

1:25.000 SCALED PHOTOGRAMMETRIC MAP PRODUCTION SYSTEM

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ABSTRACT:

By applying the latest developments occurring in photogrammetry to the map production systems, important reductions in map production costs are obtained. For instance, by starting to use digital cameras and GPS/IMU systems in taking aerial photographs and in aerial triangulation, there is an opportunity of reducing the number of ground control points that must be established due to map production, film costs, photo-laboratory costs and the scanning costs which are done at sensitive scanners. Whichever way the development of the map production procedure is aimed, by integrating the new scientific and technological developments in photogrammetry, especially in automatic feature extraction, into map production systems, the photogrammetric feature extraction process duration, which is one of the biggest components of map production cost, will be reduced. The operator effect will be lower and finally the costs will be reduced. In this paper, firstly, the photogrammetric feature extraction steps used in the present 1:25.000 scaled map production process in General Command of Mapping are examined and the production duration and costs are investigated. In the current production system, feature extraction is done by the operators from stereo models which were created by using aerial photographs. Extracted features are examined by the operators again for the cartographic and topologic rules and then the corrections required are done. Thus the photogrammetric production is completed. Secondly, a new alternative system is introduced to reduce the production duration, operator effect and the costs. In the alternative system, a DEM (Digital Elevation Model) is produced from the 1:25.000 scaled DECM (Digital Elevation Contour Map) of that map. These DEMs are edited on the 3D models and the corrections are made, streams are extracted and added into the DEM as breaklines. By using these DEMs, ortho-images with 1 m spatial resolution are produced from the aerial photographs. Also, the contours of the map are generated automatically with 10 m interval by using the same DEMs and these contours are edited on stereo models and thus auxiliary contours are added. By using the semi-automatic data extraction software, firstly, features that can be extracted from the ortho-images (roads, lakes, etc.) are extracted. Remaining point features and the line features that cannot be extracted automatically (small paths, fences, etc.) are extracted manually by the operators. Finally all data extracted automatically, semi-automatically and manually are combined and checked and the photogrammetric production steps are completed. In the latter part of this paper, the problems faced and the subsequent solutions, while applying the new alternative system, are introduced. Finally, both systems are compared to each other according to the accuracy, production duration and cost.

1. INTRODUCTION

In recent years, technology has become cheaper and more widespread and developed, and this has made it possible in photogrammetry to reduce the map production costs. Using digital cameras and GPS/IMU systems in taking aerial photographs and in aerial triangulation, there is an opportunity of reducing the number of ground control points that must be established due to map production, film costs, photo-laboratory costs and the scanning costs which are done at sensitive scanners.

On the other hand, photogrammetric feature extraction is one of the biggest components of the map production process in the sense of time spent and costs. Minimizing this step and the operator effects in map the production process affects the costs directly in a positive way. That is why it is essential to integrate automatic feature extraction developments into the map production systems.

In the second part of this study, the methodology and photogrammetric feature extraction steps applied in present 1:25.000 scaled map production process in General Command of Mapping are investigated and the time spent and costs are scrutinized.

In the third part of the study, a new alternative system is proposed to reduce the production duration, operator effect and

the costs. By introducing the alternative system, it is aimed to integrate a semi-automatic feature extraction software to the map production process. In the final part of the study, the problems faced when using the alternative system, and the reasons for them, are taken up. Both systems are compared to each other regarding the production duration and costs.

2. PRESENT WORKFLOW OF 1:25.000 SCALE PHOTOGRAMMETRIC MAP PRODUCTION

In the present work of 1:25.000 scaled photogrammetric map productions (revision of old maps), 1:35.000 scaled black and white aerial photographs are used in General Command of Mapping. The aerial photographs are digitized by scanning in the precision of 20-21 microns. Aerial triangulation is carried out by kinematic GPS and outer orientation parameters of each photograph are determined by bundle block adjustment.

In the present work, all topographic features except contour lines are extracted by the operators three dimensionally from the stereo models which are created by using the outer orientation parameters of each photograph.

Contour lines are imported from the DECM that is created for the whole country once, and verified by overlapping on the stereo models. The contour lines which are different and incorrect according to the stereo model are corrected by editing or deleting and reprocessing. Photogrammetric production is

completed after applying cartographic and topologic correction and control on the processed data by the operators.

The workflow of feature extraction and the time spent in workflow steps for any of the 1:25.000 scaled maps with the mean difficulty level in the sense of production are depicted in Table 1.

