SEAMLESS MAPPING SYSTEM FOR HIGH RESOLUTION IMAGERY

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ABSTRACT:

Digital Photogrammetry is the quality leap in the means, ability, efficiency and agility of spatial information acquirement. Digital Photogrammetric Workstation (DPW) is the mainstream product of Digital Photogrammetry System. Nowadays DPW plays important roles in acquiring spatial data. With the emergence of high resolution sensor, such as IKONOS, QuickBird, SPOT5 and ADS40, the traditional DPW doesn't adapt current situation. Innovative digital photogrammetry system should be developed to meet the network turn and industrialize production nowadays. At present, cartographic map collection is completed by means of manual measurement or human-computer interactive half-automatic abstract. Manual measurement covers approximate 80 percents of the cartographic map collection procedure. To efficiently mapping from high resolution images, a seamless mapping system based on network is proposed.

1. INTRODUCTION

Digital photogrammetry automatically obtains objects' 3D coordinates by identifying the correspondences from two or more digitized images or digital images. Comparing to Analogy Photogrammetry and Analytical Photogrammetry, Digital Photogrammetry is the quality leap in the means, ability, efficiency and agility of spatial information acquirement. Digital Photogrammetric Workstation (DPW) is the mainstream product of Digital Photogrammetry System. Nowadays DPW plays important roles in acquiring spatial data.

Cartographic Map, Digital Terrain Model (DTM) and Digital Orthorectification Map (DOM) are important digital data sources for Spatial Information Systems. DOM is automatically produced from Digital Elevation Model (DEM) and original images by sensor's geometrical model. With the advance of automatic image matching technique, DTM is also automatically obtained from stereo image pairs. At present it is not impossible that cartographic map is automatically collected from images despite the advance of object abstract technique. Cartographic map collection is completed by means of manual measurement or human-computer interactive half-automatic abstract. Manual measurement covers approximate 80 percents of the cartographic map collection procedure, so it is difficult to improve efficiency of the mapping.

With the inventing of modern satellite and airborne high resolution sensors such as IKONOS, QuickBird, SPOT5 and ADS40, high resolution images are larger than aerial images and provide a challenge for algorithmic redesign, and this opens up the possibility of reconsidering and improving many photogrammetric processing components. In recent years, considerable research efforts have been devoted to the efficient utilization of these images. Research has covered, for example, sensor modeling and image orientation, automatic digital terrain model (DTM) and digital surface model (DSM) generation and feature extraction [Li Zhang and Armin Gruen, 2006] .

Many photogrammetric processing approaches and workflows have been proposed to resolve the challenges brought forward by high resolution sensors' images. Among these approaches and strategies distributed and parallel processing is a very important one. And a few distributed and parallel processing photogrammetric systems are nowadays commercially available in the market. For example, PixelFactory© developed by Infoterra-Global company of France and PixelPipe© innovated by Intergraph company of USA are outstanding distributed and parallel processing systems. These innovated systems are applied to practical photogrammetric produce and improve produce efficiency of high resolution images. These systems emphasize the automatic processing for high resolution images such as DTM/DSM generation and orthorectification. Unfortunately, there are no corresponding packages to collect cartographic map from stereo pairs in these systems. Cartographic map is a very important photogrammetric product. Unreservedly speaking, these systems are immature systems because of lack of cartographic map collection toolkits.

Seamless mapping system proposed in this paper is a sub-system of DPGrid which is a distributed and parallel photogrammetric processing system innovated in Wuhan University. As a new generation digital photogrammetry system, DPGrid consists of an automatic processing sub-system and a human-computer interactive processing sub-system. The objectives of automatic processing sub-system are similar to PixelFactory© and PixelPipe© which are used to automatic processing. Seamless mapping system is the human-computer interactive mapping system which is designed to collect cartographic map from stereo pairs. There are a few

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dissimilarities between the seamless mapping system and traditional mapping system. Firstly, seamless mapping system is a distributed system based on network technology. Secondly, the workflow management are added to the system. Finally, during the measurement, the mosaics of digital line graphs in the overlapped areas by different operators are done by the system automatically without be intervened in by operators. These characteristics of the seamless mapping system are help to improve the efficiency of mapping.

