Today's Orthophoto Production - The Business Model

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ABSTRACT

Photogrammetry technology trends and customer demands have been changed drastically due to the availability of many digital cameras and very large orthophoto projects during the last five years. Moving to an enterprise solution is the best approach to bring the production processes under control. For an enterprise production, a highly-automated and integrated photogrammetric system is demanded. In order to increase production efficiency, the system should be able to perform many tasks of a photogrammetric workflow automatically, to visually display input/output data, and to show the progress and results of all operation.
This paper describes the PixelPipe concept, Intergraph's enterprise photogrammetry solution. This solution allows users to perform the entire photogrammetric workflow from triangulation to orthophoto production, as well as provides faster and cheaper project management, status tracking reports, and QA/QC tools. PixelPipe's main features, issues, and specifications for producing very large orthophotos efficiently are also discussed.

1. INTRODUCTION

Since the first commercial digital photogrammetric workstation (DPW) appeared about two decades ago, a large number of DPWs have been developed by different vendors. DPWs, which have been widely accepted by the photogrammetric community and used for photogrammetric productions, have a number of advantages against analytical plotters such as high efficiency and low costs.

Currently, most DPWs are specialized for a single task, e.g., automatic aerial triangulation, and they are used separately in a production environment. Each specific DPW has its own user interface and input data requirements. The user needs to prepare data and set up a project for each product to accomplish a photogrammetric task. For example, the user needs to provide approximate exterior orientation parameters (EO) with image data for automatic triangulation, accurate EO parameters, DEM boundary and morphological data in the area for DTM generation, and finally accurate EO parameters, DTM data, and seamlines for generation of orthophotos in order to finish a orthophoto project. This process is inefficient, especially for a large project.

The fundamental problem with workstation-centric processes is that there is no cohesive central management of the process. Thus, while it is obviously possible to do production this way, it is inefficient and error prone. Moving to an e*nterprise solution* is the best approach to bring the photogrammetric processes under control. For an enterprise production, a highly-automated and integrated photogrammetric system is demanded. In order to increase production efficiency, the system should be able to perform all tasks of a photogrammetric workflow automatically, to visually display input/output data such as triangulation results and DTM, and to show the progress and results of all operation.

2. INDUSTRY AND MARKET TRENDS

Photogrammetry technology trends and customer demands have been changed drastically due to the availability of many digital cameras and very large orthophoto projects during the last five years. The demand for geospatial data, especially imagery and orthophotos, has been steadily increasing. Governments, private companies, and individuals use geospatial data to make better and faster

operational decisions, and photogrammetry production shops are increasingly under pressure to reduce the cost of their jobs. For example, United States Department of Agriculture NAIP (National Agriculture Imagery Program) annually acquires 1 and 2 meter resolution natural color and color infrared imagery for the entire continental United States on a 1-year refresh cycle and delivers the imagery in the year of acquisition. This means the NAIP contractors must use photogrammetry software products that have high performance and many automation tools. There are many processes in the photogrammetric workflow, such as orthorectification, that are repetitive and well suited to automation, as they require little operator intervention. Distributed processing addresses this by allowing users to automate tasks by using a group of connected nodes (processors) to carry out these tasks simultaneously, in parallel with one another. This allows a process that would take many hours running on one computer to be completed much faster on multiple connected processing nodes.

3. CUSTOMER REQUIREMENTS

Some of the customers' requirements are listed here:

- **Reliability:** Customers want their software to work 100% of the time. The reality is that this will likely not be the case. Therefore, software should error off in such a way that the customer themselves can understand the cause of the problem and thus should be able to fix it.
- **Predictability:** Customers need to be able to predict the amount of time and level of resources that will be required for each step in the production workflow.
- **Scalability:** Customers want to know that what works on their 10,000 frame job will work on their 100,000 frame job. An expectable delay can quickly turn unacceptable as the project size increases.
- **Throughput:** Customers want as high throughput as possible but not at the expense of Reliability and Predictability.
- **Ease of Use:** Customers desire a minimum amount of human intervention. Those areas that require some degree of human intervention (i.e., seamline generation and editing and QA/QC) should be able to be accomplished by a relatively untrained individual. Customers do not want expert systems.
- **High Degree of Automation:** The size of a typical ortho production job has increased dramatically over the past 5 years. Today, a typical large-size job might range from 10,000 to 100,000 frames. End users are demanding higher quality products for less cost. This in turn is forcing data providers to find new, innovative ways to cut costs to maintain their margins. End users are requiring shorter and shorter turnaround times and are imposing costly penalties on their data providers (our customers) in the event that they fail to deliver on time.
- **Multiple Deliveries:** Customers are often required to make multiple deliveries of mosaic tiles (varying in pixel size, coordinate system, extents).
- **Collaboration** – Multiple technicians need to be able to collaboratively perform tasks such as seamline editing and the QA/QC steps. The software needs to be able to graphically display what portions of each task have been performed and by which technicians.
- **Content Management:** More and more end users are requiring that metadata contain information about the source data such as acquisition, processing, accuracy, etc. Software should be flexible enough in the data to accommodate their end user's metadata requirements.
- **Production Logging:** Customers want automated status reports. On large projects, customers usually can't wait until one process is completely finished before beginning the next one. For instance, image dodging needs to begin as soon as the first ortho is created. Similarly, output

products need to be generated as soon as enough orthorectified images are finished to fill the individual product.

4. PIXELPIPE CONCEPT

PixelPipe is Intergraph's solution for an automated and seamless solution that covers the entire orthophoto production process; all stages of the process are automated, accelerated (distributed processing), and backed up by project management, status tracking tools, and QA/QC tools. It is designed to address today's market trends and customer requirements (Figure 1).

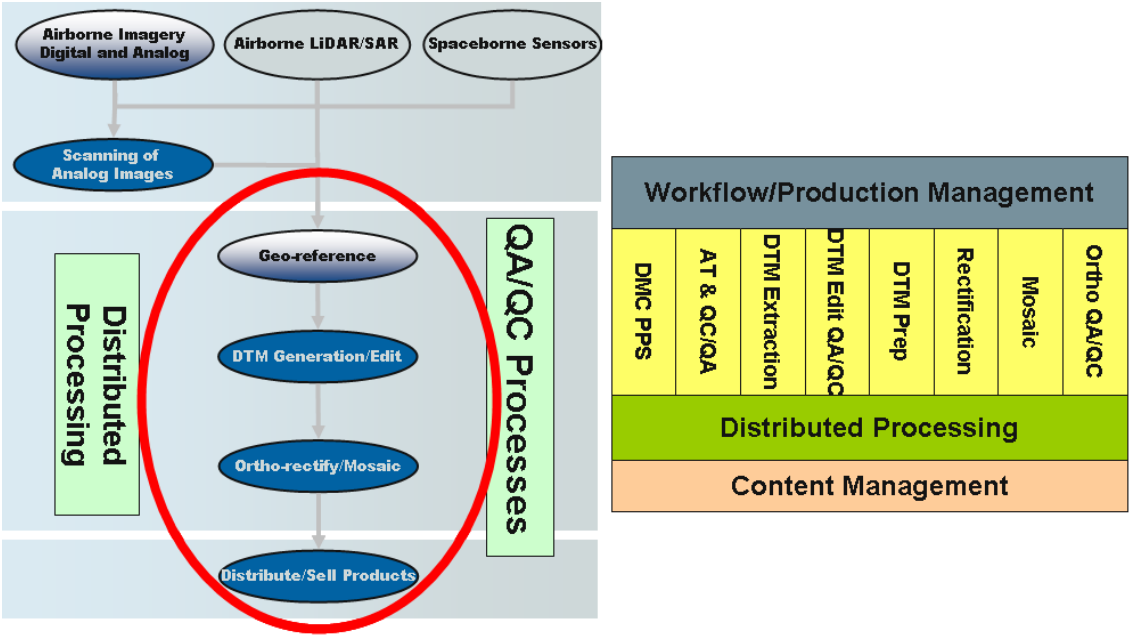

Figure 1. PixelPipe Concept and Architecture

PixelPipe shall have a very intuitive user interface and dialogs that allow the operator to set-up a project by selecting appropriate output data, parameters, and threshold values depending upon the status of the input data.

