TE1 $\lambda x = PX \Rightarrow$ camera eq.

For projective transformation T,

$$X' = TX$$

$$\lambda x = \underline{PT^{-1}}\,\underline{TX} \quad (\text{since } T^{-1}T = I)$$
$$= P'X'$$

Thus a new solution with identical image projections can be obtained from TX.

TE2 The calibration matrix helps convert the image coordinates to a standard coordinate system before 3D reconstruction using principal point, focal length, skew etc.

There is no ambiguity when cameras are caliberated.

eq. :

T,

$^{-1}T = I)$

tical image
rom TX.

ps convert the
lard coordinate
using
kew etc.

neras are

TE3 KK^{-1} should be equal to I

$$\begin{pmatrix} f & 0 & x_0 \\ 0 & f & y_0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} 1/f & 0 & -x_0/f \\ 0 & 1/f & -y_0/f \\ 0 & 0 & 1 \end{pmatrix}$$

$$= \begin{bmatrix} 1 & 0 & -x_0 + x_0 = 0 \\ 0 & 1 & -y_0 + y_0 = 0 \\ 0 & 0 & 1 \end{bmatrix} = I$$

$$\begin{bmatrix} 1/f & 0 & 0 \\ 0 & 1/f & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 & -x_0 \\ 0 & 1 & -y_0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1/f & 0 & -x_0/f \\ 0 & 1/f & -y_0/f \\ 0 & 0 & 1 \end{bmatrix} = K^{-1}$$

A is a scaling transformation
B is a translation matrix

When applying transformation K^{-1},

(i) principal point (x_0, y_0) moves to origin.

(ii) point with distance f moves to a distance of $\underline{1}$ from origin.

$$K^{-1} = \begin{bmatrix} 1/400 & 0 & -1 \\ 0 & 1/400 & -3/4 \\ 0 & 0 & 1 \end{bmatrix}$$

• $\cancel{(0, 300, 1) = (0, 3/}4,$

$$K^{-1} \times \begin{bmatrix} 0 \\ 300 \\ 1 \end{bmatrix} = \begin{bmatrix} -1 \\ 3/4 - 3/4 \\ 1 \end{bmatrix} = \begin{bmatrix} -1 \\ 0 \\ 1 \end{bmatrix}$$

$$K^{-1} \times \begin{bmatrix} 800 \\ 300 \\ 1 \end{bmatrix} = \begin{matrix} 2-1 \\ 3/4 - 3/4 \\ 1 \end{matrix} = \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}$$

$$\cos\theta = (-1, 0, 1) \cdot (1, 0, 1) = -1 + 1 = 0$$

$$\theta = \cos^{-1}(0) = 90^\circ$$

Let c be camer

$K [R\ t]\, c = 0$

$K^{-1} K [R\ t]\, c =$

$[R\ t]\, c$

P_{31}, P_{32}, P_{33}

axis = $K3 \times R$

$K3 = [0,$

axis = R

principal

TE 4 $\begin{bmatrix} a \\ 0 \\ 0 \end{bmatrix}$

$\begin{bmatrix} aR_1^T + \\ d \end{bmatrix}$

tion K^{-1},

(x_0, y_0) moves to origin.

f moves to a

om origin.

]

)

$\begin{bmatrix} -1 \\ 0 \\ 1 \end{bmatrix}$

$\begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}$

$1 = 0$

Let C be camera center, $PC = 0$

$$K[R\ t]C = 0$$

$$K^{-1}K[R\ t]C = K^{-1}0$$

$$[R\ t]C = 0 \Rightarrow$$ thus center remains the same

P_{31}, P_{32}, P_{33} is the principal axis

axis $= K3 \times R + t_3$

$K3 = [0, 0, 1]$, thus

axis $= R_3 + t_3$ which is the principal axis for normalized version.

TE 4 $\begin{bmatrix} a & b & c \\ 0 & d & e \\ 0 & 0 & f \end{bmatrix} \begin{bmatrix} R_1^T \\ R_2^T \\ R_3^T \end{bmatrix} =$

$$\begin{bmatrix} aR_1^T + bR_2^T + cR_3^T \\ dR_2^T + e R_3^T \\ fR_3^T \end{bmatrix}$$

$$\begin{bmatrix} 2400\sqrt{2} & 0 & 800\sqrt{2} & 4000 \\ 700\sqrt{2} & 2800 & -700\sqrt{2} & 4900 \\ \frac{1}{\sqrt{2}} & 0 & -1/\sqrt{2} & 3 \end{bmatrix} = P$$

$$A \overset{\shortparallel}{=} KR$$

$$f = \|A_3\| = \sqrt{\left(\frac{1}{\sqrt{2}}\right)^2 + \left(\frac{-1}{\sqrt{2}}\right)^2} = 1 \;//$$

$$R_3 = \frac{A_3}{\|A_3\|} = \left(\frac{1}{\sqrt{2}}, 0, -1/\sqrt{2}\right) //$$

$$A_2 = dR_2^T + eR_3^T$$

$$e = A_2^T R_3 = \begin{pmatrix} 700\sqrt{2} \\ 2800 \\ -700\sqrt{2} \end{pmatrix} \times \left(\frac{1}{\sqrt{2}}, 0, \frac{-1}{\sqrt{2}}\right)$$

$$= 700 + 700 = 1400 \;//$$

$$dR_2^T = A_2 - eR_3 = \left(\frac{1400}{\sqrt{2}}, 2800, \frac{-1400}{\sqrt{2}}\right)$$

$$-\left(\frac{1400}{\sqrt{2}}, 0, \frac{-1400}{\sqrt{2}}\right) = (0, 2800, 0)$$

