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PRESENT STATUS OF ORTHOPHOTOGRAPHY

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The usefulness of photomaps was recognized by Theodor Scheimpflug back in 1897 in which year he published his idea of the transformation of an aerial photograph directly into a planimetric base map. In 1903 he applied for a patent on his method and instrument for a zonal rectification of balloon photographs. In a practical test the first photomap of an aerea to the south of Vienna was produced.

With the development of air survey methods after the first World War the production of photomaps and their practical use also increased.

The first known production of photomaps for civil use was carried out 1920 by the "Konsortium Luftbild GmbH - Stereographik GmbH" in Munich for the design of a channel for the Isar River. Photomaps at scales 1 : 10.000 and 1 : 20.000 for an area of 150 sq.km were produced by rectification.

In 1921 a forest area of 4.500 ha was covered by aerial photographs from which photomaps were produced at scales 1 : 6.500 and 1 : 5.000 with a mean square error of 2,5 mm in the map scale.

In the following years the demand for photomaps increased and their accuracy was further improved. Between 1922 and 1925 the Konsortium produced photomaps in 1 : 5.000 and 1 : 10.000 for areas totaling 1.000 sq.km for forestry purposes, river improvement and for housing development.

Hansa Luftbild alone produced from 1925 to 1945 photomaps at scales 1 : 1.000, 1 : 2.500, 1 : 5.000 and 1 : 25.000 for areas of more than 100.000 sq.km. Also in other countries increasing numbers of photomaps were produced for civil use, however, because of the manual method of production with the necessary rectification in parts, assembly and reproduction, production was time consuming and costly.

In the search for more economical methods of production, back in 1929 Professor Lacmann first mentioned a method of differential rectification for the production of so called orthophotos from aerial photographs. However, it took years before practical instruments were available for the production of orthophotos.

The break-through with practical instruments and methods was made at the beginning of the 1960ies. In the United States orthoprojectors were developed using 3 anaglyph projectors such as Balplex and Kelsh. The first orthophoto system really suitable for practical production was the Orthoprojector GZ-1 Gigas/Zeiss. The Provincial Survey Directorate of North Rhine-Westphalia and Hansa Luftbild were the first institutions which used this system already in 1966/67 regularly. In 1970 off-line operation was introduced with scanning and data storage of profiles separated from projection with the aid of a read-out unit conected to the GZ-1 projector.

Over the next period of 10 years, Hansa Luftbild produced about 1.200 double model orthophotos annually. Biggest client was the Provincial Survey Directorate of North Rhine-Westphalia with the production of photomaps 1 : 5.000, 40 cm x 40 cm from aerial photographs 1 : 12.500.

For other clients orthophotos in scales between 1 : 1.000 to 1 : 25.000 were produced from aerial photographs taken with 15 cm, 30 cm and 60 cm focal length.

In the meantime development of new orthophoto systems has progressed and a complete new generation of computorized orthoprojectors with various software packages is available, allowing production of black and white and color orthophotos of unequaled geometric and photographic quality.

With these modern computerized orthoprojectors, the data acquisition of terrain data is not bound to special ancillary equipment like the SG 1 storage unit and LG 1 read-out unit of the GZ 1, but it is now completely independent. The method employed for data acquisition is now more a question of required accuracy and economy.

Among others, the method of measuring profiles and storing them for the orthoprojection is still applied. On magnetic tape registered profile data are directly entered into the computer of the orthoprojector to stear the orthoprojection. Spacing of profiles during data acquisition in the stereo models can

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be selected according to terrain ondulation and required accuracy. In the Orthocomp of Zeiss an interpolation between registered profiles during the projection is possible, improving the orthophoto further.

In very flat areas covered by small scale aerial photographs one can use the coordinates of the 9 points obtained from adjustment of aerotriangulation to construct 3 profiles in y-direction which can be used with sufficient accuracy for orthophoto projection.

The development of suitable and flexible software for the computation of digital height models (DHM) is another important step in data acquisition for orthocomp production. Independent of focal length and scale of aerial photographs and of the scale of the orthophotos, profiles for the orthoprojection can be computed from a digital height model.

During the photogrammetric restitution of stereomodels, contour lines can be registered continuously on magnetic tape. From these data, profiles for orthophoto production can be obtained by computer processing and stored on magnetic tape which can directly be used for the orthoprojector. Once profiles are stored for a particular area, they can be used over again with new aerial photographs. If topographic maps with contour lines are available of a particular area, profiles can also be produced by putting a transparent grid over the map and digitizing every intersection between grid lines and contour lines, adding the proper z-coordinate to these points. Depending on economy, accuracy and speed required, all methods described previously have been applied in the production of orthophotos by Hansa Luftbild. Because of this flexibility in the production, allowing the combination of profiles from various sources with photographs of different scales and focal length to be used in the production process, the orthophoto is now a very powerful and economic tool for mapping. Even in built-up areas, large scale orthophotos from aerial photographs taken with long focal length lenses of up to 610 mm can be produced without undue perspective distortion of buildings.

