IACV Homework Computed Results

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Abstract

This document has been organized to only give an overview of the results obtained by running the code. Both for an increased understanding of the analytical theory and the utilization of the code, the "Report" document should be read.

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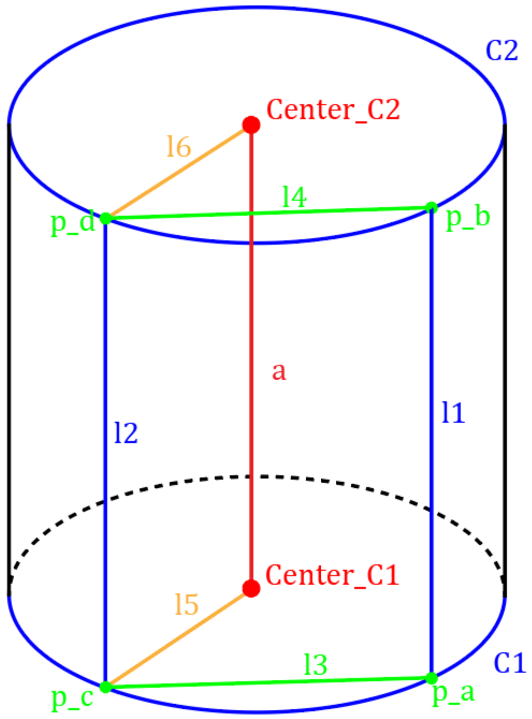
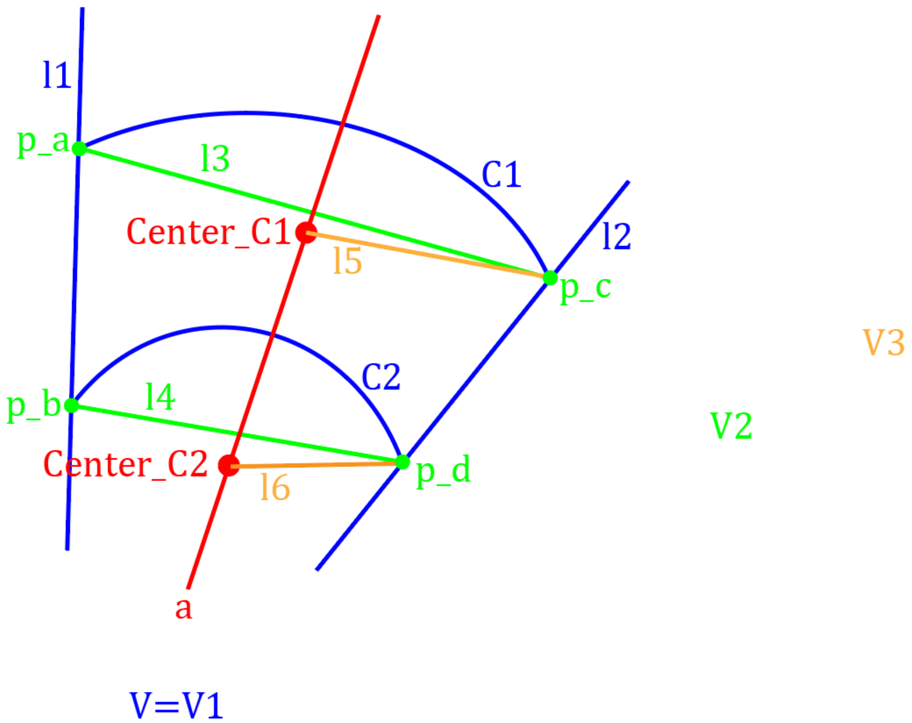
Introduction