$\|R_2\| = 1$, so $d = 2800$ //, $R_2 = (0, 1, 0)$

Not sure ho

TE6 $\bar{x}$

$\bar{x}$

Nx

$N^{-1}N$

$$\begin{bmatrix} \ldots 4000 \\ \ldots 1900 \\ \ldots 3 \end{bmatrix} = P$$

$\left(\frac{\ldots 400}{\sqrt{2}}\right)$

$(0, 2800, 0)$

$(0, 1, 0)$

Not sure how to continue.

TE6

$$\bar{x} \sim Nx$$

$$\bar{x} \sim \tilde{P}X$$

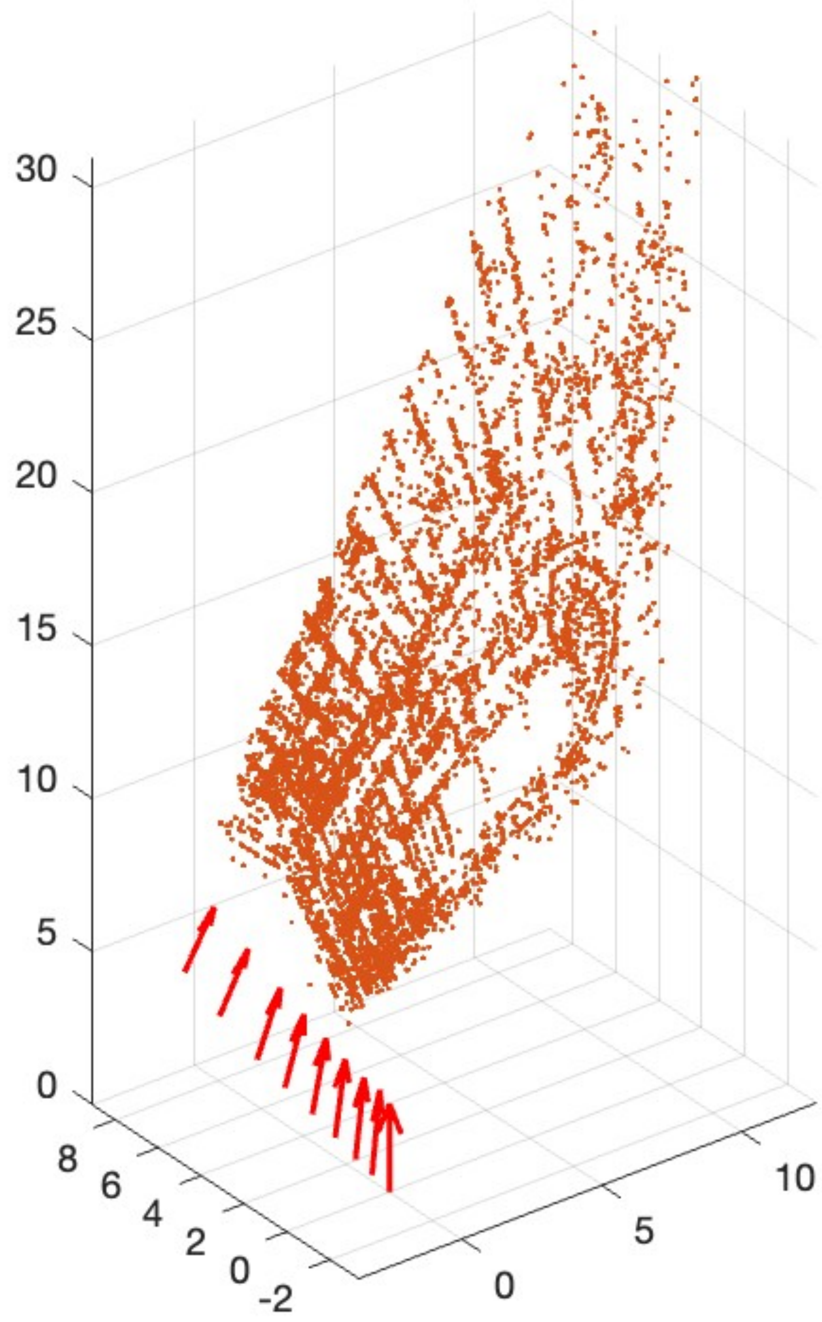
$$Nx \sim \tilde{P}X$$

$$N^{-1}Nx \sim N^{-1}\tilde{P}X$$

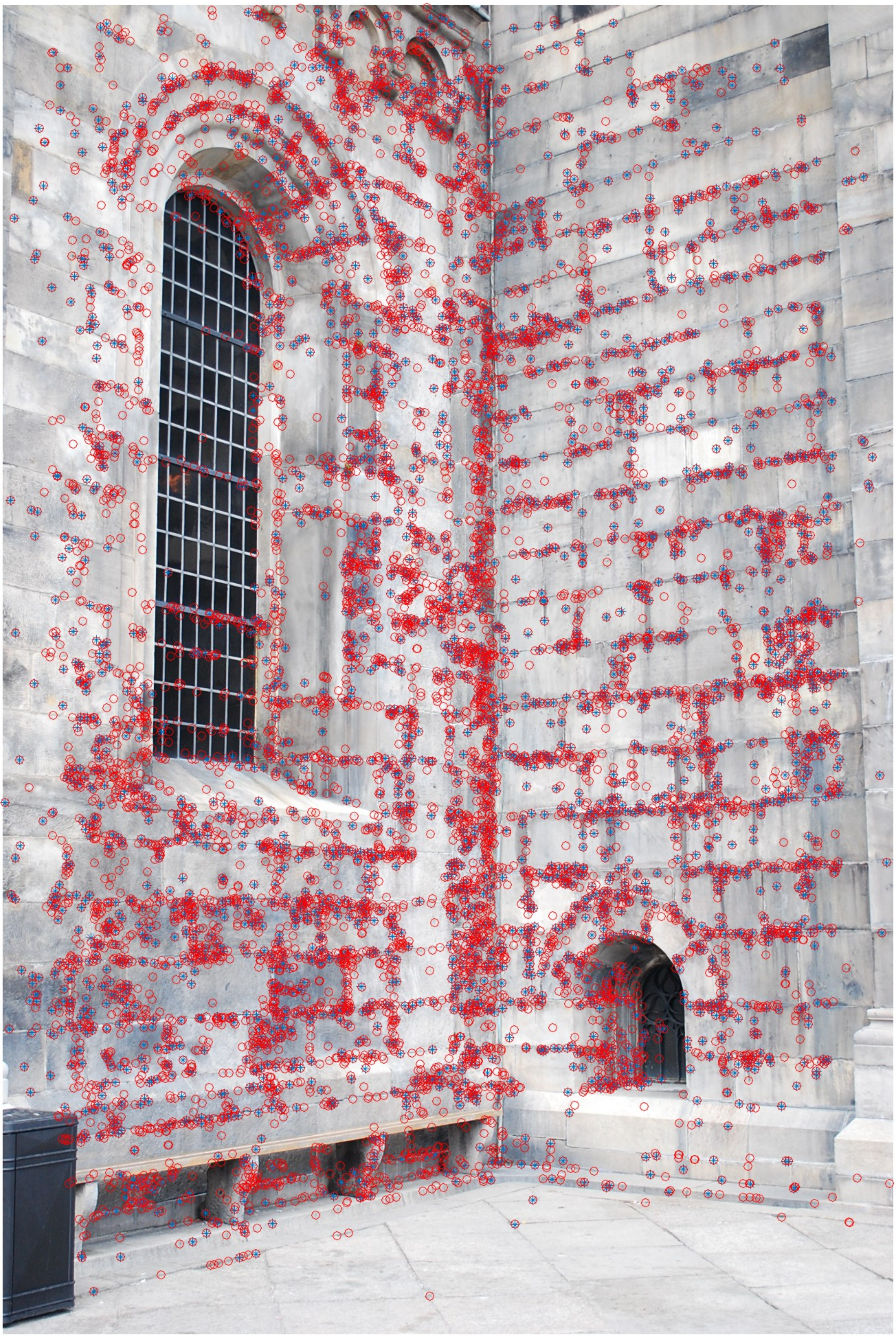
$$x \sim \underbrace{N^{-1}\tilde{P}}_{P}X$$

