Introduction to 3D vision

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Camera model

Stereo vision

Photogrammetry

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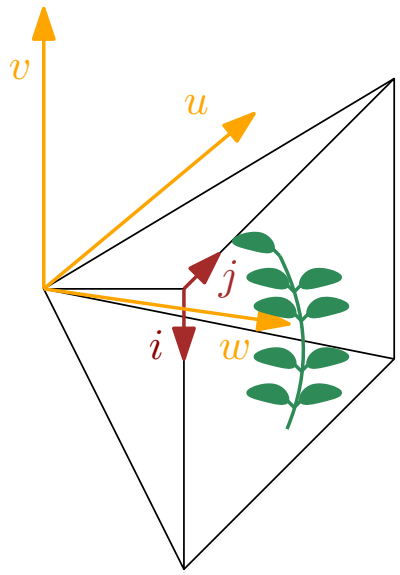
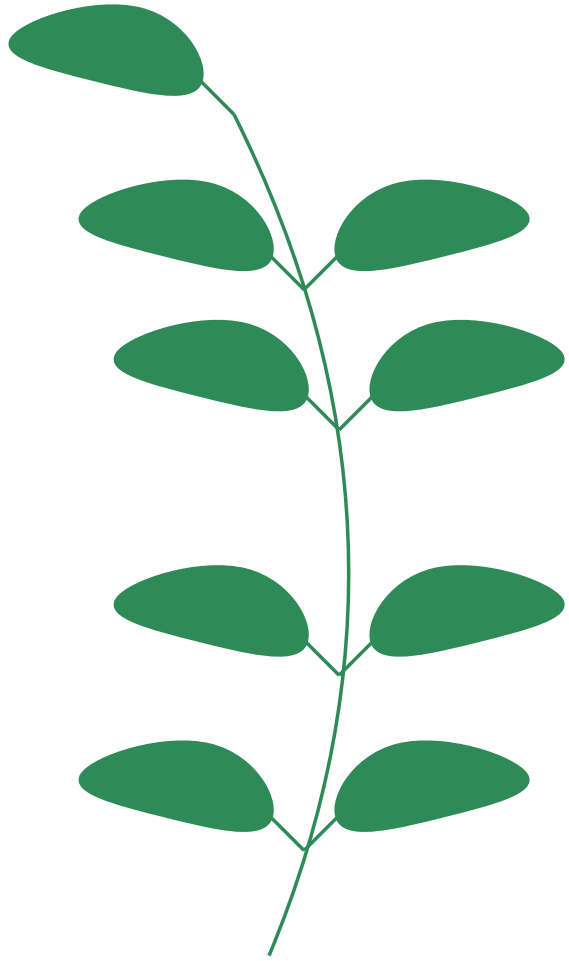
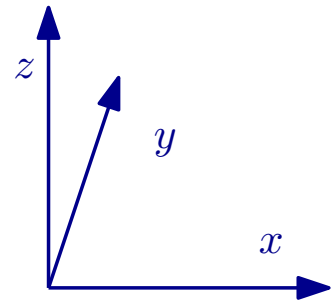
Photogrammetry

