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Digitization of Old Maps Using Deskan Express 5.0

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Summary: The Faculty of Geodesy, University of Zagreb purchased Deskan Express 5.0 at the end of 2002. It is a large format (A0+) flatbed scanner produced by the Australian company Shapemakers. It is unique for its scanning technology and price in range of large format scanners. The scanner's construction makes it a good choice for scanning sensitive materials because the template does not move during scanning. Therefore, it can be used to scan old maps. Another important advantage is portability; its weight is less than 20 kg and a flat surface of 1×1.5 m is needed for installation. Institutions keeping old maps prefer scanning in their premises. The scanner has been used to scan approximately 300 old maps in various institutions in Croatia. The main purpose of scanning was to prepare map exhibitions which included map reproductions rather than originals. Exhibition preparation expenses were thus reduced. On the other hand, digitized old maps are to be researched in the future with all advantages of digital media. Quality of the final raster image obtained using original software was improved with a personal solution. For that purpose, new calibration software and stitching procedure were applied. It is possible to scan maps larger than A0, which was sometimes necessary. Although the scanner is not in range of professional equipment, it is good for making reproductions and reading raster images.

1. Introduction

The Faculty of Geodesy of the University of Zagreb purchased the DeSKan Express Color 5.0. scanner in 2002. It is the product of the Australian firm Shapemakers (former Abakos Digital Images). The largest format the scanner is capable to scan is A0. Scanning is based on moving the scanner head over a map. Scanning results in strips (max 7) which are subsequently connected using software. The scanner is successfully applied for scanning various topographic, tourist, and especially old maps. Nevertheless, some problems were detected during its application.

There used to be a small number of firms or institutions in Croatia which provided high quality large format scanning, the price of which was high. The Faculty of Geodesy made a contract to produce a digital catalogue of trigonometric points for military purposes which had to be based on the topographical map at the scale 1:50 000 (150 sheets for the territory of Croatia). This map did not exist in suitable digital form at the time. The DeSKan Express Color 5.0 scanner was purchased to accomplish the task and have the possibility of additional map scanning on demand in the future.

2. DeSKan Express 5.0

The scanner in working environment is shown in Fig 1. The scanner is portable and a flat surface of the size A0 or more (table or floor) is the minimum requirement for proper installation and use. The installation process is simple and takes only few minutes.

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Figure 1: DeSKan Express 5.0 in working environment

DeSKan is a flatbed scanner, which means the template, e.g. a map, is fixed, it does not move through any transportation mechanism, and the possibility of damage is minimized. The scanning head moves over the template and that property is of special importance for old and sensitive materials. In addition, the template does not have to be as thin as a paper, its thickness can be up to 1 cm.

DeSKan's main part is the HS600 scanner (made by Japanese firm Omron) with an automatic document feeder (ADF) of the A4 size and the capacity of 25 sheets. When the scanner is mounted on ADF, documents are rolled through the device like with office printers. When detached from the ADF, it can move along any flat surface using its rubber wheels (Fig. 2).

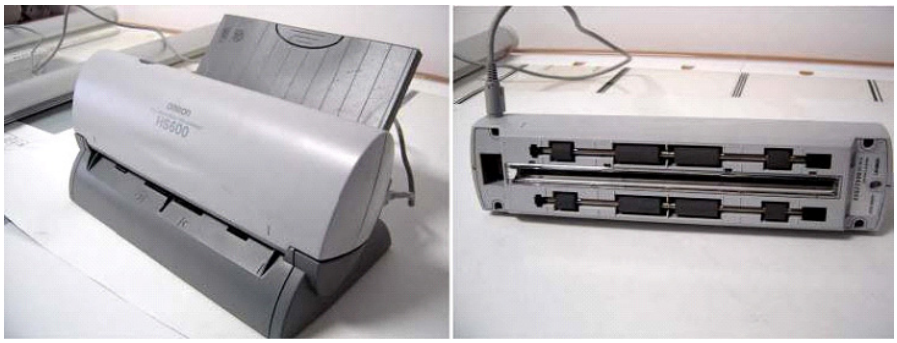

Figure 2: HS600 scanner on the ADF base (left) and rubber wheels used for movement over surface (right)

