DIGITAL PHOTOGRAMMETRIC PRODUCTS FROM AERIAL IMAGES, USED FOR IDENTIFYING AND DELIMITING FLOOD RISK AREAS

Ionescu Ion [a], Badea Dragos [a], Dogaru Margarita [b]

[a] UTCB, University of Civil Engineering Bucharest – Faculty of Geodesy, Bucharest 124 Lacul Tei Bd. , Romania
(ionescu_ion_1946@yahoo.com, badea_dragos@yahoo.com)
[b] National Centre of Geodesy, Cartography Photogrammetry and Remote Sensing, Bucharest 1A Expozitiei Str. , Romania,

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ABSTRACT:

Using the strategy applied by Federal Agency of Emergency Management from USA, geo-referenced photogrammetric products and digital water height data, recorded during floodings, can be used for generating Flood Insurance Rate Map or safety flooding maps. During the process digital images of the orthophotos are used as base maps for overlaying the digital flood data on it. This way, the safety flooding map is a fusion of three elements: a digital ortophoto used as base map, digital water height data applied for hydrological and hydraulical analyses together with the digital flood data obtained as a result from them. In this context, in this paper are presented digital photogrametric products that can be used to identify and delimiting the flooding risk areas. For the beginning, these maps have been realised for Siret basin area. From the natural phaenomenas with strong influences for Romania during past 5 years, we can observe the floodings which have produces major damages, that have significantly afected our economy. Identification, localization and delimiting these areas exposed to natural hazards, a significant element being the flooding, have the role of developing Flood Insurance Rate Map, used for prevention and protection management.

1. INTRODUCTION

Traditional photogrammetric product is the topographic paper printed map which represents the planimetry of the terrain (natural and manmade) and height contours coresponding to map scale. In present time, clasical maps are replaced by digital ones based on specific informations stored in GIS. Although the applications of GIS are many, all of them are practicaly based on the “base layers” of GIS which include digital ortophoto images, digital height contours, points, vectors and polygons which may contain hydrographic, comunications and many other structure and data that can be photogrammetricaly maped.

Using data stored in GIS or derived informations, we can generate other photogrammetric products like planimetric maps, topographic maps or flood insurance rate map. Having that in mind, the paper presents digital terrain models (DTM) and digital: ortophotoplans and topographic maps that started to be generated for Siret river basin.

2. PHOTOGRAMMETRIC PRODUCTS REALIZED FOR IDENTIFICATION AND DELIMITING THE FLOODING RISK AREAS.

2.1. Digital terrain model (DTM)

First photogrammetric product was DTM. In order to generate it, there were used classic images (recorded on film). These images were recorded with RMK Top 15 equiped with forward motion compensation, then transposed in digital form by scanning with DSW 600 using Scan Film software. The images have been radiometricaly corrected with Image Equalizer. DTM was generated using the software module ATE – SOCET. SET.

Automatic Terrain Extraction (ATE) is a very important application from SOCET.SET, because the field data are considered the base of many digital photogrammetric products. Final Products like: ortophotoplans, perspective scenes and image maps, require field data.

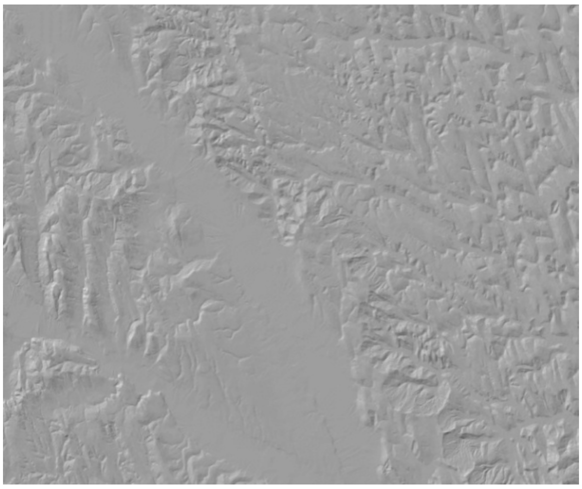

Figure 1. Represent a section from the Digital terrain model of the Siret river basin. (Botosani area)

In ATE are two methods for calculating height levels: adaptive and un-adaptive. Adaptive method uses a deduction mechanism to adaptive generate the strategy of image matching, based on field data, while the un-adaptive method requires strategies specified by operator. (BAE Systems, 2002) In this paper the adaptive method has been applied and all the parameters required by SOCET.SET were used.