PixelPipe provides such features as:

- Graphical Project Interface
- Data Management
- Multi-user Transaction Control
- Workflow Guidance
- Distributed Processing Engine
- Production Logging/Reporting Tools
- Helper Functions
- Workflow Builder Tools

PixelPipe builds on the powerful tools already available in Intergraph's Earth Imaging solutions portfolio. It provides a powerful, scalable and seamless solution from one vendor for all aspects of orthophoto production, including:

- Image and metadata management
- Intelligent distributed processing
- Rigorous QA/QC processes including queued edit
- Automation – "one button orthos"

The PixelPipe process starts with a project definition phase. In general, the high-level parameters such as input/out parameters and options, project definition, intermediate products, and metadata will be stored in the database whereas large data, such as elevation data (LiDAR) and imagery will be stored in the network file system.

Once the project has been defined, a workflow-planning environment allows the user to select and control each process that has to be completed. This environment should query metadata for each item in the project, so as to display the status and progress. In the following sections, only orthophoto and ortho-finishing products are discussed assuming images are already georeferenced and surface date are available.

4.1 ImageStation OrthoPro

ImageStation OrthoPro is an integrated orthorectification product that addresses the complete ortho production workflow, including project planning, rectification, dodging, true ortho, tone balancing, automatic seamline generation (manual and automatic), "one-button ortho", mosaicking, and quality assessment using aerial frame, line scanner, and satellite imagery (Madani, 1999). All of the above processes in OrthoPro are enabled for distributed processing, thus increasing throughput and reducing computation time (Figure 2).

Figure 2. OrthoPro Workflow

OrthoPro takes as input orientation data and images from a photogrammetry project, and a set of one or more DTM files covering the project area and outputs orthorectified image mosaics. Input orientation data in a variety of common formats can be imported, and input images and DTMs in a variety of standard formats can be used directly without translation. A key feature of OrthoPro is the ability to process data in different coordinate systems on-the-fly without translation. That is, the input orientation data and DTMs can be in different coordinate systems, and the output orthophoto mosaics can be in yet a different projection. OrthoPro also allows for manual or automatic processing. With manual processing, the user runs each step in sequence, whereas with automatic processing, the user can define all the job parameters and hit "Start", and have all the steps completed without operator intervention. Output products can be either a single mosaic or a tiled set of mosaics based on a user-defined database. For output format, the user can specify GeoTIFF, Intergraph, USGS DOQ, or JPEG 2000. Figure 3 shows the basic OrthoPro environment and control panel for processing.

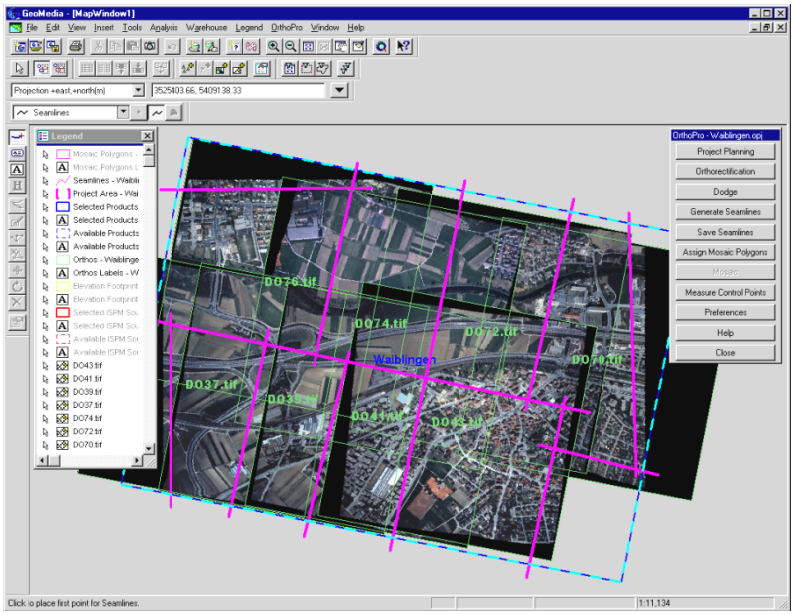

Figure 3. OrthoPro User Environment and Control Panel

The OrthoPro *project* is an Access database file that contains the entire predefined feature and other data that are needed to create mosaicked orthophotos. The OrthoPro project also records all the operations, including all the parameters that are defined through the OrthoPro workflow such as the project area coordinates, pixel size, rotation angle, orthorectification settings, seamlines, and so on.