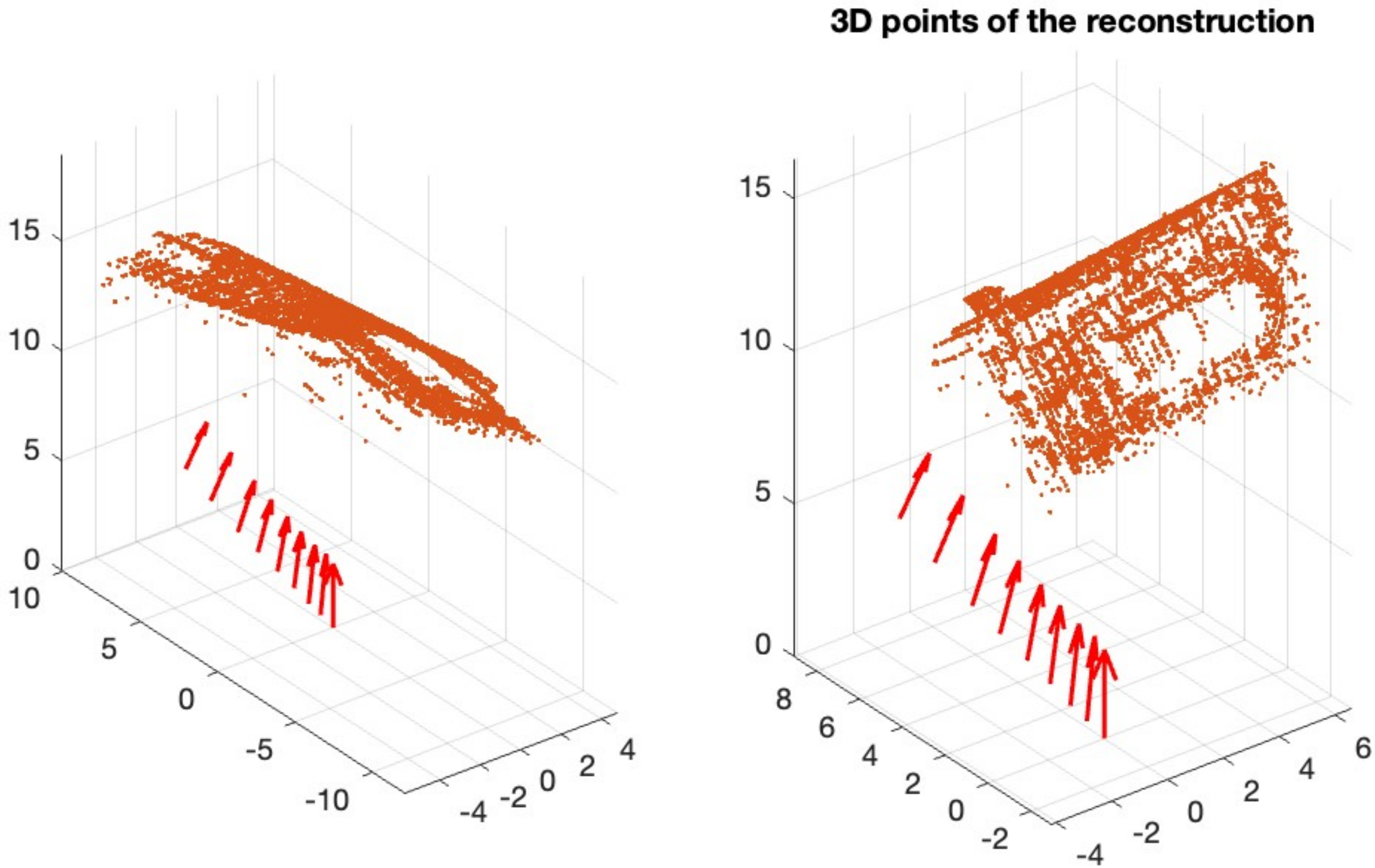
$$P = N^{-1}\tilde{P}$$

3D points of the reconstruction

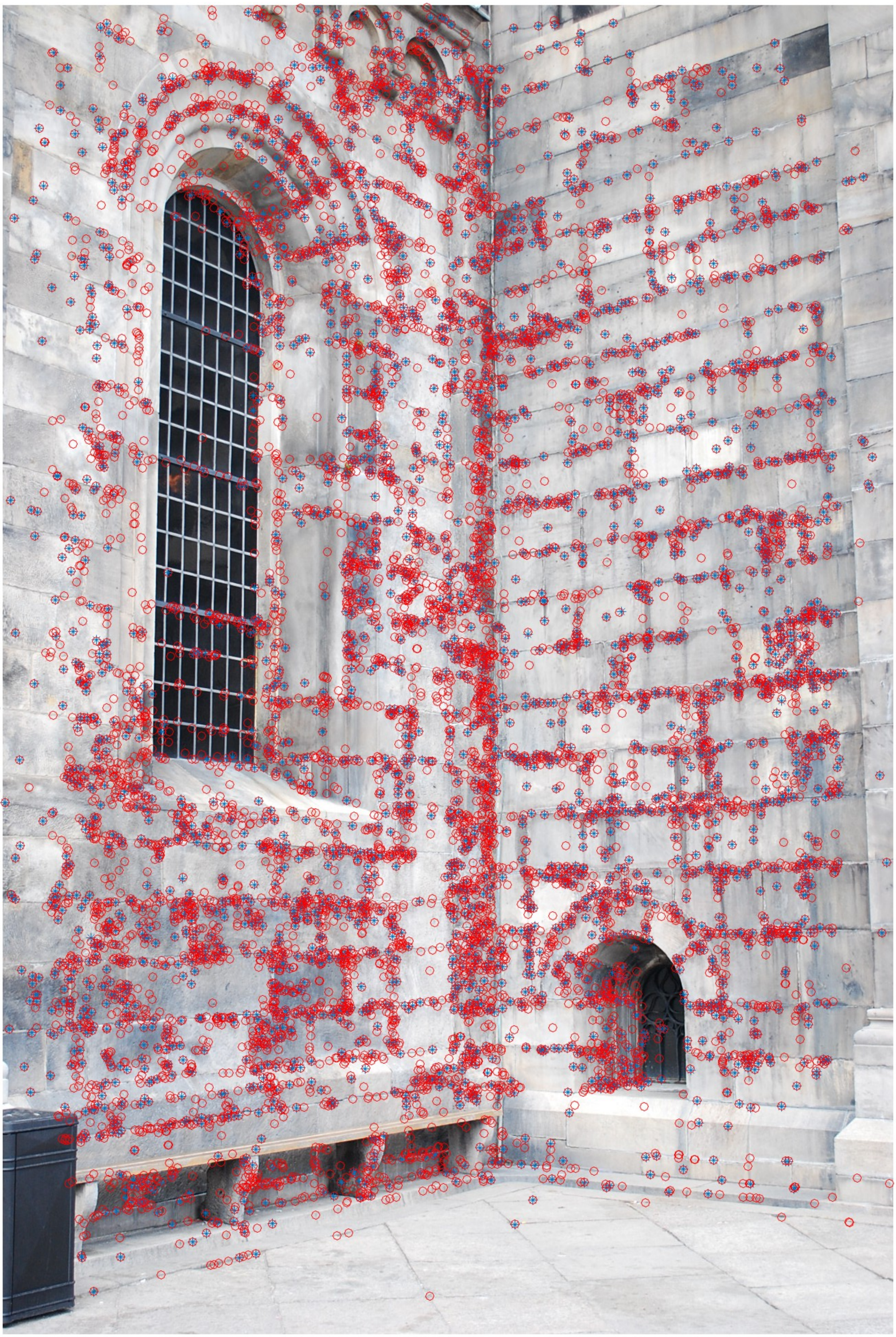