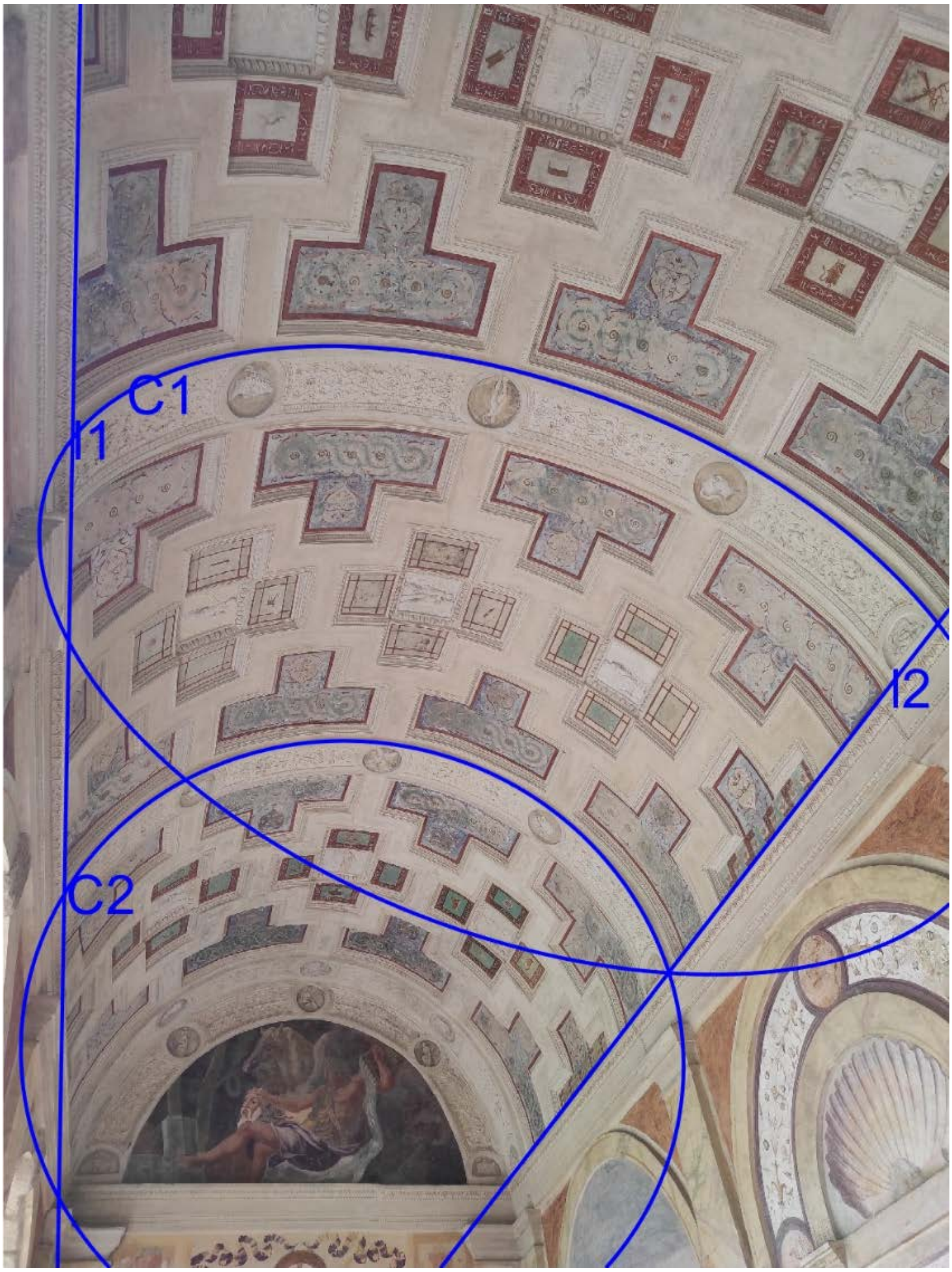
The following naming conventions for the lines, points and conics was used.





