DIGITAL PHOTOGRAMMETRY GRID (DPGRID) AND ITS APPLICATION

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ABSTRACT

Digital Photogrammetry Grid (DPGrid) is the new generation of processing system with high efficiency for digital photogrammetry, developed based on computer network, cluster parallel processing and the new development of photogrammetry, in Wuhan University, P. R. China. The general situation of DPGrid is introduced firstly in this paper, including brief introduction of hardware, normal photogrammetry, fast update of orthoimage, and special photogrammetry of DPGrid. Then some applications in quick update of orthoimage, low altitude photogrammetry and emergency response are introduced.

KEYWORDS: digital photogrammetry, grid, parallel processing, computer network, application

INTRODUCTION

Digital Photogrammetry workstations (DPW) are developed based on the traditional analog and analysis photogrammetry. Its original intention was to replace the film observed through the optical system by digital image displayed on computer screen. Than, the map and orthoimage are generated by computing based on generated digital terrain model (Wang Zhizhuo 1978, Wang Zhizhuo 1998). Although DPW has used many techniques of digital image processing, pattern recognition and image matching, it mainly simulates the traditional photogrammetry by computer. Furthermore, it is closely related to the development of computer science.

Along with the development of computer science and digital photogrammetry, photogrammetric equipment must evolve ahead. In 2002, it was suggested that the DPW in the form of single unit should progress to digital Photogrammetry system (DPS) (Z.Zhang & J.zhang, 2002). One of the basic requests of digital photogrammetry is that automation and human-machine interaction should be separated. It requires that the theory of photogrammetry should have some development. Nowadays, the progresses of photogrammetric theory include: (1) the contrary and unification theory on independence and constraint for observations in image matching; (2) the theory of multi-baseline digital photogrammetry (Z.X.Zhang et al, 2007a); (3) the theory of generalized point photogrammetry (Zhang Z., Zhang J, 2004; Zhang Zuxun et al, 2008).

For applying the new results of the theory research on digital photogrammetry to improve the automatic capability, a new digital Photogrammetry system ---- DPGrid (Digital Photogrammetry Grid) had been developed in the School of Remote Sensing and Information Engineering, Wuhan University (Z.X.Zhang et al, 2007b; Zhang Zuxun et al, 2009). The progresses of computer network and cluster parallel processing are introduced into digital photogrammetry. Photogrammetric automation and human-machine interaction are separated completely, so that photogrammetry production gets higher efficiency. DPGrid includes tow parts: (1) automatic portion: cluster processing with parallel computing based on the Grid; (2) human-machine interaction portion: distributed seamless mapping system (DPGrid.SLM) based on network. The software in automatic portion of DPGrid includes normal photogrammetry, fast update of orthoimage, special photogrammetry and quality evaluation of aero-photography. Once established, DPGrid is widely used in applications of orthoimage updating, low altitude photogrammetry and emergency response.

BRIEF INTRODUCTION OF DPGRID HARDWARE

The hardware of DPGrid is consists of parallel computing based subsystem and distributed processing based subsystem.

Cluster Processing Subsystem with Parallel Computing Based on the Grid

Cluster processing subsystem with parallel computing based on the Grid includes blade based Cluster processing subsystem and PC based Cluster processing subsystem.

Blade based subsystem. As shown in Figure 1, (a) is the whole subsystem; (b) is blade computers; (c) is the structure of Cluster processing subsystem based on blade computers. Blade computers, controlled by a PC, are for cluster processing. Nowadays the subsystem is consists of 20 blades and 5TB disk array.