DeSKan comes with a special base for scanning large formats. The base consists of a Plexiglas plate (three pieces for easier transportation) on which the map is placed. The glass plate is placed over the map, and the scanning head is mounted on the plate. Both plates have special engraved marks used for connecting and geometrical correction of the scan. Width of one strip is around 20 cm and multiple strips are required for scanning wide documents. The glass plate should be moved across the Plexiglas plate manually, and special fittings and rollers are provided for that purpose.

HS600 is a self-motorized scanner with a linear CCD sensor with physical resolution of 600 dpi and 30-bit color depth. It is connected to the PC using a parallel port. The standard TWAIN interface can be used for scanning as with any other TWAIN compliant scanner. The problem is the

TWAIN interface was written only for operational systems Windows 95/98/ME. Manufacturer‘s support is discontinued and there is no interface for modern Windows or Unix/Linux operating systems. Detailed specifications for writing a user driver have never been published.
The software which comes with the scanner makes the whole process of large format scanning very simple, and it is easy to learn how to use it.

3. Improvement of DeSKan Express 5.0

During the scanner application, some problems were found for which we thought solutions could be found. Tutić (2004) researched the scanner’s properties and proposed new calibration procedures. Problem overviews, their solution and results follow.
The first problem concerning DeSKan is working operating systems: only Windows 95/98/ME. This problem could not be solved in (Tutić 2004) because there were no specifications for writing the user driver. The only procedure that could be used for that purpose is the one used on the SANE[1] project (the project for Linux scanner drivers). This involves reverse engineering, which does not guarantee success. The next problem is use of the parallel port for connection which negatively affects the scanning speed. Both problems were solved by Omron in the newer version of HS600 named HS600U. HS600U is the same as HS600, and it is connected to the USB via a special adapter. It comes with new drivers, which work on Windows 2000/XP. The Faculty of Geodesy purchased a used HS600U scanner at the end of 2009. Scanning speed was increased by only 40%. According to specifications, the scanning speed is supposed to be several times greater. The cause of this difference is presently unknown.
The second problem was the existence of vertical (perpendicular to sensor) colored lines. The user’s guide recommends repeating the calibration process, but the lines would exist even after such a calibration. The scanner comes with a calibration template with constant tone value over the whole sensor width and it is used to even the response of each CCD element. Vertical lines were assumed to be caused by the calibration process or dust in optics. After writing the new calibration program, the problem was eliminated (Fig 3.).

Figure 3: Colored vertical lines in scan (up), the result of calibration using original program with visible vertical lines (middle) and with a personal calibration program (down)

[1] SANE – Scanner Access Now Easy [http://www.sane-project.org]

In addition to the calibration template which comes with HS600, we used an additional template with 21 known gray values. Additional calibration was thus performed. Nevertheless, it was found that use of an additional color calibration template could improve the results further, especially the lighter part of the spectrum (Fig. 4). In Fig. 4., the black line represents the ideal response to the linear gray scale, and the red, green and blue curves show the results after calibration using second order transformation. It can be seen the largest differences are in 0-50% of the black. More complex transformation should be used to obtain better results along with a calibration template with more known color values.

