STEREOMETRICA: A NOVELL COMPREHENSIVE STEREO VISION TOOLBOX FOR DEVELOPERS AND INVESTIGATORS

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ABSTRACT

Standard digital stereo photogrammetric systems are mainly designed to accomplish specific tasks and hence they may be regarded as problem oriented systems. However, for the solution of variety of conventional and non-conventional problems in computer vision and photogrammetry a vision based tool box may offer a great flexibility and adaptability for handling different tasks. In this paper the design and implementation of a first comprehensive toolbox (StereoMetrica) for the solution of numerous problems in computer vision and digital photogrammetry is described. This paper first presents the general structure of StereoMetrica vision system and then discusses its design considerations.

Keywords: stereo vision, comprehensive math modeling, reconstruction, fusion, recognition

1. Introduction

In recent years research activities in the field of computer vision has increased extensively. These research topics are mainly associated with complex algorithmic formulations and, hence, demand a comprehensive toolbox which allows easier way of developing routines and handling the stereo and multiple images data for the solution of the sensor orientation, 2D/3D object extraction, recognition, reconstruction, etc. Therefore, a comprehensive and flexible vision based toolbox designed to handle conventional and non-conventional principal tasks in computer vision and photogrammetry may offer great advantages and simplification for the related research activities. In this paper we introduce our software package system (StereoMetrica) which is designed and implemented to be used as a toolbox for the solution of photogrammetric and computer vision tasks such as the solution of the conventional and non-conventional sensor's orientation parameters, image registration, parametric and non-parametric multi image matching, 2D/3D object extraction, region growing, information fusion, neuro-fuzzy recognition and learning potentials and 3D object reconstruction.

The main features of this toolbox may be summarized as: 1- 2D/3D modeling of sensor/object geometric relations for variety of metric and non metric sensors covering close range or aerial views as well as satellite imageries. The mathematical models for the determination of the sensor object orientations include standard collinearity condition equations, DLT, multi quadratic, etc. 2- Comprehensive pictorial information processing such as data fusion, 3D object extraction and classification with the possibility of utilizing a neuro fuzzy technique for the recognition and training potentials as well as fuzzy and classical image matching tools for the design of the user defined image matching strategies. 3- Transparent intermediate computational stages allowing the user to have control over the individual computational steps. The user algorithmic developments can also be tailored into the structure of the system. 4- Sophisticated user interface for interactive operations are also available.

With regard to the exclusive potentials offered by the MATLAB software system, StereoMetrica is developed in MATLAB version 6 environment. For those routines which involved large number of computations and executed non-efficiently by MATLAB, C++ routines were developed and linked to the MATLAB software system. StereoMetrica system also fulfills the following requirements:

- Compatibility with MATLAB standards,
- Possibility of data transfer (input/output) to the standard computer vision soft wares,
- Efficient link between StereoMetrica and MATLAB tools.

The main links between StereoMetrica and MATLAB are via image processing and fuzzy tools. Thus, the fuzzy tools and other related image processing routines must be available in the version of MATLAB which is considered to be used with StereoMetrica. The inter-relations between StereoMetrica, MATLAB and the other external routines are presented in Figure 1.

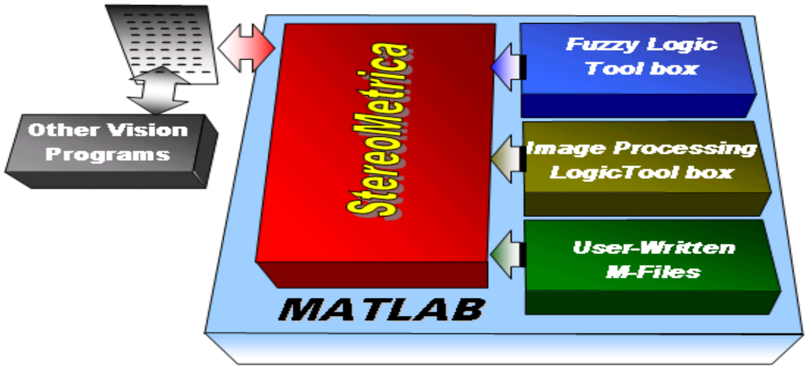

Figure 1. Inter-relations between StereoMetrica, MATLAB and other external routines

2. StereoMetrica Overall Structure

SteroMetrica is designed based on the following four main sections: project setup, 2D/3D connection, Correction/Fusion, data collection/recognition, 2D/3D reconstruction (Figure 2).

