WEBTOP PHOTOGRAMMETRY -
A TOOL FOR DISTRIBUTING PHOTOGRAMMETRIC IMAGERIES AND KNOWLEDGE

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ABSTRACT

The interest to use Internet for accessing and distributing geospatial data has emerged rapidly since the invention of WWW-technology. Related to photogrammetry, there are several experiments and sites using digital orthophotos. The functions supplied for a user of a web browser include commonly zooming and panning of the imagery, and overlay of vector-formatted geospatial data. The technical realization to support these functions usually relays on the three-tire architecture in which a web server transmits image request to an image server via Common Gateway Interface (CGI). In this paper we further elaborate this topic. The paper addresses especially the issue of using a standard web browser as a tool for making 3-D measurements on digitized aerial photographs. It also demonstrates how to implement the interaction in a web browser, how to cope with the large image sizes, how to store the measurements locally and/or how to transmit them to the server. The implementation of a prototype system is based on Java. The paper also points out the application areas where this concept of WepTop photogrammetry is considered to be most suitable.

1. INTRODUCTION

The interest to use Internet for accessing and distributing geospatial data has emerged rapidly since the invention of WWW-technology. Internet and WWW-technology jointly have provided the necessary infrastructure for establishing services on geospatial data, based on new kinds of principles. Related to photogrammetry, there are several experiments and sites using digital orthophotos (see e.g. MIT). In this paper we further elaborate this topic. The paper addresses especially the issue of using a standard web browser as a tool for making 3-D measurements on digitized aerial photographs.

2. WEBTOP PHOTOGRAMMETRY - WHAT AND WHY?

By WebTop photogrammetry we denote an approach in which photogrammetric measurements are carried out in a web browser. The basic requirement is that a photogrammetric image or a part of it is displayed by the browser and that a cursor can be used to point out features on the image. It is also necessary that the image coordinates of the cursor can be transformed in the browser environment to the coordinates in a ground reference system.

For orthophotos and the like this is straightforward: the computations include only scaling and shift of the origo. For 3-D measurements on a stereo pair of images the task is slightly more complex; the feature of interest must first be located on the two images, after which the 3-D coordinates in the ground reference system can be computed using the basic formulas of analytical photogrammetry. How much additional functionality is built on the top of this basic function is a design issue that is treated later in this article.

To get an understanding of the why-aspect of WebTop photogrammetry, it is useful to review some of the development steps in digital photogrammetry. When a digital stereo plotter was first introduced on conceptual level, the idea was that it could be implemented on the top of image processing hardware and software with combined utilization of the existing software of an analytical stereoplotter (Sarjakoski, 1981).

The first operational systems (Miller et al., 1992) were based on dedicated hardware and software to a great extent. As in the original concept these can be classified as digital substitutes of analytical stereoplotters. The early systems for civilian market (Miller et al.,1992; Kaiser, 1991) already started to apart from this concept. First of all, the systems were called *digital photogrammetric workstations* (DPW, also softcopy photogrammetric workstation).
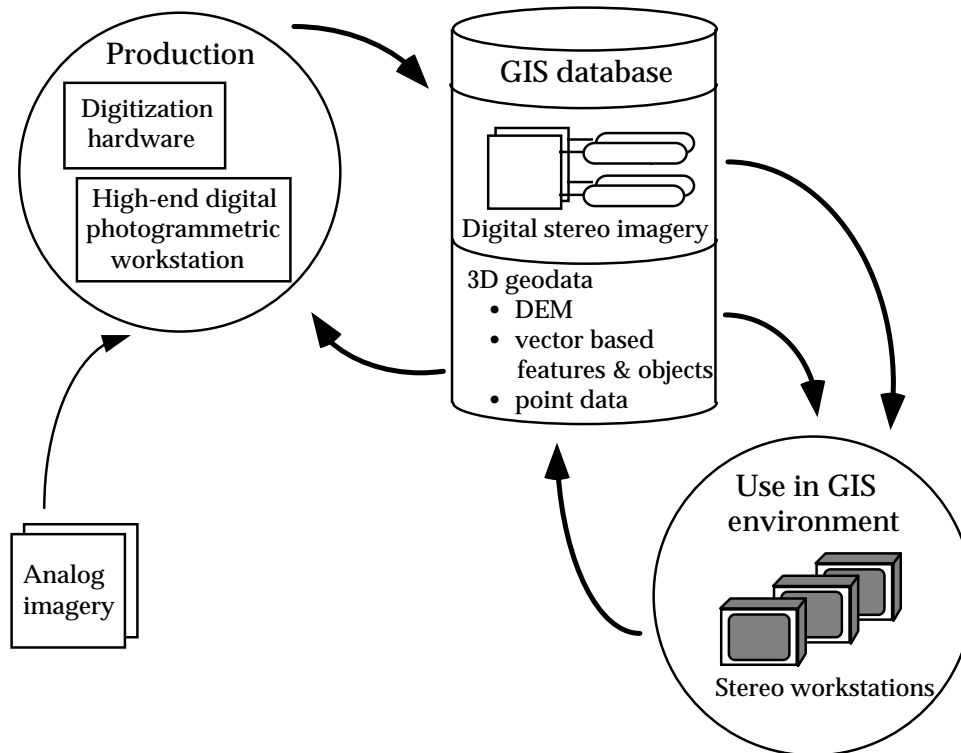
Figure 1. Production and use of digital imagery (Sarjakoski, 1990, 1994).