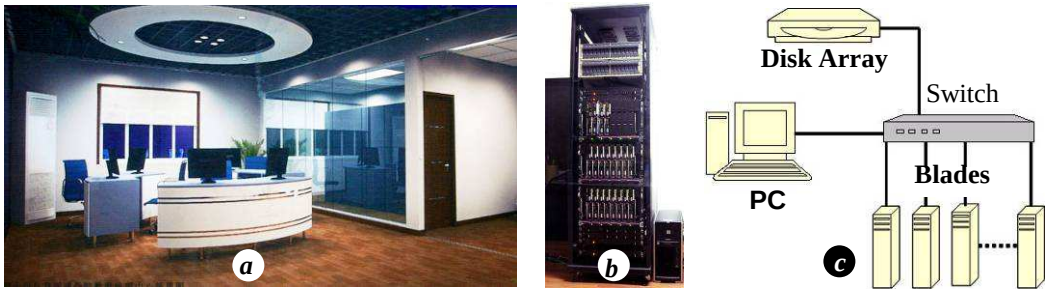

Figure 1. Blade based subsystem.

PC based subsystem. PC based subsystem includes immovable and movable Cluster processing subsystem.

(1) PC based immovable subsystem

Figure 2 is the sketch map for PC based immovable subsystem. It revealed powerful ability of data processing in the fast response for China earthquake rescue.

(2) PC based movable subsystem

Figure 3 shows the PC based movable subsystem. It exhibited higher efficiency and flexibility in orthoimage update.

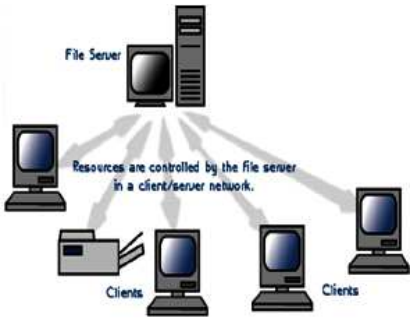

Figure 2. PC based immovable subsystem.

Figure 3. PC based movable subsystem.

Distributed Seamless Mapping System Based on the Network

Figure 4(a) is the structure sketch map, (b) is its application in the project "Mapping in West Regions of China".

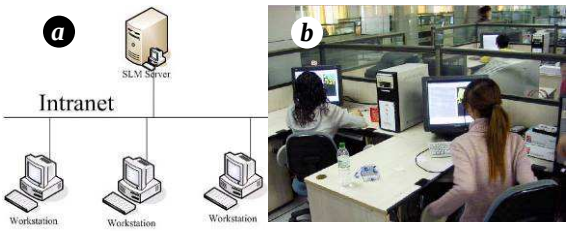

Figure 4. Seamless mapping system.

BRIEF INTRODUCTION OF DPGRID

DPGrid Normal Photogrammetry

DPGrid normal photogrammetry includes image preprocessing, image matching, aerial triangulation calculating, DEM generating and orthoimage producing etc. The flow is shown as Figure 5. All of the tasks have realized parallel computation. The frame of parallel processing is shown as Figure 6. It is constructed according to the feature of photogrammetry processing, including master program and calculation program etc. The master program decompounds the entire task of photogrammetry process to subtasks, distributes them to each computation node and monitors performance of subtasks. Every computation node accomplishes calculation of subtasks.

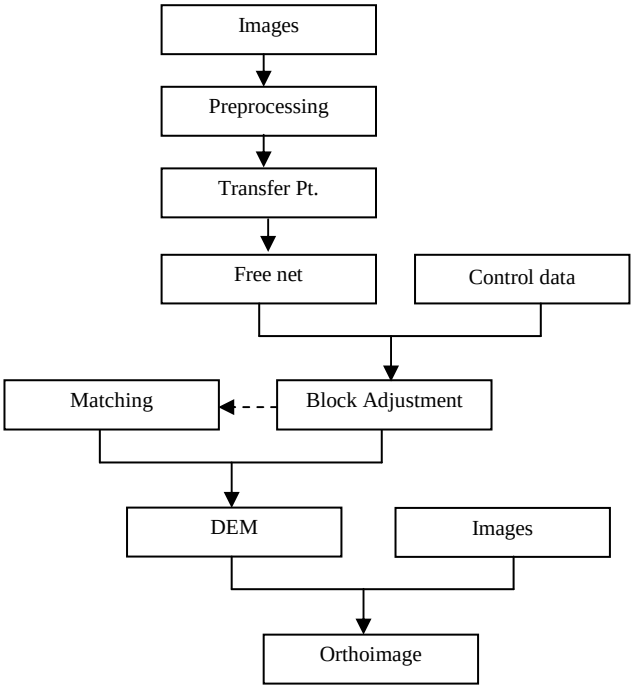

Figure 5. Normal photogrammetry flow.

