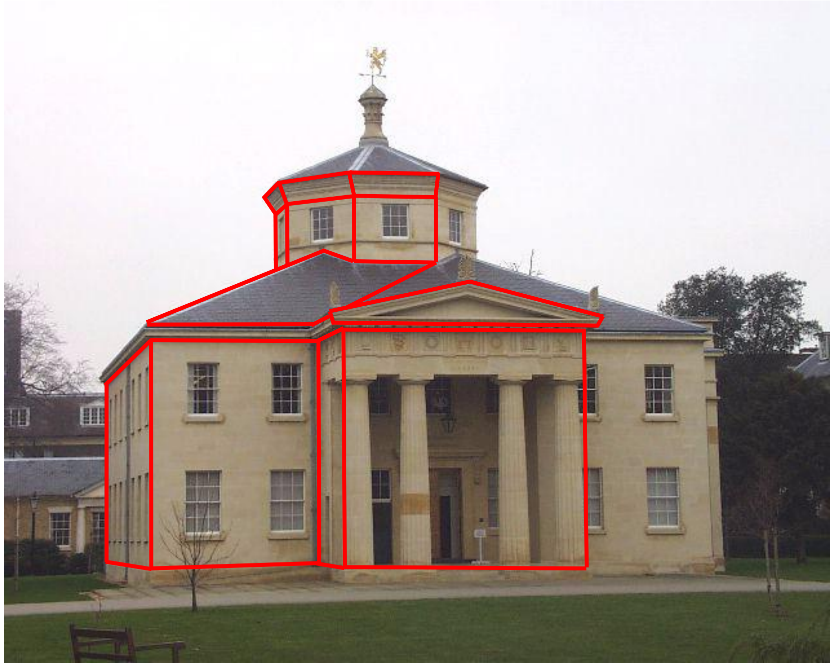




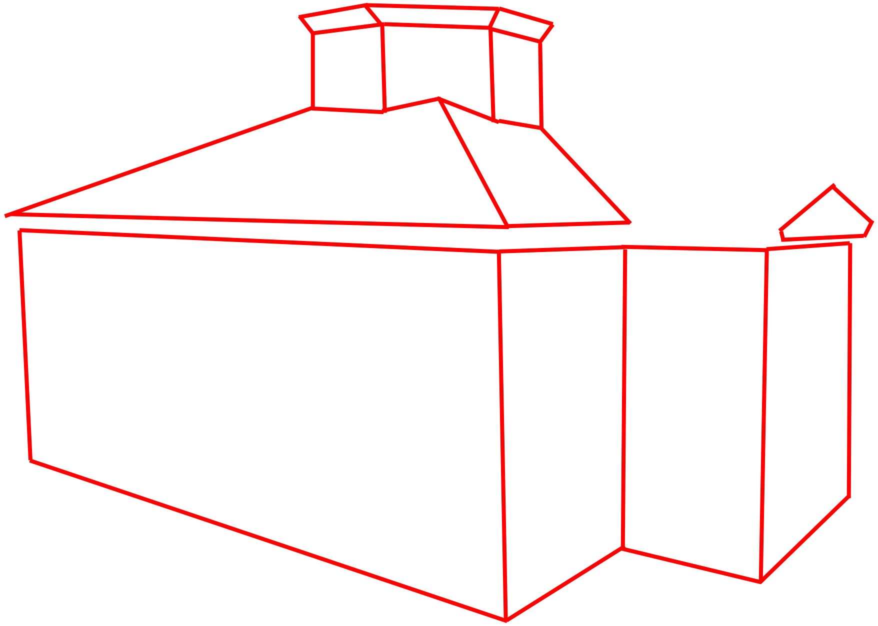
Location of corresponding polygons



Location of corresponding polygons