Secondly, a standard graphics workstation with Unix operating system was the central building block of these systems. Even the stereo viewing hardware and image processing hardware were not specially made for photogrammetric purposes but also used in other domains of digital image processing and computer graphics. Thirdly, the user-interface of the photogrammetric software also started to utilize the window environment of graphics workstations.

Another direction of development was initiated when DPWs were implemented using personal computers (Cagnon et al., 1990; Sarjakoski and Lammi, 1993). The general motivation in these works has been the goal to develop a low-cost and user-friendly DPW that could be used also by others than professional photogrammetrists and also in other fields than conventional photo-grammetric mapping. As stated by Nolette et al. (1992), the design of their workstation was based on the principle to go a significant step towards "zero-cost hardware" photogrammetry which seemed to be the goal also for geographic information systems (Dangermond and Morehouse, 1987).

The use of personal computers as a basis for DPWs has reached a totally new dimension when personal computers with Microsoft Windows-NT operating system have reached such a status that in many areas they suit equally well for graphics-oriented tasks as Unix-based workstations. As a consequence, many of the commercial DWPs have been ported to operate on Intel-based personal computers with Windows-NT. We may conclude that this has brought professional photogrammetric tools to the *desktop level* and much more widely available than earlier.

The transition to fully digital approach in photogrammetry has launched also other trends. Automation is one of them. Research and development on automatic feature extraction and on automatic collection of data for digital elevation models is extensive today. The topic is important but goes beyond the scope of this paper. Another trend is the interest in *processes and services.* A commonly made observation has been that the use of orthophotos as background images in a geographic information system gives good opportunities for verifying and updating the related geospatial data, see e.g. (Leberl, 1991). This implies rather directly that orthorectifation of the imagery is carried out as a preprocessing task in which the end-users are not involved. We have emphasized that the same principle could also be applied for stereoimagery (Sarjakoski, 1990, 1994), to facilitate photogrammetric 3-D measurements in GIS-environment (Figure 1).

The idea that photogrammetric measurements can be carried out by non-photogrammetrists is called as *democratization of photogrammetry* by Leberl (1991). In the outlook of the challenges of digital photogrammetry he concluded the that "the transition of photogrammetry into some shrink-wrapped software much like a spreadsheet or word processing package removes the intimating mystery of photogrammetry and leads to a democratization of photogrammetric technology".

On this line, WebTop photogrammetry can be seen as a far reaching solution for the challenge of offering an access to interactive photogrammetric services for a wide audience. Assuming that the infrastructure of general WWW-services has already been established for the community in question, it is possible to realize "zero-cost hard- and software" photogrammetric services in the sense that the marginal cost per end-user session becomes very low. The general issues related to pricing and degree of cost-recovery start to play dominating roles in this situation.

3. FUNCTIONAL REQUIREMENTS

As visioned in this paper, WebTop photogrammetry would be applied mainly as a part of other web-based applications in which open access to geospatial data is central. A typical application area could be spatial planning process in which some feedback from citizens is expected (Sarjakoski, 1998).