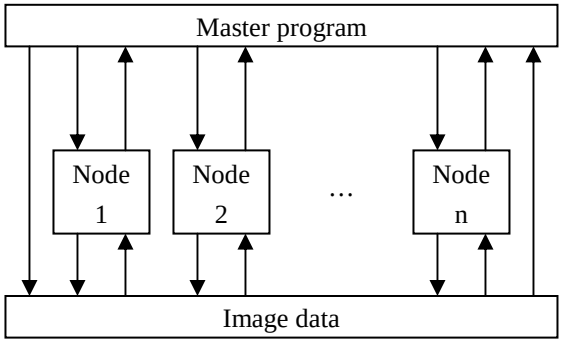

Figure 6. Frame of parallel processing.

The technique of advanced high-powered parallel computation, mass storage and network communication etc. are applied so the system efficiency is enhanced consumedly. Improved algorithm of image matching is used, thereby automatic aerial triangulation and automatic generation of DEM are achieved, and the level of the automation is increased greatly. Utilizing optimized orthoimage production based on Voronoi map, automatic search of mosaic line on the orthoimage with the intelligent algorithm based on ant colony, and eliminating the tone difference on the images by the tone balance method of least square block adjustment, the quality of orthoimage is ensured and efficiency of orthoimage production is increased greatly.

Fast Update of Orthoimage of DPGrid

Fast update of orthoimage of DPGrid includes fast update of orthoimage based on aerial images and satellite images.

Fast update of orthoimage based on aerial images. The flow of fast update of orthoimage based on aerial images is shown as Figure 7. While the connect points are automatic extracted, the mass control points are selected from the old DOM and DEM. In despite of the selection is difficult in the regions such as higher mountain and forest, the efficiency is higher than manual work. The precisions of the mosaic and new orthoimage are ensured adopting the selected mass control points to aerial triangulation.

Fast update of orthoimage based on satellite images. The flow of Fast update of orthoimage based on satellite images is shown as Figure 8. The matching and orientation of satellite image with DOM/DEM are based on the initial position created according RPC, and the strategy of matching level by level and orientating level by level. The matching and orientation of satellite image with DLG/DEM are based on the theory of generalized point (Zhang Zuxun et al, 2008).

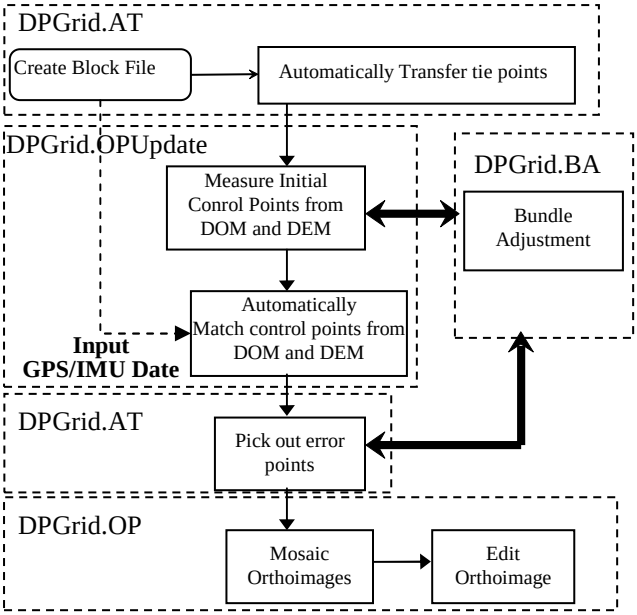

Figure 7. Flow of fast update for aerial images.