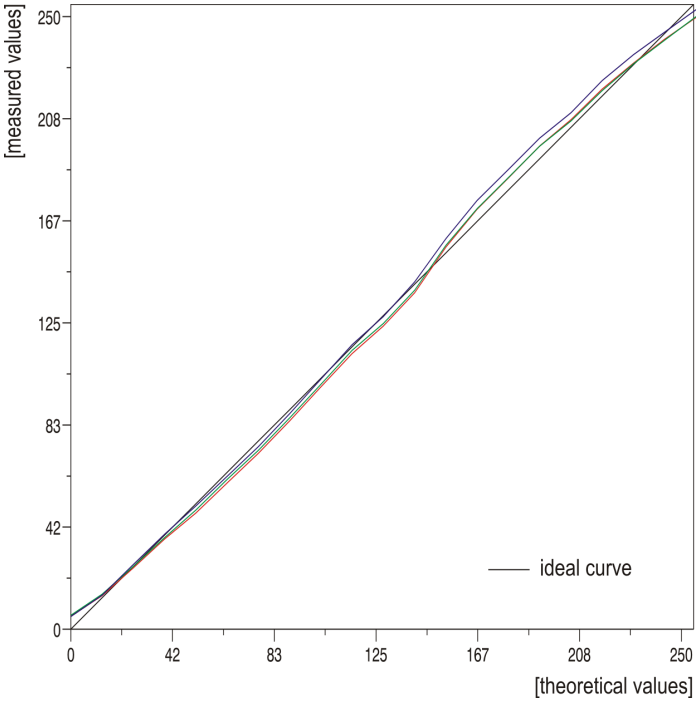

Figure 4: Response of the red, green and blue channel to the gray scale after calibration

The new calibration also takes into account the chromatic aberration correction. The chromatic aberration is visible as a positional shift between red, green and blue channel. In Fig. 5., the effect of chromatic aberration on the edges with high contrast is visible (upper part). Calibration results are shown in the lower part of Fig. 5. The chromatic aberration was modeled as a constant shift along the sensor's moving axis, and the linear model was used in the sensor's direction. A special calibration template consisting of horizontal and vertical black lines on white paper was made for measuring the chromatic aberration.

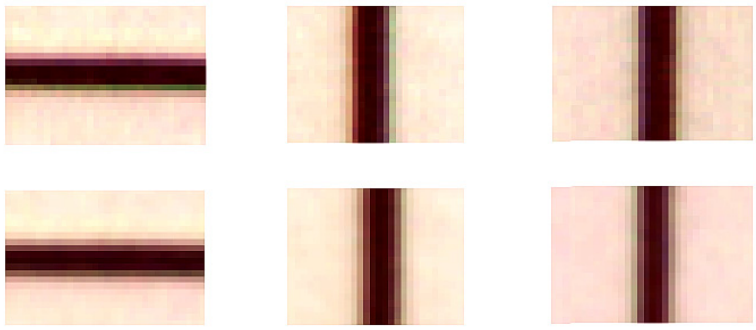

Figure 5: The effect of the chromatic aberration on edges with high contrast (up) and the result after calibration (down)

The last problem related to scan quality is the quality of connections and artifacts of raster resampling during geometrical transformations (Fig. 6)

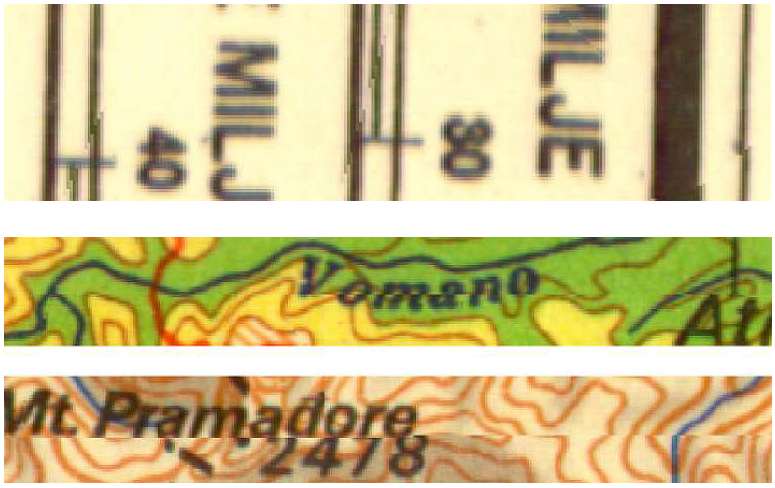

Figure 6: Stair effect in raster (up) and low quality of connections (middle and down) after scanning

The new scanning software uses bilinear geometrical transformation for geometrical correction and bicubic resampling which ensure that no artifacts are visible in the corrected raster. Bicubic resampling is used several times during calibration; therefore some blurring is evident and the sharpening filter needs to be applied. It was proven that extra sharpening yields even better results for plotting purposes.