A basic assumption that can be made for WebTop photogrammetry is that the user is already familiar to use a web browser. Taking another perspective, it is highly desirable that very little additional skills would be required from the user. The browser should function as an universal interface (meta interface) to all related geospatial and other services. Therefore the photogrammetric part must be embedded seamlessly following the hypermedia approach applicable in the WWW-environment. As with web applications in general, use of application dependent plug-ins, which have to be loaded into the user's browser environment, is undesirable because of the additional concern by the user.

Dealing with photogrammetric aerial images, we will need many of the browsing functions used already in some form in DPWs. These include browsing a set of accessible images, selecting an image, and selecting the working area from an overview image. Once the working area has been selected, we must be able to choose suitable resolution level for the measurements. Because our goal is to make 3-D measurements, the use of at least two images is necessary. For 3-D measurements especially two alternatives seem to be feasible: 1) the fully manual one in which the user points a feature on two images and 2) so called one-eye-stereo concept (Lang et al., 1995; Englert

and Gülch, 1996) which is based on the principle of pointing a feature on one of the images and then matching it from the others. The later uses more automation but can yield erroneous results without user control.

Direct stereoscopic measurement is not yet a viable solution for web applications aimed to be used by a wide group of people, because a stereoscopic viewing system is needed. It is interesting to note, however, that there are several companies that manufacture low-cost stereoscopic shutter glasses and also offer software development toolkits for stereoscopic viewing in browser (see e.g. NuVision; StereoGraphics; Vrex). While game programs using stereoscopic animation become more popular, this kind of solution for WebTop photogrammetry should not be overlooked.

4. SYSTEM ARCHITECTURE

The technical realization relays on the three-tire architecture in which a web server transmits image request to an image server via Common Gateway Interface (CGI). This implementation is widely used with maps and ortho images (Lehto et al., 1998). The image server retrieves data from its database to the web server from where a Java applet can acquire it (Figure 2).

The only difference from traditional three-tire architecture is the use of a Java applet in the web browser which has the further responsibility to manipulate and display the data. The data requested can be image data, image orientation data or vector data. Data format is not really an essential issue, because data and the data format requests from image server are made by the Java applet.

The amount of data to be transferred is one of the issues that has to be resolved when accessing imagery over the network (Intranet, Internet) with the Java applet. Simply transferring a whole large-size aerial image through the network to the end-user is not an efficient solution because it takes time and system resources. The three key techniques for solving this problem are window-based image transfer, JPEG-compression, and the use of imagery on different resolution levels (so called image pyramids).

Large-size aerial images are essential for accurate 3-D measurements. It is not advisable to acquire the whole image when one needs only a small portion of it. Window-based image transfer is the solution for this problem. The applet will request the orientation of the whole image but image data for only the current view. Measurements are performed on static imagery so the applet does not need updates and it does not increase the network traffic.

To minimize network traffic it is necessary to compress image data. The basic idea of image compression is to

reduce the storage size of the image and at the same time preserve valid image information. JPEG compression can be used to reduce storage requirements with the compression ration of about 1:10 for aerial colour images (Lammi and Sarjakoski, 1995). It is especially suitable for web-applications because it is one of the image formats that are directly supported by web browsers and Java.

Different resolution levels allows the user to get an overview expression from the image before and after measurement. If scaling is done in the applet memory, the applet has to request whole image over the network. That would be, as stated earlier, very inadvisable due to the large amount of data. The use of image pyramids is the only feasible technique for handling different resolution levels effectively over the network. For network performance it is not important whether image pyramids are done by image server just in time or retrieved directly from database. However, for good overall performance database should include different resolution levels of images.
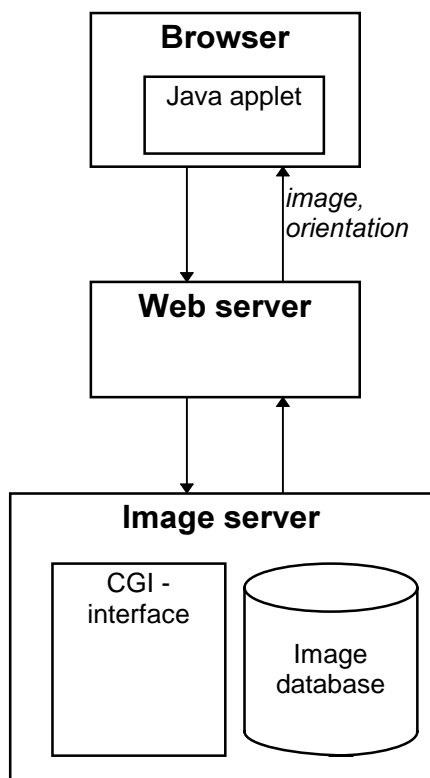
Figure 2. The main components of a system for WebTop photogrammetry.