Feature Extraction Steps	Duration (hour)
Creating stereo models (approximately 9 pieces)	1
Feature extraction	88
Control and correction of DECM data	16
Controlling the extracted and edited data on the stereo models	4
Format conversion	1
Cartographic and topologic editing of extracted data	40
Total	150

Table 1: The workflow and time spent table for photogrammetric feature extraction and data editing procedures in the 1:25.000 scaled map production.

As it is seen from Table 1, the revision of a 1:25.000 scaled map lasts for approximately 19 days. This period doesn't include the field study after the feature extraction and the cartographic works. It can easily be deduced that this process is quite expensive for any organization producing maps. The 1:25.000 scaled map, produced after the workflow given in Table 1 in the present production system is given in Figure 1.

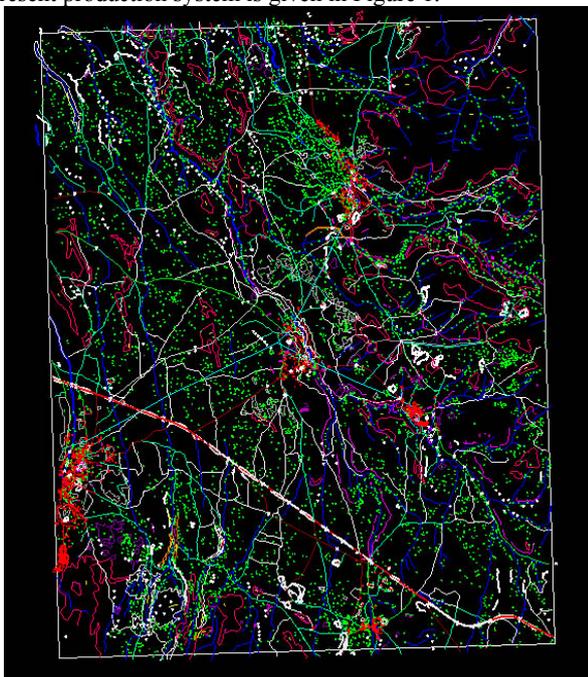


Figure 1: The 1:25.000 scaled map produced in the present production system.

3. A NEW 1:25.000 SCALED PHOTOGRAMMETRIC MAP PRODUCTION SYSTEM

In this study, for the aim of reducing the production duration, operator interaction and costs, a new production system will be introduced as an alternative for the current photogrammetric feature extraction system.

In this proposed system, it is aimed primarily to extract features (roads, lakes etc.) that can be extracted semi-automatically from orthophoto images via semi-automatic data collection software developed and completion by operator of missing point features and line features (narrow tracks, hedges etc.) that can not be extracted automatically.

To achieve this aim, DEM was generated from 1:25.000 scaled DECM of the same map and this DEM data was modified by editing on the stereo models generated from exterior orientation parameters determined from bundle block adjustment and dry/wet streams were added to DEM after feature extraction as breaklines. By using DEM data, orthophoto images with a resolution of 1m. were generated from aerial photographs which cover the map sheet. Besides, contour lines at 10 m. intervals were generated automatically from the same elevation data and auxiliary contour lines were added via editing on stereo models.

Photogrammetric production process of a 1:25.000 scaled map is planned to be completed after combining all data extracted automatically, semi-automatically and manually, then checking the data by means of topology and cartography and making necessary corrections interacted with operator and software. Photogrammetric processes and time spent for updating 1:25.000 scaled map sheet via production/update system that is suggested as alternative are shown at Table 2.

Feature Extraction Steps	Duration (hour)
Creating stereo models (approximately 9 pieces)	1
Making DTM from DECM, Control of the DTM data on stereo models and addition of the vertex lines.	8
Orthophoto image and making mosaic	4
Vector data generation with semi-automatic data generation software which build on mosaic.	60
Control of the generated data and completion of missing data.	4
Generating contours from DTM automatically, controlling contours on stereo models, completion of missing data and correction of errors.	8
Controlling the extracted and edited features on stereo models.	4
Format Conversions	1
Cartographic and topologic edits of generated data.	24
Total	114

Table 2. Photogrammetric generation and data edit processes of a 1:25.000 scaled map revision and process times in available workflow.

As seen on table2, revision of a 1:25.000 scaled map with suggested revision system takes approximately 14 work days (excluding topographic and cartographic works).

1:25.000 scaled map produced with suggested production system and the process steps listed on Table 2 is shown in Figure 2.

Summary information about semi-automatic data generation software which is used in suggested map production method is presented below.