4.2 Distributed Processing in OrthoPro

Photogrammetry shops are increasingly under pressure to reduce the cost of their photogrammetry production. This means they need photogrammetry software products that have higher performance and many automation tools (Long, 2005).

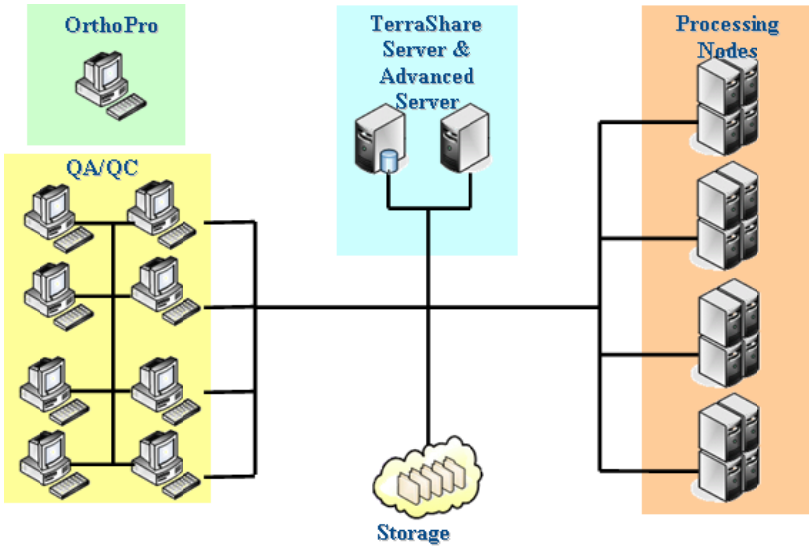

Figure 4. OrthoPro Distributed System

There are many processes in the photogrammetric workflow, such as orthorectification, that are repetitive and well suited to automation, as they require little operator intervention. Distributed processing, a function of TerraShare Advanced Server, addresses this by allowing users to automate tasks by using a group of connected nodes (processors) to carry out these tasks in parallel with one another and simultaneously. This allows a process that would take many hours of computation on one PC to be completed very quickly on multiple connected processing nodes (Figure 4).

For each application that will be used with distributed processing, one full application of that product must be installed. This is used as the submitter application to define and to monitor the processes that will be distributed across any number of distributed processing applications.

4.3 Performance Comparison between Conventional and Distributed Processing

Distributed Processing theoretically should linearly decrease the time required to process a number of tasks depending on the number of processing nodes used. For example, if 100 rectifications on one processor completes in 10 hours, then using distributed processing and 10 identical processors should take 1 hour to complete. This example, of course, assumes many things and is not representative of what will be achieved in practice. Factors that will affect the performance include the network performance under these loads and server or storage performance, which can affect the efficient access of the images by the processing nodes (Long, 2005).

4.4 ImageStation PixelQue

PixelQue is designed specifically to provide the finishing tools needed in orthophoto production. PixelQue provides image inspection, quality control, image enhancement, and image editing. By combining all the tools needed in one package and tailoring them for production, the process of orthophoto finishing is made more efficient and productive (Figure 5).