Wireframe reconstruction



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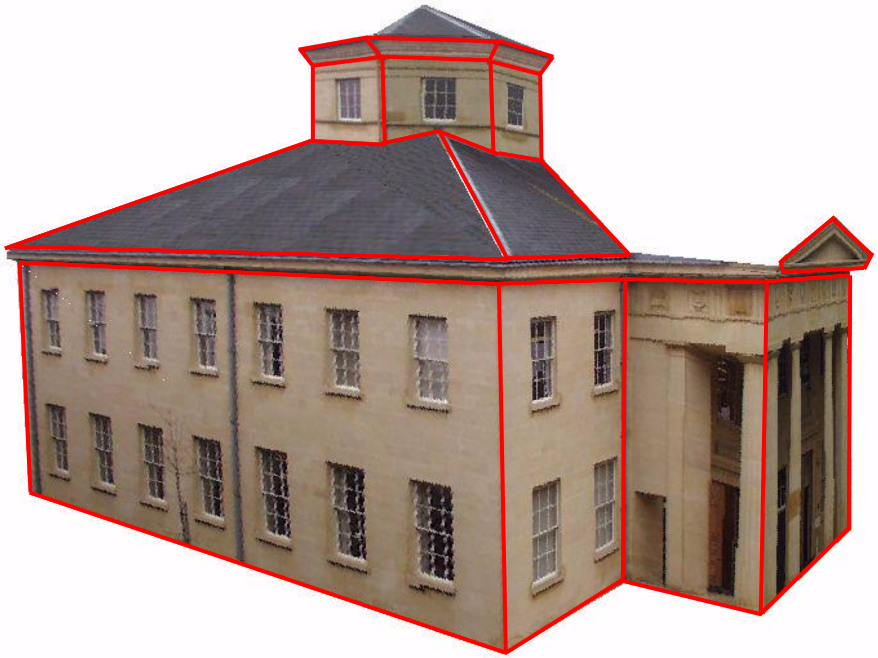
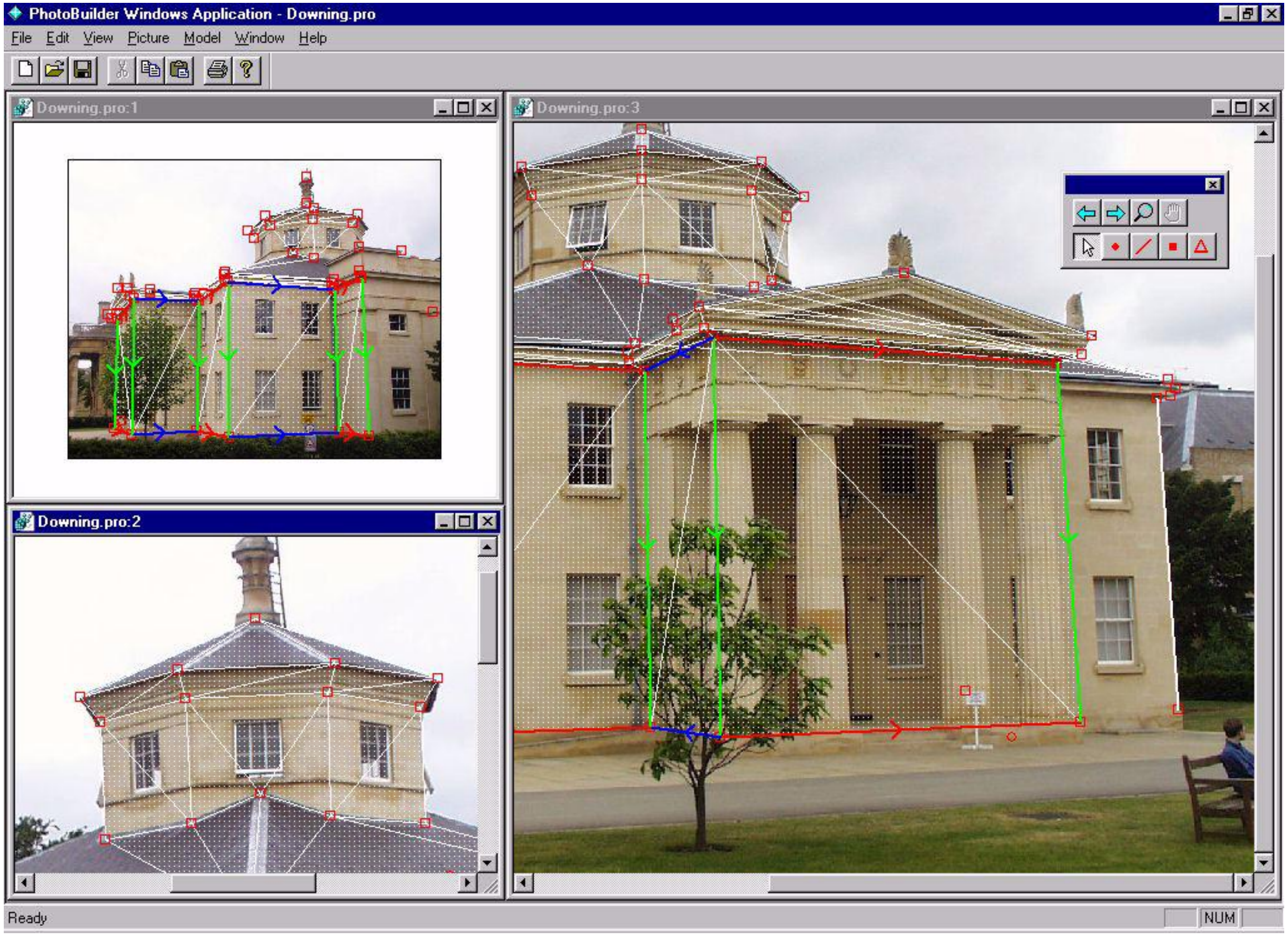
Wireframe reconstruction