Project the 3D points into camera 1

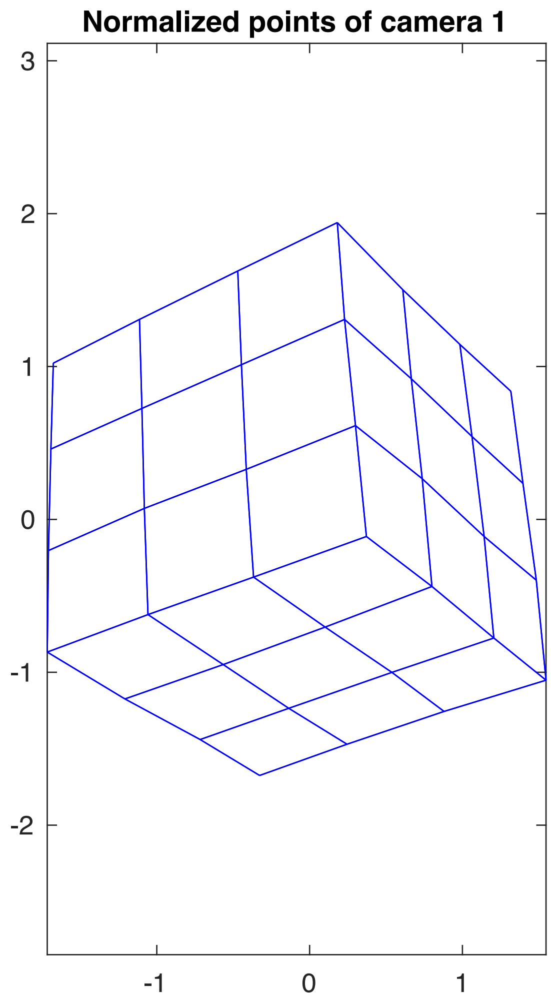


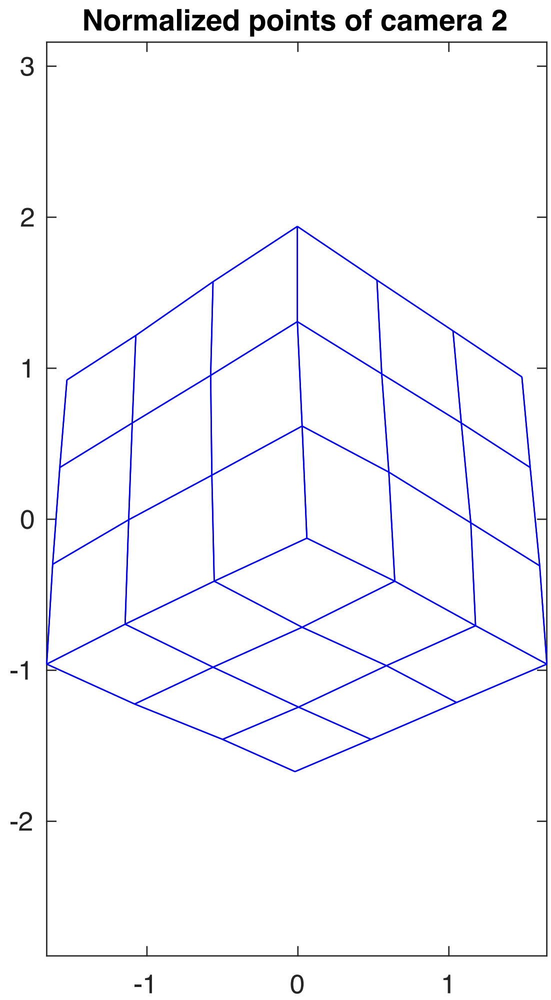

3D points of the reconstruction

