

Cameras, stereo

Laboratory of robotics and control systems
ITT PROJECT MANAGEMENT SERVICES L.L.C

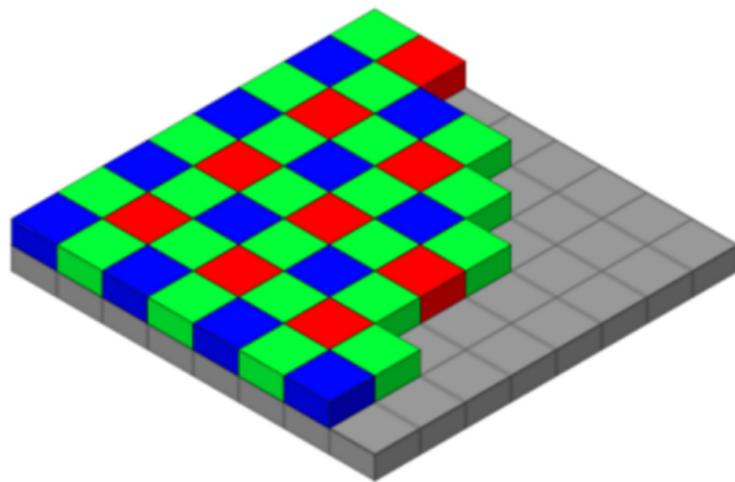
Digital camera

Characteristics:

- Resolution
- Field of view (FoV)
- Shutter type

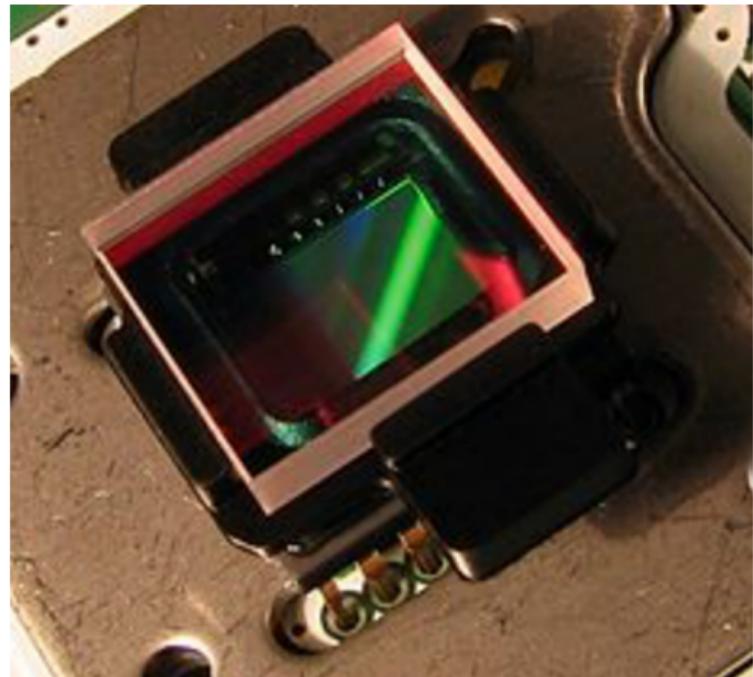
Keep an eye on:

- Parameters autoadjustment
- Overheating, disconnecting, empty frames



Resolution

- Limited by optics
- Limited by bandwidth

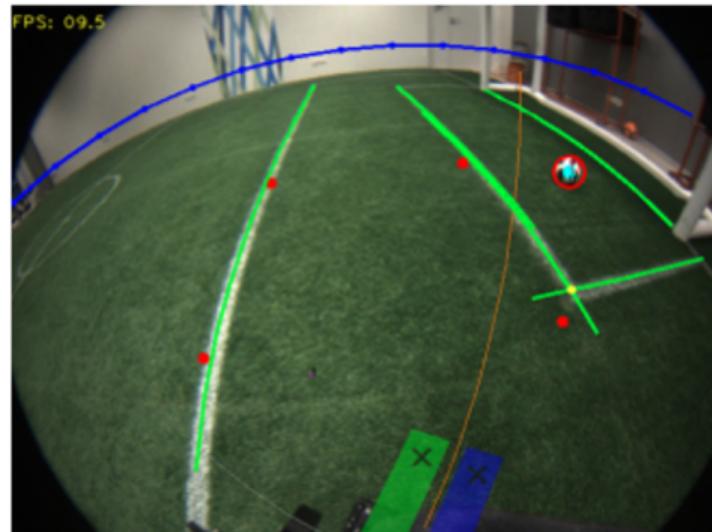


Field of View

For wide-angle optics:

- Huge distortion
- Varying (effective) pixel density

Distortions should be taken into account during NN training



Shutter type

Scanning (rolling) shutter

- Distortions in dynamic scenes
- Affordable price

Rolling Shutter



Global shutter

- High power consumption
- High price
- Low photosensitivity

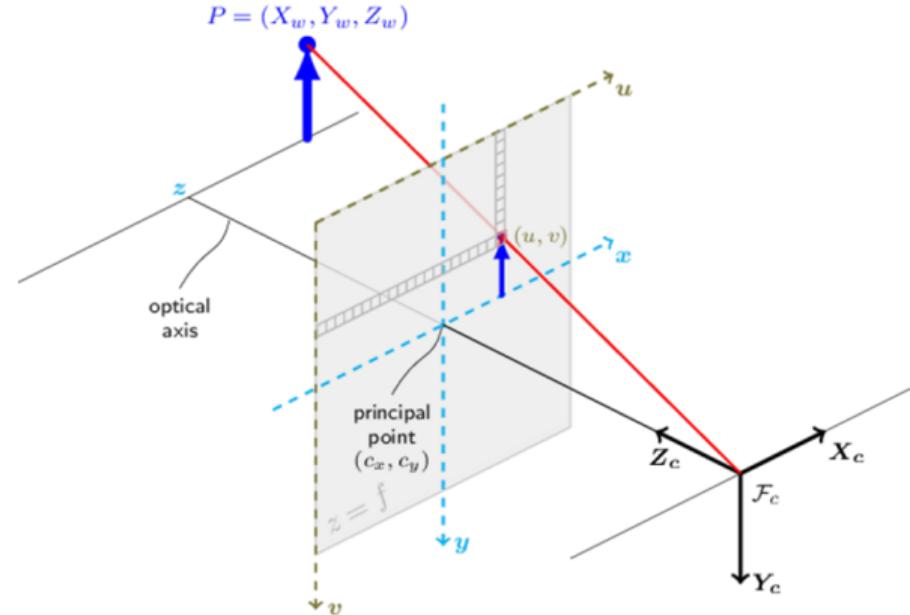
Global Shutter



Camera model

Internal camera parameters - focus and origin coordinates

$$A = \begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix}$$



Distortion

- Depends on the lens characteristics
- Requires calibration



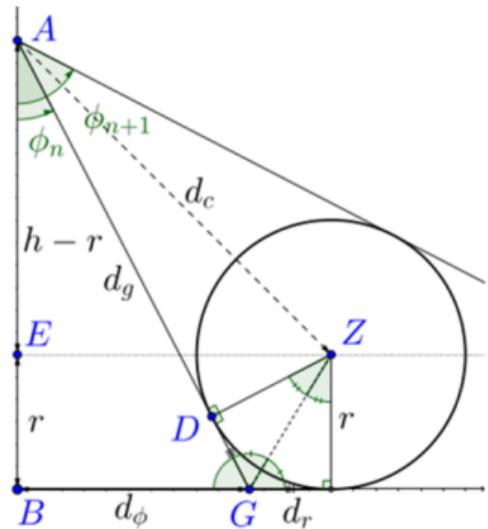
Distortion

- Depends on the lens characteristics
- Requires calibration

$$\begin{bmatrix} x'' \\ y'' \end{bmatrix} = \begin{bmatrix} x' \frac{1+k_1r^2+k_2r^4+k_3r^6}{1+k_4r^2+k_5r^4+k_6r^6} + 2p_1x'y' + p_2(r^2 + 2x'^2) + s_1r^2 + s_2r^4 \\ y' \frac{1+k_1r^2+k_2r^4+k_3r^6}{1+k_4r^2+k_5r^4+k_6r^6} + p_1(r^2 + 2y'^2) + 2p_2x'y' + s_3r^2 + s_4r^4 \end{bmatrix}$$

