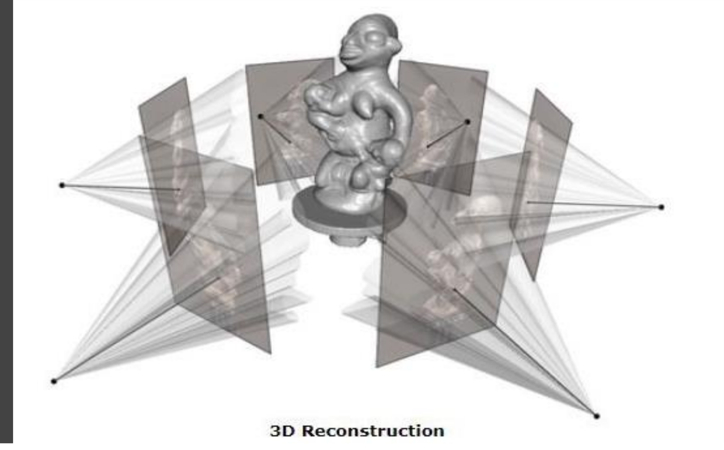

3D RECONSTRUCTION – STRUCTURE FROM MOTION

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Motivation

3D reconstruction from multiple image aims to estimate three dimensional structures from image sequences with coupling local motion signal, such as rotation. Images for the same object taken by a camera at different positions, by moving camera around the object, can be used to reconstruct 3D structure. This method is termed as Structure from Motion (**SfM**). There are some important application for **SfM**, such as cultural heritage preservation and survey. Since **SfM** provides a non-invasive approach for structure detection i.e. without direct interaction, it replace traditional invasive surveying when there are serious constraints on feasibility of invasive surveying detectors.

Methodology

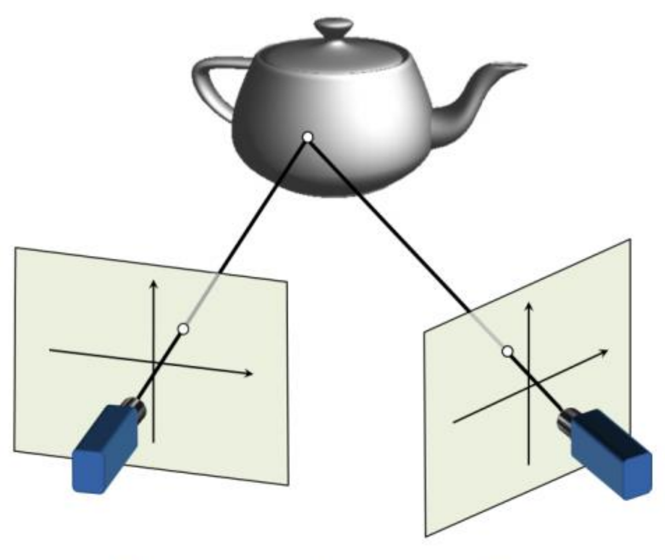


Fig. 1.2 The principle behind stereo-based 3D reconstruction is very simple: given two images of a point, the point's position in space is found as the intersection of the two projection rays. This procedure is referred to as 'triangulation'.

Estimating Fundamental Matrix

$\mathbf{x}_1^T \mathbf{F} \mathbf{x}_2 = 0$ for 8 point correspondences:

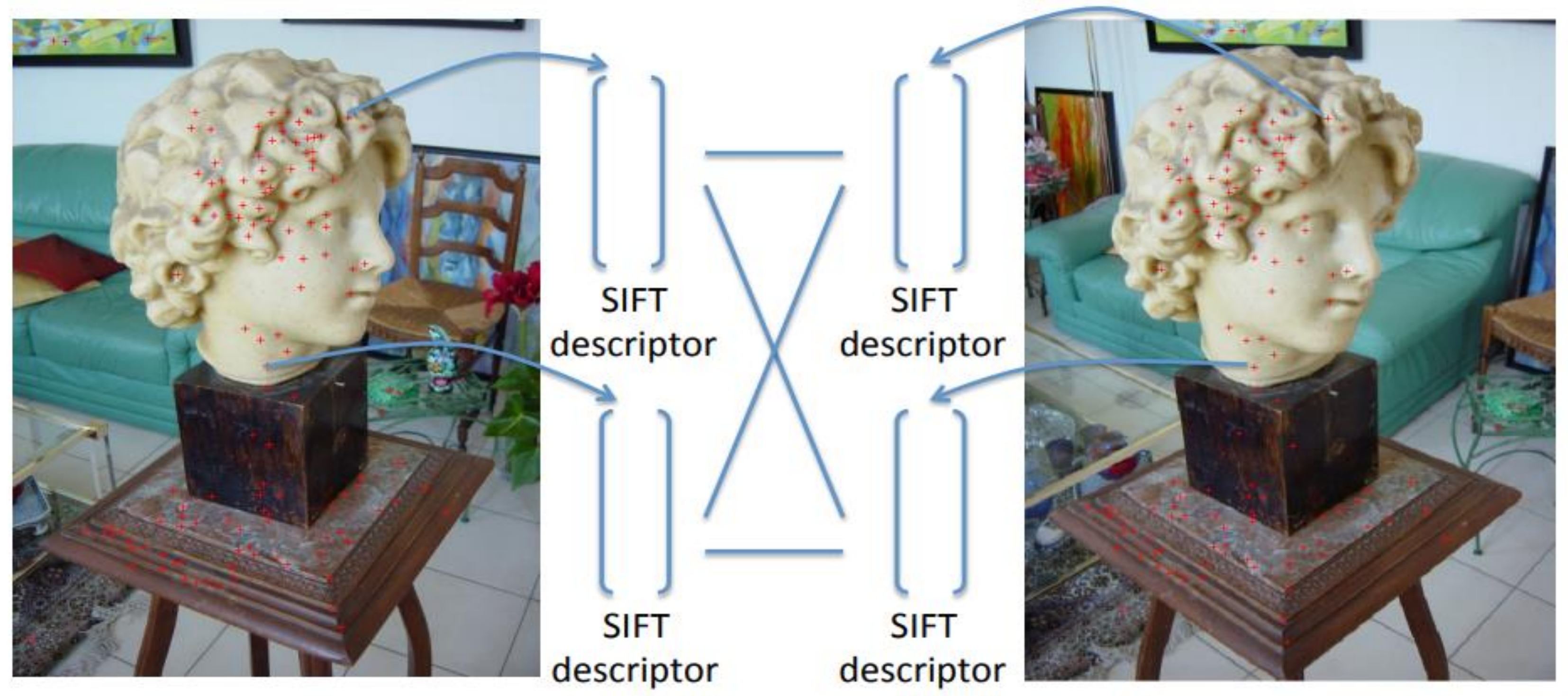
$\mathbf{x}_1^1 \leftrightarrow \mathbf{x}_2^1, \mathbf{x}_1^2 \leftrightarrow \mathbf{x}_2^2, \mathbf{x}_1^3 \leftrightarrow \mathbf{x}_2^3, \mathbf{x}_1^4 \leftrightarrow \mathbf{x}_2^4, \mathbf{x}_1^5 \leftrightarrow \mathbf{x}_2^5, \mathbf{x}_1^6 \leftrightarrow \mathbf{x}_2^6, \mathbf{x}_1^7 \leftrightarrow \mathbf{x}_2^7, \mathbf{x}_1^8 \leftrightarrow \mathbf{x}_2^8$