Project the 3D points of T1 into camera 1



Project the 3D points of T2 into camera 1


Normalized points of camera 1
3
2
1
0
-1
-2
-1
0
1


Normalized points of camera 2
3
2
1
0
-1
-2
-1
0
1

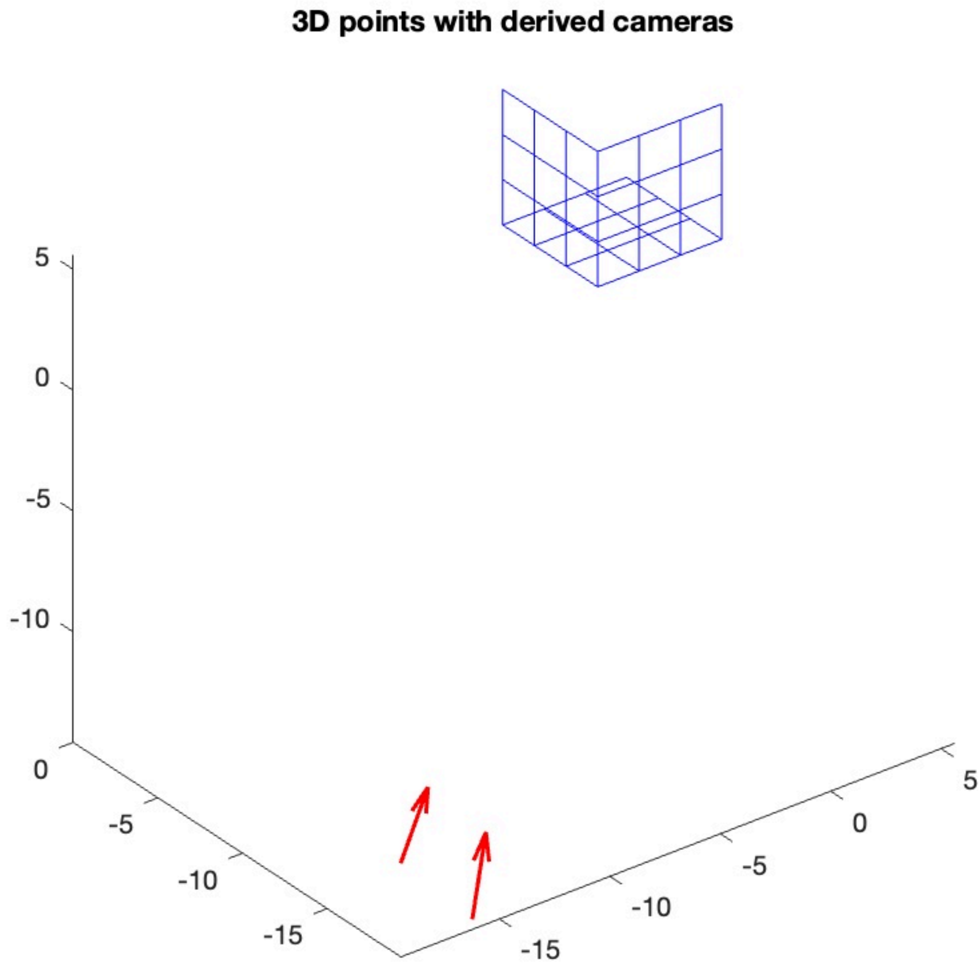

3D points with derived cameras
5
0
-5
-10
0
-5
-10
-15
-15
-10
-5
0
5

Image 1