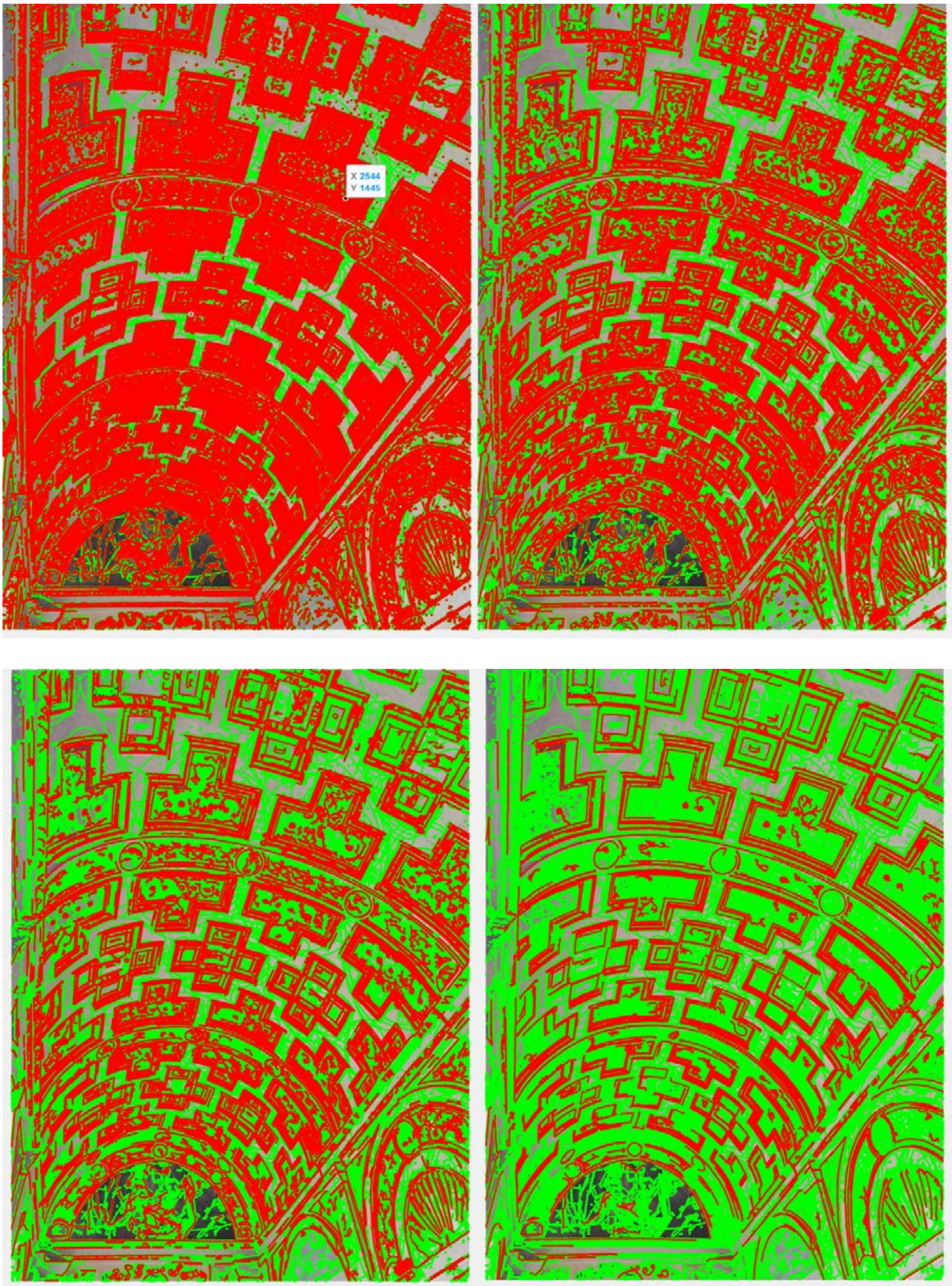
0A. Feature Selection Result

Generatrix lines and conics can be chosen manually by selecting 2 and 5 points on the curves respectively:



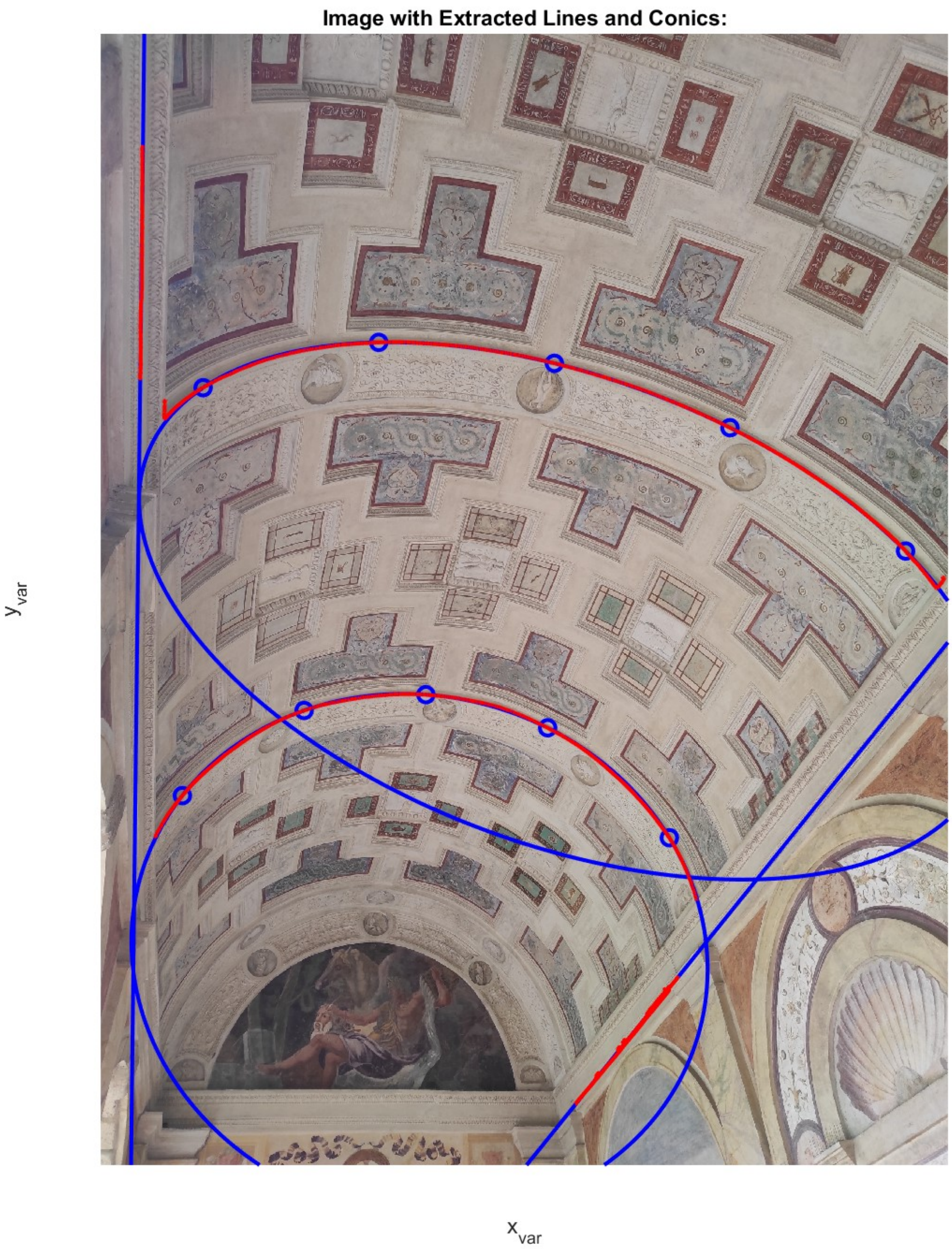
0B. Edge/Ellipse Detection Algorithms

- Below are the detected edges and ellipses in the image with increasingly long point arrays defining each edge/ellipses going to the right-most image.
- The ellipse detection algorithm was decommissioned since the edge detection also provides elliptical looking edges which is enough for feature extraction.



0B. Image with (Filtered) Extracted Features

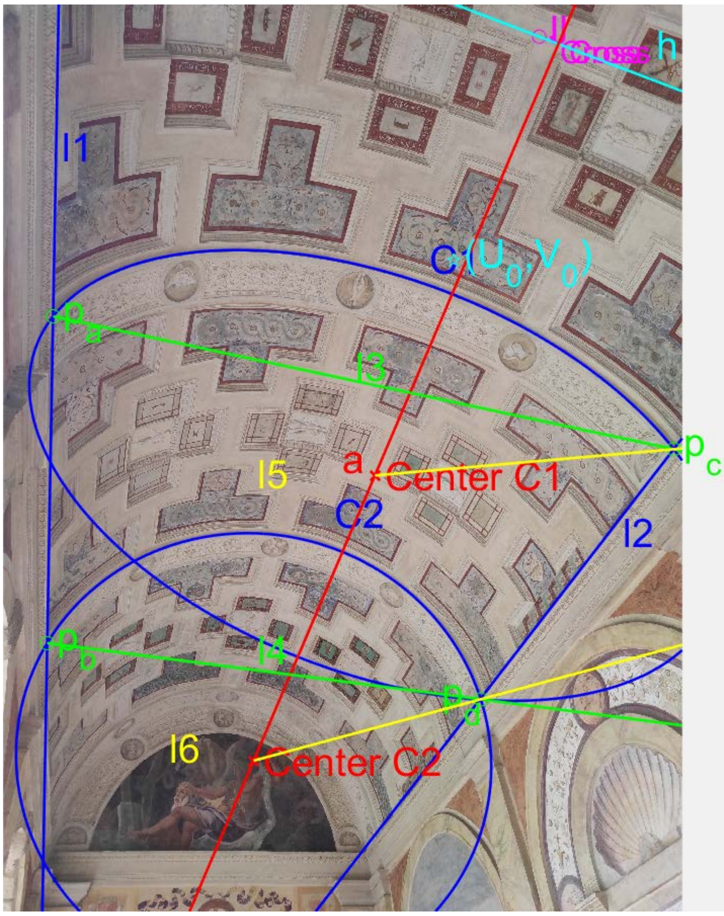
- The red lines correspond to the edges that have been extracted from the image and filtered until they correspond to the edges that can be used to define the 2 conics and 2 generatrix lines.
- The blue lines correspond to the generatrix lines fitted to the linear edges using "polifit".
- The blue conics correspond to the conics fitted to the conic edges by sampling 5 points from the middle portions of each edge and fitting a conic to those 5 points



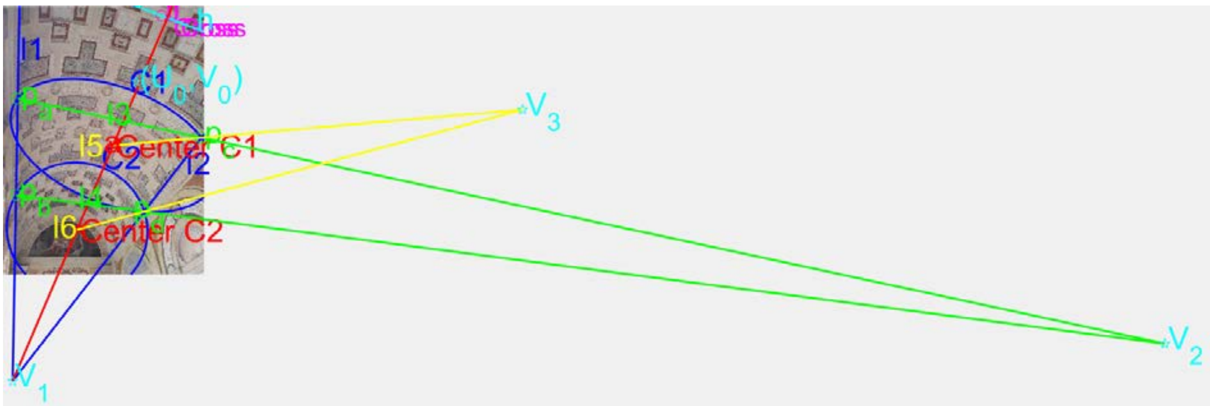
1, 2. Horizon Line: h, Cylinder Axis: a, Vanishing Point of a: V=V1