The high resolution of modern air survey cameras and improved film quality permits enlargements from photographs to orthophotos without perceptible loss of details. The limiting magnification factor comes from the size of the projection drum. Here we are limited to about 5,5 times magnification. If a further enlargement should be required this can be done with the aid of a reproduction camera.

When producing a photo map series of an area with predetermined sheet layout, it is important that in flight planning the position of flight lines and the overlap between neighbouring photographs are such that 2 stereo models cover one map sheet. The centre photograph is than used for the projection with the sheet corners exposed on the orthophotos according to their coordinates. With very large orthophoto scales the aim should be to cover 2 map sheets with 1 orthophoto. Taking this into consideration during flight planning, one needs not to assemble orthophotos to a final size map sheet, saving additional costs in the production process and avoiding possible loss in photograph quality. Under such conditions the demand on the air survey crews concentration and performance are high, especially if suitable navigation charts are not available or if the terrain shows little details.

For small scales, aerial photographs with 80 or 90 % overlap can be exposed from which those pictures are selected which are in an optimal position for orthophoto projection. If proper navigation charts for such an aerea are not available, a small scale photo flight is carried out over the area from which an uncontrolled mosaic is made which serves as base for flight planning and navigation. If the required photo scale is a large one, the cost of the film material for 80 or 90 % overlap is very high as compared to the operating cost of the aircraft. Besides, on large photo scales, the cycling time of the camera between exposures will not allow 80 or 90 % overlap. One has to use pin point photography, otherwise an assembly of orthophotos or parts of it to cover a map sheet cannot be avoided.

New systems for aircraft positioning in combination with navigation computer and remote controlled aerial cameras with automatic exposure will improve strip navigation during flight and positioning of exposure.

The combination of orthophoto with line elements such as property boundaries, contour lines, spot heights a.s.o. - will assist the user in the interpretation of the orthophoto. For inventory purpose and many planning and design projects photomaps are superior to line maps. Also as a base for the production of thematic maps can the photomap be a useful tool.

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The user of a photomap has to interpret the contents of the photographic image himself, while on a line map the topographic interpretation is done by the stereo-operator. For an untrained person in photo interpretation this will be a disadvantage. However, for experienced experts like geologists, hydrologists, hydrolic engineers, forest engineers and other qualified users, the content they can extract from a photomap for their specific tasks is higher than from a line map. This is especially true if additional information such as contour lines, drop lines and others are added to the photomap.

Let me explain this on a little example. For hydrologic computation of surface water run-off the engineer needs size and outline of the water shed, shape of the terrain and natural slopes with their direction and surface conditions with type of vegetation and artificial structures. For flood protection computations, cross sections up to the high water mark are required in addition, their locations depending on local situation which only the hydrolic engineer can decide on. This is only one case where the combinations of orthophotos with contour lines are superior to line maps.

Within the last 4 years Hansa Luftbild has carried out quite a number of foreign mapping projects for inventory and engineering design. For all of them photomaps were required by our clients. These projects were for:

- Geology and mining
- Hydrology and hydrolic engineering for river improvement, design of hydroelectric power dams and storage basins,
- Highway engineering, design and inventory
- Powerline location
- Agriculture for land use and soil surveys
- Forestry
- Cadastre
- Planning of cities and regions

So far, I did not mention the stereo-orthophoto because we have no experience with their production and use and have never been asked by one of our clients to supply them. In the meantime it seems that there might be an increasing demand for them, especially in the fields of regional planning, geology and hydrolic engineering. We assume that with the increasing demand for photomaps there also may be potential users for stereo-orthophotos once they are introduced to this product.

With all the possibilities of data acquisition from various sources there exists in my opinion the danger that users of photomaps have no information on the geometric quality of the photomap. For this reason I like to make a proposal to all producers of orthophotos and photomaps.

In future I would like to see on all orthophotos and photomaps besides scale and focal length of aerial photographs, date of survey flight and other common information, an indication about the source and quality of the height information used in the production process of the orthophotos.

With these informations, the user of the photomap has an indication what geometric quality he can expect from this photomap. If such an information is missing, later users might expect an accuracy which was originally not asked for. They might be disappointed and never use photomaps again. After all, photomaps produced by modern orthophoto systems are no longer a cheap "Ersatz" (substitute) for line maps.

In Germany the market for orthophoto products is limited not because there is no need or acceptance for them, but because in the meantime almost all provincial government survey offices have their own systems installed and operating, leaving little work for private air survey companies.

