

A VIRTUAL SIMULATOR FOR PHOTOGRAMMETRY

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ABSTRACT:

This paper shows the use of synthetic images obtained from digital surface models to optimize, on the one hand, photogrammetric planning, and on the other, computer animations. Synthetic images are generated in a photogrammetric simulator built up to project 3D models onto images, after defining a virtual (or real) photogrammetric camera with known inner orientation parameters. The outer orientation parameters are saved whenever a synthetic image is taken. The 3D model is design with simple own format metadata, and is able to recognize 3D solids stored in a library. Each solid is spatially georeferenced and can be combined with any others to generate complex structures. When projecting the 3D model to the set of images, the simulator checks visibility conditions in order to create either distorted or undistorted perspective views. These views are mathematically equivalent to real photographic shots. Besides, the virtual simulator can also be used to optimize before-hand data collection on simple or complex scenarios. Additionally, this virtual simulator for photogrammetry is able to produce free-attitude single or multiple stereo pairs; the latter possibility allows the creation of manual or automatic computer animations. The recreation of image shots is also possible if the inner orientation parameters are changed. Therefore, the performance of each camera for each photogrammetric project can be analysed before starting it.

1. INTRODUCTION

Virtual reality is an unreal space concept linked to both digital technology and computer vision and becomes a powerful tool to carry out, among others, engineering studies, design analysis and architectural projects. Synthetic images are considered as input sources built up from virtual solid objects. They are computed based upon mathematical models that try to emulate optical and geometric photographic processes.

Virtual reality applications are used to create visual effects for advertisement, video games, animated movies, etcetera. Generally speaking, these applications strengthen qualitative features such as colour and texture. However, metrical features are not in the same level of rigour as regards 3D bodies and 3D environments. This paper tries to emphasize the idea of quantitative 3D models in qualitative virtual models in such a way that photogrammetric users could take profit of metrical features on synthetic images for virtual applications. The essence of our virtual simulator is the application of photogrammetric computations for the generation of synthetic images either in real or in virtual environments making use of virtual reality.

2. SYNTHETIC IMAGES

On the one hand, a photograph is an expression of “drawing with light” obtained from the real world through different media, mainly air and glass. On the other hand, a synthetic image (also called a synthetic photograph) is an expression of a perfect world in which a set of virtual objects are projected onto images after following a couple of principles of photography and imaging (Fig. 1). Therefore, metric processing with

synthetic images is an ideal abstraction from the real world that allows the user to test and control the whole set of variables that affect the geometry of the imagery: position, attitude, objects' shape and position, and, last but not least, lens distortion.

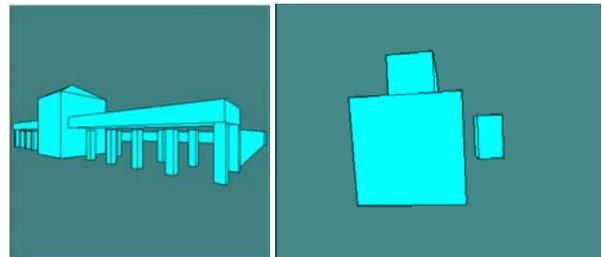


Figure 1. Example of two synthetic images

3. PHOTOGRAMMETRIC SIMULATOR

A photogrammetric simulator has been implemented in order to generate easily and quickly synthetic images of 3D virtual or CAD objects.

All the synthetic images are generated following the pinhole principle (Fig. 2). It can support both real and fictitious (ideal) cameras, as well as analogue or digital ones.

Inner parameters that define the geometry of the camera are stored on a database, and are activated after selecting a camera. Principal distance, principal point coordinates, radial and tangential distortion parameters as well as affinity parameters can be included and used to model the camera (Lerma, 2002).

The virtual simulator modifies the geometry of the whole set of images on-the-fly whenever the camera for the project is selected.

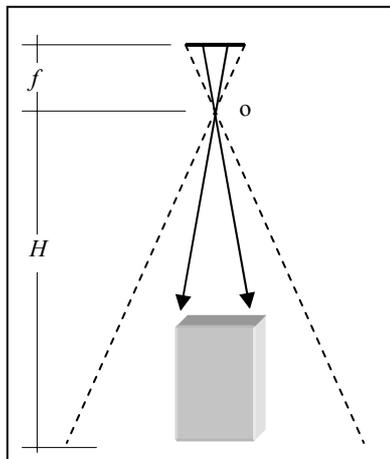


Figure 2. Principle of the pinhole camera

A virtual camera must be positioned on site to take the perspective views. This is accomplished after fixing the six exterior orientation parameters to each imagery: three exposure station coordinates (X_L, Y_L, Z_L , in a ground or object coordinate system) and three rotation angles (Omega, Phi, Kappa). Fig. 3 shows the interface developed to adjust the exterior orientation parameters of a camera over a typical city scenario.