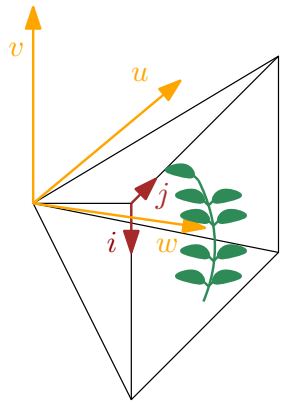
Pinhole camera model

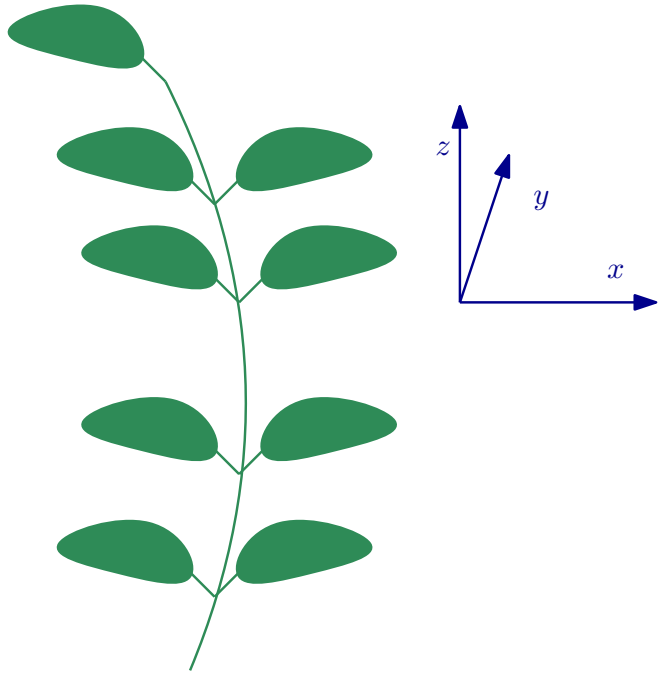






Camera pose

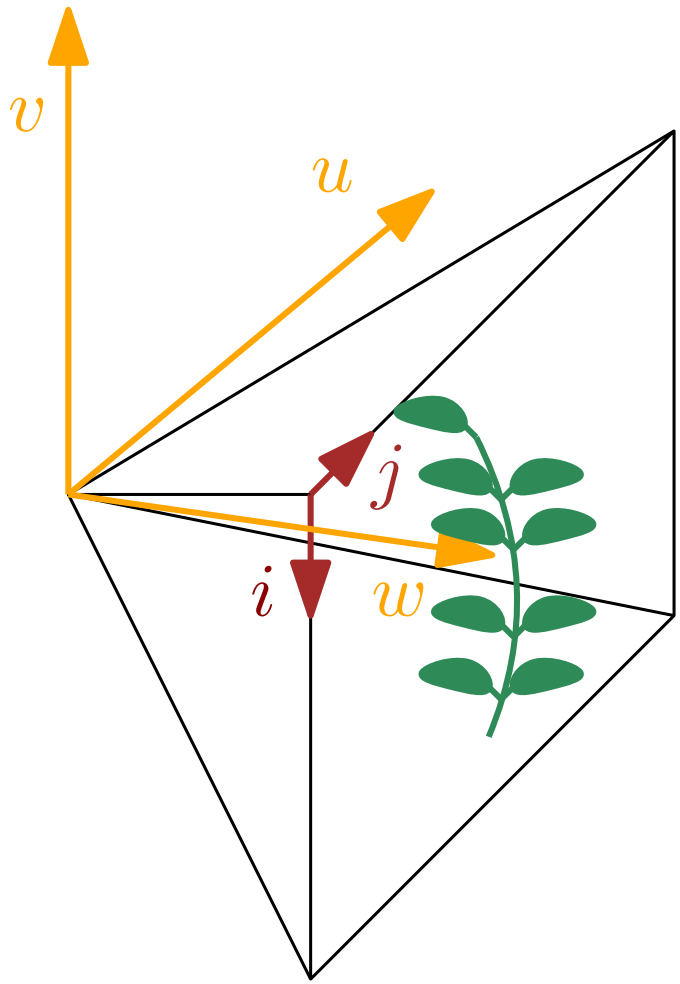




Extrinsics: rotation R and translation T.

$$\begin{pmatrix} u \\ v \\ w \end{pmatrix} = R \begin{pmatrix} x \\ y \\ z \end{pmatrix} + T$$

Fundamental matrix



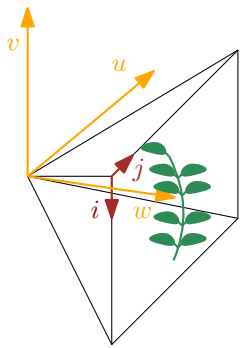
$$j = f_x \frac{u}{w} + c_x, i = f_y \frac{v}{w} + c_y$$

