AN APPROACH FOR PHOTOGRAMMETRIC FIELD OF VIEW ANALYSIS

Arif GÜNAY[1], Emin Özgür AVŞAR[2]

[1]Istanbul Technical University, Geomatics Engineering Department
Maslak, Istanbul, Turkey

arifgun@hotmail.com, avsarem@itu.edu.tr

Keywords: photogrammetry, camera, field of view

Abstract:

Selection of the camera and lens is an important parameter according to the characteristic and aimed accuracy of the study. Another parameter is the whether field of view of the camera, according to designated or feasible camera locations, covers the targeted area and/or points. Firstly a field of view pyramid for a known camera was drawn and manually rotated to ensure whether target points stand in it or not. To automate this methodology an algorithm; based on the relations between plane and point, was developed. Since the field of view pyramid is formed by four planes intersecting on the projection centre and each of these planes split the object space in two parts, by using the plane equations, it is possible to define the position of the target points according to these planes. Sensor size and focal length are the other important factors to analyze a camera, since they are directly related to field of view angle. For unknown sensor size and focal length; the algorithm calculates the necessary sensor size within boundary value respectively. With known sensor size and focal length; algorithm calculates coordinates of four bend points and composes the equation of the four planes respectively. After introducing the target points coordinates to these equations, a simplified mathematical (1 for all positive and -1 for all negative values) report is formed. The algorithm also provides these results graphically and independent from the numbers of cameras.

1. INTRODUCTION

Cameras locations should be fixed in continuous monitoring projects like deformation analysis. Target quality and accuracy of the project is the most important parameter effects on camera and lens combination selection. However, whether the target area and /or points occur or not occur in the field of view of the camera; according to designated or possible camera locations, will be an important factor in terms of network design. In this study, basic principles and steps of the prepared algorithm; that evaluates camera specifications depending on the specific camera and target point positions, will be introduced.

2. FIELD OF VIEW ANALYSIS

2.1 Graphical Approach

In the present study; according to sensor size and focal length of the randomly selected camera-lens combination and target points, camera plane view is formed two dimensionally and displayed (Figure 1. a). As the second step; same situation discussed three dimensionally and as a result field of view pyramid was obtained (Figure 1. b). The basic approach here depends on the remaining of the maximum target points in the field of view of the camera, by manually rotating the field of view plane or pyramid. This method only presents a graphical approach. In addition, the method is useless in terms of both time and difficulty and error-prone since it is user-based.

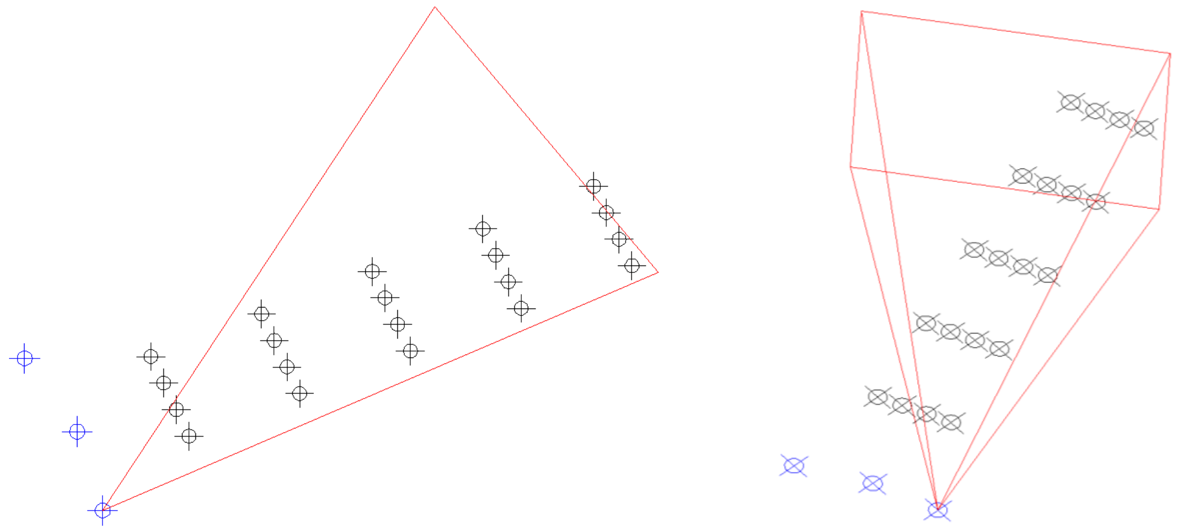

Figure 1: a) Plane view b) FOV Pyramid

1.2 Mathematical Principles and Mathematical Approach

Performing field of view/pyramid analysis will be possible with some mathematical additions based on the graphical approach. The first stage will be determining the necessary viewing angle, in order to cover all target points. This angle can be also described as the angle between the outermost points. Therefore, the approach will be determining directions from camera location to the target points' locations. The maximum and minimum direction values will show the outermost target points and the difference between these direction values will give the necessary viewing angle.

After obtaining the necessary viewing angle; one can calculate the necessary sensor size (with a given focal length) with the given formulas below, while f is focal length, α and β are the necessary angles and SW and SH are the sensor width and height.

Since the field of view pyramid is formed by four planes intersecting on the projection centre and each of these planes split the object space in two parts (positive/negative), by using the plane equations, it is possible to define the position of the target points according to these planes. While all planes and points will be in the same coordinate system, if the result for a point is positive on plane's formula and negative on adverse plane's formula; it is sure that this point is between this two planes. Thereby inverse signed resulted points for plane D1-D3 and D2-D4 will be in the FOV pyramid (Figure 2).

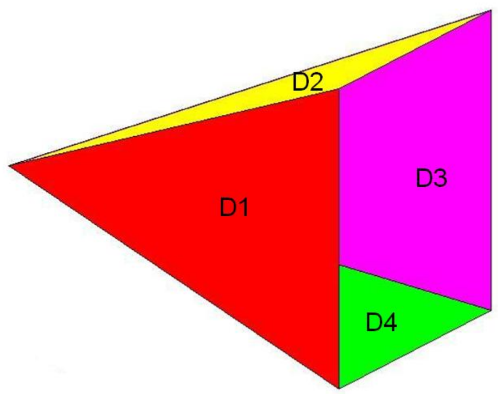

Figure 2: Field of View Pyramid formed by 4 Planes

Since three points on the same plane is enough to define the plane equation and one of these points will be the projection center of the camera, main objective become depicting the other two points (Figure 3).

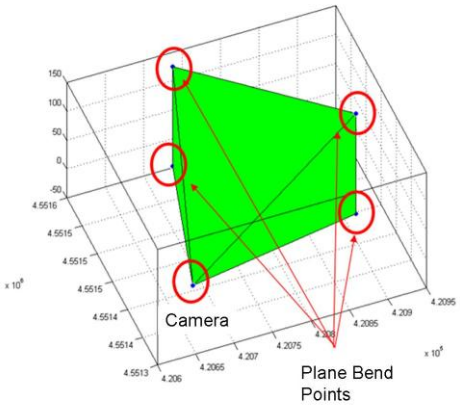

Figure 3: Field of View Pyramid and Bend Points

Sensor size and focal length are the other important factors to analyse a camera, since they are directly related to field of view angle. First of all; the algorithm calculates the necessary angles (α in XY plane and β in XZ plane) to view all points. These will introduce two cases for the algorithm to calculate the bend points:

Unknown sensor size and focal length: The algorithm calculates the necessary sensor size within boundary value respectively by using the below formulas, while f is focal length, ε is the boundary angle and SW and SH are the sensor width and height.

Known sensor size and focal length: By manipulating the previously given formula, it also possible to calculate the supplied angle (αK and βK) with known sensor size and focal length.

It is easy to say all target points stand in the FOV; if $\alpha K > \alpha$ and $\beta K > \beta$.

After taking condition these cases; algorithm centres the target points in XY and XZ plane and calculates a constant edge according to approximate distance of targets from the camera. With using these values; algorithm calculates coordinates of four bend points and composes the equation of the four planes respectively. After introducing the target points coordinates to these equations, a simplified mathematical (1 for all positive and -1 for all negative values) report is formed (Table 1).

Table 1: Abstract Table

Target Point	D1	D3	D1&D3	D2	D4	D2&D4	D1&D2&D3&D4
1	1	-1	0	1	-1	0	0
2	-1	-1	-2	1	-1	0	-2
3	1	-1	0	1	-1	0	0
4	1	-1	0	1	1	2	2
5	1	-1	0	1	-1	0	0
6	1	-1	0	1	-1	0	0

In the above table; columns 2, 3, 5 and 6 indicate relation between point to each plane, columns 4 and 7 indicate the situation between adverse plane and column 8 indicates control information for the pyramid.

The example table given above can be described as follows:

- Points 1, 3, 5 and 6 stands in FOV pyramid.
- Point 2 is on the left side (for example) of plane D1 and D3 and between plane D2 and D4, therefore it is out of FOV pyramid.
- Point 4 is between plane D1 and D3 and above (for example) the plane D2 and D4, therefore it is out of FOV pyramid.

4. CONCLUSION AND REMARKS

Algorithm; described above, can be used for determining appropriate camera-lens combination and appropriate camera locations at the precursor preparations of continuous monitoring projects.

The algorithm also provides these results graphically and independent from the numbers of cameras (Figure 4).

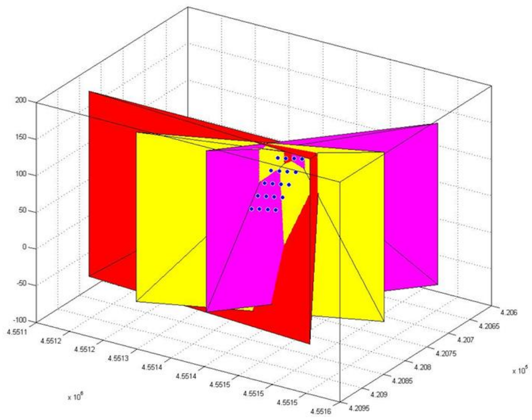

Figure 4: Graphic results for three cameras

The algorithm is incomplete in terms of point positioning accuracy analyze. Work is in progress to address this deficiency.