2.2. Planimetric maps and topographic maps

A planimetric map shows the plane position of the terrain details, but without having the contour lines or other ways for 3D terrain topography. As it is known, many planimetric maps are generated through aerial images (aerial photograms) using stereo-photogrammetry methods. (Maune D., Huff L., Guenther L., 2001)

An aerial image is a perspective view of the terrain, like it is viewed from above, view which is also called orthogonal image. (Mikhail, M, E., Bethel, S, J., McGlone, C, J., 2001) If the image or the photogram is recorded vertically, for example the camera's optical axe coincide with local vertical axe, the higher planimetric details will have on image a different scale towards the objects situated at a lower height regarding medium Sea level. The size or magnitude of the displacements caused by relief, of recorded details in image, is a function of focal distance of camera's lenses or imaginative camera optics, the height of the terrain detail to be represented and the distance between it and image center. The displacement due to ground relief is corrected through stereo-photogrammetric procedures, which by the nature take in account these variables. More, if the aerial images are not recorded rigorous vertical (very rare situation due to dynamic factors of the airborne platform) they present displacements because of longitudinal and transversal inclinations of the platform in the moment of recording the image. Specific stereo-fotogrammetric procedures are correcting the displacements generated by platform inclinations together the ones generated by ground topography.

The effective result is that the planimetric maps are not in a normal way precision products if we consider horizontal aspects, if in the process of creating the map, the terrain heights are not considered. Exception from this rule are the administrative borders, parcel limits and other features which do not appear on aerial images. (Maune D., Haff L., Guenther L. 2001)

Topografic maps in a normal way are including planimetric details and the ways of height contours lines, ground points with representative or dominant heights levels. (spot heights). These products in appearance aren't indicating that the topographic maps should include DTM converted in contour lines.

All the requirements of topographic mapping can be satisfied through stereo-photogrammetry or in combination with digital height data produced by IFSAR or LIDAR equipments.

Figure 2. Represents a topographic map for the Siret river basin. (Botosani area)

2.3. Otophoto maps

Digital Ortophotomaps do not include the height data itself, but they can't be produced in an efficient manner from the point of view of the costs, without digital heights contained in DTM. At the base of planimetric maps sits the images (aerial images or aerial photograms), which are practically perspective views of the terrain.

When these images are digitized, they are still include the displacements caused by relief and inclinations of the acquisition platform. The aero-triangulation produces the six elements for exterior orientation for each image as we all know, and the digital photogrammetric workstation (PC) can make corrections for inclinations of aerial image acquisition platform, but not for the inclinations caused by terrain topography. By projecting the image over the corresponding DTM of the area, the new image draped over DTM is compensating the displacements caused by terrin topography, and offer an approximative orthogonal projection, which is closer (at least theoretically) to a orthogonal space view. But this is real only for planimetric details situated at ground level from DTM. Tall planimetric details like towers and buildings are still displaced outwards and lateral sides are viewed on image as function of their height and the distance from image center, draped on DTM.

Into a real digital ortophoto, the roofs of the very tall buildings must appear exactly on their foundations, and the lateral corresponding pixels must not appear in image. (Jensen J. 1996). The lateral sides should not appear in image, this would be an orthogonal image. Still the sides of the tall buildings are recorded on images and we are underlining that there are not yet simple solutions for erasing this pixels, which must not be present there. From this reason, many digital ortofoto images are not representing rigorous orthogonal images, equivalents to views of terrain surface recorded from photographic infinite.