Abstract

The idea of transforming aerial photographs directly into a photomap was first published in 1897 by Theodor Scheimpflug. In 1903 he applied for a patent for his method and instrument for zonal rectification of balloon photographs. Production of photomaps for civil applications by rectification of aerial photographs in sections and assembly to photomaps started in 1921. In 1929 Professor Lacmann developed a concept for differential rectification for the production of orthophotos. It took another 30 years before instruments and methods of orthophoto production were operational.

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Today we have a complete new generation of computer operated orthoprojectors, with flexible software, to produce orthophotos and photomaps speedily and economically. Their possible use for inventory and for various planning and design activities has not yet been fully recognized. The modern photomap with its manyfold uses is no longer just a cheap substitute for a linemap.

In this presentation, production possibilities for various user tasks will be discussed.

DER GEGENWÄRTIGE STAND DER ORTHOPHOTOGRAPHIE

Zusammenfassung

1897 veröffentlichte Theodor Scheimpflug erstmals die Idee, Luftbilder in Bildkarten zu transformieren. Ein Patent auf das Verfahren und das von ihm dazu entwickelte Gerät wurde 1903 angemeldet. Die Produktion und die zivile Nutzung von Luftbildkarten, damals noch als Bildpläne bezeichnet, wurde 1921 aufgenommen. Professor Lacmann hat 1929 auf die Möglichkeiten der differentiellen Entzerrung von Luftbildern hingewiesen. Es vergingen noch weitere 30 Jahre, bevor geeignetes Gerät für die praktische Herstellung von Orthophotos von den Geräteherstellern angeboten wurde.

Heute steht uns eine neue Generation von rechnergesteuerten Orthoprojektoren mit entprechenden Rechenprogrammen zur Verfügung, die eine schnelle und wirtschaftliche Herstellung von Orthophotos ermöglichen. Die Vielfalt der Nutzungsmöglichkeiten der Luftbildkarten für Bestandsaufnahmen sowie Planungs- und Entwurfsaufgaben ist noch lange nicht voll ausgeschöpft. Die moderne Luftbildkarte ist nicht mehr nur ein billiger Ersatz für die Strichkarte.

Der Vortrag zeigt Herstellungsmethoden für verschiedene Anwendungszwecke von Luftbildkarten auf.

SITUATION ACTUELLE DE L'ORTHOPHOTOGRAPHIE

Résumé

L'idée de transformer les prises de vues aériennes en photocartes fut divulguée en 1897 par Theodor Scheimpflug. Une demande de brevet fut déposée en 1903 pour sa méthode et l'appareil qu'il mit au point dans ce but. La production et l'utilisation civile des photocartes encore appelées photoplans, débutèrent en 1921. En 1929, le professeur Lacmann développa une méthode de redressement différentiel des prises de vues aériennes. Il fallut attendre encore trente ans avant que les méthodes et les appareils pour la production d'orthophotos devinrent opérationnels.

Aujourd'hui, nous disposons d'une nouvelle génération d'orthoprojecteurs commandés par ordinateur, équipés d'un logiciel flexible, permettant de produire des orthophotos et des photocartes de façon rapide et économique. Les possibilités offertes par les photocartes pour l'inventaire, la surveillance, l'aménagement des ressources terrestres sont loin d'être connues dans toute leur ampleur. La photocarte moderne n'est plus seulement un succédané bon marché des cartes dessinées.

L'exposé présente des méthodes de production de photocartes pour des utilisations variées.

EL ESTADO ACTUAL DE LA ORTOFOTOGRAFIA

Resumen

En 1897, Theodor Scheimpflug publicó por primera vez la idea de transformar fotografías aéreas en fotomapas y en 1903, solicitó una patente por el procedimiento y el correspondiente instrumento que había desarrollado. La producción y el aprovechamiento de los fotoplanos para fines no militares se inició en 1921 y en 1929, el Prof. Lacmann llamó a atención sobre las posibilidades de la rectificación diferencial de fotografías aéreas. Sin embargo, pasaron más de 30 años hasta que los fabricantes del ramo pudieron ofrecer un instrumento idóneo para la producción eficiente de ortofotoplanos.

En la actualidad, disponemos de una nueva generación de ortoproyectores mandados por ordenadores con sus respectivos programas de cálculo que permiten la producción rápida y económica de ortofotoplanos. En cuanto a las múltiples posibilidades que brindan los ortofotoplanos para los fines de inventarios, planificación y proyectado, éstas todavía no han sido aprovechadas en toda su amplitud. Puede afirmarse que el moderno ortofotoplano ya no constituye más un sucedáneo barato para el mapa trazado.

En la conferencia se exponen algunos métodos de producción de ortofotoplanos para varias aplicaciones.

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