In section 2, the architecture of seamless mapping system is described and the functions of the corresponding parts are also introduced. In section 3, the workflows of the seamless mapping system is discussed in detail. And the corresponding effective figures of different stages in the whole workflow are given. In the final section, we draw a conclusion that the efficiency of mapping from high resolution images can be improved by applying the seamless mapping system.

2. ARCHITECTURE

A Seamless Mapping System is build based on C/S (Client/Server) architecture. The whole system consists of a single server and multiple workstations. Server and workstations are connected by an underground high-speed or fast-speed network. The whole system is configured as the figure 1.

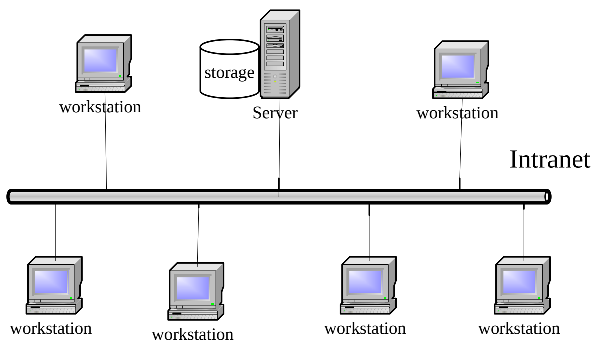

Figure 1. Seamless mapping system architecture

Server acts as the following roles in the whole seamless mapping system: automatic processing, depository of data and task scheduling. Sever is accessed by workstation and data corresponding to tasks are automatically download to workstations. Then these tasks are done by operators in their workstations and the final mapping products are submitted to server. With the collaboration between server and workstation, workstation and workstation, and workstation and operator, the mapping tasks are divided two parts: automatic processing and human-computer interactive processing. By separating the automatic processing and manual measurement a mapping task is more efficiently accomplished by comparing to processing workflow in traditional DPW (Digital Photogrammetry Workstation). The improvement of efficiency is more obvious in the case of mapping from high resolution satellite imagery.

2.1 Server

Server usually is a high performance PC equipped with large volume of storage. All automatic data processing tasks such as image pre-processing, automatic triangulation, DSM generation and orthorectification are processed on server. Usually these automatic processing tasks are parallel processed by a blade cluster system or a PC cluster at the server end. The parallel process will improve the efficiency of the seamless mapping system. Beside of the parallel processes, project management, task management, task distributing and task monitoring are very important jobs which are done by server. Parallel processes will not be discussed in the paper. The paper emphasizes the latter. In the latter discussion, work unit is referred to task.

Project management includes property setting, data organization and personnel management. The property setting is used to set the project parameters such as project root path, sensor type and automatic processing parameters. The objective of data organization is to establish a project environment. With this step server maintains all file system metadata for images and corresponding auxiliary data and other information, for example, which raw data should be included, how many stereo pair and which both images to form a stereo pair, etc. Personnel management is used to record the personnel information and set their roles in the mapping procedure.

Task management is a very important job because the whole distributed collaboration mapping workflows in a seamless mapping system are based on the job. The first step in task management is task planning. How is a whole project divided into many parts which are dealt out to operators? It is the work for task planning. There are two strategies to be used to plan task in a seamless mapping system. The first strategy is planning task according to map of standard format. The second one is planning task according to image bounds. The former is applied to both line array image and frame image. The latter is just only applied to line array image. The two strategies applied to satellite line array imagery are shown in the figure 2 and the figure 3 respectively.