Figure 3 a and b. Present the ortophoto for the Siret river basin. (Botosani area)

2.4. Flood Insurance Rate Maps obtained from digital photogrammetric products

From the natural phenomenas with a powerful impact over Romanian territory over past 5 years, the floodings are evidetiated as having produced major damages, which have significantly affected Romanian economy. Identification, localization and extracting the exposed areas to natural hazards, from which flooding represent the major factor, have as a final the elaboration of Flood Insurance Rate Maps which will be used to establish the scientific measures of prevention and protection.

Flood Insurance Rate Maps are practically a product obtained by combining photogrammetric products that we early enumerated. In essence, a Flood Insurance Rate Map contain a planimetric map which is a base layer on which we are overlaying height data corresponding to a reference flood (Base Flood Elevation – BFE). And the borders of the risk area (Special Flood Hazard Area – SFHA) computed from hydrological modeling of the height data for the entire collecting basin and from hydraulic modeling of height data from valleys and flood planes, but which are not including the effective ways of contour lines. (Maune D., Haff L., Guenther L. 2001).

IF the paths of the contour lines are imposed on Flood Insurance Rate Map, which in essence are planimetric maps, like we already have specified, an user will see that the limits of the SFHA are intersecting the contour lines, as the gradient of flooding water is oriented in the same way with flowing direction and according with PC models for standard flooding events (the annual risk is 10%, 2%, 1% or 0.2%, referenced as floodings at 10,50,100 or 500 years).

A river effectively is not flooding at a specified height, but on variable heights reached along it.

For the new Digital Flood Insurance Rate Maps, according to the concept used by Federal Emergency Management Agency) are used digital ortophoto image as base map, on which are overlayed the geo-referenced digital height data of the flooding.

Base map digital ortophoto	+	Digital height data used for hydrological and hydraulical modeling, but also for specific analyses	+	Digital flooding data (BFE) and the Special Flood Hazard Area (SFHA) obtained from hydrological and hydraulical modeling (H&H).

= Digital Flood Insurance Rate Map (DFIRM)

Figure 4. The components of Digital Flood Insurance Rate Map (Maune D., Haff L., Guenther L. 2001)

This concept suggests that a Digital Flood Insurance Rate Map is a result of combining the next photogrammetric products:

1. A digital ortophoto image which have a base map or base layer in GIS, 2. Digital height data used for hydrological and hydraulical modeling (H&H) and also analyses made during this modeling process, 3. BFE and SFHA – Base Flood Elevation and Special Flood Hazard Area which are obtained from hydrological and hydraulical modeling (H&H). Digital Flood Insurance Rate Map (DFIRM) resulted from combination of photogrammetric products can be used for prediction of the areas that can have the chance of being flooded of 1% or greater, during one specified year.

A problem which is obvious for Digital Flood Insurance Rate Map is that the product must be always updated because the terrain is changing in time, like deforestation and land covering with pavement.

Together with introduction of technology of the DTM, the hydrological modeling are realized on different DTM's classes, which can be obtained more rapidly, more efficient, and with the level of precision as requested.

3. CONCLUSIONS

Digital model of the terrain represent a major operation in the frame of diverse applications of the geospatial informations. Digital terrain models, especial those referring to digital relief modeling, used for a wide variety of applications like: ortophotoplans and ortophotomaps, identifying and delimiting flood risk areas, 3D city modeling, different categories of flight for aerial and spatial vehicles, training in a virtual fight theatre, and many others, the number of virtual applications being unlimited. Recently, Digital Earth, (DE) have explored and implemented in a informational work-frame about Earth, facilitating users to interact, research, and simulations on the virtual face of the planet. As a conclusion, the Digital Terrain Models will become critically permissive for diverse applications for Digital Earth. (DE).

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