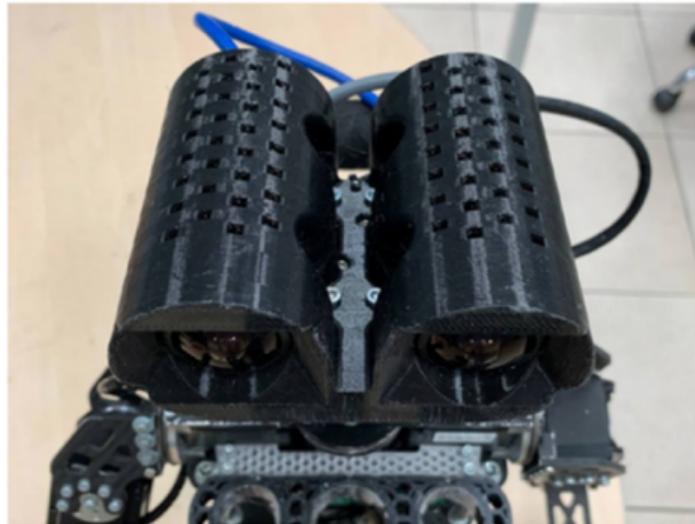
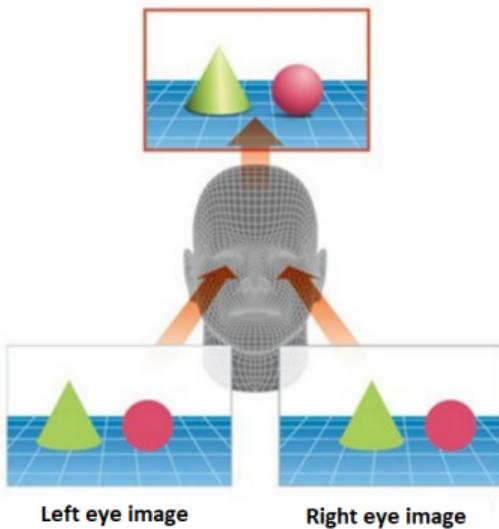
World coordinates

- Geometric considerations
- Earth is flat



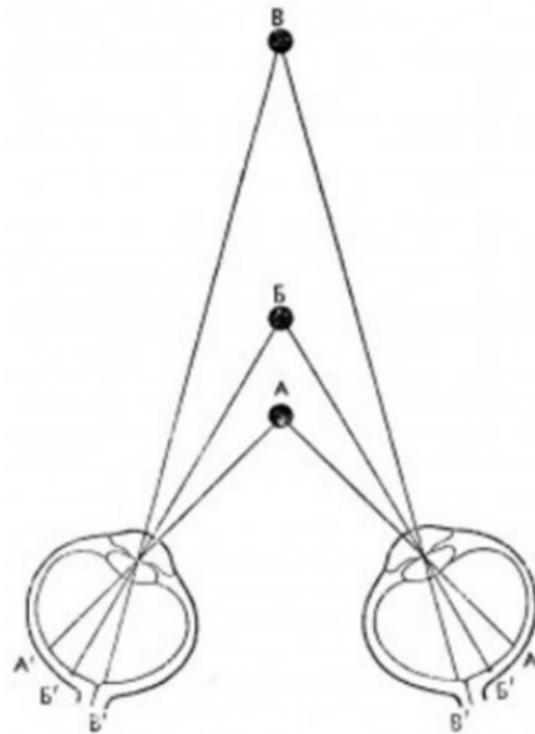
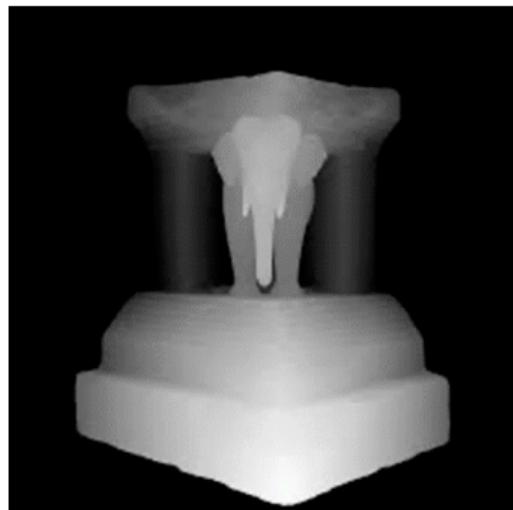
Stereo