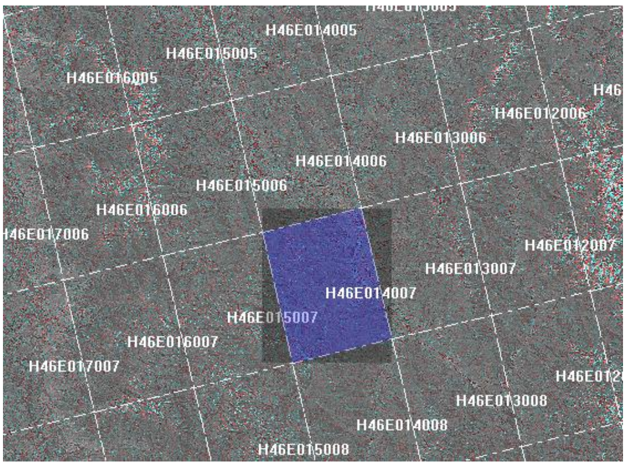

Figure 2. Diagram of task planning by map of standard format

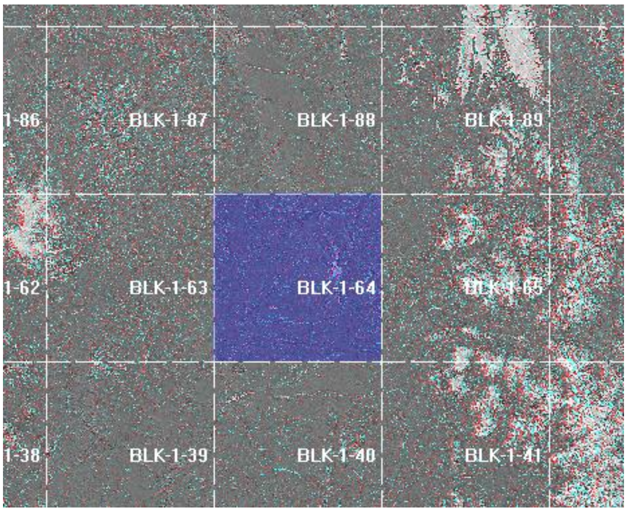

Figure 3. Diagram of task planning by image block bounds

There is an extra automatic process for digital aerial photo in seamless mapping. Generally speaking, a stereo model which is made up with adjoining photos between them forward lap is about 60% is appropriate for stereoscopic measuring. However, the forward lap between aerial digital images is usually about the 80%. A stereo model which is made up with adjoining digital aerial photos is not appropriate. Because digital aerial cameras are extensively used for photogrammetry and digital aerial photo is becoming an important data source for digital photogrammetric process. In order to stereoscopic measuring from the data source, a technique to find most appropriate stereo models from the photos in a block is developed and implemented in seamless mapping system. Through the technique stereo models are automatically created for a task. These models are stored at the server end and are prepared to be downloaded to workstations.

Finished the task planning, task data are created automatically by server from raw data of project. The new invented data sets form work units in seamless mapping system. At the client end these work units are processed by different operators. The whole project is divided and ruled like so.

Because of being deposited on the server, task data should be accessed by operators by a certain means. In the seamless mapping system, task data is accessed through authentication. That is, operators on the clients must successfully log on the server with their user identities and passwords and then download data from the server to their workstations. In order to access data by operators it is necessary that tasks must be dispensed to operators and set corresponding roles for different operator. The dispensing work is done on the server by administrators. When all tasks are dispensed, operators are able to access their dispensed tasks at the client end.

Mapping is a long term procedure. During the procedure all dispensed tasks processed at the workstations should be monitored by administrators to estimate the progress of whole mapping project. Task monitoring at server end is a very useful function for administrators to do this kind of estimation. With the help of task monitoring, it is convenient for administrators at their offices to monitor the progress of the individual task without going to produce departments. Through the monitoring function administrators know which operator is processing which task and how much the task have been done. The task monitoring is illustrated as the figure 4.

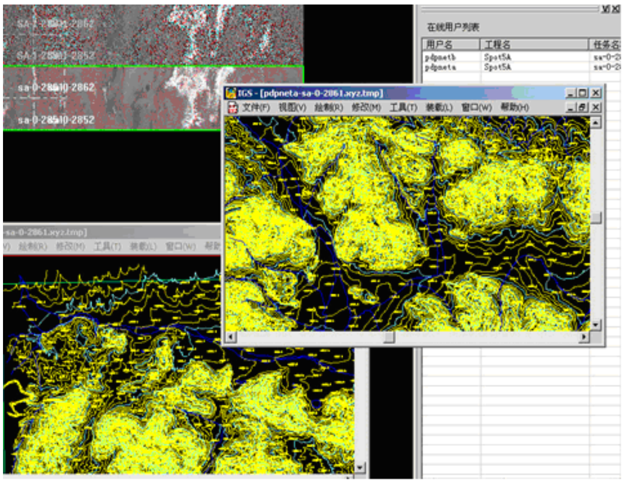

Figure 4. Monitoring of cartographic mapping progresses

Beside the above discussed functions, server also has a function to support concurrent access and transport task data. With the function task data is able to access by operators.