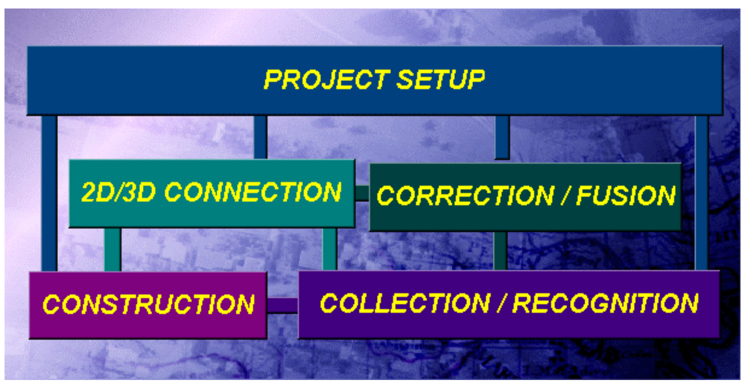

Figure 2. General Structure of StereoMetrica

These are described in some details in the following paragraphs:

2.1. Project setup

This includes set of sections and subsections which govern preliminary information setup such as: the project definition, image and sensor types, auxiliary data, 2D/3D geometric connection strategy, etc. The geometric connections are categorized according to the mathematical model, sensor type, auxiliary data and additional parameters. Figure 3 presents all possible 2D/3D geometric connections between image and object spaces which can be handled by StereoMetrica. Figure 4 shows the StereoMetrica user interface for the project setup.

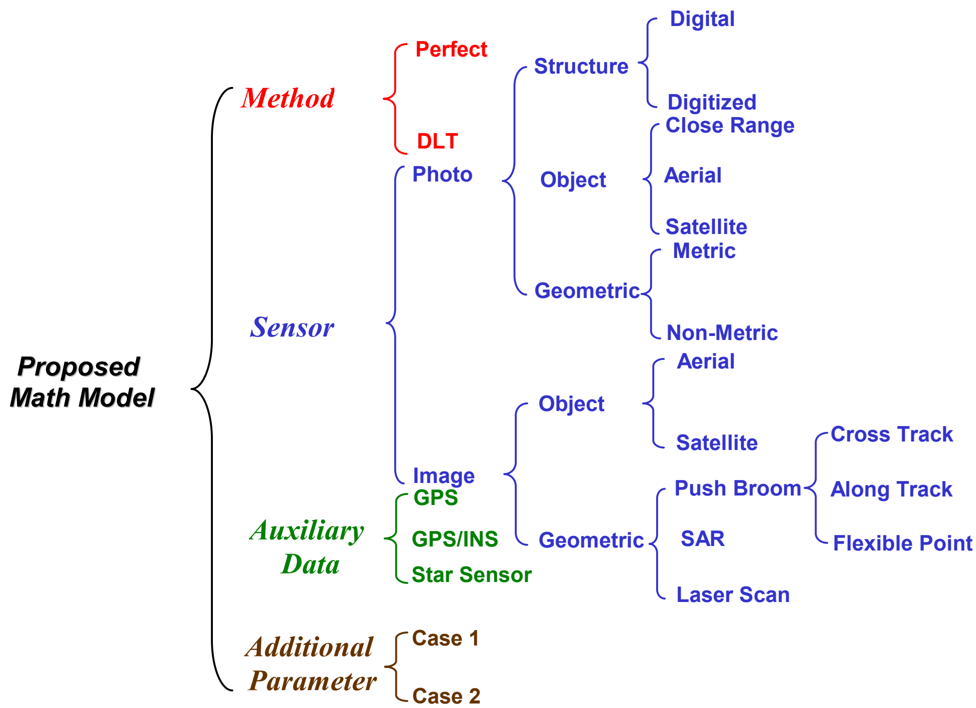

Figure 3. 2D/3D geometric connections between image and object spaces in StereoMetrica

