Advanced Robotics

Lecture 11

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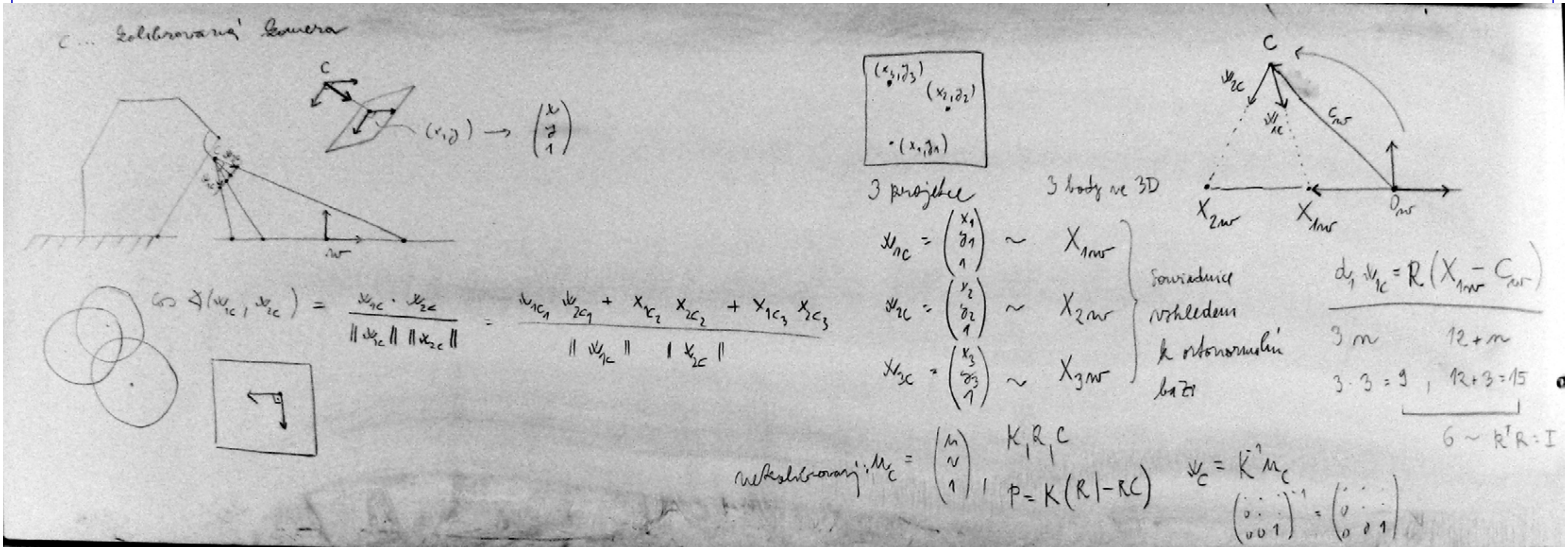
P3P - Camera pose from images of 3 known 3D points



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P3P - Absolute Camera Orientation
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```
> restart:
  with(ListTools):
  with(LinearAlgebra):
  with(Student[LinearAlgebra]):
  with(Groebner):
  Digits:=10:
```

Algorithms

Cartesian product of two lists

```
> LxL:=proc(X,Y)
        Flatten(map(x->(map(y->Flatten([x,y]),Y)),X),1);
  end proc:
```

P3P Problem

The calibrated perspective camera observes three poins 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 cordinate 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 sytems are cartesian, we get three equations in three variables d1, d2, d3 of degree two

D12 = ||X1_w - X2_w||^2 = ||X1_c - X2_x||^2 = ||d1 x1_c - d2 x2_c ||^2
D23 = ||X2_w - X3_w||^2 = ||X2_c - X3_x||^2 = ||d1 x1_c - d2 x2_c ||^2
D31 = ||X3_w - X1_w||^2 = ||X3_c - X1_x||^2 = ||d1 x1_c - d2 x2_c ||^2

which we can solve for multiplieds d1, d2, d3

Sumulation

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);
```


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