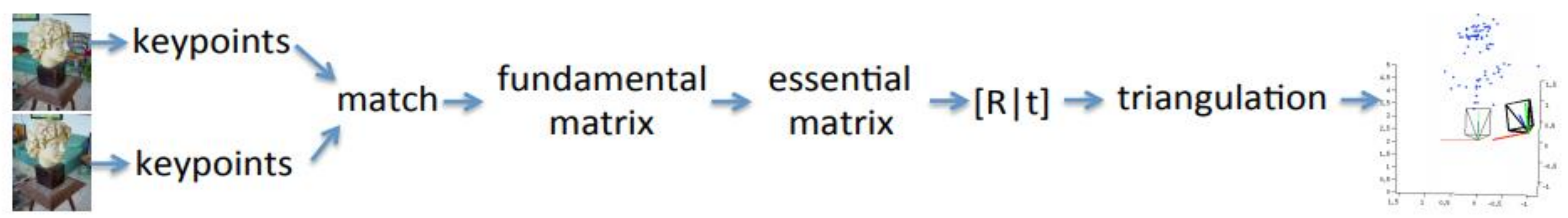
$$\begin{bmatrix} x_1^1x_2^1 & x_1^1y_2^1 & x_1^1 & y_1^1x_2^1 & y_1^1y_2^1 & y_1^1 & x_2^1 & y_2^1 & 1 \\ x_1^2x_2^2 & x_1^2y_2^2 & x_1^2 & y_1^2x_2^2 & y_1^2y_2^2 & y_1^2 & x_2^2 & y_2^2 & 1 \\ x_1^3x_2^3 & x_1^3y_2^3 & x_1^3 & y_1^3x_2^3 & y_1^3y_2^3 & y_1^3 & x_2^3 & y_2^3 & 1 \\ x_1^4x_2^4 & x_1^4y_2^4 & x_1^4 & y_1^4x_2^4 & y_1^4y_2^4 & y_1^4 & x_2^4 & y_2^4 & 1 \\ x_1^5x_2^5 & x_1^5y_2^5 & x_1^5 & y_1^5x_2^5 & y_1^5y_2^5 & y_1^5 & x_2^5 & y_2^5 & 1 \\ x_1^6x_2^6 & x_1^6y_2^6 & x_1^6 & y_1^6x_2^6 & y_1^6y_2^6 & y_1^6 & x_2^6 & y_2^6 & 1 \\ x_1^7x_2^7 & x_1^7y_2^7 & x_1^7 & y_1^7x_2^7 & y_1^7y_2^7 & y_1^7 & x_2^7 & y_2^7 & 1 \\ x_1^8x_2^8 & x_1^8y_2^8 & x_1^8 & y_1^8x_2^8 & y_1^8y_2^8 & y_1^8 & x_2^8 & y_2^8 & 1 \end{bmatrix} \begin{bmatrix} f_{11} \\ f_{12} \\ f_{13} \\ f_{21} \\ f_{22} \\ f_{23} \\ f_{31} \\ f_{32} \\ f_{33} \end{bmatrix} = 0 \Rightarrow \begin{matrix} \mathbf{Ax} = \mathbf{b} \\ \mathbf{Af} = \mathbf{0} \end{matrix}$$

Direct Linear Transformation (DLT)

How to extract feature points for 3D reconstruction?
How to calculate extrinsic matrix from images?
How to find and track those feature points in multiple images?
How to establish the relationship between multiple images using those feature points?