- Active (usually infrared projector) or passive
- Similar to binocular vision



Depth map

- Based on disparity
- Brighter = closer



Active infrared stereo

- Projector
- RGB camera
- Infrared stereo pair
- Works under insufficient lighting



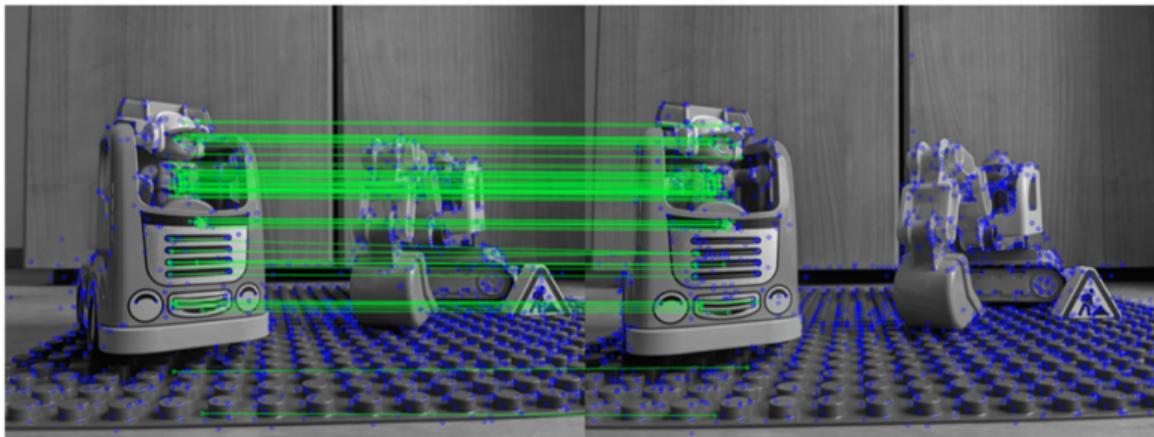
Matching

- Depth map obtainment
- Point matching



Matching

- Depth map obtainment
- Point matching



Block matching

- Channel-wise sum of absolute differences with sliding window
- Noisy

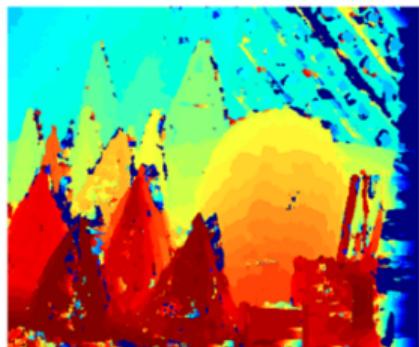
$$\sum_{dx=-W}^W \sum_{dy=-W}^W |I_c(x+dx, y+dy) - I_r(x+u+dx, y+v+dy)|$$