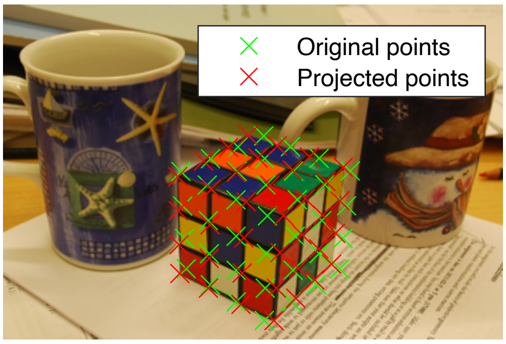
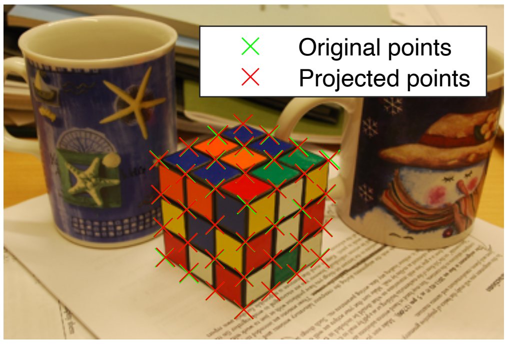
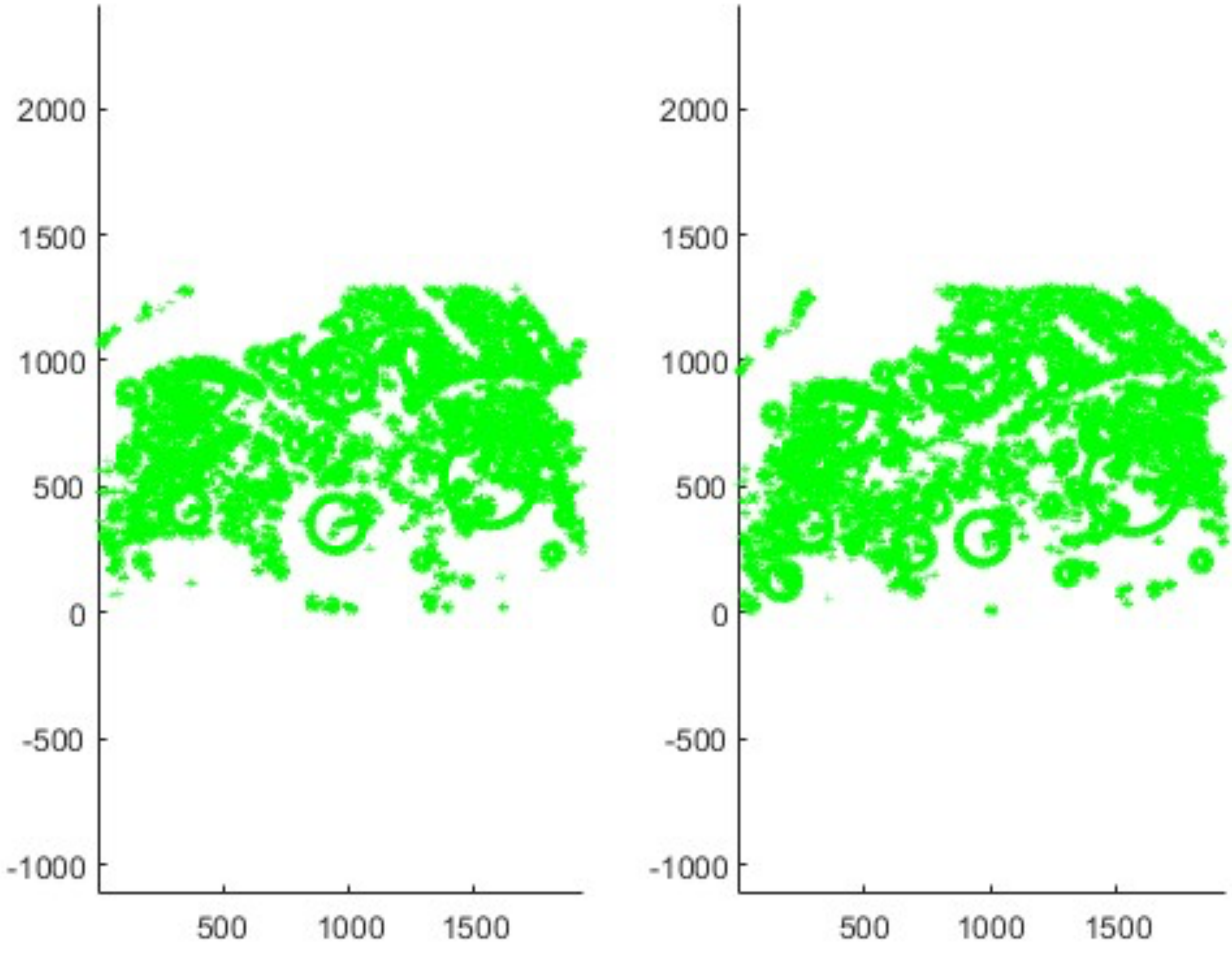
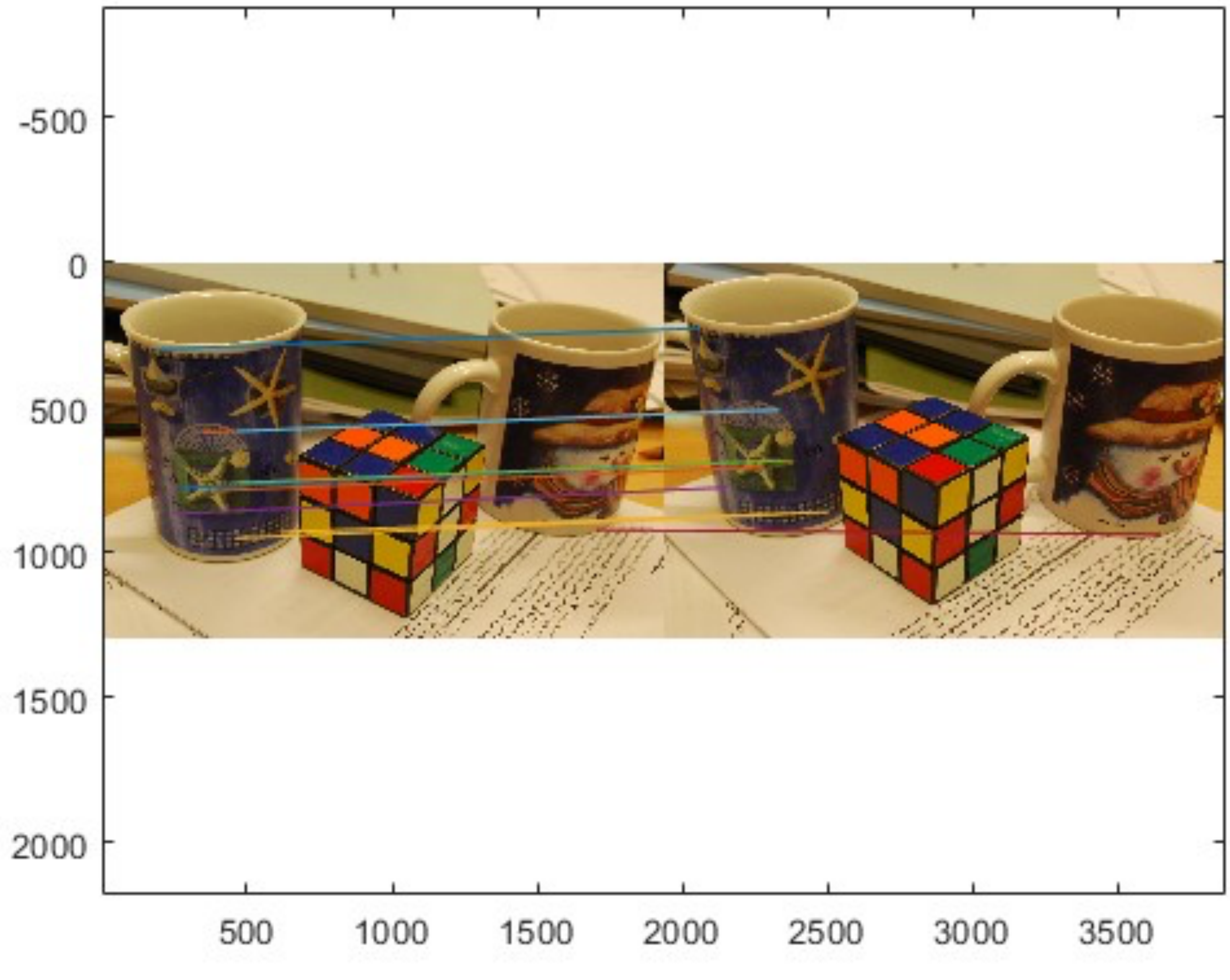