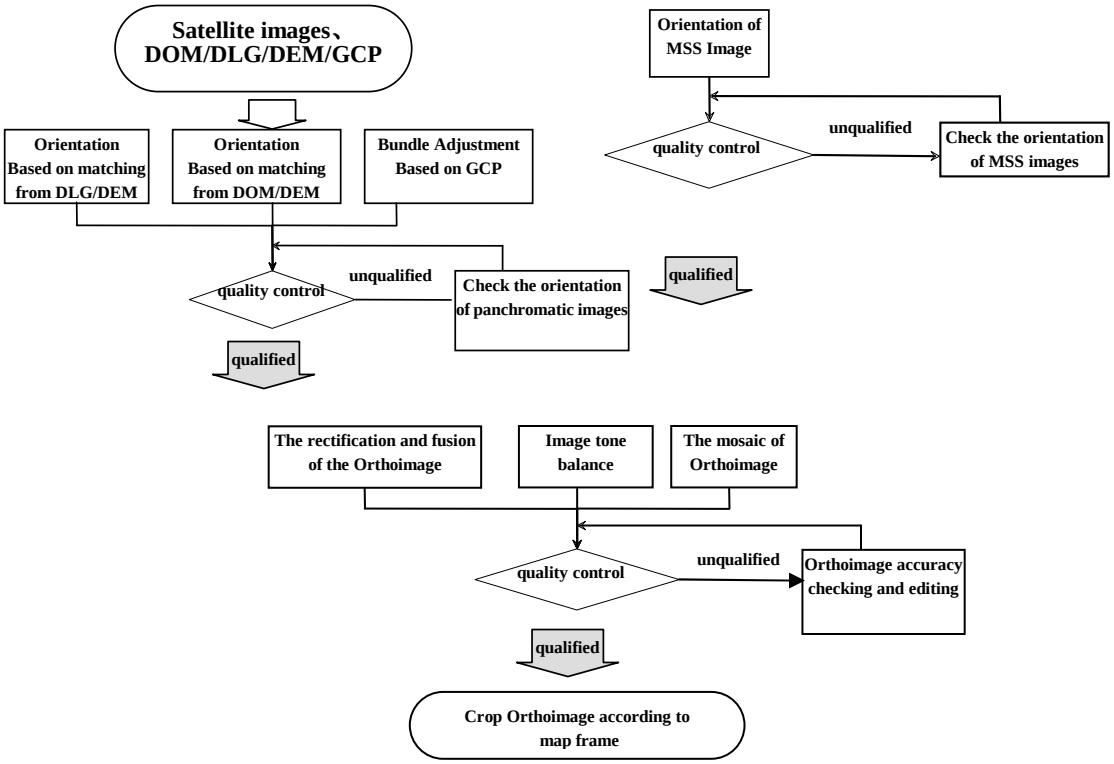

Figure 8. Flow of Fast update for satellite images.

DPGrid Special Photogrammetry

DPGrid special photogrammetry includes low altitude photogrammetry and emergency response photogrammetry.

DPGrid low altitude photogrammetry. The flow of spatial information acquirement in DPGrid low altitude photogrammetry is shown as Figure 9. The image matching is found on SIFT (Scale Invariant Feature Transform) operator for the images with large rotation angle (such as 28º in strip) and roll angle (such as 12 º between strips) in the low altitude photogrammetry.