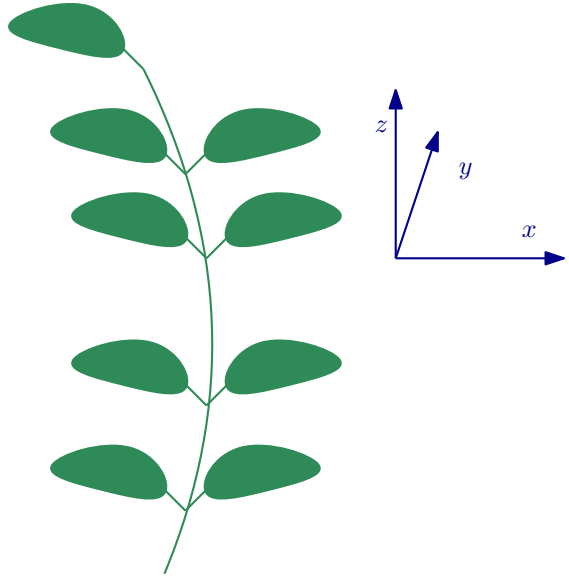
$$\begin{pmatrix} j \\ i \\ 1 \end{pmatrix} = F \begin{pmatrix} u/w \\ v/w \\ 1 \end{pmatrix}$$

where

$$F = \begin{pmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{pmatrix}$$

Pinhole camera model

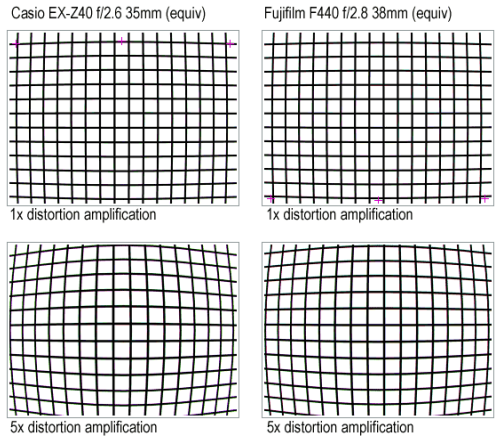




$$\text{Extrinsics: } \begin{pmatrix} u \\ v \\ w \end{pmatrix} = R \begin{pmatrix} x \\ y \\ z \end{pmatrix} + T$$

$$\text{Intrinsics: } \begin{pmatrix} u \\ v \\ w \end{pmatrix}$$

Camera distortion



OpenCV model

$$r = \sqrt{x^2 + y^2}$$

$$x_{\text{corrected}} = x(1 + k_1 r^2 + k_2 r^4 + k_3 r^6)$$

$$y_{\text{corrected}} = x(1 + k_1 r^2 + k_2 r^4 + k_3 r^6)$$

Simplified radial: $k_2 = k_3 = 0$.

Summary

Camera parameters

5 to 7 parameters: $f_x, f_y, c_x, c_y, k_1, (k_2, k_3)$.

Pose parameters

6 parameters: 3 for R, 3 for T.