Image 2




2000
1500
1000
500
0
-500
-1000
500
1000
1500
2000
1500
1000
500
0
-500
-1000
500
1000
1500


-500
0
500
1000
1500
2000
500
1000
1500
2000
2500
3000
3500

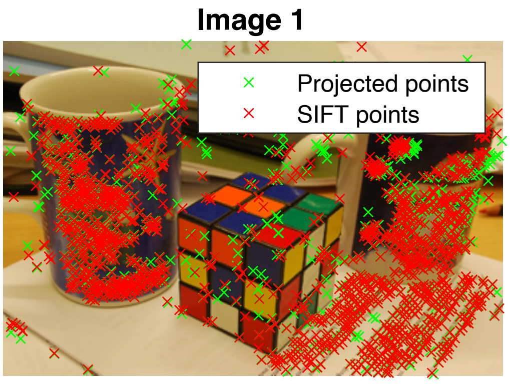


Image 1
Projected points
SIFT points

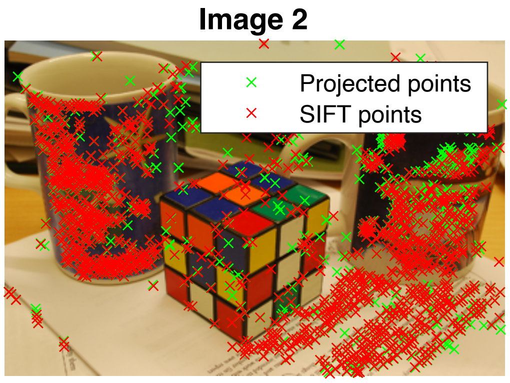


Image 2
Projected points
SIFT points

Image 1 with normalization

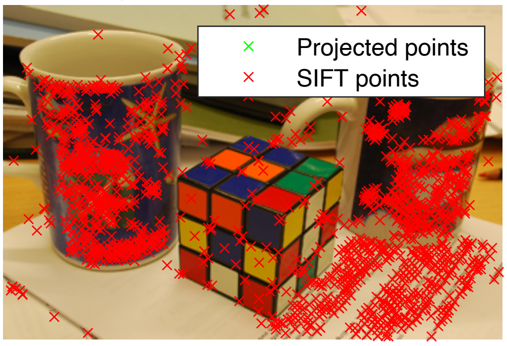


Image 2 with normalization