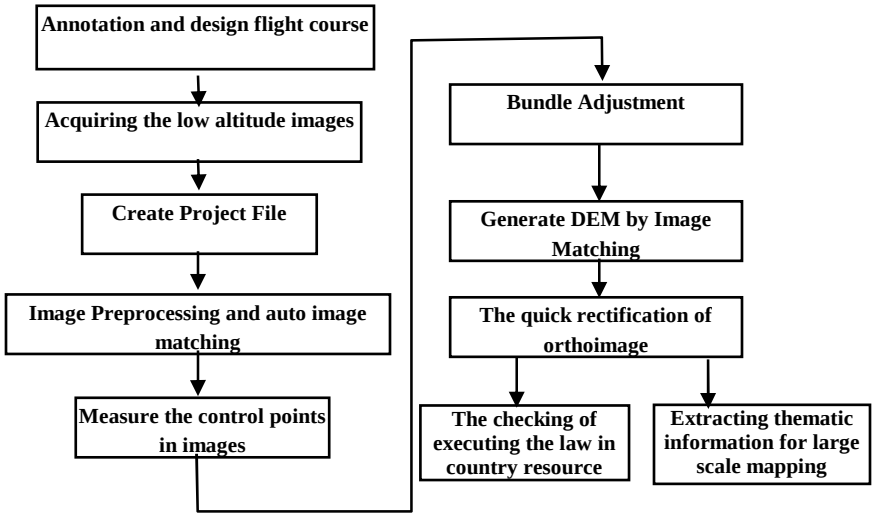

Figure 9. Flow of spatial information acquirement in DPGrid low altitude photogrammetry.

DPGrid emergency response photogrammetry. The flow of DPGrid emergency response photogrammetry is shown as Figure 10. Irregular photography must be carried out in emergency response, the flight is along the main road, and hovering is over the town to acquire more information of residential area. The rotation angles of images are quite large, the variety of the overlaps are very big too. POS is not calibrated so its precision is lower. Thus the image matching is based on SIFT operator and object space. The orthoimage is produced with the mosaic line determined by the Voronoi map created from the photography centers. Aiming at the requirement of earthquake rescue, series of measure tools are developed, including distance and area measurement on the orthoimage, volume measurement on the DEM superimposed by orthoimage, superimposing the contour lines onto orthoimage, roaming and measuring 3D coordinates in the virtual 3D environment, etc.

APPLICATIONS OF DPGRID

Since DPGrid had been established in July 2007, there have been many applications, including quick update of orthoimage, low altitude photogrammetry of the counties in west regions of China and emergency response in earthquake rescue.

Quick Update of Orthoimage

Orthoimage update of 6000 map sheets with scale 1:10000 and GSD 2.5m had been completed in survey and mapping courtyard and information center of Guangdong country and resource bureau, Guangdong, China. Orthoimage update of 227 map sheets with scale 1:10000 and GSD 0.5m had been completed in information center of Guangdong country and resource bureau. Orthoimage with scale 1:2000 over 15 km2 had been updated in the urban of Suzhou city. The ability of automatic matching and update of orthoimage has been improved 4 to 8 times. 4 computer nodes can accomplish the orthoimage update of 20 frame satellite images. Figure11 shows an old orthoimage on a region of Guangdong, China, and Figure12 shows its updated orthoimage.

Low Altitude Photogrammetry of the Counties in West Regions of China

Low altitude photogrammetry is more suitable for mapping application in small region relative to middle, high and space photogrammetry. Many counties in west regions of China occupy smaller area, and separate faraway each other. The low altitude photogrammetry is the optimal selection for producing the orthoimage with scale 1:2000 over each county in west regions of China. The images are photographed in low altitude by unpiloted aircraft. Orthoimages with scale 1:2000 over 15 counties in west regions of China have been produced by DPGrid low altitude photogrammetry subsystem in SunMap Company. Figure 13 shows orthoimages of 5 counties.