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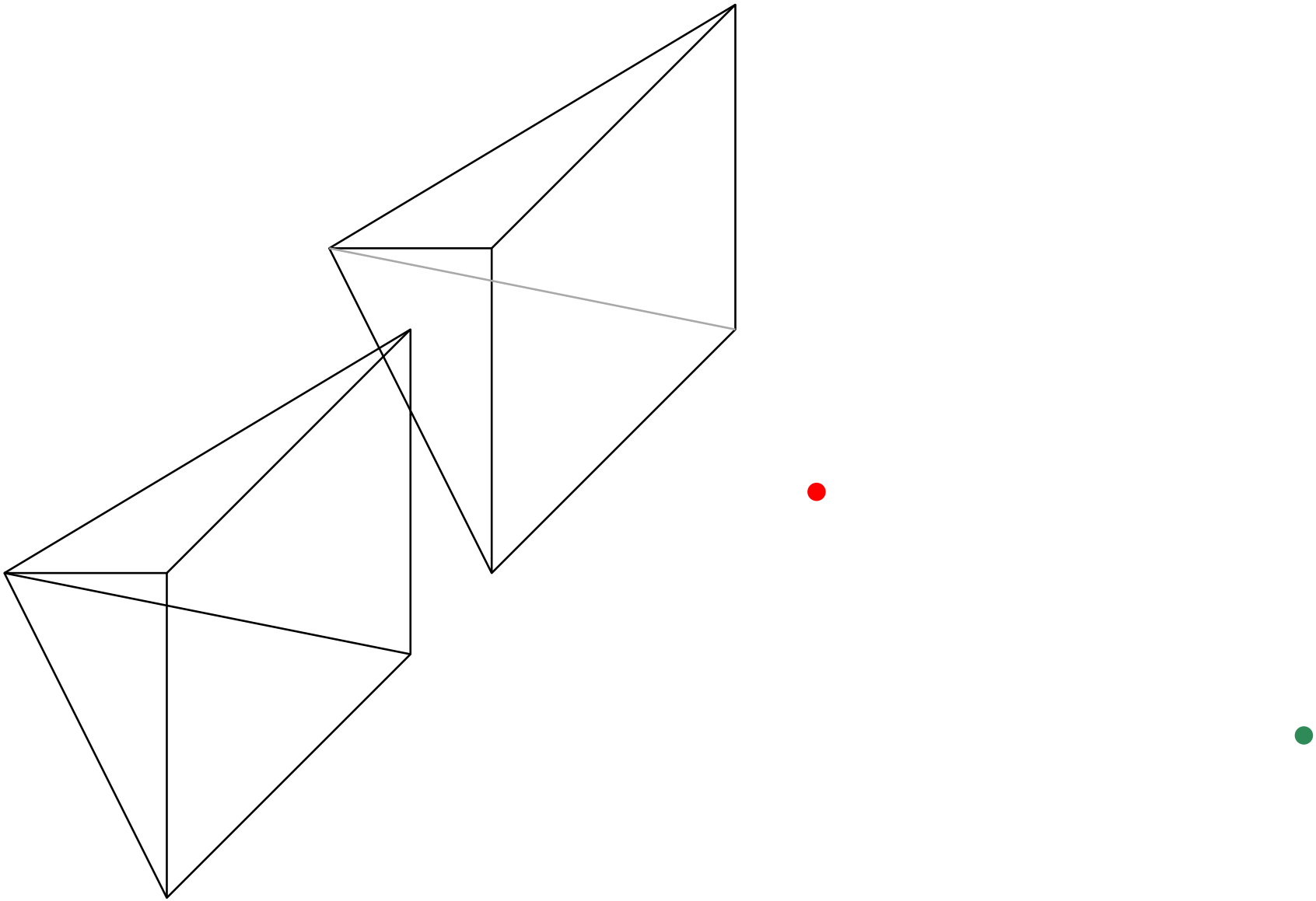