The below images show the useful features, points and line found on our image with the convention defined in “Introduction”:

- Cyan colored line $\boldsymbol{h}$ near the top right denotes the horizon line orthogonal to the cylinder axis.
- Red colored line $\boldsymbol{a}$ going through the middle of the image denotes the cylinder axis.



- Cyan colored star $V = V_1$ at the intersection point of the axis and the generatrix lines defines the vanishing point of the cylinder axis.
- Cyan colored star V_2 defines the vanishing point of lines l_3' and l_4'
- Cyan colored star V_3 defines the vanishing point of the lines l_5' and l_6'



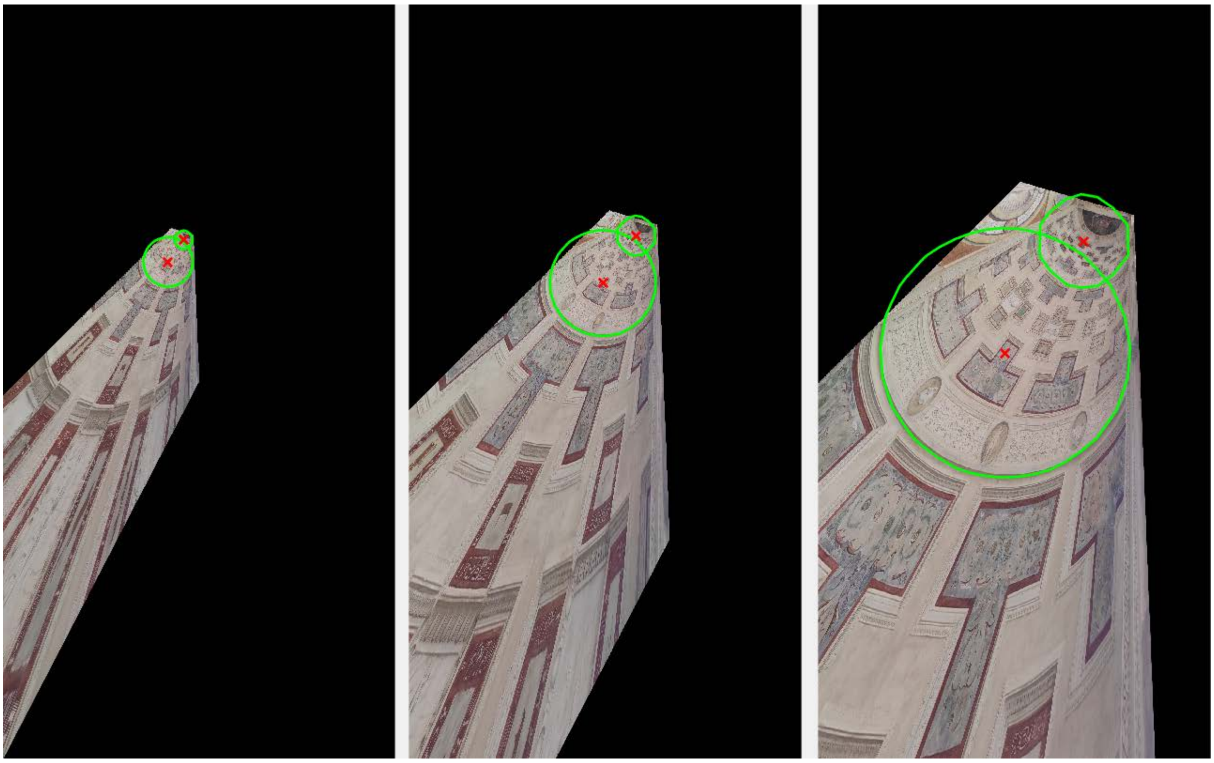
3. Calibration Matrix K

```
K =

   1.0e+03 *

    3.8084         0    2.3041
         0    3.8084    1.3092
         0         0    0.0010
```

- Rectifying homography H_{rect} was found as:

```
H_rect =

   -0.9641   -0.2657   -0.0001
    1.8583   -6.7432    0.0084
   -0.0004    0.0011    1.0000
```

- The rectified image (And rectified conics) using this homography is given as below:



Preamble to 4.