2.2 Workstation

Workstation is a common PC with stereoscopic observation equipments, where cartographic map is collected by an operator. As the above description, mapping is divided into two parts: automatic processing and human-computer interactive processing. Automatic processing is done at the server end, interactive process is done at the client end. Workstation is human-computer interactive process software at the client end. Function of a workstation is very simple. It just is used for operators to manual measurement in stereo image pairs just like as the traditional mapping system in DPW, but there are some differences between the workstation and DPW.

Firstly, the way of dispensing task is more convenient. In the DPW environment, task dispensing is accomplished just by a manual means. Administrators tell operators do what tasks and where data related these tasks are obtained. Then operators manually copy data from computers where data is deposited to their computers according the administrator indications. This kind of dispensing task is cockamamie and low efficient. However, dispensing task is automatically processed and data deposits are transparent for operators in the seamless mapping system. When operators log on the server from their workstation, all tasks dispensed by administrators at the server end are listed in the form of GUI (Graphical User Interface) at the client end. For an operator, what to do is just to click the task items in the GUI and the data related the selected task will be transported to their workstation. The diagram of task acquirement is shown in the figure 5.

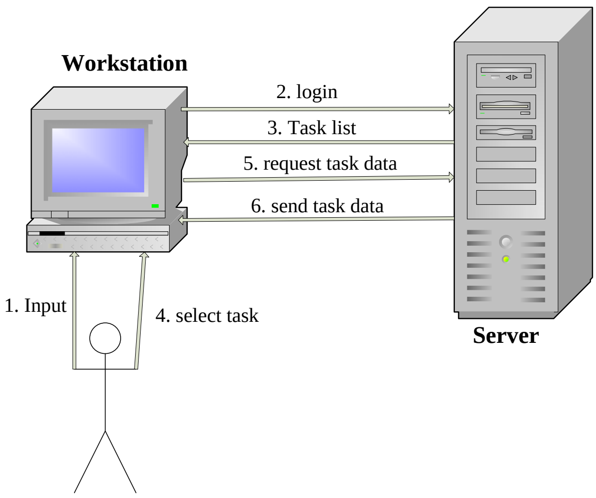

Figure 5. Diagram of task acquirement

Secondly, it is easy for operators at the different workstations to cooperate during the mapping. Because tasks are created according to a certain bounds, a task is adjacent to eight other tasks. When cartographic map of a task is being interactively measured by an operator, the cartographic maps of other eight tasks will be seen in the corresponding overlapped areas by the operator. The work is automatically done by seamless mapping system. Automatic mosaic of cartographic maps is helpful for improving mapping efficiency. In the case of DPW, cartographic map mosaic is manual and cockamamie. Automated mosaic of cartographic maps in seamless mapping system is realized by the data interchange and share of cartographic maps belonged to different operators or workstations. There are two kinds of mosaic: online mosaic and offline mosaic. Online mosaic means that cartographic map mosaic is done during operators are measuring at their workstations. Offline mosaic means that cartographic map mosaic is done when some operators are not measuring at their workstations. Automated mosaic of cartographic maps is illustrated as the figure 6.

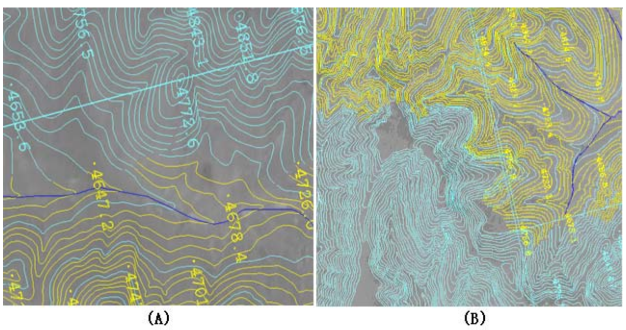

Figure 6. Automated mosaic of cartographic maps. (A is the stereoscopic view in a workstation and B is the stereoscopic view of the same ground area in another workstation. Yellow contours are measured in location workstation. The blues are measured in another workstation)