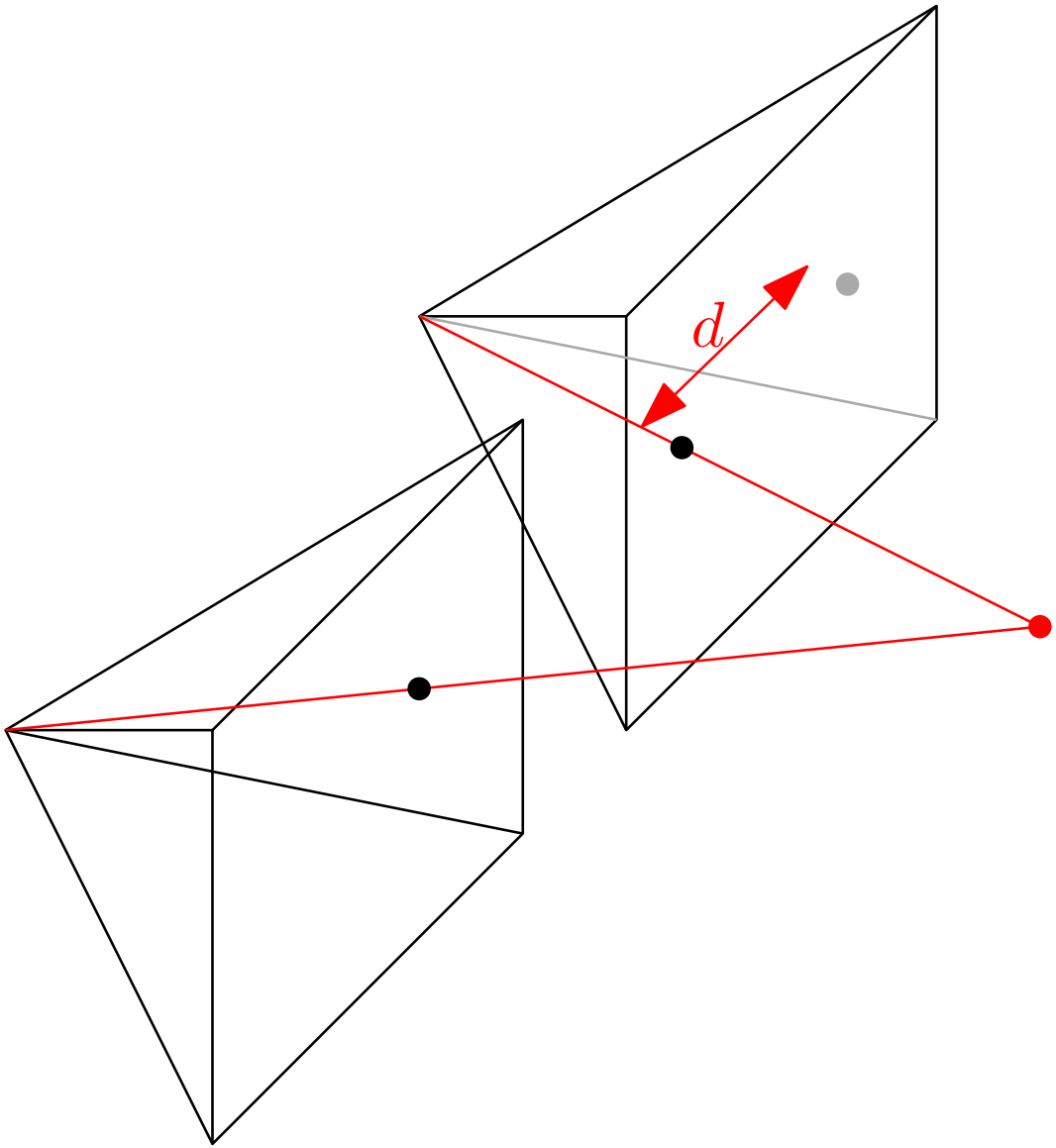
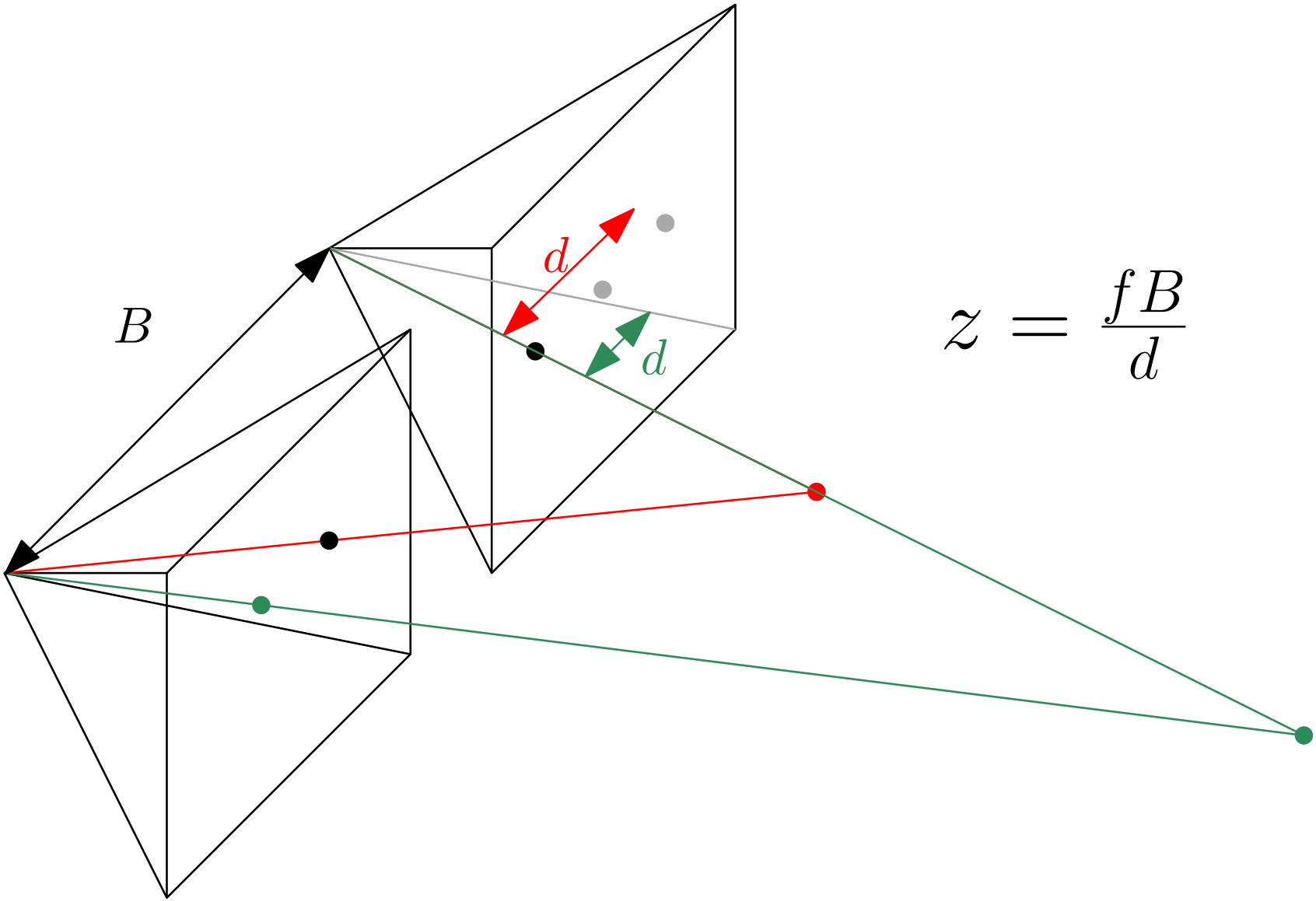
Basic principle