Connecting strips is not automated in the new software. It is done manually in a standard raster editing program. Therefore, post processing time is increased. The advantage is that visual inspection of the connections is performed during the connecting process. The transition on the connections is smooth and avoids visual detection of connections. Connections with and without smooth transition effect are shown on Fig. 7. The problem with connections occurs when the template is not flat enough and even the glass plate is unable to flatten it.

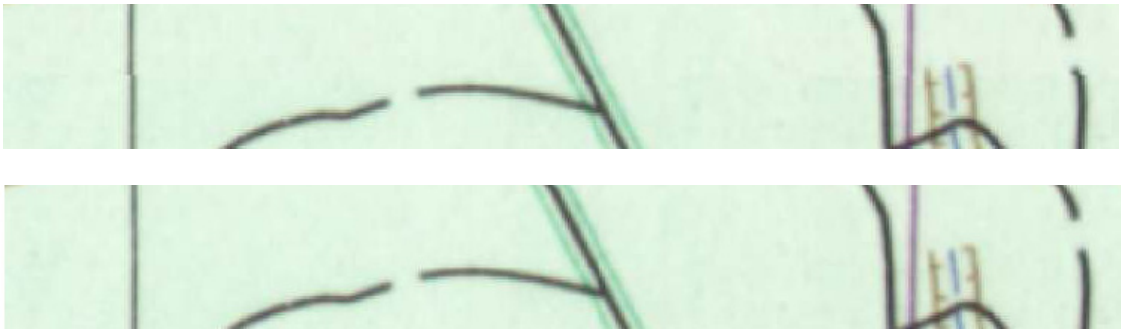

Figure 7: Quality of connections with the new geometric correction (up) with additional smooth transition effect (down)

Even with the original software, artifacts in the raster are only visible when magnified on the computer monitor. When rasters are plotted, the problems mentioned are less prominent. Using the new software, even zooming reveals no substantial scanning errors or deformations of any kind.

In addition to the described problems which were solved, other scanner's properties were determined. Geometrical accuracy was measured, both software have an accuracy of 0.1 mm at the

resolution of 300 dpi, which is satisfactory. The influence of external light on radiometric values was measured and it was concluded that the scanner in not sensitive to external light. Whether scanning is performed in complete dark or under asymmetrical external light (only part of the template is under powerful light), results are not significantly different.

4. Use of DeSKan Express 5.0

DeSKan Express 5.0 was used to scan maps for:

- The digital catalogue of trigonometric points (150 sheets of the topographic map at the scale 1:50 000) (2002)
- The book Five Centuries of the Geographical Maps and Charts of Croatia (2002)
- The exhibition Cartography of Zadar (2003)
- The exhibition Cartography of European Cities (2003)
- The exhibition Cartography of Lika (2004)
- The exhibition Maritime Cartography (2007)
- The exhibition Cartography of Varaždin (2009)

Most of the scanning of old maps was performed in the premises of the institutions keeping them. It was necessary because the institutions would not let the maps be used externally. Because of the easy portability of the scanner, it was not a problem. A total of several hundreds of old maps have been scanned so far. In addition, the scanner was used to scan maps used in students' works, articles, conferences, etc.

