Diagnostic Medical Image Processing
Prof. Dr.-Ing. Andreas Maier
Exercises (DMIP-E)
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Projection Models

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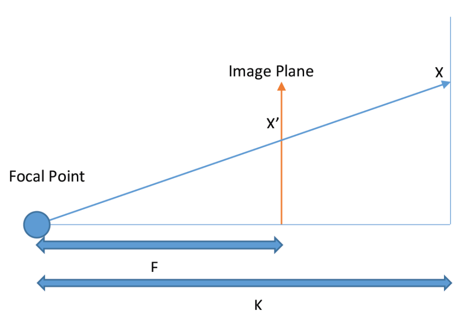
Exercise Sheet 3

7 Projections

(i) We want to find the projection of the point X on the image plane as shown in the figure.

- What kind of projection is that and how is X mapped to its projection point X' on the image plane?
- Which difficulty is connected with this mapping?
- Which kind of mapping could we use instead if we wanted to approximate the projection from above?
- For both projection models, write down the mapping for 3-D to 2-D *cartesian* coordinates.



(ii) Of the following projection models, for which ones do all projected points pass through the origin of the camera coordinate system?

☐ respective projection ☐ orthographic projection

☐ weak-perspective projection ☐ paraperspective projection

☐ perspective projection ☐ no-perspective projection

2+1

8 Homogeneous Coordinates

(i) Find the intersection point of the following two lines:

$$l_1 : 3x + 4y = 6,$$
$$l_2 : \quad x + y = 2.$$

(ii) Compute the intersection of the parallel 2-D lines [a,b,c] and [a,b,c'] (notation from the lecture).
(*Hint*: Check out which 2-D point you get if you calculate the cross product of the coordinate axes.)

(iii) Can you find an inhomogeneous 2-D representation of the intersection point? Otherwise describe why you cannot.

(iv) Do these results in 2-D match the intuition that parallel lines "meet at infinity"?

1+1+1+1

9 Camera Parameters

(i) What are extrinsic camera parameters and intrinsic camera parameters?

(ii) With your new digital camera (focal length f=0.3 cm, zero pinhole offset, perfect square pixels, i.e., $k_x = k_y$, camera skew is exactly 90°) you want to study the effects of perspective distortion. Therefore you take a picture of the rails at an inoperative side track near your local train station. The coordinates of the camera's optical center with respect to the world coordinate system are $C = (0, 0, h)^T$, where $h = 60\,\text{cm}$. The camera's principal axis is parallel to the rails. Write the expression for the camera's full projection matrix P.

(iii) An object is observed and its center is located at $\mathbf{x}_0 = (1.2, 3.6, 2.0)^T \in \mathbb{R}^3$. The object is rotated around the x-axis by $\theta_x = 30°$ and by $\theta_y = 90°$ around the y-axis. Furthermore the camera is translated by $\mathbf{t} = (1.3, 2.2, 2.0)^T$. Finally the object is projected perspectively to the image plane with focal length $f = 4$.

- Does it make a difference which rotation to perform first? Why?
- State the translation, rotation and projection mapping in a single transformation matrix T and apply T appropriately to find the homogeneous point $\mathbf{x}'_1 \in \mathbb{P}^3$.
- Calculate the projected center $\mathbf{x}_1 \in \mathbb{R}^3$.

0.5+1+1.5

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