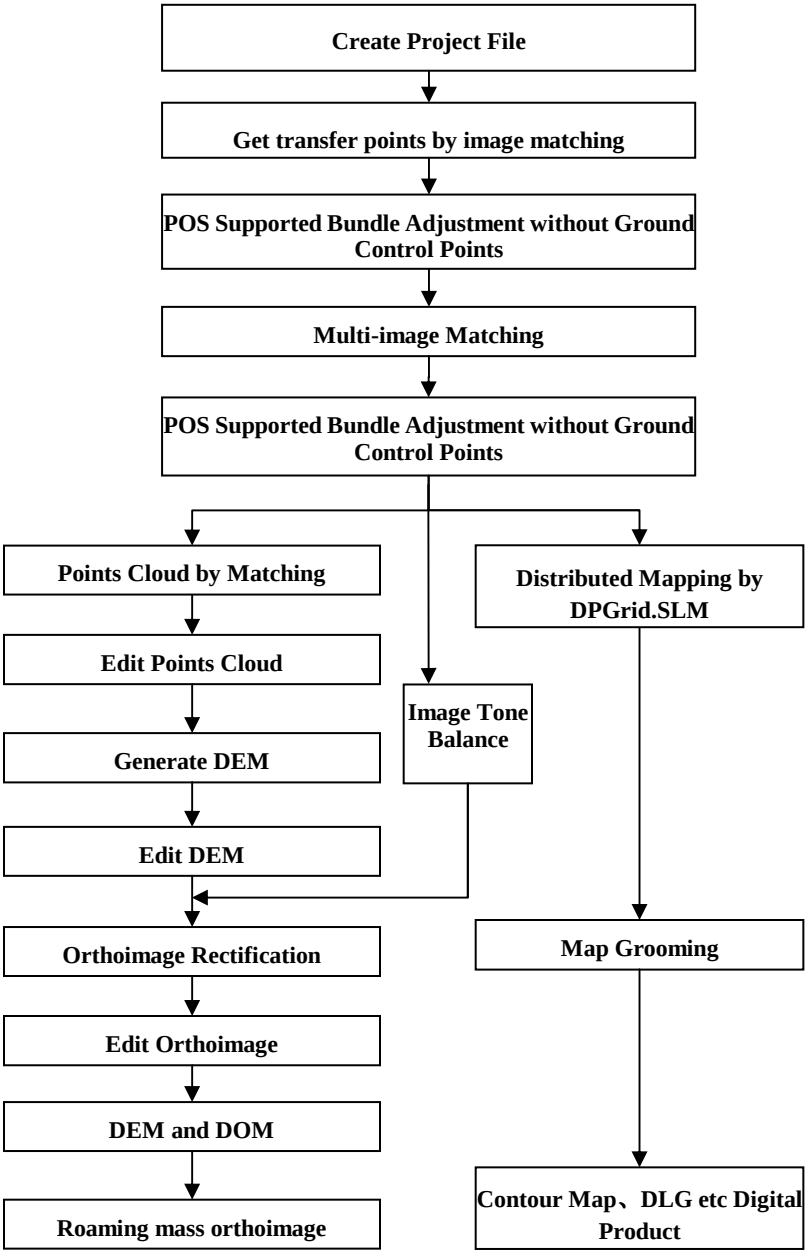

Figure 10. Flow of DPGrid emergency response photogrammetry.

Figure 11. Old orthoimage.

Figure 12. Updated orthoimage.