Basic principle



Basic principle



Disparity map

Goal

Compute d at every point in the image.

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Stereo vision

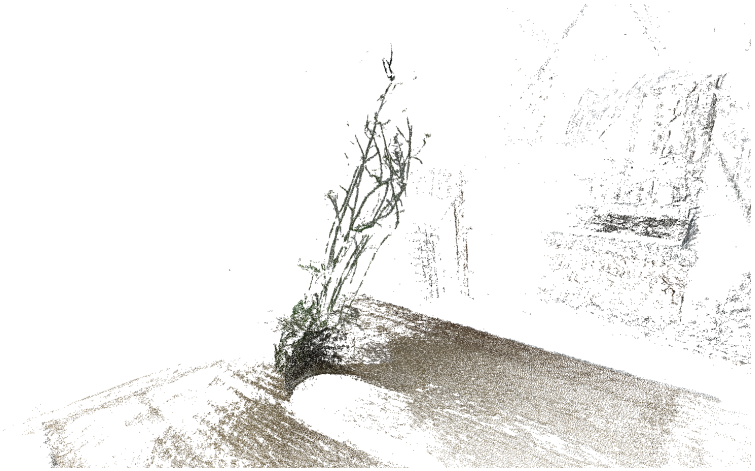
Photogrammetry

Principle

RGB Images

$\Rightarrow$

Point Cloud



Solutions

Free and open source: colmap, openMVG+openMVS, ...

Commercial: agisoft, ...

Pipeline

- Feature detection and computation
- Feature matching
- Pose estimation
- Dense point cloud generation