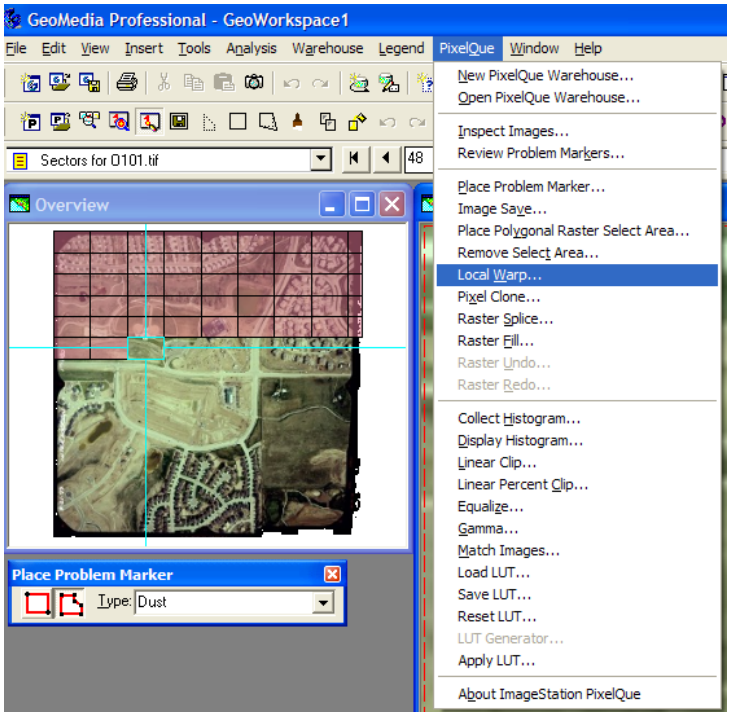

Figure 5. PixelQue Main Dialog

PixelQue includes tools for:

- **Image Inspection and Reviewing:** Provides systematic and efficient QA/QC of images and orthophotos. If, during inspection, problems are found, they can be marked with attribution added to indicate the type of problem for later correction. After the problems are found and problem markers are placed during the inspection process, they can be fixed by an operator who is driven to each problem area by the queued edit function. The operator can then add attribution to indicate that the problem is resolved.
- **Image Enhancement:** A range of functions to adjust the radiometry of either a single or group of images/orthophotos:
  - **Collect & Display Histogram:** Collects a single (cumulative) or separate image histograms at a defined image overview level and displays the collected histograms for the selected images.
  - **Linear and Linear Percent Clip -** enhances selected images linearly by stretching image histogram with the selected minimum and maximum values or the percentage of image histogram.
  - **Equalize -** enhances selected images by equalizing the images' histograms with the input weight.
  - **Gamma -** enhances selected images in a non-linear manner with the input gamma.
  - **Match Images -** matches selected images with the reference image to make them consistent.
  - **LUT generator** - edits images' Look Up Tables (LUTs) graphically. Image LUTs can be loaded, saved, reset, and applied to create new images.
- **Image Editing:** Corrects blemishes and other problems. Provides functionality to create or remove raster select areas by defining which pixels of a raster are to be used as the source and/or target for any given raster edit.
  - **Pixel Clone -** provides dynamic cloning capability (interactive raster copying tool).
  - **Local Warp -** provides local warp capability.
  - **Raster Splice -** provides the ability to copy raster data from one image to another.
  - **Raster Fill -** allows the user to fill an area of the raster with a solid color.
  - **Undo/Redo** - provides the ability to undo raster editing commands that may have given undesired results and to redo an operation that has been undone.

5. CONCLUSION

PixelPipe is Intergraph's enterprise photogrammetry for an automated and seamless solution that covers the entire orthophoto production process; many stages of the process are automated, accelerated (distributed processing), and backed up by project management, status tracking tools, and QA/QC tools. It is designed to address today's market trends and customer requirements.

OrthoPro is one of the main components of the PixelPipe solution. This product addresses the complete ortho-production workflow. OrthoPro integrates the orthophoto production process into an efficient, streamlined workflow resulting in significantly improved production throughput.

Distributed processing has been implemented in OrthoPro on the TerraShare framework and has been shown to increase geospatial data production throughput by distributing the processing of individual images onto multiple computers on the network. The actual improvement in time will vary based on the user's hardware configuration, including network and disk speed and also data distribution.

PixelQue is another component of the PixelPipe solution. It is designed specifically to provide the finishing tools needed in orthophoto production. PixelQue provides image inspection, quality control, image enhancement, and image editing. By placing these tools in one product, the user benefits. Georeferencing embedded in the image file header is preserved and not deleted when the image is saved, and four band and 16-bit images are supported.

Further developments of the PixelPipe solution will extend the scope of enterprise photogrammetry to include the entire flowline from image acquisition to mosaicking, including

- image acquisition and post mission processing
- aerial triangulation
- automatic DTM extraction, editing, and management

so that a single solution from one vendor can provide a high throughput solution for today's orthophoto projects.

6. REFERENCES

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