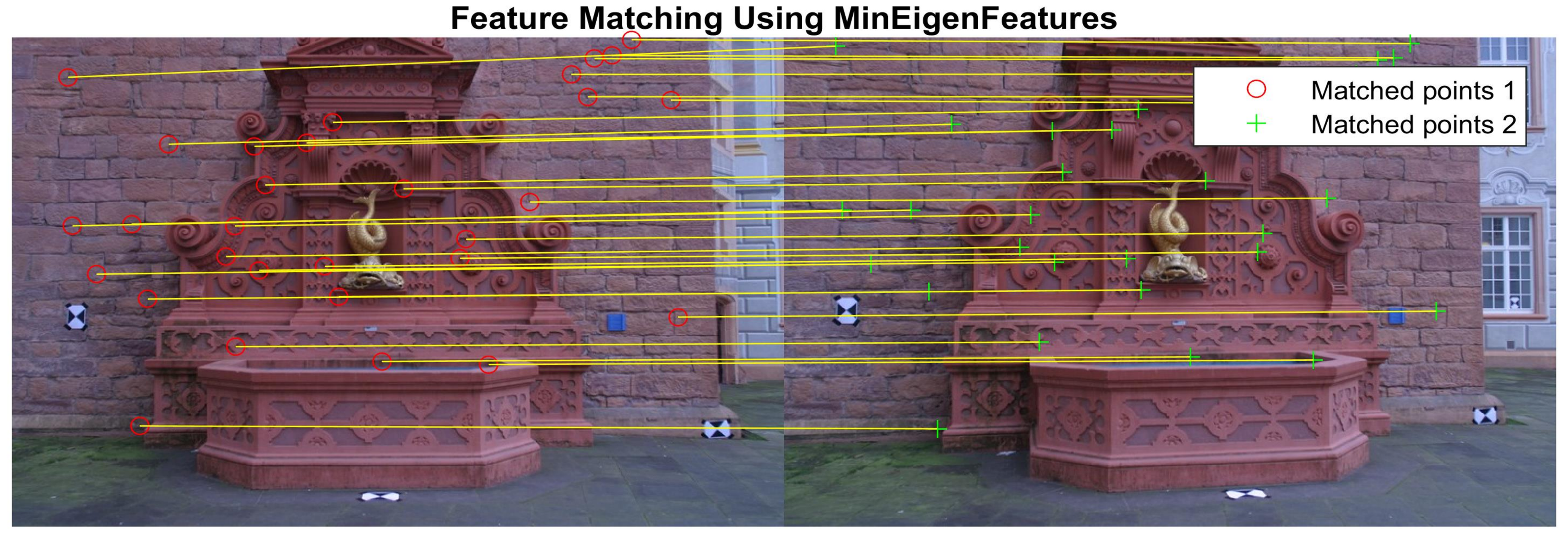
Point Match for correspondences



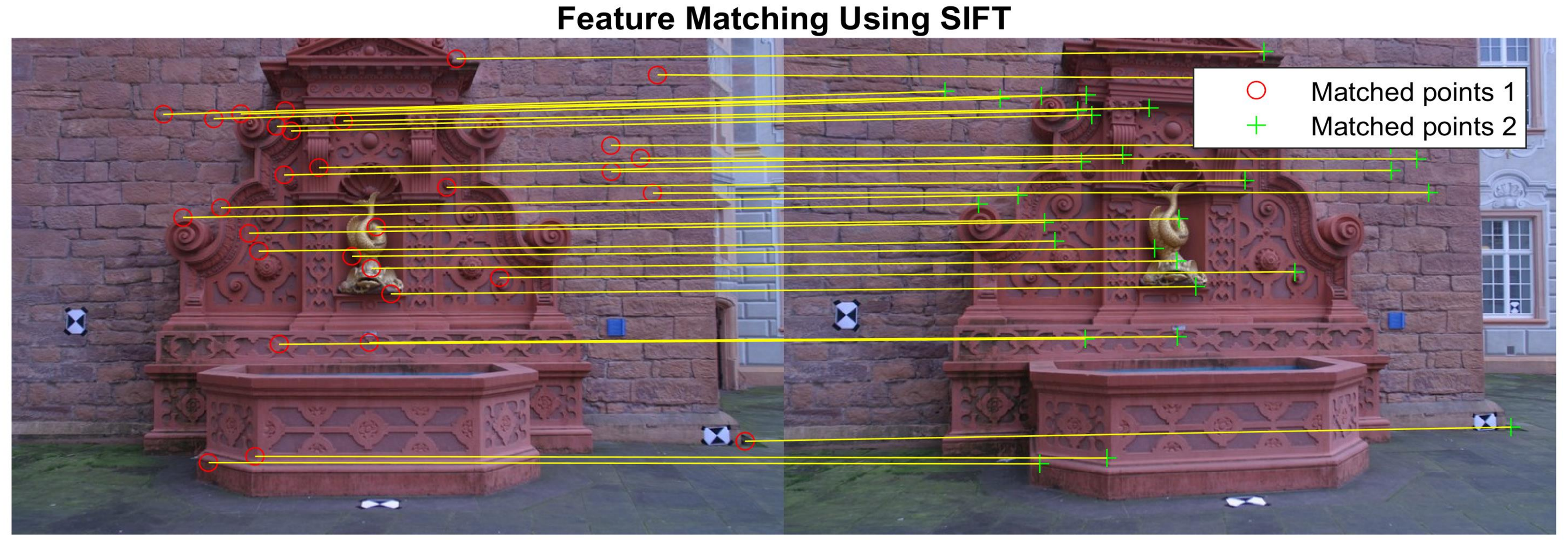


Feature Extraction and Correspondence Matching

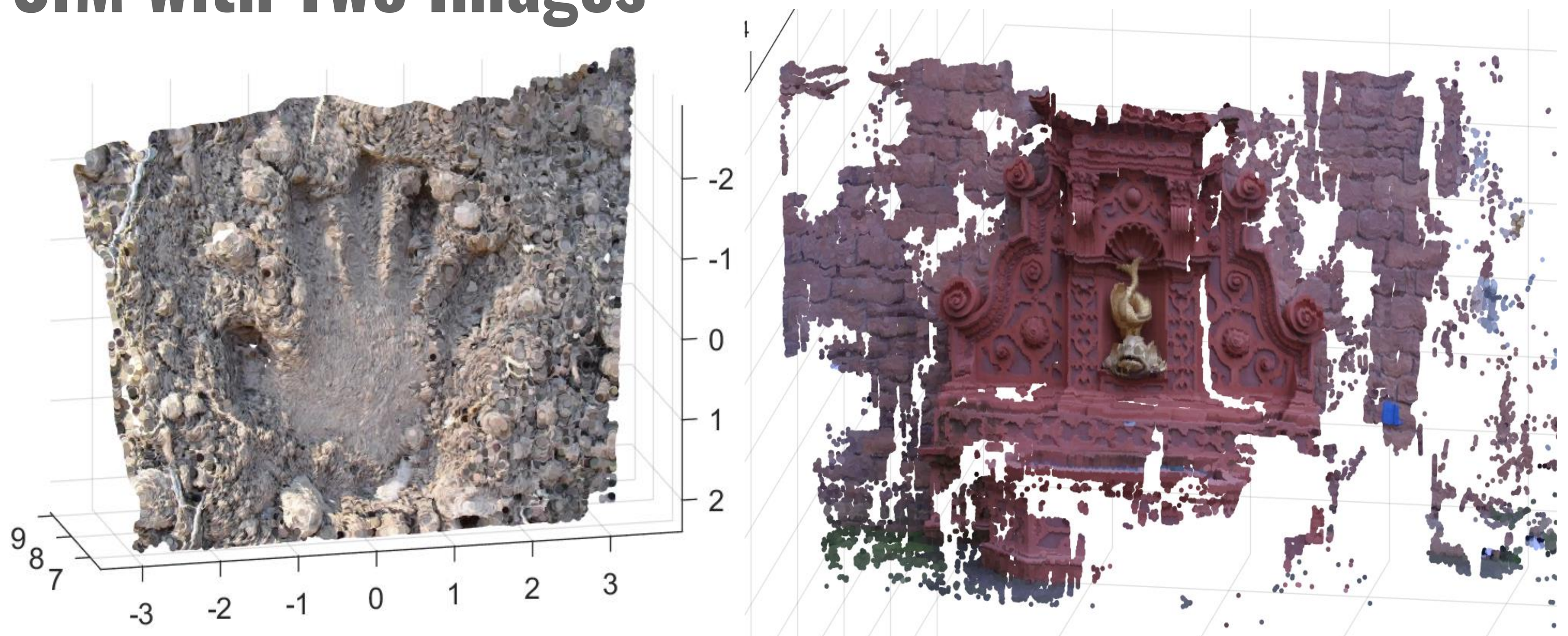