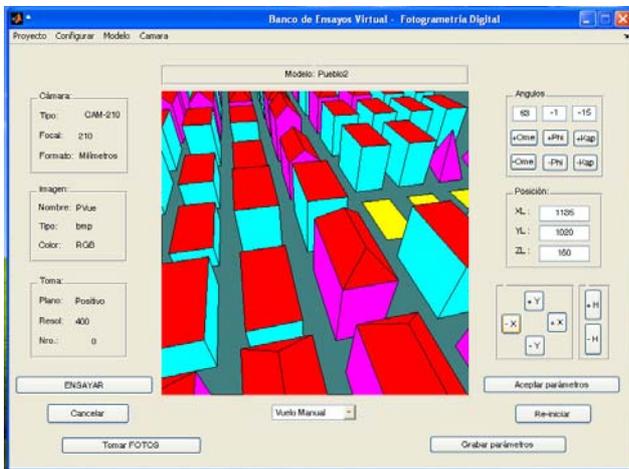


Figure 3. Graphical interface for the photogrammetric simulator

The right-hand side of the graphical interface (Fig. 3) allows the user to type both positions and angular orientations, and to move freely the camera over the target before saving the exterior orientation parameters. Besides, it is also possible to set up automatic sequential shoots following either ring strips or linear strips. The resulting images might have a common overlap area either selected before-hand by the user or it can be automatically computed to minimize the number of shoots (above a minimum end lap and side lap).

In order to create all the synthetic perspective images, a digital surface model of the target (scenario) must be uploaded to the

system. It consists of a set of simple volumetric objects with known position, shape, orientation and size that are linked altogether by means of metacommands to build up virtual and complex 3D models. The software has at one's disposal the library with all the predefined 3D objects. Fig. 4 shows a digital surface model of a planned scenario (city). Fig. 5 plots a perspective view of the same scenario as if it was viewed from the top.

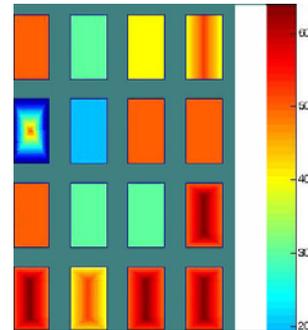


Figure 4. Digital surface model of a city. Colour bar symbolizes heights

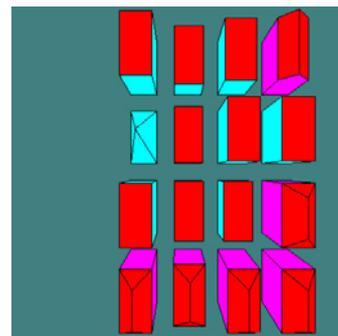


Figure 5. Perspective view of the digital surface model plotted in Fig. 4

When a digital surface model has been loaded and a camera specified, the photogrammetric simulator always plots on-the-fly the corresponding perspective view of the 3D model in the centre of the screen (Fig. 3). The scene shots are equivalent to images acquired with a photographic camera. In fact, the camera is always targeting the scene.

The simulator is always checking the inclusion of new objects in the field of view, the visibility condition for each one of the objects' surfaces as well as the occlusions among them (Alshwabkeh and Haala, 2005) to eventually build up perspective views in a similar way as an actual photographic camera.

4. APPLICATIONS

Synthetic images can be used to set up and improve project planning either in close-range applications or aerial applications. A typical example is the determination of proper exposure stations not only in rural areas but also in urban areas with high buildings or skyscrapers. Figures 6 and 7 show an example dealing with planning of urban districts. For this

project, an overlapping of 70% end lap only allows maximum ground coverage for image content near the nadir point. After this graphical (and also mathematical) analysis it was obvious that the selection of a higher principal distance or an increase in the forward overlap to create properly true orthoimagery.