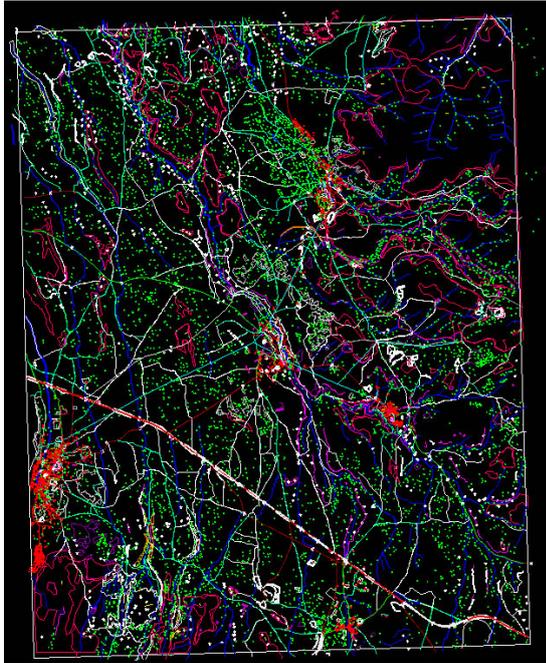


Figure 2. 1:25.000 scaled map produced with suggested workflow.

3.1 Semi-Automatic Feature Extraction Software

The semi-automatic feature extraction software thus developed is based on level-set and image segmentation algorithms. There are three problems during the design process. The first problem is to start the algorithm. This is solved by pointing to any pixel on the feature that will be drawn by the operator. Thus, the level cluster algorithm can start from the point that operator selects. This solution makes the approach semi-automatic.

The second problem is to decide the criteria for drawing process will continue from pointed node or not. It is solved by using the color values of pixels which constitute the raster image. The color value of the pointed node or the mean color value of neighboring pixels, according to a defined neighborhood degree, are compared and the algorithm is continued if the value difference is smaller than tolerance value or stopped if the value is bigger than the tolerance value. In other words, segmentation is carried out according to the color differences of pixels. After determining the feature and completing the pointing works the feature must be obtained as vector data and so transformation from raster to vector data is effected.

The semi-automatic feature extraction program that solves three problems mentioned below consists of 5 main stages. These stages are:

- Selection of the point or pixel of a feature that will be extracted by the operator,
- Making the image segmentation of a selected pixel by using the color differences with the neighboring pixels,
- Propagation of segmentation and storing in heap sort format by using level-set method
- To get 1 bit (black or white) raster mask data from those pixels.

Automatic extraction of features in a known vector format by using raster to vector conversion tool on the raster mask data. The first four steps were implemented by coding in the Borland C++ programming language without using any libraries except for system libraries. The fifth step was implemented by using an

open source code which was found on internet. The code was revised in Visual C++ language. Effectively, the entry of vertex tolerances and corner coordinates became possible. (Eker, 2006).

3.2 Image segmentation algorithm

Image segmentation depends on the color differences between pixels. A tolerance value is entered to increase flexibility by the operator. Therefore, by increasing the tolerance value in high-contrast-images, the operator will have the capability of digitizing large area by in one operation. The initial value for the segmentation algorithm is determined as 2 multiplied by the width multiplied by the height of the image.

Segmentation starts by marking first point of the feature. The mean value of that pixel and neighbouring pixels according to neighbouring level is determined as the reference color value. If the neighbouring level is 0, the value of pixel; if the neighbouring level is 1, the mean of the pixel and neighbouring 8 pixels' values is determined as beginning value (Eker, 2006). When calculating differences between the color value of reference points and neighboring pixels, color differences in three bands (red, blue and green) are calculated separately and examined if they are lower than the threshold value.

3.3 Propagation by level group and storage

The starting value needed for propagation by the level-set algorithm or for moving ahead through a feature is met by the semi-automatic nature of the developed algorithm. Propagation of the surface will begin from the pixel that is marked by the operator and the zero level-set function is defined by the location of this pixel.

The other component needed for level-set function is the threshold value which controls the propagation. The solution for threshold values is realized by calculation of color differences that is mentioned above.

After starting the propagation a solution for the problem of the direction in which it will continue through the pixels satisfying the threshold values, remains. A high speed algorithm is beneficial in solving this problem. The functioning can go on propagating from the pixel which has the smallest value (Sethian,1998). But what will the smallest value describe?

In the developed algorithm, for the question of what the smallest value would represent, the first pixel marked by the operator is accepted as a zero level group function and every neighboring pixel (the first pixels in west, east, north and south direction) is checked by the color difference algorithm described above and for the pixels that meet the condition, the distances from the zero level group (first marked pixel) are calculated and in this way the continuation of propagation through pixels with the shortest distance of separation is provided.