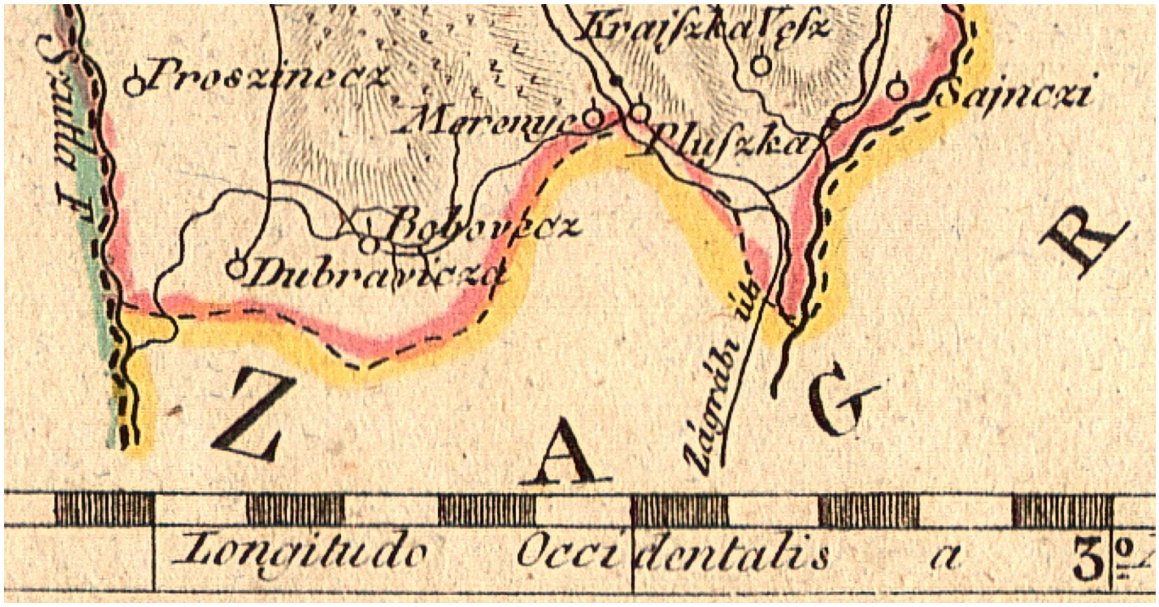

Figure 8: Enlarged part of the scanned map using personal software.

The personal software and procedure were used for calibration and connecting (described in §3) the scans for the latest exhibition, Cartography of Varaždin. The results were far better than those obtained using original software. Scans obtained using this new method are suitable not only for reproduction, but also for examining on a monitor, using zoom. The raster does not have substantial visible effects resulting from the scanning process.

The scanning resolution of 300 dpi is satisfactory for most purposes, but sometimes graphics of old maps is so detailed that even better resolution could be recommended. An enlarged part of the map obtained using personal software is shown in Fig. 8.

5. Future considerations

Most of the problems concerning quality were solved using the new calibration software. Further improvements are possible in the color calibration process and in full automation of the connecting process. Problems which have not been solved yet: it is not possible to control scanner movement via user program but only via the TWAIN interface, and scanning speed is still rather low.
Low scanning speed does not affect scan quality, but it limits the use of DeSKan to minor projects. Presently, approximately 1 hour is needed for sensor to move over the A0 size template, and almost as much is needed for full post processing (including calibration, connecting, cropping and further refinement of scans). The authors are going to try to find a solution, but success is not guaranteed in advance since the communication protocol between the scanner and the computer is not known.
According to the state of digitization of old maps in Croatia and activities of the Faculty of Geodesy and Croatian Cartographic Society, the scanner is going to be used in the future for purposes of publications and map exhibitions. Even though DeSKan is not a high quality professional device, the results for various purposes are satisfactory. This is especially true for the scans obtained by personal scanning process used for the latest map exhibition, Cartography of Varaždin.

References

Tutić, D. (2004): The improvement of the software for DeSKan Express 5.0. Masters thesis. Faculty of Geodesy of the University of Zagreb.