Software for Videogrammetry Image Matching

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Abstract: - In the last years the automation of the digital photogrammetries systems has been increased considerably due fundamentally to the current computers power. This paper presents an alternative to the terrestrial photogrammetry in the three-dimensional determination of an object (building, wall, table). This alternative is the videogrammetry and it consists on locate and define an object in the space using a video sequence. Both, the video camera as the computer used for the data treatment are common material (wich everybody can afford), wich increases the practical utility of the method. The designed methodology uses algorithms like automatic search for the localization of homologous points along the whole video sequence. The mathematical pattern here exposed allows to obtain the three-dimensional coordinates of the object, and in this way, with this method is easier for the user to obtain a higher precision than the classical photogrammetries methods using conventional photographies cameras.

Key-Words: - Video, Correlation, Videogrammetry, Computer vision, System automation, Image matching

1 Introduction
The photogrammetry is a science developed to obtain real measures from pictures (so much terrestrial as aerial) to make topographical maps, mensurations and other applications. Pictures are usually used taken with a special camera located in an airplane or in a satellite. The distortions of photographic projection are corrected using a machine denominated stereoplotter.

By means of videogrammetry, we are finding in principle the same objective that with the terrestrial photogrammetry (the three dimensional determination of an object). In order to achieve that, we will use the same geometric and mathematical concepts with some modifications due to the method particularities:

a) Very next projection centers (they are separated only a by few millimeters).
b) Full automation technics for geometric fitting.

The tasks to carry out will be:

a) To locate in the space the video frames, regarding an absolute coordinated system.

- Identification of 4 or more control points in the first frame with the introduction of the corresponding absolute coordinates (this operation is the only one that the user must carry out).

- Automatic search of these points along the images sequence.

b) To find points with appropriate characteristics and their posterior search along the whole image sequence.

2 Test zone
About the first frame we know the terrestrial coordinates of some points marked on the wall, and the approximate coordinates of the taking point.

Fig. 1. Frame 1 of 100. Test sequence.
The figure 2 shows the trajectory sketch, the camera follows. The motion was carried out manually, and therefore, it suffers accelerations and variations in the trajectory.

![Trajectory sketch](image)

**Fig. 2. Trajectory sketch.**

### 3 Video digitization

The video was taken with an analogical video camera, recording in SVHS tape. The video digitization was carried out using a computer with a common digital card (chip BT787), and a HDD IDE of 5Mbs transfer rate. Images of 704 x 576 pixels and 24 color bits were obtained at 15 frames per second. In the recording of images it was avoided using compression MPEG that had distorted the values of the pixels among serial frames, although if it was necessary to use JPEG applied to each independent frame to be able to arrive until the rate 15fps.

### 4 Georeference

In order to locate the geometry projection (of a frame) with the absolute coordinate system, we need to determine the rotation \(R(w, \varphi, k)\) and the projection center \(O(X, Y, Z)\). This operation is denominated resection in the space (Fig. 3) and it has to apply independently each one of the 100 frames.

To be able to adjust these equations (1), some approximate values of the variables should be obtained.

\[
M = R^T (w, \varphi, k)
\]

(1) Collinearity equations.
(4) Stellar method.

Finally, by knowing all these approximate parameters, it is applied (1).

4 The camera trajectory follow
Due to the errors in the determination of the projection centers coordinates (XYZ), a dispersion takes place (Fig. 4), along the whole trajectory.

Fig. 4. Camera trajectory.

The same thing happens with the axes rotations.

Fig. 5. Rotation angles w, φ, k.

4.1 Homogeneous trajectory
Finally, we carried out lineal approaches by segments to the previous curves, distributing the projection centers and the rotations on these segments. We can say in this way that the reality is closest because we suppose that abrupt variations don’t exist in intervals of 2 or 3 frames, it is due to two reasons:

- The video has been taken at 15 Frames/second.
- The movement of the camera was made manually.

6 Epipolar images
The following step before beginning to look for homologous points by means of correlation algorithms in all the frames, consists on obtaining the epipolar frames.

Fig. 6. Epipolar lines in two serial frames.

To obtain the epipolar frames, it would be enough to apply the coplanarity condition. This condition says that the two projection centers and the terrestrial point (P) should be contained in the same plane (Fig. 6).

Mathematically this method can become unstable because the centers of projection of two serial frames are very near. For this we have designed an alternative.

6.1 Epipolar frames in a line
Considering:
1- That the frames are orientated in the space O (XYZ), R(w, φ, k).
2- That the projection centers are aligned in small segments.

We can rectify the taking axes whose projection centers are contained in a lineal segment, so that we project the frames in a parallel plane to the base (line which joins the projection centers) and perpendicular to the taking axes.

Once we obtained the new parameters R(w, φ, k), of each taking, we can calculate the epipolar frames where the parallaxes ‘y’ disappear in the images.

Fig. 7. Epipolar frames.
7 Matching points

The image matching has two different phases in our work:

1 - A first phase with a small interaction with the user, where 4 or more control points are selected in the first frame and where it inserts the terrestrial coordinates of these points. The program looks for these points in the other frames and it calculates the first external orientation of the takings (church + stellar + colinearity).

2 - A second phase where the program finds in the first frame automatically all the points that present some appropriate characteristics to be correlated and located for all the frames.

Both in the first phase to determine the size from the appropriate window to each point, like as second phase to find the reliable points to correlate, the program uses an operator that we have denominated operator ‘p-moment’. With this operator we will determine the quality of the point and the size of search window.

7.1 P-moment operator

The p-moment operator has been designed considering theoretical-practical suppositions:

\[
P_{\text{moment}} = \frac{\sum (f - \mu)^2}{N^2}
\]

Where:
- \(N\) is the pixels number of the window.
- \(f\) is the gray value.
- \(\mu\) is the gray value average of the window.

Operator functionality:

a) To indicate the goodness of a point and their environment about the possibility of being found accurately in another different frame.

b) To define the size of the appropriated window to correlation.

This operator is applied increasing the size of the window successively thus some graphics are obtained (Fig. 8). This graphics indicates us the size of the good window.

Fig. 8. Operator p-moment graphic.

8. Global equation system

Once obtained the correlated points in all the frames (for example, 200 points for each frame, in total would be 20,000 points), the objective is to create a equations system and to apply again (1), but this time globally to the whole video sequence. Thus we have obtained:

1 - The defining the geometry projection of the whole video sequence with the maximum precision (projection centers and rotations).

2 - The obtaining the terrestrial coordinates of a series of points (in this case 200), with a high precision, because these points exist in the 100 frames of the sequence.

9. Conclusion

The two method applications presented in this article are:

1 – The three-dimensional situation of an object with a high precision due to the great data redundancy.

2 – The use of the epipolar frames to create a video with stereoscopic vision.

The fundamental advantage of the method exposed, is that using a common video camera (analogical or digital), and a computer, it is possible to obtain a photogrammetric terrestrial model.

Maybe this will be the future of the terrestrial photogrammetric, which can be reached to the great calculation power of the current computers.
Fig. 9. First phase results.

References:


