Digital photogrammetry, based on the latest technological advances, usually requires the use of extremely expensive and complex workstations. As a consequence, the most common system of photogrammetric photograph processing focuses on solving photogrammetric problems on stand-alone workstations. Moreover, both photogrammetry and remote sensing are applied by a small number of users only, and the attempts at making them available to a wide group of clients have not brought the expected results so far. On the other hand, however, the Internet offers us completely new possibilities, raising hopes for effective processing of metric photographs through wide area networks (WAN) and local area networks (LAN).

The solving of photogrammetric problems on workstations is connected with major expenditures for the acquisition, implementation and updating of a photogrammetric system. Moreover, photogrammetry remains almost unknown outside the circles of specialists in geodesy and cartography. Despite the fact that photogrammetry provides a very detailed image of the outside world, without resorting to a complicated language of symbols, it is still ignored in many spheres of life, where it could be of great help. As a result, the role of photogrammetry in gathering geodetic and cartographic information, as well as in widely understood spatial information systems, remains limited.

In this paper I concentrate on the possibilities offered by computer networks, and especially the Internet. Practical application of the solutions proposed allowed to create a system based on a central unit – a server of applications and Internet pages – providing its photogrammetric resources to clients – computers equipped with standard Internet browsers (e.g. Internet Explorer, Netscape, Opera). Only original software was used in the studies, and photogrammetric material were commonly available metric aerial photographs of the surroundings of a university campus located in Olsztyn (north-eastern Poland), acquired within the confines of the European Union program PHARE, as well as images showing the region of Aalborg (Denmark). Photogrammetric software available on the market was not used at any of the research stages. This approach enabled the application of original solutions of aerial photogrammetry. Solutions for terrestrial fotogrammetry are published [Renuncio 2001], [Grissemeyer et al, 1999]. At present the system is employed at...
the Department of Photogrammetry and Remote Sensing, University of Warmia and Mazury in Olsztyn. Using a browser, we can perform the following tasks:
- choose any stereopair of a block of photographs,
- choose any fragment of a photograph from any level of a photograph pyramid,
- determine the pixel coordinates of homologous points and match them automatically,
- determine the coordinates of a point in a local coordinate system,
- draw a polygon on the photograph and on this basis determine the area on the ground,
- determine elements of the exterior orientation of a single photograph.

The above functions are performed by means of elements of the HTML, implementing JAVA applets and servlets [Janowski et al, 2001]. The solution is presented graphically in Figure 1.

![Diagram](Fig.1. Solution in the client-server technology.)

Images and their orientation parameters are stored on the server and provided to the client using relevant methods of transmission. Photographs are transferred in the JPEG format. This means that their orientation was determined before, and its elements were recorded in sets in a generally available catalogue. Pyramids of original photographs in the BMP format can be found in another, unavailable through the Internet, catalogue on the server. In order to get the necessary fragment of a photograph, the user determines its center, the size of this fragment and the pyramid level. These parameters, together with the user label (login), are sent in the applet to the server. Then the function doGet is called on the server. The function doGet call another function, that generate a file (in the JPEG format) containing the photograph fragment chosen by the user, and a text file containing the photograph parameters. At the same time, the client, i.e. a browser, receives information about order execution. According to the rules assigned to browsers in the client-server technology, only the client can get generated images and their parameters – the server cannot send them to the client.

Following the methods of homologous point determination, applied in photogrammetry, I used the method of area matching in my solution. The measure
of similarity between pixel sets is the coefficient of correlation, calculated in the JAVA applet on the client side [Paszotta, 2000].

Elements of photograph orientation are transferred to the user when he/she chooses the relevant stereopair. Therefore, it is possible to determine the ground coordinates of the points indicated. The calculations are done in the JAVA applet on the client side. Their results are presented in Figure 2.
Fig. 2. Determination of ground coordinates.

The software applied in browsers, as well as event handling, enable not only to present photographs and determine coordinates, but also to draw lines in the image to mark the contours of objects (e.g. land parcels) and measure their areas. The next stages of this solution include polygon matching and the determination of the spatial coordinates of polygon vertexes.

Having solved the above problems, we can pass to more complex tasks, such as e.g. setting the exterior orientation of a single photograph. This is a crucial problem, whose solutions have already been formulated within the frames of research project OEEPE [Paszotta, 1999; Shan, 1999; Höhle, 1999]. Let us describe briefly its essence. Our task is to determine elements of the exterior orientation of an aerial photograph. Instead of the coordinates of control points, we have an orthophotomap compiled earlier, and a DTM. As mentioned before, the photograph, orthophotomap and DTM image may be placed on the Internet pages (Figures 3, 4, and 5).
Fig. 3. Aerial photograph in the JAVA applet on the Web.

Fig. 4. Orthophotomap in the JAVA applet on the Web.
We will skip the solutions elaborated during tests, and get down to the simplest way of orientation element determination, based on manual indication of corresponding points on an orthophotomap and photograph. Orientation elements can be determined from collinearity equations:

\[
x = -c_k \frac{a_{11} (X - X_0) + a_{12} (Y - Y_0) + a_{13} (Z - Z_0)}{a_{31} (X - X_0) + a_{32} (Y - Y_0) + a_{33} (Z - Z_0)}
\]

\[
y = -c_k \frac{a_{21} (X - X_0) + a_{22} (Y - Y_0) + a_{23} (Z - Z_0)}{a_{31} (X - X_0) + a_{32} (Y - Y_0) + a_{33} (Z - Z_0)}
\]

where:
- \( c_k \) - camera constant,
- \( a_{11}, a_{12}, ..., a_{33} \) - elements of rotation matrix for angles \( \omega, \varphi, \kappa \);
- \( X_0, Y_0, Z_0 \) - co-ordinates of the projection centre.

Data flow charts are shown in Figures [6] and [7].
Fig. 6. Technology of photogrammetric image processing in the Internet environment, using JAVA.

Fig 7. Determination of elements of the exterior orientation of a single photogrammetric photograph in the Internet environment, using JAVA, an orthophotomap and a DTM.

In order to use collinearity equations, we have to know the image coordinates of points and ground coordinates X, Y, Z. In the solution adopted the user indicates the pixel coordinates of a point in the photograph, and the image coordinates are determined by the servlet. Similarly, the user indicates a point on a orthophotomap and transfers its coordinates in the pixel system to the server. The server program (servlet) first calculates ground coordinates X, Y. The third coordinate (Z) is determined using a set of DTM points and the interpolation method. We need at least three points to determine orientation elements. An example of calculations for four points is presented in Figure [8]. The user obtains the results of calculations on an Internet page. The sever allows to apply any method of automation while determining exterior orientation elements, described within the confines of the OEEPE test. The elements obtained enable to generate a new orthophotomap. A comparison between the new map and its previous version makes it possible to verify
the correctness of calculation results [Paszotta, 2000]. An orthophotomap can be generated through the Internet, but the process will be described in detail in another paper.

The methods discussed are at present employed on specialized computerized photogrammetric stations. The solution presented in this paper may be applied in the Internet environment. This allows to eliminate both the inconvenient procedure of image ordering and transporting by various media, and problems with software distribution and updating. It constitutes an alternative to the technology in which - in order to e.g. determine the area of a wheat field cultivated by a farmer - we have to order, purchase and receive photographs and camera calibration data, and then use a photogrammetric station for stereo digitization or orthophotomap generation. It is certain that the possibilities offered by the Internet are and will be widely used in photogrammetry.

Fig. 8. Determination of exterior orientation elements

References


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