Block matching

- Channel-wise sum of absolute differences with sliding window
- Noisy

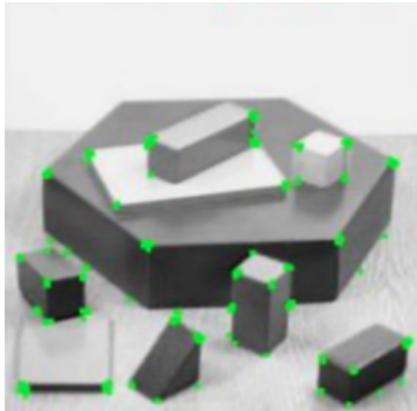


Depth map from basic block matching



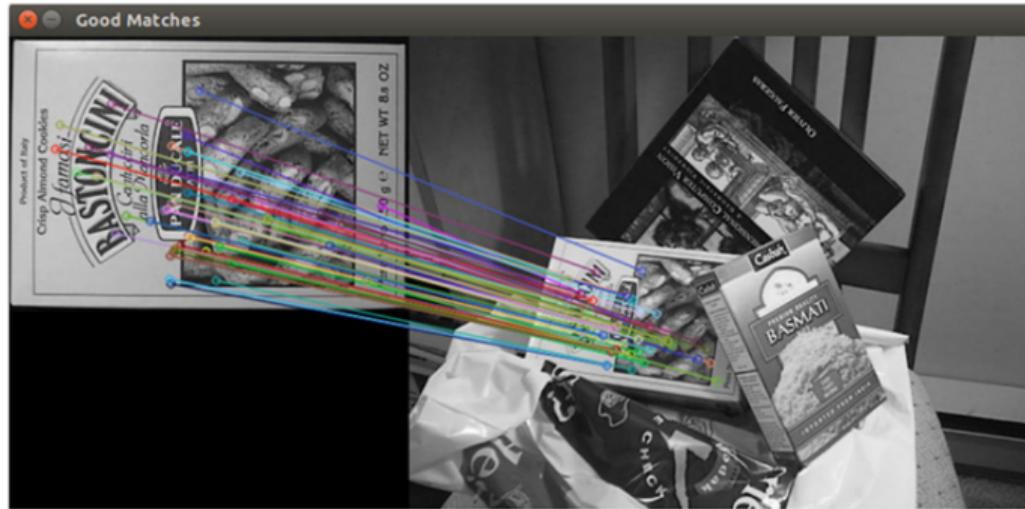
Key points

- Corners, distinct elements
- Much less in number than pixels
- Easily trackable



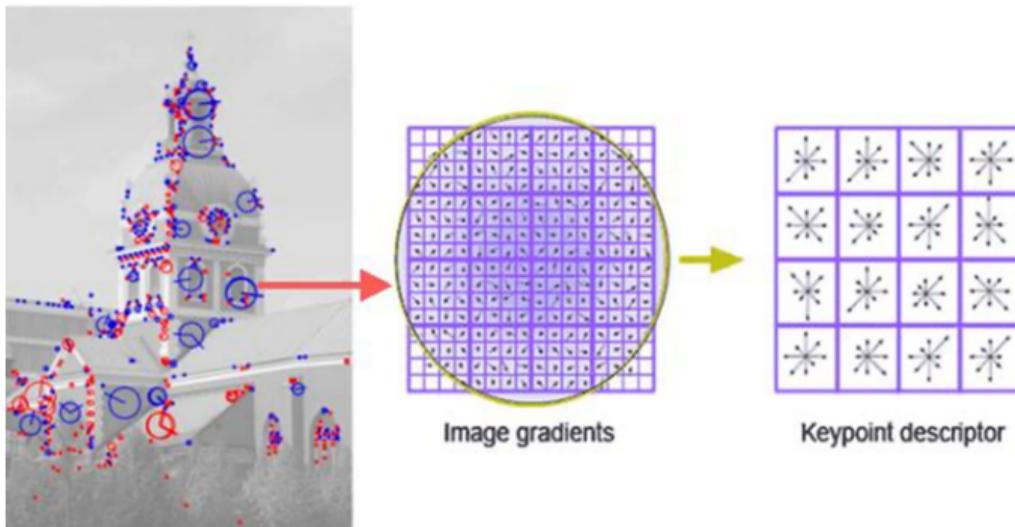
Descriptors

- Gradient histograms...
- ...in vector form



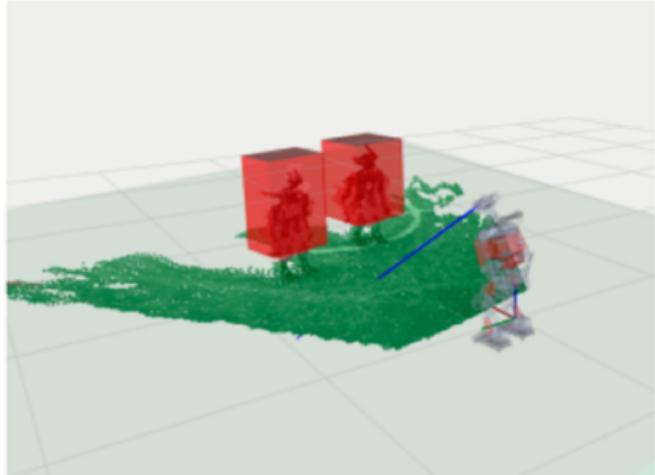
Descriptors

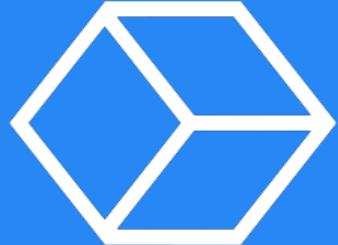
- Gradient histograms...
- ...in vector form



Applications

- 3D scene processing
- Synthesis of intermediate frames, opponent detection





Thank you for your time

Laboratory of robotics and control systems
ITT PROJECT MANAGEMENT SERVICES L.L.C