The two kinds of mosaic are implemented differently in seamless mapping system. The online mosaic is implemented by the peer-to-peer mode. In this mode each workstation acts as a servant and a client. That is, when a workstation is requested to provide another workstation map mosaic service, the workstation acts as a servant and the workstation which request service acts as a client. In return, when the workstation which request service is requested to provide map mosaic by another workstation, it also acts as the servant. When it is preparing to launch a map mosaic request, a workstation must know which workstations provide services and where these workstations are. In seamless mapping system, server which acts as a commander knows which workstations are working, and what tasks is being processed, and which tasks are the neighbours of a specified task, so server is acts as a location indicator. A workstation requests with specified task identification to server for locations of other related workstations before launching map mosaic. After it received the location information, the workstation, as a client, connected and communicated to other workstations to do map mosaic. However, not all of the workstations to be connected and communicated are on power or doing the corresponding tasks. In that case, for the workstation as a client, map mosaic lacks for integrity. In order to solve the problem, offline mosaic is implemented as a second strategy for mosaic in seamless mapping system. Offline mosaic is a supplement to online mosaic. Different from online mosaic, offline mosaic is implemented by the client-to-server mode. In the c/s mode, a mapping server as a mosaic servant and a workstation which launches mosaic sessions acts as a mosaic client. Because cartographic maps are automatically upload to mapping server from workstations when tasks are finished or workstation is going to be power off, it is convenient for a workstation to obtain the corresponding offline cartographic maps from the server.

Automatic mosaic is very helpful for operators to collect cartographic map. With the help of automatic mosaic operators are able to collaborate on cartographic map collection. The collaboration improves the efficiency of cartographic map collection.

Thirdly, model switch in stereoscopic measurement based on digital aerial photos is more convenient for operators than in the traditional digital photogrammetric workstation. Model switch is accomplished by an operator manually selecting the corresponding stereo pair. Model switch is a hard and inefficient work if there is a lot of stereo pair. The case is common in the photogrammetric process of digital aerial photos. Fortunately, the problem is solved very well in seamless mapping system. As described above, mapping task is dispensed according to extension of a sheet map, so a task usually contains many stereo models. These stereo models related to the task are found and located at the server end. For a workstation, it should provide an operator a way to correctly and seamlessly roam among these models during stereoscopic mapping. In order to achieve the objective, a grid based on object space is assigned to a task, the intervals of the grid is decided by taking account of information of strips in a block and other related block parameters. For each of cells in the grid, a best suitable stereo pair is located from all of related models. With the help of the grid and these best suitable models, model switch is implemented in seamless mapping system. Automatic model switch makes collecting cartographic map in multiple models be seen like as in a single large stereo model and reduce the unnecessary manual model switch. It improves the efficiency of cartographic map collection.

Finally, raw data and intermediate data and final results are stored at the server end. At the client end, only intermediate data are obtained from the server end. It’s not serious any more that data on the workstation is damaged because these data are able of be download from the server. It is not necessary to stored raw data and final results, so the requirement of workstation is lower than the traditional DPW and is helpful to reduce the produce cost.

3. WORKFLOWS

Seamless mapping system is a combination of CS mode and P2P mode, features and advantages of server and workstation are discussed above. The whole workflows of seamless mapping system are introduced in the following. Whole workflows are illustrated as the figure 7.