Feature Matching Using MinEigenFeatures



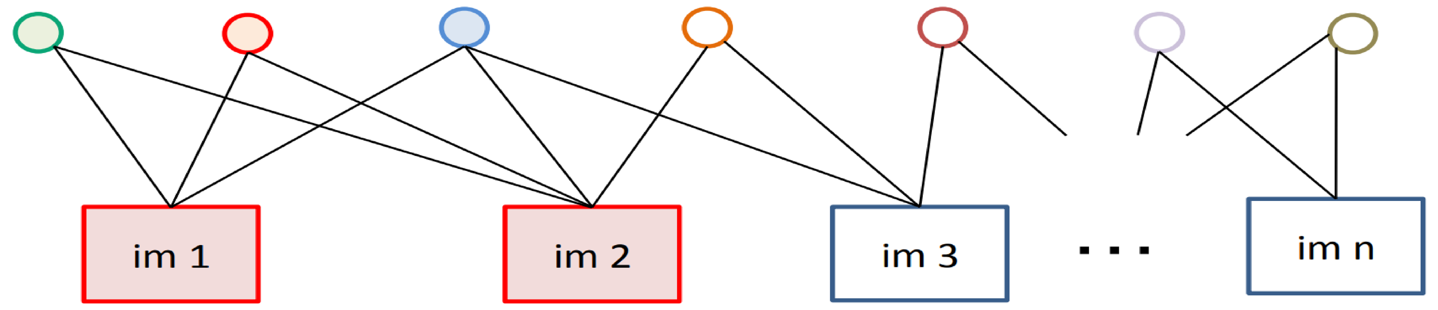
Feature Matching Using SIFT



SfM with Two Images



SfM with Multiple Images



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