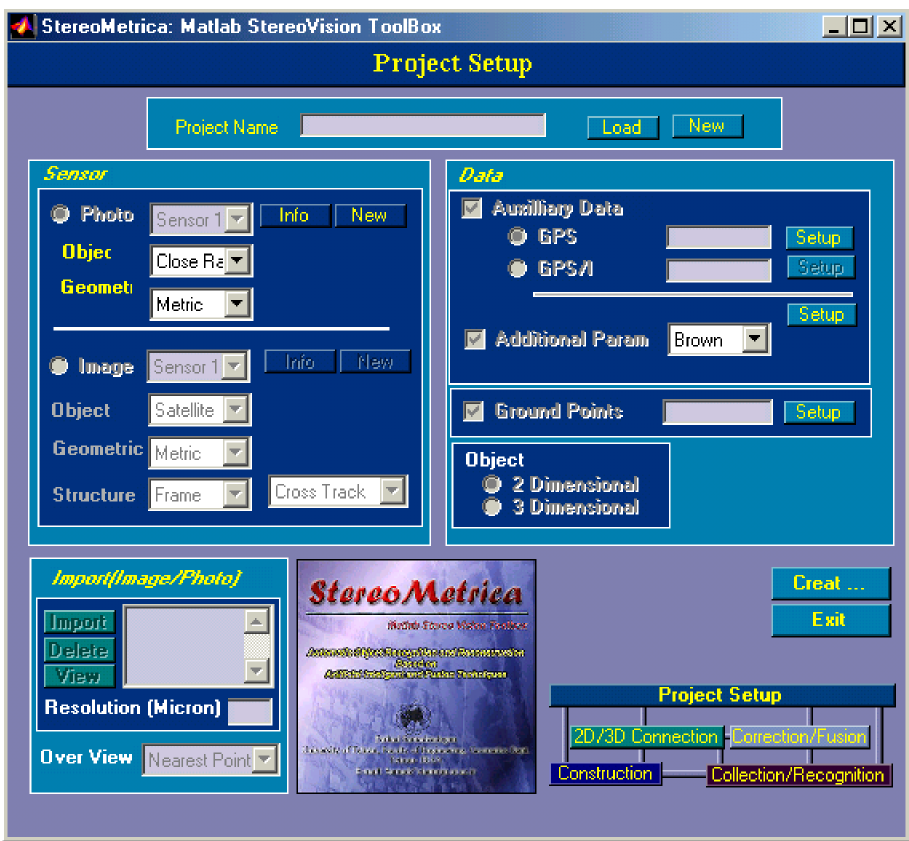

Figure 4. StereoMetrica user interface for the project setup

2.2. 2D/3D connection

Based on the previously defined sensor types, a 2D/3D connection strategy may be adapted and the relevant computations are executed (Figure 5).

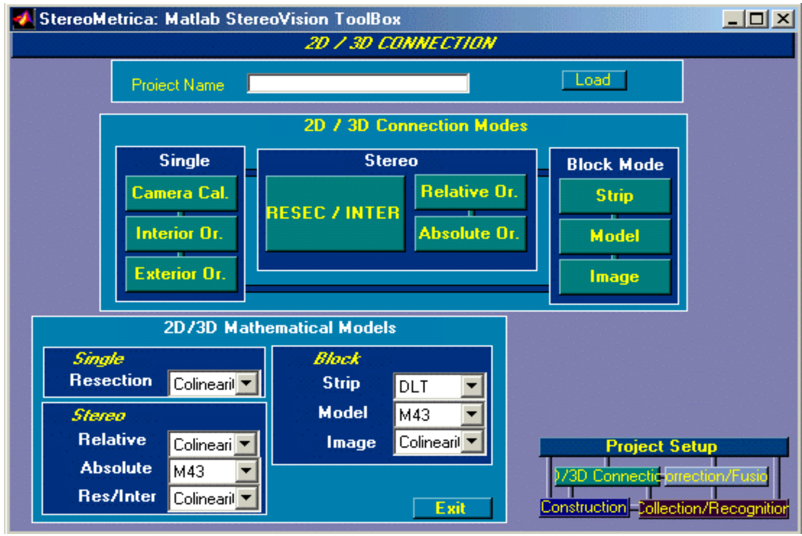

Figure 5. StereoMetrica user interface for the 2D/3D Connection

For example, if the defined imaging sensor is a metric camera, then interior orientation and standard space resection/intersection tools may be called. The working space for interior orientation stage comprises three main subsections, namely: (1) possibility of global and local view for any sub-image section, (2) full sets of transformation tools for interior orientation and (3) navigator. These tools easily allow the fiducially mark measurement process to be carried out manually or automatically. The existence of comprehensive tools allows dynamic movement and image enlargement to facilitate the global and the local view of the image. After the completion of this stage the exterior orientation parameters may be computed using space resection/intersection tools. The working window for this stage comprises three main subsections: (1) local and global view of stereo images using anaglyphic stereoscopic viewing method which permits stereoscopic point measurement, (2) full sets of standard transformation equations for the solution of exterior orientation parameters and (3) navigator. Special tools are also provided for enabling or disabling the presence of ground control points and check points for obtaining the appropriate accuracy level. Figure 6 demonstrates the user interface for the exterior orientation.