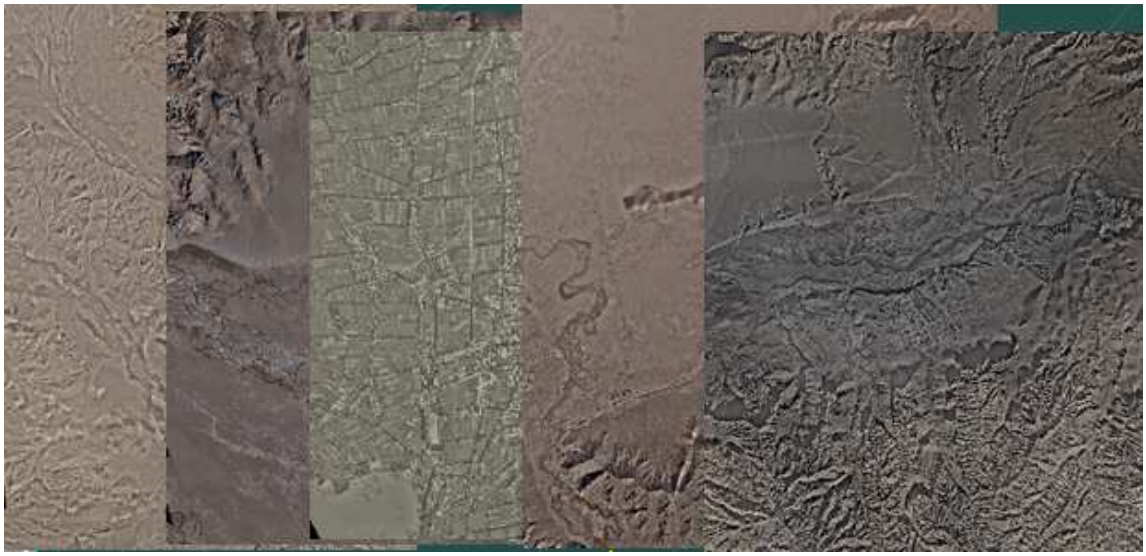

Figure 13. Orthoimages of 5 counties in west regions of China.

The Fast Response for Earthquake Rescue

During the rescue process of Wenchuan earthquake in 2008, DPGrid system generated 0.3m resolution ortho image (219 GB) of Wenchuan within 20 hours. The processing of 4507 DMC images and rapid production of orthophoto map were completed within 111 hours. Figure14 shows the ortho image based on DPGrid automatic selection of mosaic lines and parallel digital rectification. In Figure14, the lines are the mosaic line and the crosses are the position of exposure stations (Zhang Zuxun et al, 2009).

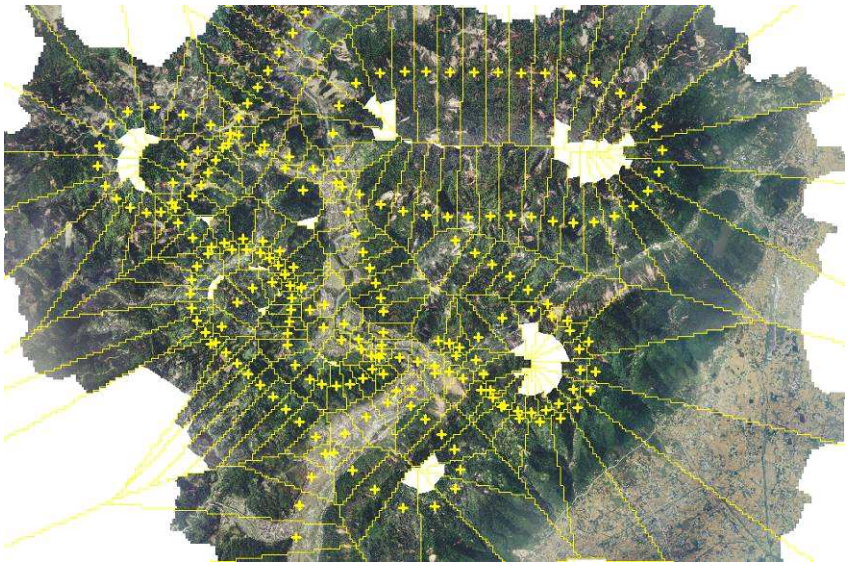

Figure 14. The ortho image generated by DPGrid in fast response of earthquake rescue.

CONCLUSION

The technique of advanced image matching, high-performance parallel computation, mass storage and high speed network are used in DPGrid, automatic and fast processing of aerial and satellite remote sensing data, and quick generation and update of spatial information are achieved. Its capability is higher than the current DPWs. It can be applied to national basic surveying and mapping, investigation of land resource, environment and disaster monitoring, investigation of ocean resource, agriculture and emergency response.

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