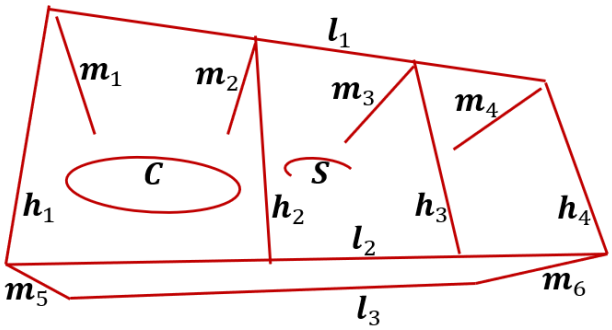
Homework 2024-2025

Scene. A piece of forniture is a rectangular parallelepiped, whose width (along the X-axis) is $\boldsymbol{l} = 1$. The other dimensions, namely the depth $\boldsymbol{m}$ along the Y axis and the height $\boldsymbol{h}$ along the Z-axis are unknown. In addition, a horizontal circumference (i.e., parallel to the X-Y plane) is visible. Furthermore, an unknown horizontal planar curve is also visible, placed at midheight $\boldsymbol{h}/2$.

Image. A single image is taken of the above rectangular parallelepiped by an uncalibrated, zero-skew, camera. (*Its calibration matrix* $\boldsymbol{K}$ *depends on* ***four*** *unknown parameters, namely* f_x , f_y *and the two pixel coordinates* U_o, V_o *of the principal point*). A set of lines parallel to X-axis are visbile, and their images $\boldsymbol{l_1}, \boldsymbol{l_2}$ and $\boldsymbol{l_3}$ are extracted; a set of lines parallel to the Y-axis are visible and their images $\boldsymbol{m_1}, \boldsymbol{m_2}, \boldsymbol{m_3}, \boldsymbol{m_4}, \boldsymbol{m_5}$, and $\boldsymbol{m_6}$ are extracted; a set of vertical lines (i.e., parallel to the Z-axis) are also visible and their images $\boldsymbol{h_1}, \boldsymbol{h_2}, \boldsymbol{h_3}$ and $\boldsymbol{h_4}$ are extracted. In addition, both the image $\boldsymbol{C}$ of the circumference and the image $\boldsymbol{S}$ of the unknown horizontal curve are also extracted.



Part 1 – **Theory**

1. From the $\boldsymbol{l_i}$ and $\boldsymbol{m_j}$ lines, find the vanishing line $\boldsymbol{l'_\infty}$ of the horizontal plane.
2. Using the results of the previous point, find a (Euclidean) rectification mapping $\boldsymbol{H_R}$ for a horizontal plane (e.g., the lower horizontal face of the parallelepiped), and compute the depth $\boldsymbol{m}$ of the parallelepiped.
3. From the results of the previous points, use the lines $\boldsymbol{h_i}$ to find the calibration matrix $\boldsymbol{K}$.
4. Using the results of the previous points, determine the height $\boldsymbol{h}$ of the parallelepiped.
5. Using $\boldsymbol{S}$ and the results of previous points, compute the X-Y coordinates of a dozen points (at your choice) of the unknown horizontal curve.
6. Using **K**, localize the camera with respect to the parallelepiped.

Part 2 - **Matlab**

1. Consider the image Look-outCat.png. Using feature extraction techniques (**including** those already implemented in **Matlab**) plus possible manual intervention, extract the images of useful lines and both the image $\boldsymbol{C}$, of the circumference and the image $\boldsymbol{S}$ of the other planar curve.
2. Write a Matlab program that implements the solutions to problems 1 – 6 and show the obtained results.
3. Plot the rectified curve $\boldsymbol{S}$ and show different views of the recovered 3D model of the rectangular parallelepiped.