- The pose parameters $[i_\pi \quad j_\pi \quad o_\pi]$ of the rectified image plane π in 3D is found as follows:

```
i_pi =          j_pi =          o_pi =

-1.8269e-04    -9.4428e-05    -0.6050
-2.9735e-05    -9.5511e-05    -0.3438
-1.1643e-04     1.7256e-04     1.000
```

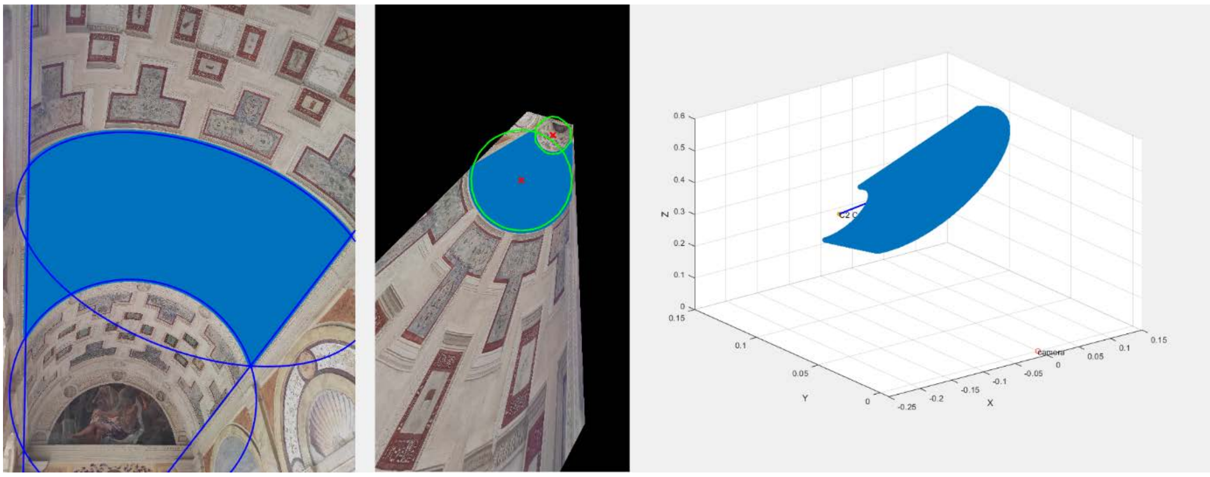
- These pose parameters along with the rectifying homography found in the previous section can be used to map any point u in the original image plane, to the rectified image plane as x_π, and to the 3D coordinates within the rectified image plane in 3D as x_{world}.

$$u = H_{rect}^{-1} x_\pi$$

$$x_\pi = H_{rect} u$$

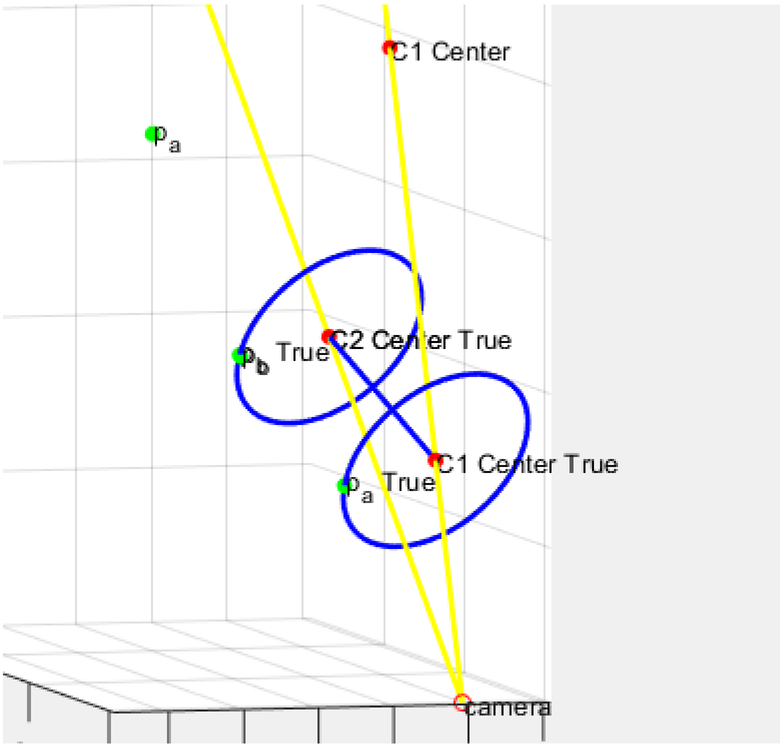
$$x_{world} = \begin{bmatrix} i_\pi & j_\pi & o_\pi \\ 0 & 0 & 1 \end{bmatrix} x_\pi = \begin{bmatrix} i_\pi & j_\pi & o_\pi \\ 0 & 0 & 1 \end{bmatrix} H_{rect} u$$

- Applying these mappings to the target cylindrical surface left between the generatrix lines and the conics we can transform these points as follows: (Left to right: Target points in the original image, in the rectified image, in 3D coordinates within the rectified plane)