5. INTERACTIVE MEASURING TOOLS BY JAVA

A web browser interface is widely thought as a future platform for various applications. There are strong reasons to belief that in the next millennium everyone who use computers is expected to be acquainted with a web browser and its interface.

The concept of WebTop photogrammetry requires an interface that a random user can easily adopt. The user does not have to have any specific knowledge of photogrammetry or computer science. Only by clicking the web browser the user can measure objects from images. There are various ways to implement such WebTop photogrammetry.

The first solution is based on a simple three-tire architecture. The web browser sends user's mouse clicks to web server that transmits clicks to measuring server via the CGI. The measuring server creates a new image with coordinate information overlaid after every click and the web browser loads it from the server. This solution is functional but it is inefficient due to the repeated transfer of the image data.

The second way to implement the system would be a fully Java based solution. The solution consists of two Java applications called client and server. Applications are connected with a socket layer and they have their own protocol for transferring information themselves. Such a protocol has capabilities to transfer Java objects. This kind of solution is flexible and network efficient. An object based transfer method makes it possible to adopt new data types easily. However, on the server side the general performance of the Java applications could be a problem. The execution of Java code is slower than machine code because the compiled Java code has to be converted to the machine code in runtime.

The security aspect plays an important role in WWW applications. Because of the rapid evolution of web browsers and web servers, the WWW has become a safer place than it was in its early days for both the users and the service providers. By implementing new communication methods the service provider takes a certain risk. Even an experienced and skilful programmer cannot foreseen all possibilities of misuse.

The implementation of a prototype system is a hybrid combination of the two solutions presented above. The client side in the browser is implemented by a Java applet and the server side by a normal web server and a CGI image server. The CGI image server is a console program written in C++ programming language that needs no platform specific window handling. So the server code is easily transferable between different server system platforms.

The Java language is developed by Sun Microsystems Inc. and it was announced in the spring 1995. The rapid expansion of Internet and WWW-environment created a need for applications that can run on different platforms and web browsers. Compiled Java code is platform independent so the same code works on all platforms.

Figure 3. A typical layout of the windows used in WebTop photogrammetry. The window on the left is a browser window displaying an overview image. The window on the left has been opened by a Java applet and contains a stereo imagery for the area in interest. A measured distance is displayed there also, the other measurement data being displayed in a separate window on the top.

An applet is a small Java program that can be embedded in another application, usually in a web browser. At this time both dominant web browsers - Netscape Navigator and Microsoft Internet Explorer - support Java applets. Because Java capabilities are built into web browsers or loaded as a plug-in, a Java applet itself requires no installation.

Java is a fully object-oriented general purpose programming language. It includes a rather complete set of mathematical functions and contains so called Abstract Window Toolkit (AWT) that provides tools for window based programming, such as frames, buttons, edit controls etc. The AWT also provides variety of facilities for generating graphics and manipulating images. As such it is well suited for the implementation of the photogrammetric extensions into browser environment.

Figure 3. demonstrates the display of the system for WebTop photogrammetry that is under development by the second author of this paper. It should be noted that by using Java we can display images either in the standard window of the browser, as done for the overview image, or in separate windows opened by the applet. Also other windows can be used, as done for the measurement results.

6. CONCLUSIONS

In this paper we have studied the development in digital photogrammetry and in computer technology revealing WebTop photogrammetry, i.e., the possibility to make 3-D photogrammetric measurements in a web-browser environment. This development seems to be a natural step in the process of offering better on-line services on geospatial data. A system based on the conventional three-tire architecture is suitable also for this application. The underlying image server must store also the orientation data that is transmitted to the browser with the image data.

The Java language is in our experience a suitable tool for implementing the photogrammetric functions into the browser. By using a window-based transfer and JPEG compression of the image data the amount of data to be transferred in one transaction remains limited. This makes it possible to use WebTop photogrammetry even with such medium speed communication connections as ISDN or recent modems. The most plausible Internet applications are related to situations in which citizens are requested to verify the correctness of geospatial databases, or even supply some corrections on them. Intranet solutions could be used in cities and other organizations in a similar way for ad hoc needs, especially outside the mapping units.

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