For the completion of the propagation, updates have to be done (Sethian,1998). In an update procedure algorithms for the calculation of distance squaring are used (Sethian,1998)

Minimum mass structure (heap sort) is used for storage and communication of marked pixels. In minimum mass structure the smallest image cell is on the top. Some functions are needed to protect the heap sort: Adding the image cell to the heap, making the image cell stable in the heap, taking out the image

cell which has the minimum distance and updating the heap for every image cell addition or extraction.

It is purposed by this storage structure to do the following big volume processes; reaching the image cells, testing and calculating the spread, marking image cells and storing the marked image cells.

3.4 Conversion from raster to vector

The algorithms of conversion from raster to vector are valid for the 1 bit image files which contain two types of data (0 or 1) (ESRI 1997). So that, in developed software, an image string is made that the marked pixels are full, the others are empty after completing the processes; selecting and marking the image cells. Making this image string is a masking process. This mask raster image is afterwards recorded as 1-bit (1 color) raster in BMP format. Visual C++ code (URL 1) which is available on internet for conversion from mask raster image to vector data is restored and new opportunities are added. Centers lines and border lines of the details converted to vectors one by one from raster data with a functional interface by establishing a connection with main program and a coordinated vector data is made by entering the left-bottom corner coordinates and both dimension (x,y) image resolutions in main program. Additionally the opportunity of making the vector data to the required smoothness by entering the tolerance is supplied in the functional interface. Density of the vertex points, of the vector data which are made by conversion from raster to vector by entering the smoothness tolerance, is adjustable (Eker, 2006). If the break point tolerance is chosen to be zero, all pixels are included to calculate without any smoothing. In case of the incidence of an increasing breakpoint tolerance, pixels with increasing intervals are taken into account instead of all pixels and the final vector is smoother. But over-increasing the tolerance level may cause failure on the accuracy (Eker, 2006)

4. CONCLUSIONS

In comparing both production systems, the recommended one provides approximately 5 working days in saved time. From the production duration point of view, this gain can not be neglected.

While making feature extraction in orthophoto images and using the recommended production system, extraction of some features can be difficult, especially for some line features and those defined by their height values (electrical lines, towers, minarets etc.) which cannot be evaluated at first glance. Also, some features like dry streams become hard to be observed. Therefore, those features that are extracted on orthophoto images and have their height values from DEM, should absolutely be checked and completed by overlapping on stereo models. In addition to this, height errors must be corrected. As an example, information about the numbers of the point features which are evaluated just only from orthophoto image is given in Table 3.

Feature	Stereo	Mono	Ratio
Building	1142	986	%86
Tree	4796	2571	%53
Bush	336	32	%10
Sheep-fold	23	18	%78
Stone	342	222	%64
Spring	5	1	%20
Culvert	100	60	%60

Fountain	5	2	%40
Water Reservoir	6	3	%50
Industrial Building	10	10	%100
Mosque	6	4	%66
Governmental Building	8	3	%38
School	9	1	%11
Lean-to roof	3	3	%100
Antenna	3	2	%66

Table 3: Differences which resulted from the extraction of point features using both stereo and mono images.

In this study; the accuracy of the features which were digitized by using the suggested map production system, was investigated. For this purpose, 35 common Ground Control Points (GCPs) were selected in both maps, which were produced by using the existing and the suggested systems. The coordinates of the GCPs were measured in both maps and the RMS errors were calculated. At the calculation, the coordinates derived from the map of the existing production were accepted as reference.

In planimetric coordinates, ± 1 meter accuracy was achieved while the vertical accuracy was determined as ± 3 meters. The results of the accuracy assessment are good enough for 1/25.000 scaled topographic maps but it should be taken into consideration that these results are reliable only for this test map area or for similar topographies. So as to have more conclusive results, it would better to apply similar studies for the areas that have different topographic characteristics.

Finally, it is believed that the software can be more useful for semi-automatic feature extraction if the deficiencies listed below are eliminated

Incorrect feature extraction might occur if the appropriate tolerance limits are not introduced to the software.

When the images with the very big sizes are used, software errors may happen because of the requirement of much memory. The quality of images significantly affects the performance of contrast and noise algorithms.

Surface and pattern characteristics of the line features also effect the algorithm conclusion.

If this software is used in the production flow then advanced filters like anisotropic diffusion and edge enhancement algorithms should be integrated. Also integrated should be different interpolation methods to fill the gaps that occur because of the obstacles. Availability of image pyramid methods should also be investigated to have better results.

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