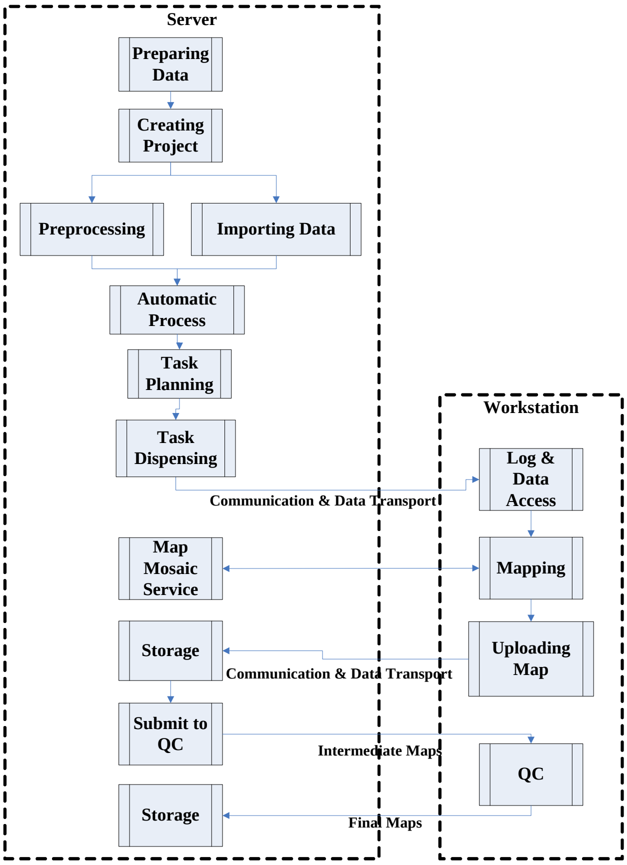

Figure 7. Workflows of seamless mapping system

The whole workflows begin with the data preparing at the server end. In the step, all raw data and metadata must be collected and deposited at the server end. All necessary data are collected and the next step is to create a project at the server end. A project is the process unit of the remained steps in the whole workflows. A new block and strips are set up in this step. In order to automatic process of data, pre-processing is necessary. Pre-processing includes format conversion and geometric and radiated processing of images. Data importing is also necessary in practice to reuse the data produced in other systems. Automatic process includes automatic tie point measurement, automatic aerial triangulation, and automatic DSM matching and DOM generation. Parallel and distributed computation technologies are applied to improve the data process efficiency of the whole system. In the hardware respect, blade cluster or multiple PC cluster are able to be used in the step. Because cartographic map are unable to automatically processed by computers at present. Mapping must be dispensed to operators and be done by operators by the means of human-interactive measuring from stereoscopic stereo image pair. In the task planning step, administrator determinates how mapping tasks will be split and dispensed. According the number of available operators, mapping of a project are be split into many smaller mapping tasks and these smaller tasks are dispensed to different operators by administrators.

After mapping tasks are dispensed, operators log in and obtain data related to their tasks on their workstations. There is no requirement of much specialization knowledge for operators in seamless mapping system. For operators, all that for them is just stereoscopically measure cartographic map on stereo image pairs. During their mapping, online or offline cartographic map mosaics are activated automatically by their systems. This step involves communications and data exchanges of workstation-server and workstation-workstation. When cartographic maps are measured over, operators can submit their products to the corresponding mapping servers. The mapping tasks of operators are just finished half. At the server end, these submitted cartographic maps will be dispensed automatically to quality checkers according to information of the tasks planning and dispensing. The checkers at the workstation end log and obtain these cartographic maps and related stereo models from the server and estimate these maps. And finally they submit their estimation of maps to the server. Operators should modify their maps according the estimation made by checkers and then submit the products which meet requirement of quality. At this stage, it is can be said that for operators the mapping tasks are accomplished.

Once all smaller mapping tasks are accomplished, these cartographic maps are stored into cartographic map databases or be dispensed and be made use of immediately by other departments.

4. CONCLUSIONS

Seamless mapping system is a distributed and collaborated mapping system. Automatic processes and manual processes are separated in mapping workflows. The separation improves the computer's automatic process efficiency. The task dispensing and task data obtaining are automatic done, there is no needs for operators to know what tasks they are dispensed and from where they obtain the related data. So it is easy to use the seamless mapping system for operators. Through the communications and interoperation among servers and workstations the workflows of mapping is more smooth, especially automatic map mosaic is helpful for collaborations of operators in practice and also improves the efficiency of manual collection of cartographic map. In the case of collecting map from digital aerial images, seamless switch of different stereo model in practice reduces a lot of workloads which must be done in the traditional digital photogrammetry workstation.

The seamless mapping system is being applied to practices and is regarded with respect from customers. The figure 8 is a scene that operators are collecting cartographic map in seamless mapping. The results of practices indicate that the efficiency of collecting cartographic map in seamless mapping system improves by 10 percents than in the traditional DPW.

Figure 8. The photo of mapping cartographic maps with Seamless Mapping System.

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