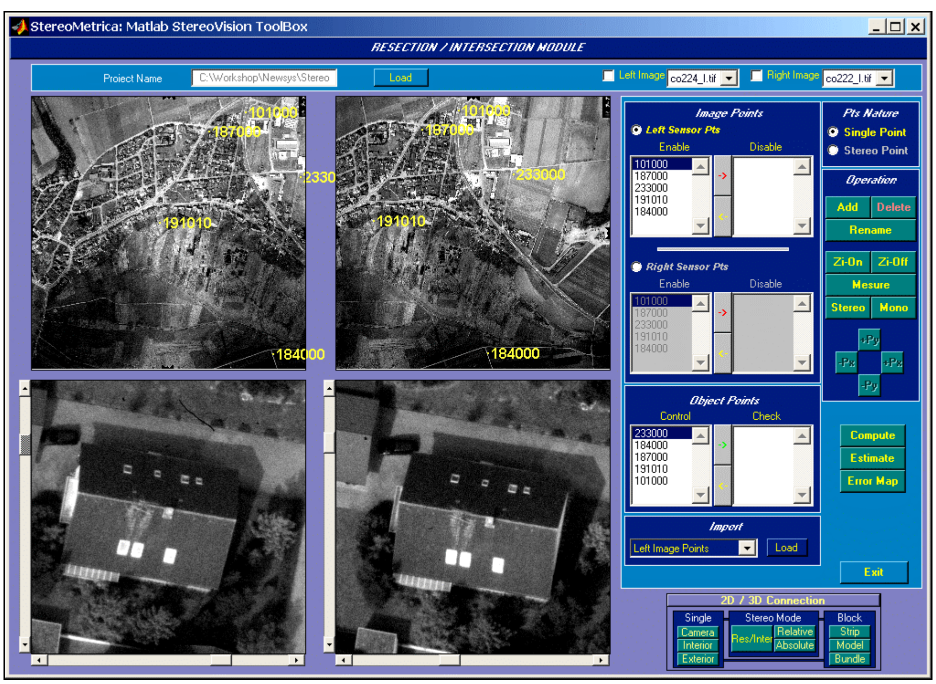

Figure 6. StereoMetrica user interface for the Resection/Intersection

2.3. Correction/Fusion

The correction tools perform image resampling leading to the generation of the rectified, partially rectified or ortho-images. These tools take as input variables the parameters obtained by the 2D/3D connection stage. If several images of a single scene are available, fusion may be applied to those images giving rise to a single image which integrates the distinct characteristics of multi images.

2.4. Collection/Recognition

After the completion of 2D/3D connection between the sensor and the object space, it is then possible to call the extraction and recognition tools. These tools take as their argument the object's descriptors to be used for extraction and recognition. These descriptors, for example, could be structural, spectral and textural (STS) attributes of the objects. By introducing the STS components as arguments of the extraction and recognition tools, the relevant tools are activated to extract the STS attributes of the objects from multiple images. These STS descriptors are then used as input to the objects recognition tools by which the objects are automatically recognized (Figure 7).

2.5. Reconstruction

In the last stage the user can call the reconstruction tools by which the recognized objects are reconstructed based on three different strategies of point based, area based or volume based reconstruction schemes. If an unrecognized object is encountered, the nuero-fuzzy learning tools can be used to train the system using known sample data sets. Figure 7 shows the user interface for the extraction, recognition and reconstruction of the 3D objects.

Figure 7. StereoMetrica user interface for the object recognition and reconstruction

3. Conclusion

The proposed toolbox has been tested using stereo images of an urban area for automatic extraction, recognition and reconstruction of 3D objects. The detailed reports of the basic concepts employed for each individual toolbox is given in Samadzadegan 2002. The main features of StereoMetrica toolbox may be summarized as follows:

- 2D/3D modeling of sensor/object geometric relations for variety of metric and non metric sensors covering close range or aerial views as well as satellite imageries.
- Comprehensive pictorial information processing such as data fusion, 3D object extraction and classification with the possibility of utilizing a neuro fuzzy technique for the recognition and training potentials as well as fuzzy and classical image matching tools for the design of the user defined image matching strategies.
- Transparent intermediate computational stages allowing the user to have control over the individual computational steps. The user algorithmic developments can also be added to the structure of the system.

Reference

Samadzadegan F, (2002) Automatic 3D Object Recognition and Reconstruction Based on Artificial Intelligence and Information Fusion Techniques. Ph.D. thesis, Tehran University, Faculty of Engineering, Dept. of Surveying and Geomatics Engineering.