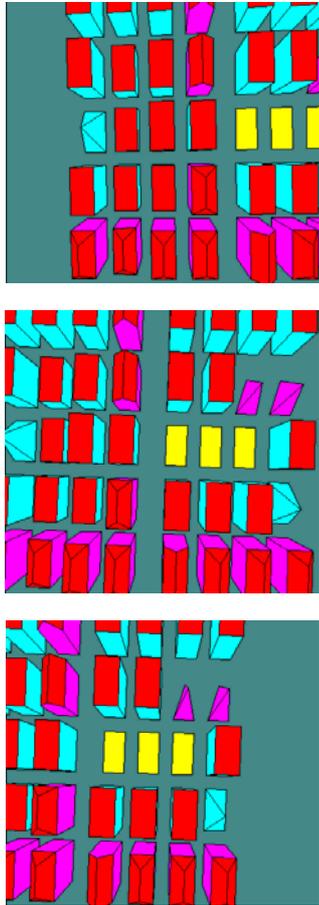


Figure 6. Overlapping of three successive photos along linear strip with 70% end lap

Fig. 7 determines the set of images when a circular ring is planned for shooting. For this project, an automatic 75% overlap was automatically computed to allow enough redundancy. In fact, following this way, four stereo-pairs were obtained if the last four images are rotated $\kappa=200^\circ$ (1-5, 2-6, 3-7 and 4-8 stereo-pairs).

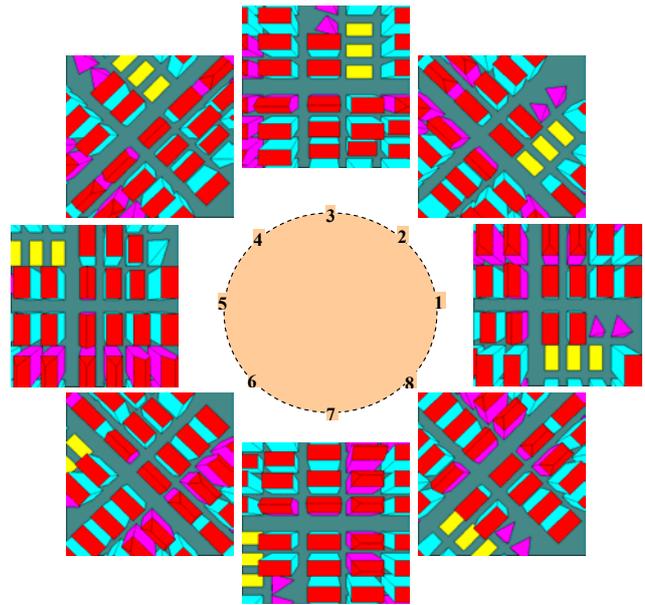


Figure 7. Overlapping of eight successive photos along ring strip with 75% end lap

The same kind of issues can be handled with this simulator for architectural photogrammetry, whenever the contextual information of the building or site negatively affects the documentation procedure. For example, urban morphology with narrow streets or alleys, high buildings and shadows, and last but not least, street furniture are items that must be considered for close-range photogrammetric planning. In these cases, the careful analysis and good planning are mandatory to carry out successfully the documentation tasks.

Another application that could require simulators is the determination of the exterior orientation parameters to follow up afterwards predefined paths, e.g. in industrial close range applications or in robotics.

Finally, sequences of synthetic images can be automatically programmed to build up either mono or stereo movies. The simulator interpolates positions and attitudes from the exterior orientation parameters previously fixed or saved.

5. FUTURE UPDATES

The simulator developed up to now could be enhanced including not only matrix sensors but also linear or punctual ones. A very interesting case would be the analysis and comparison of panoramic cameras against matrix sensors, as well as the inclusion of laser scanner systems on static and dynamic platforms.

Besides, it will not only be useful for analysing and planning georeferenced images in image space but also in object space; management of orthorectified imagery may be as critical as raw images.

6. CONCLUSIONS

This paper has shown the way synthetic images obtained from digital surface models can be used to optimize both photogrammetric planning and computer animations. The

synthetic images generated are mathematically equivalent to real photographic shots. Therefore, depending on the purpose of the project, they can be used for training on planning before flight or terrestrial picture acquisition. Furthermore, this kind of virtual simulator allows the user to feel confident with its mathematical procedure (software) to determine output results, and last but not least, allows the user to check the best equipment (sensor or camera) to carry out future projects.

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