4,5. Orientation of the Cylinder Axis in 3D, Radius/Distance

- Using the logic defined explicitly in the "Report" in section: "Q4 Preamble MatLab Implementation (P4_5_demo.m)" we can find where one of the realizations of the 3D cylinder in space is as follows:



- The 3D cylinder can in fact be anywhere in 3D space as long as the conic centers are shifted along their viewing rays and the axis orientation is preserved.
- **The orientation of the cylinder axis in 3D** was found to be in the direction of the following vector:

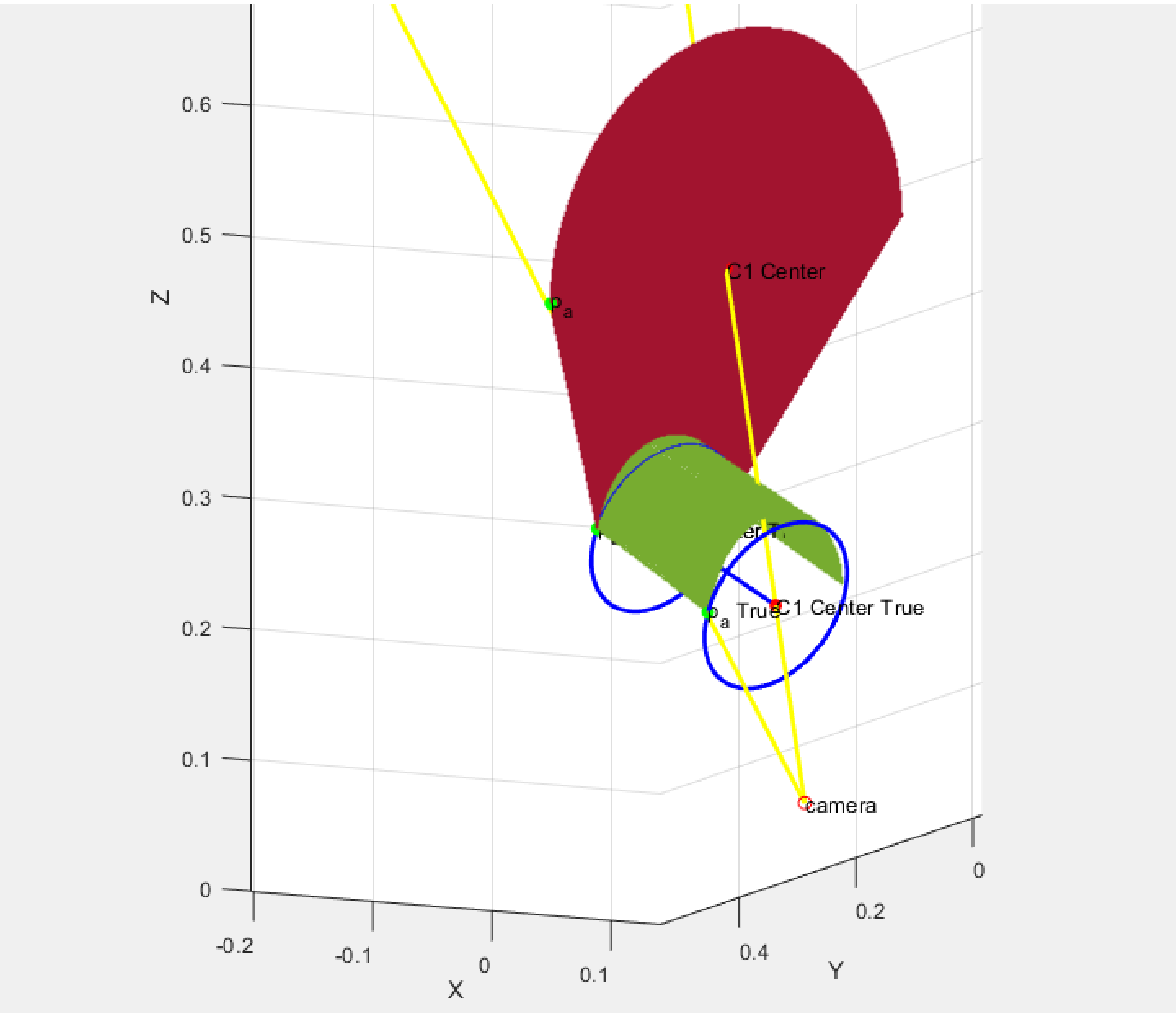
```
axis_direction_vector_True =

   -0.3214
    0.7817
    0.5344
```

- The **Radius/Distance** measure of the cylinder was found to be:

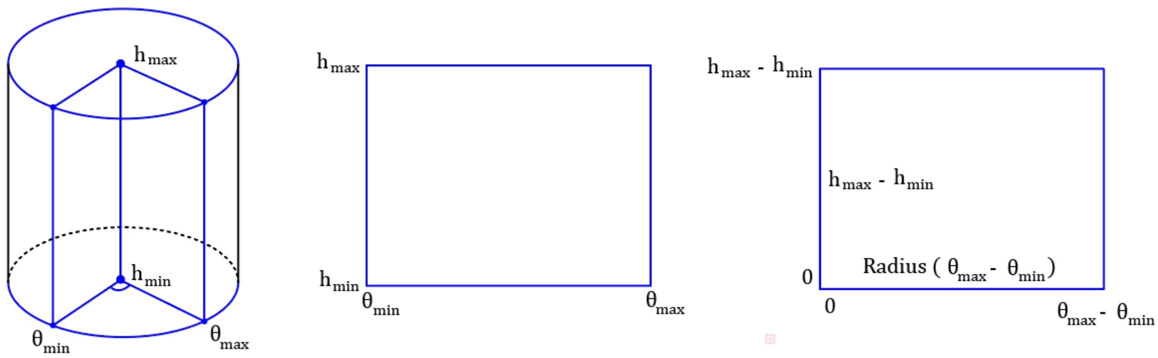
```
Radius_over_Distance = 0.5174
```

6. Unfolding of the Target Cylindrical Surface

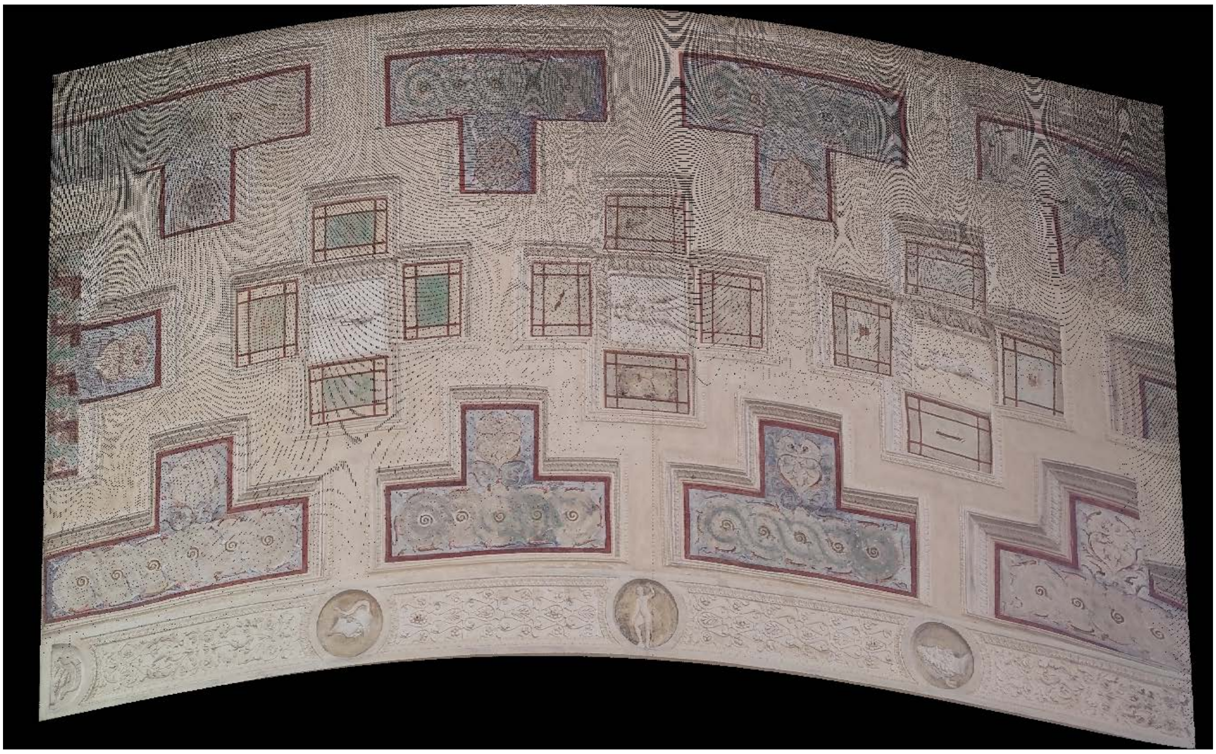
- After the cylinder in 3D was found all the cylindrical surface points were moved along their viewing rays to the points they intersect with the 3D cylindrical surface as follows:



- Then the points were defined by cylindrical coordinates (h, θ) but plotted linearly to unfold the cylindrical surface as follows:



- The resultant unfolded image was:



- The slight curve to the unfolded image is due to many imperfections in rectification and 3D mapping, however at this point we know for a fact that the cylindrical surface should be rectangular in the unfolded form. Therefore, the above image was squared to the θ axis by shifting each column of pixels until the bottom most pixels hit the θ axis. (Think of it analogically as squaring a stack of papers on a desk) Finally the unfolded image is given as follows: