POLYGON-BASED TRUE ORTHOPHOTO GENERATION

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ABSTRACT:

Obscured areas are serious defects in large-scale and urban orthophotos. In recent years several rectification schemes minimizing these defects were proposed. These methods use raster-based algorithms for the detection of obscured areas and reconstruction of true orthophoto images. The common drawbacks of image-based approaches are that they require a lot of additional memory for intermediate structures and are slow and resolution dependent. In our paper we propose to use a polygon-based algorithm for the detection of obscured areas. Such a polygon-based approach is fast, accurate, and resolution independent. Spatial overlay processing provides the selection of the best orthophoto image for the recovery of detected obscured areas. The proposed method allows easy integration of true ortho image reconstruction techniques with existing commercial image processing software and spatial analysis tools.

1. INTRODUCTION

1.1 Orthorectification Process

Original aerial images come in a perspective projection (a view from a camera focal point). For GIS usage, orthophoto images (images in orthogonal projection) are needed. The process of transforming original images into orthoimages given an accurate large-scale elevation model is illustrated at figure 1.

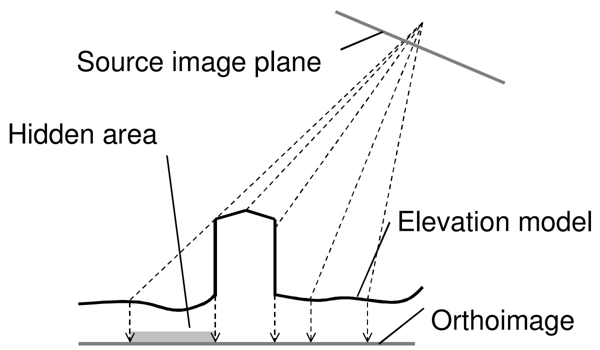

Fig 1: Illustration of orthorectification process

1.2 Double Mapping Effects

In an urban landscape there are unavoidably hidden areas for which no information on the original aerial image exists. The presence of hidden areas results in double mapping effects on resulting traditional orthophoto images (see Figure 2 and Figure 3).

Fig.2: Large scale orthorectified image with double mapping[1]

[1] All images are courtesy of BlomInfo A/S, Denmark

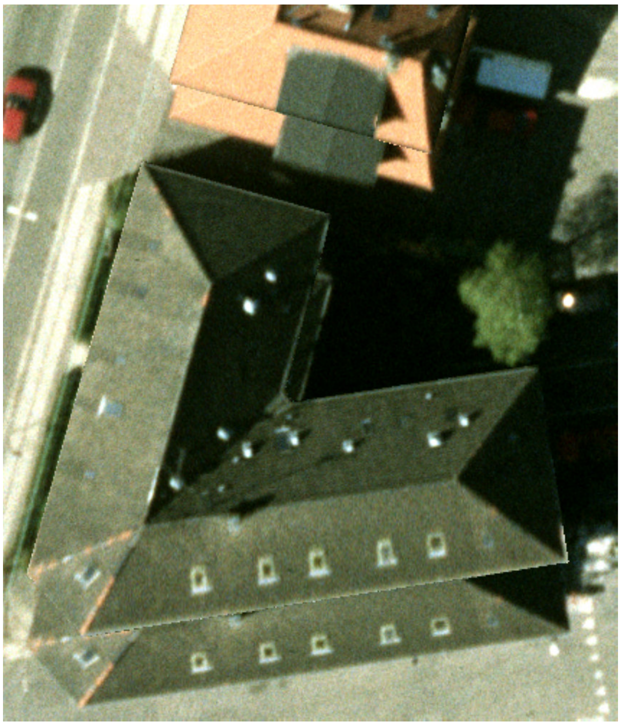

Fig.3: Additional example of double mapping effects

1.3 What is "True Ortho"?

Here, the term "True Ortho" means a processing technique to compensate for double mapping effects caused by hidden areas. It is possible to fill the hidden areas by data from overlapping aerial photo images or to mark them by a specified solid colour.

1.4 Traditional "True Otho"

In recent years several orthographic rectification schemes compensating for double mapping effects were proposed for generating large-scale true orthophotos (see, for example, F. Amhar 1998 or J.-Y.Rau 2000). These schemes use image-based hidden area detection algorithms (modifications of Z-buffer).

Before the orthorectification process begins, a Z-buffer is generated. The Z-buffer is a matrix having the same resolution as original aerial image. A distance from projection centre to elevation surface and the surface primitive identification code are stored for each pixel. Each polygon constituting the elevation model is projected into the original image plane. The projected polygon is then rasterized. That is, for each pixel covered by it, a distance from projection centre to the unprojected polygon is calculated. If the distance is less than the distance value already stored in Z buffer, then the distance and identification code are updated. In result, for each pixel of the original image, an identification code of the polygon visible through it is found. Then the identification code matrix is used during the orthorectification process to determine whether the particular orthoimage pixel is really visible from the original aerial image.

2. POLYGON-BASED SOLUTION

In this paper, usage of a polygon-based hidden area detection algorithm is proposed. It avoids the generation of large auxiliary distance/identification code matrices.

2.1 True Ortho Generation Workflow

1. Generate conventional orthophoto image
2. **Detect hidden areas** (parts of ortho image footprint not available on original aerial image).
3. Use available mosaicking software to fill the areas on orthophoto image by a specified color or by raster data available from overlapping images.

2.2 Hidden Area Detection Algorithm

1. Combine various available elevation data into a common polygonal surface.
2. Project polygons onto source image plane.
3. Find complete overlay face arrangement. Intersecting the projected polygons results in an image place subdivision into faces. List of overlapping polygons is calculated for each face.
4. Find the visible polygon for each face. It is easy because within a face polygons can be unambiguously ordered by distance to projection centre.
5. Project each face back to polygons visible through. The set of the back-projected faces defines part of elevation model visible on the original aerial image.
6. To get hidden areas, project visible parts of elevation model onto orthoimage plane and subtract them from the orthoimage footprint.

It is important that no raster data are used. Camera orientation parameters and elevation model only are needed for the algorithm.

Potentially the algorithm can be very time consuming because intersection of projected polygons can result in the number of faces about the squared number of polygons. However, in practice the number of faces is not significantly larger than the number of polygons, because projection centre (aircraft) is far above the urban landscape. So the algorithm takes just a fraction of time needed for the alternative Z buffer generation.

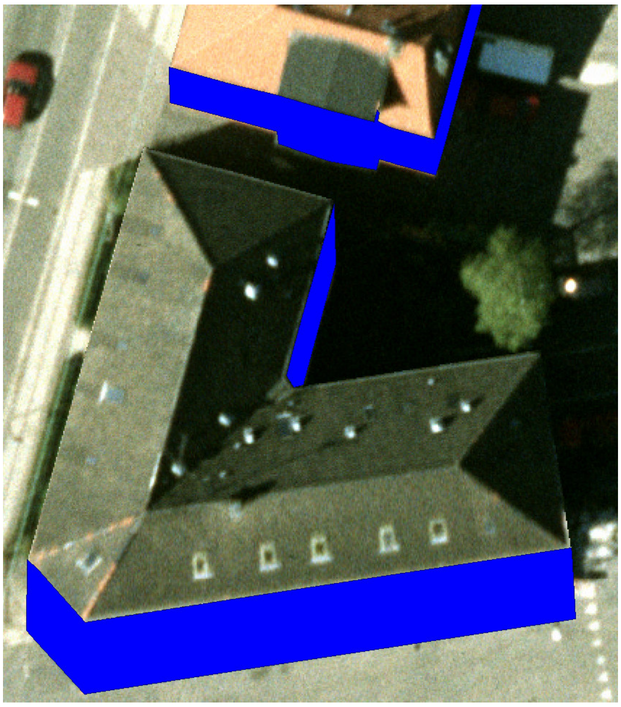

Fig. 4: Orthophoto with hidden areas marked blue

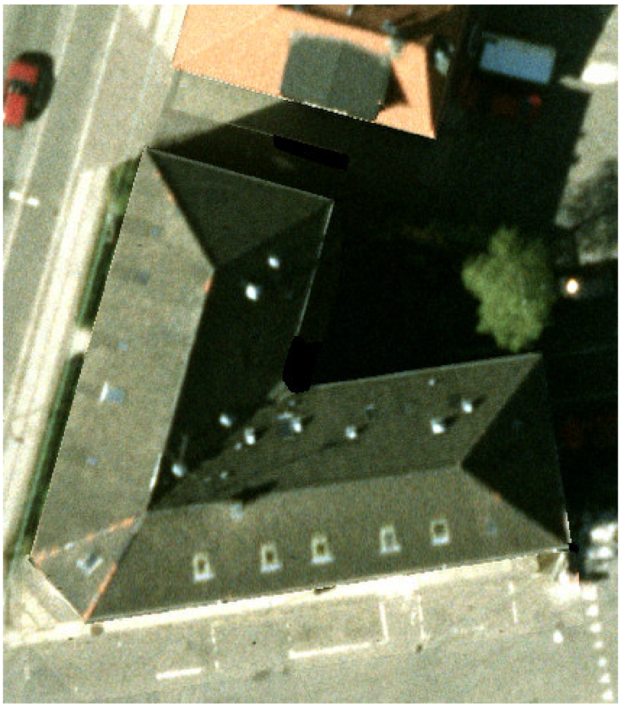

Fig. 5: "True ortho" image with hidden areas recovered from overlapping image.

3. CONCLUSION

3.1 Benefits of the Proposed Method

- Significantly smaller memory usage. There is no need to allocate large distance/identification code matrices.
- Resolution independent. It explicitly generates hidden area features as vector data.
- Further analysis (seamlines generation) and elevation model validation are easily accomplished based on the vector data.

3.2 Implementation Advantages

- Allows easy integration of hidden areas compensation techniques with existing software (Z/I Imaging ImageStation OrthoPro software). It is just an additional step in a standard workflow. There is no need to modify existing raster operation.
- Efficiently uses Intergraph GeoMedia Topology API for all complex geometry manipulations.

3.3 Future Work

- Update the current surface triangulation storage format to provide more accurate building model representation.
- Optimize elevation model creation workflow to provide simple and precise way to digitize building roofs, bridges, etc.
- Apply the same polygon-based hidden area detection technique for shadow zone detection and enhancement.
- Adopt the true ortho technique for line scanner imagery.

4. REFERENCES

Fahmi Amhar, Josef Jansa, Christine Ries, 1998. The Generation of True Orthophotos Using a 3d Building Model in Conjunction with a Conventional DTM. IAPRS, Vol. 32, Part 4 "GIS-Between Visions and Applications", Stuttgart, Germany.

Jiann-Yeou Rau, Nai-Yu Chen, Liang-Chien Chen, 2000. Hidden Compensation and Shadow Enhancement for True Orthophoto Generation, Proceedings of ACRS2000. http://www.gisdevelopment.net/aars/acrs/2000/ts4/digi0003.shtml