IMAGE OF THE ABSOLUTE CONIC: WHERE IS IT?

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Abstract

Image of the absolute conic is the key of most camera self-calibration methods. We propose a simple yet convincing method to solve the projected absolute conic by using only a single view, based on the semi-real quadrangle. The output of every case is a non-degenerate circle. This is the good news! This circle is then employed for the self-calibration process.

Motivation

The Absolute Conic (AC) is projected to the image plane as the image of the absolute conic (IAC). In this work, we propose a method to solve the IAC by considering three aspects: 1. using only single view, 2. employing two vanishing points, 3. avoiding degenerate cases.

Camera Self-Calibration

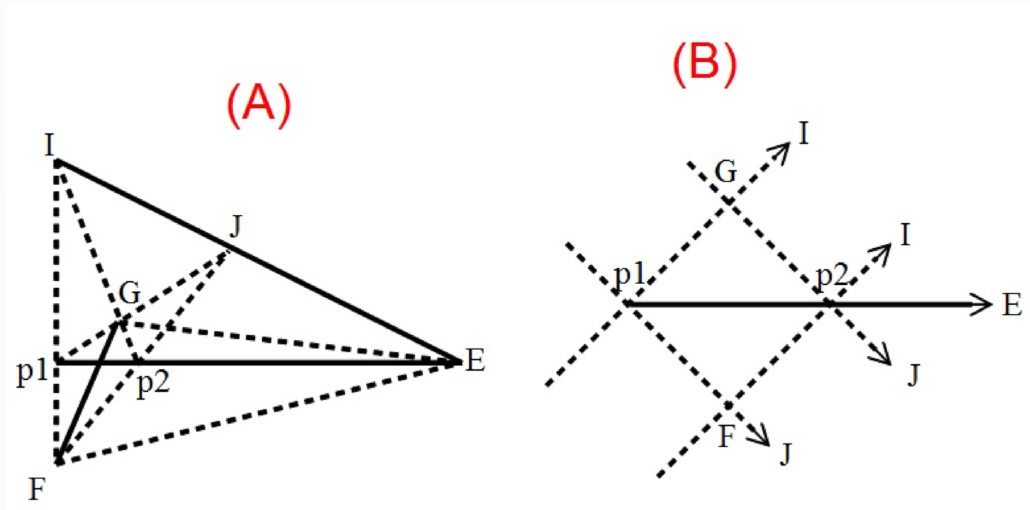
A process of determining intrinsic camera parameters is called Camera Self-Calibration. In [1, p. 210] has been proven that IAC depends only on intrinsic camera parameters $\mathbf{K}$, where IAC $\boldsymbol{\omega} = (\boldsymbol{K}\boldsymbol{K}^{\boldsymbol{T}})^{-1}$. By this relationship, it also means that $\mathbf{K}$ can be decomposed from $\boldsymbol{\omega}$.

Two-point Perspective

In two-point perspective view, only two vanishing points are being kept on the horizon. These two points, along with another two circular points at infinity $I = (1, i, 0)$ and $J = (1, -i, 0)$, can be used to define IAC .

Semi-Real Quadrangle

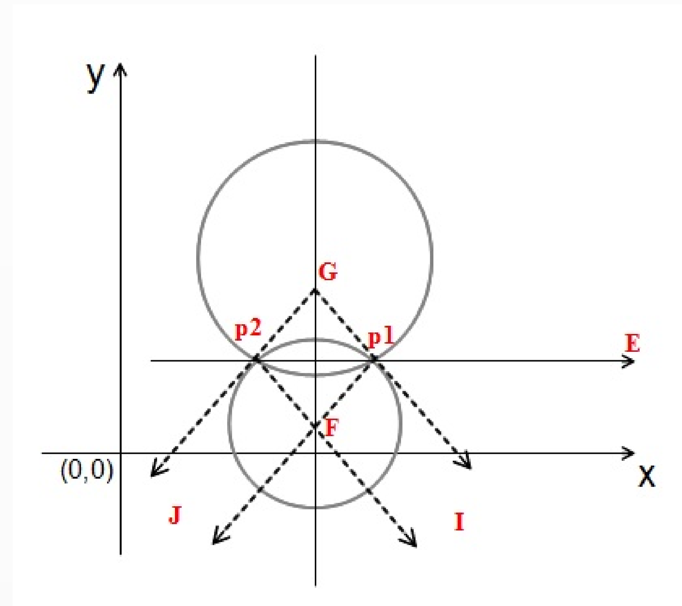
The two vanishing points $(p1, p2)$ are a pair of real points and the other two points (I, J) are a pair of imaginary points. These two pairs, determine a semi-real quadrangle of 2nd kind, as explained in detail in [2, p. 27]. Point I and J in this case are assumed as the two points on the AC which then projected to the image plane, making up the IAC.



Semi-real Quadrangle of 2nd kind

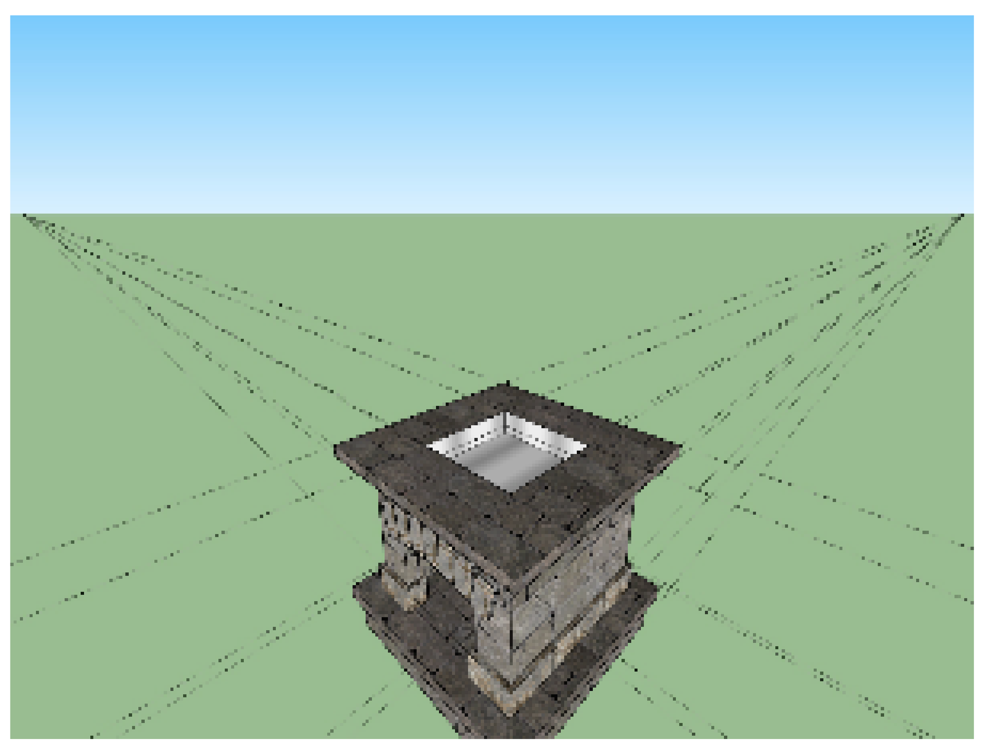
Image of Absolute Conic

From the semi-real quadrangle, we then have two circles intersect at the two vanishing points. The line between $p1$ and $p2$ is real and it visualizes the radical axis. The line between F and G is also a real line. Thus, the two circles are real. The IAC that we are looking for is one of these two circles.



Results

Once the IAC is found, the next step, finding $\mathbf{K}$ can be done by decomposing $\boldsymbol{\omega}$ into $(\boldsymbol{K}\boldsymbol{K}^{\boldsymbol{T}})^{-1}$ or, by using the inverse of it to get the Dual of IAC $\boldsymbol{\omega}* = \boldsymbol{K}\boldsymbol{K}^{\boldsymbol{T}}$. It is then decomposed by using Cholesky method. In the experiments, the camera is simulated using Google SketchUp with camera format: 35mm 4-Perf 1.33 Camera Aperture. One of the results is as shown below.



p1(19, 267), p2(1271,267)

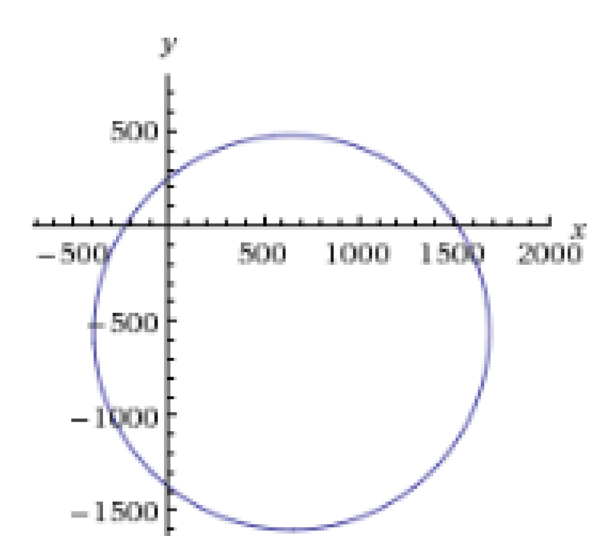


Image of the Absolute Conic

The image size is 1284×966 and setting up the focal length at 11 mm, the output of the intrinsic matrix $\mathbf{K}$ is

$$\begin{bmatrix} 703.72 & 0.0096 & 708.5256 \\ & 714.6 & 967.0 \\ & & 1 \end{bmatrix}$$

A Future Direction

Instead of two possible outputs of IAC, the next task should be finding the best IAC candidate out of two. Better algorithm for minimizing errors between the espected and the output of $\mathbf{K}$ is also needed.

References

[1] Hartley, Richard, and Andrew Zisserman. Multiple View Geometry in Computer Vision. Cambridge university press, 2003.

[2] John Leigh Smeathman., Hatton, The Theory of the Imaginary in Geometry: Together with the Trigonometry of the Imaginary, Cambridge University Press, 1920.