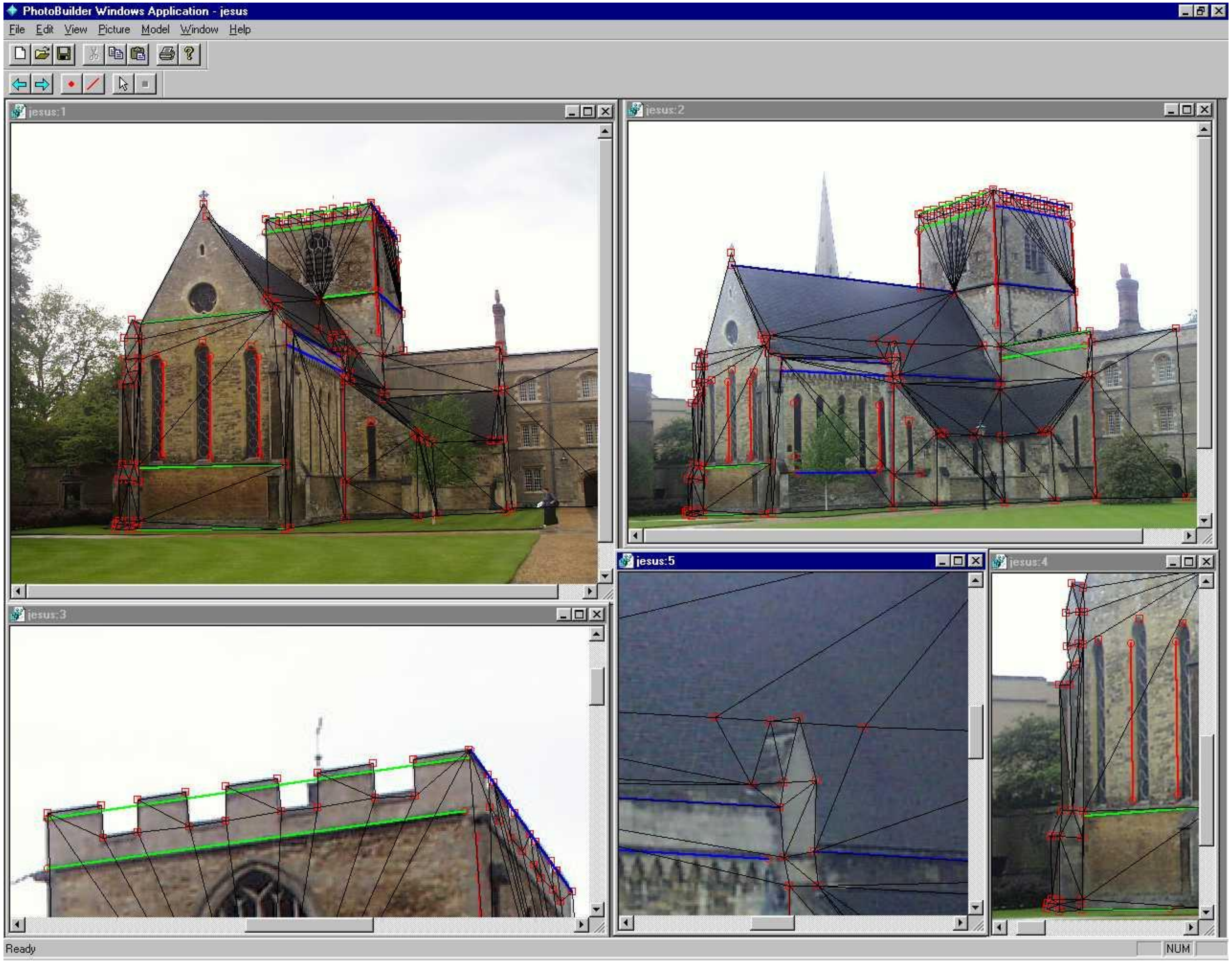


PhotoBuilder for Microsoft Windows™



Multiple views and ray bundle adjustment

PhotoBuilder for Microsoft Windows™



PhotoBuilder for Microsoft Windows™

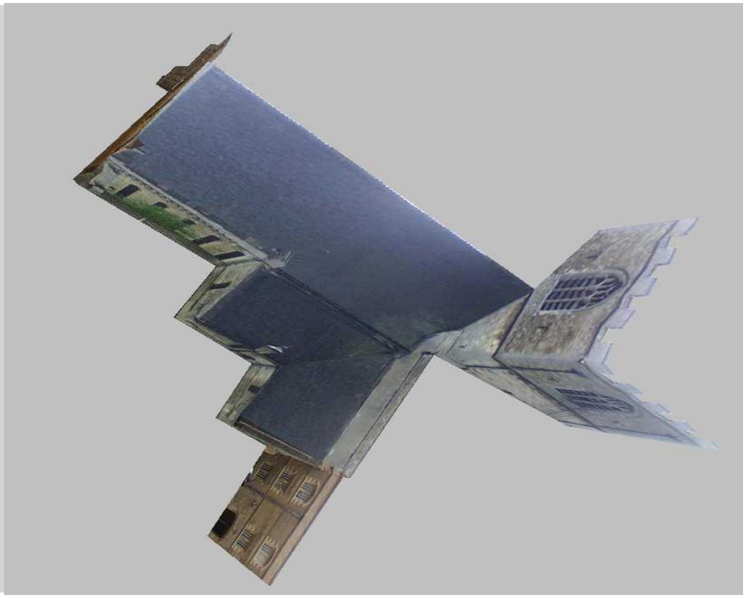


Image matching and mosaicing

Image matching

Removing outliers

Raw matches (40% outliers)

MLS Filtered matches (16% outliers)

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Mosaicing: Results

Mosaicing: Results

Summary (1)

Photorealistic models from uncalibrated images of architectural scenes