Homework 2025-2026

Scene. The observed scene includes a cylindric vault containing curved elements, called diagonal arcs or ogival ribs, plus some straight segments. The straight segments are either vertical or horizontal. The horizontal segments are parallel to the cylinder axis. The set of diagonal arcs can be subdivided into two families $A = \{..\ a_i\ ..\}$ and $B = \{..\ b_j\ ..\}$. Each family containes equal, parallel and equidistant diagonal arcs. The distance $\boldsymbol{d}$ between two neighboring arcs of the same family is given: $\boldsymbol{d} = 1$.

A diagonal arc of a family, e.g., $a_i \in A$, crosses some diagonal arcs b_j of the other family at nodal points N_{ij}. The arcs a_i and b_j are **symmetric** with respect to the vertical plane π_{ij} *perpendicular* to the cylinder axis passing through the nodal point N_{ij}. In addition, for each diagonal arc a_i there is one diagonal arc b_i of the other family, that crosses a_i at an *apical* (highest) nodal point N_{ii}, and a_i and b_i are **symmetric** with respect to the vertical plane π_v *parallel* to the cylinder axis.

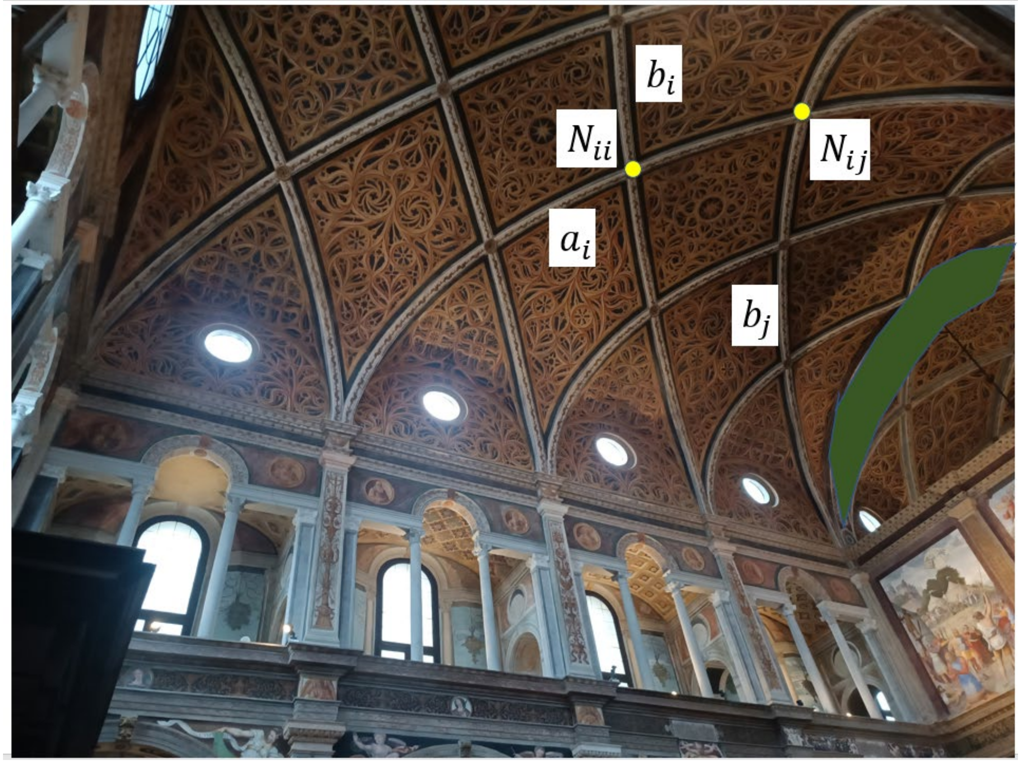

Image. A single image is taken of the above elements by an uncalibrated, zero-skew, camera. (*Its calibration matrix* $\boldsymbol{K}$ *depends on* ***four*** *unknown parameters, namely* f_x , f_y *and the two pixel coordinates* U_o, V_o *of the principal point*). Several lines are visible, including vertical lines (in black) and horizontal lines parallel to the cylinder axis (in green and in yellow); the yellow line connects the apical nodal points. Notice that parallel lines in white are horizontal, since they connect nodal points that are symmetric wrt the plane π_v.

Part 1 – **Theory**: explain in detail how to

1. From the above mentioned sets of lines, find the vanishing line $\boldsymbol{l'}_\infty$ of any plane perpendicular to the cylinder axis.
2. Find the vanishing point of the direction of the cylinder axis.
3. Using both the results of the previous points and the image of some of the diagonal arcs, find a (Euclidean) rectification mapping $\boldsymbol{H_R}$ for one of the vertical planes perpendicular to the cylinder axis. Compute the position of a non-apical nodal point on the choosen plane.
4. From the results of the previous points, compute the calibration matrix $\boldsymbol{K}$ of the camera.
5. Using the results of the previous points, choose one of the diagonal arcs and compute the 3D coordinates of a dozen of its points (e,g, wrt a camera reference).
6. Using **K**, localize the cylinder axis wrt the camera.

Part 2 - **Matlab**

1. Consider the image San Maurizio.png. Using feature extraction techniques (**including** those already implemented in **Matlab**) plus possible manual intervention, extract the images of useful lines and edgepoints on the curved arcs.
2. Write a Matlab program that implements the solutions to problems 1 – 6 and show the obtained results.
3. Plot one of the curved arcs, and show different views of it in 3D.