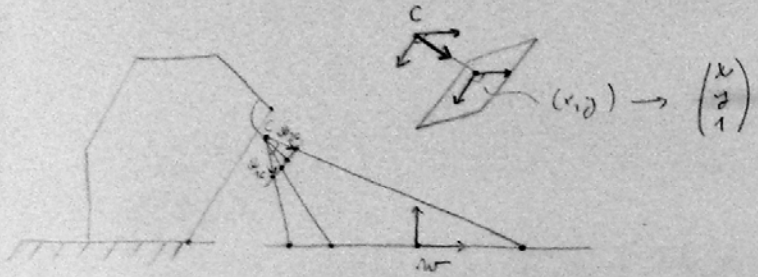


Advanced Robotics

Lecture 11

P3P - Camera pose from images of 3 known 3D points

... kalibrovana' kamera



$$\cos \angle(w_{1c}, w_{2c}) = \frac{w_{1c} \cdot w_{2c}}{\|w_{1c}\| \|w_{2c}\|} = \frac{w_{1c1} w_{2c1} + x_{1c2} x_{2c2} + x_{1c3} x_{2c3}}{\|w_{1c}\| \|w_{2c}\|}$$

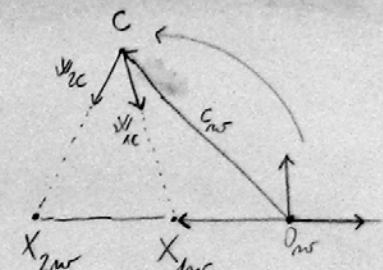
$$\begin{pmatrix} x_1 \\ y_1 \\ 1 \end{pmatrix} \quad \begin{pmatrix} x_2 \\ y_2 \\ 1 \end{pmatrix} \\ \dots \quad \begin{pmatrix} x_n \\ y_n \\ 1 \end{pmatrix}$$

3 projekce

$$\begin{aligned} w_{1c} &= \begin{pmatrix} x_1 \\ y_1 \\ 1 \end{pmatrix} \sim X_{1nr} \\ w_{2c} &= \begin{pmatrix} x_2 \\ y_2 \\ 1 \end{pmatrix} \sim X_{2nr} \\ w_{3c} &= \begin{pmatrix} x_3 \\ y_3 \\ 1 \end{pmatrix} \sim X_{3nr} \end{aligned}$$

3 body ve 3D

související
 vzhledem
 k ortonormální
 bázi



$$d_i w_{ic} = R (X_{inr} - C_{nr})$$

$3 \cdot m \quad 12 + m$
 $3 \cdot 3 = 9, \quad 12 + 3 = 15$
 $6 \sim R^T R = I$

nekvalitativní: $M_c = \begin{pmatrix} m & & \\ & n & \\ & & 1 \end{pmatrix} \quad K, R, C$

$P = K(R|RC)$

$w_c = K^{-1} m_c$
 $\begin{pmatrix} \dots \\ 0 \dots 0 \\ 0 \dots 1 \end{pmatrix}^{-1} = \begin{pmatrix} \dots \\ 0 \dots 0 \\ 0 \dots 1 \end{pmatrix}$

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```
P3P - Absolute Camera Orientation
T. Pajdla, Z. Kukelova
11 Dec 2008
> restart:
with(ListTools):
with(LinearAlgebra):
with(Student[LinearAlgebra]):
with(Groebner):
Digits:=10:

Algorithms
[ Cartesian product of two lists
> IsL:=proc(X,Y)
    Flatten(map(x->(map(y->Flatten([x,y]),Y)),X),1);
end proc:

P3P Problem
The calibrated perspective camera observes three points X1_w, X2_w, X3_w along rays with direction
vectors x1_c, x2_c, x3_c. Vectors X1_w, X2_w, X3_w are written w.r.t. the world cartesian coordinate
system. Vectors x1_c, x2_c, x3_c are written w.r.t. the camera cartesian coordinate system. There exist
multipliers d1, d2, d3, for which

X1_c = d1 x1_c
X2_c = d2 x2_c
X3_c = d3 x3_c

Since both systems are cartesian, we get three equations in three variables d1, d2, d3 of degree two

D12 = |X1_w - X2_w|^2 = |X1_c - X2_c|^2 = |d1 x1_c - d2 x2_c|^2
D23 = |X2_w - X3_w|^2 = |X2_c - X3_c|^2 = |d2 x2_c - d3 x3_c|^2
D31 = |X3_w - X1_w|^2 = |X3_c - X1_c|^2 = |d3 x3_c - d1 x1_c|^2

which we can solve for multipliers d1, d2, d3
[ Simulation
[ Known points in space
> X1_w := <0, 0, 0>;
X2_w := <1, 0, 0>;
X3_w := <0, 1, 0>;

X1_w :=  $\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$ 
X2_w :=  $\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$ 
X3_w :=  $\begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$ 

[ their distances
> D12 := DotProduct(X1_w - X2_w, X1_w - X2_w);
D23 := DotProduct(X2_w - X3_w, X2_w - X3_w);
D31 := DotProduct(X3_w - X1_w, X3_w - X1_w);

D12 := 1
D23 := 2
D31 := 1

[ The camera with center C and rotation matrix R
> C_w := <0, 0, 1>;
R_cw := convert(RotationMatrix(Pi/3, <1/3, 1, -1/7>), Matrix);
```