MAP REVISION USING DIGITAL ORTHOPHOTOS

C. Armenakis and A. M. Regan

Canada Centre for Topographic Information / Centre canadien d'information topographique
Geomatics Canada / Géomatique Canada
615 Booth St. / 615 rue Booth, Ottawa, Ontario, K1A 0E9
tel.: (613) 992-4487, fax.: (613) 947-7948
e-mail: costas.armenakis/anna.regan@geocan.nrcan.gc.ca

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ABSTRACT

As a number of topographic organizations is in the process of completing their spatial databases, most of their current efforts are directed towards maintaining their databases and maps up to date through an extensive revision program. This paper presents the results of the development and implementation of a concept for map revision of the 1:50 000 National Topographic Series maps using digital orthophotos, and refers to some potential methodologies to support change detection from multi-temporal orthoimages.

1. INTRODUCTION

The National Topographic Series (NTS) of maps serve as the fundamental framework for a number of applications from resource development, environmental protection and conservation to transportation, communications, search and rescue operations and sovereignty. Maps have been produced using conventional and digital methods and most of the current efforts are directed at maintaining the existing databases and maps up to date through an extensive revision program. There is a constant effort to improve the process and minimized the time to update the topographic database and to produce maps which satisfy the increasing demand for current and accurate geo-related information.

This paper presents the results of the development and implementation of a concept for map revision of the 1:50 000 National Topographic Series maps using digital orthophotos, and refers to some potential methodologies for automating change detection.

2. METHODOLOGY

Usually, a topographic database represents the "previous/old" state of the geographical domain, while recent air photography represents the "current/new" state. To identify the differences between the two data sets, one has to compare the contents of the two different databases. The use of homogeneous data from both sources will facilitate the comparison operations. This homogeneity refers to similar-type of data reduced to a common reference. One way to perform this comparison is by viewing both data sets simultaneously. This is accomplished with the superimposition of the existing "old" digital vector data over digital "new" aerial orthophotography. The digital orthophotos provide for an accurate orthographic reference (geometrically equivalent to a line map) for the images of the features. The integration of vector and raster data allows the operator to view the map vector data as an overlay on the image and thus, to detect visually patterns of non-matching elements between the two data sets.

The updating operations of existing "old" vector data from "new" orthoimages require the following steps:

- change detection
- photo-interpretation (feature classification)
- collection of new data (feature extraction)
- integration of old and new data for populating the database
- map production.

The digital orthophotos are used as a raster backdrop for the vector data to be updated. The updating of the database is performed by interactively extracting the new planimetric features from the image in a monoscopic mode using heads-up digitizing. The digitizing from the screen can be done on cheaper non-stereo workstations in a distributed, networked processing environment. The steps of the revision process are illustrated in Figure 1.

3. SYSTEM REQUIREMENTS

To meet the production requirements of this methodology for revising "old" vector data, the systems used must offer certain functionality, such as: generation of digital images by scanning diapositives of aerial photographs, production of digital orthophotos and mosaics from existing DEM or by generating the DEM from the newly digitized photographs using stereo-image matching techniques, image processing functions, integration of vector and raster data capabilities, digital mapping functions, topology creation and cartographic editing. These capabilities are found in the softcopy (digital) photogrammetric workstations and in vector-raster GIS systems.

4. IMPLEMENTATION

A pilot project was carried out in order to prototype the implementation of the proposed methodology and its integration with the available in-house systems. This project involved the production of mosaicked orthophotos covering the Jasper 1:50 000 NTS map. The area covered by the JASPER, Alberta/British Columbia map is 32X26sq.km.

4.1 Orthoimage generation

The task of generating the digital orthophotomosaics involved the scanning of 25 aerial photos flown at a scale of 1:60 000. The photographs were digitized at resolution of 1000dpi (1.5m at ground) and quantized at 256 gray levels (8-bit images) using the Helava/Leica DSW100 scanning workstation.

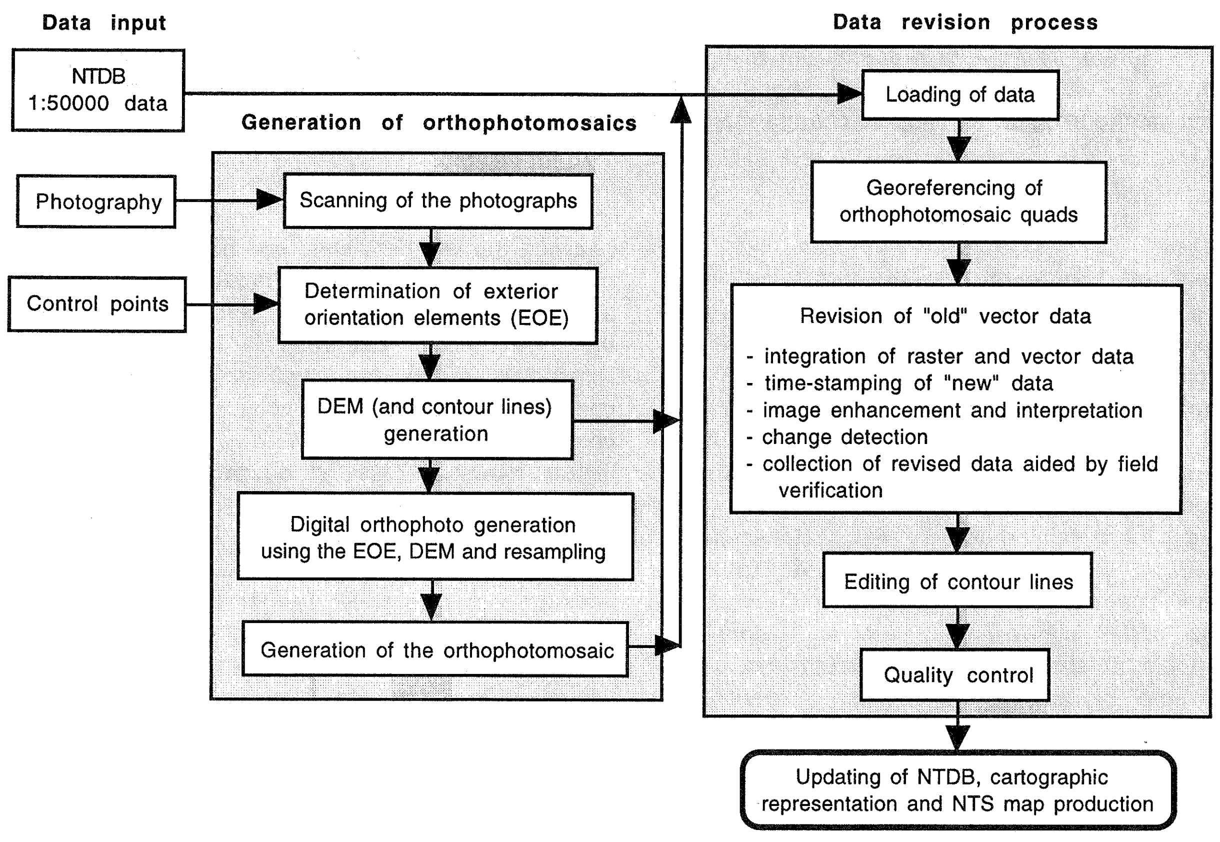

Figure 1: Database and map revision process

The Helava/Leica DPW770 digital photogrammetric workstation was used for the DEM and orthoimage generation. The exterior orientation parameters were determined using the available control points from the Aerial Survey Database (ASDB). The control points were transferred and cross pugged to current photography from previous photography. The DEM generated on a 50m grid which resulted in 332 800 elevation posts with an estimated RMS of 1.5m. Contours were generated as well, and 3D contour inspection was performed by draping the contours on the stereo-model for stereo-interactive contour editing.

The orthoimage was produced pixel by pixel using the collinearity equations and the gray values are assigned using the nearest neighbour interpolation resampling technique. The output ground pixel size was set to be at 2m, which was determined as the average value between the scanning and the human eye resolution of 10lp/mm (Armenakis et al., 1995).

To cover the entire map data set in a seamless way, the individual orthophotos were mosaicked and radiometrically corrected. Due to the large size of the mosaicked raster file (208Mb) the sheet was divided into four orthoquads with each quad being a more manageable 52Mb. The orthoquads were exported along with geolocation data to the CARIS GIS system where they were used as raster backdrops for the revision process.

4.2 Data revision

The revision of the 1:50 000 NTDB (National Topographic DataBase) vector data based on the digital orthophotomosaics was done using the CARIS GIS. The metric accuracy of the registered orthophotomosaics was evaluated by measuring the coordinates of check points from the orthophotomosaic and comparing them with given values. For the four quads used for the revision of the Jasper data, the standard deviation of the coordinate differences were from ±1.17 to ±1.67m in x and from ±1.50 to ±2.69m in y, sufficient to meet the NATO A rating planimetric accuracy requirement for the 1:50 000 maps.

The criteria for collecting new data or revising existing features were based on the following factors:

- the amount and type of change detected
- the accuracy of the existing feature
- the topology
- the feature morphology, and
- the significance of the feature.

The orthophotomosaic quads were displayed one at a time and the CARIS file manager utility was used to integrate the raster and vector data to facilitate the use of superimposition for the collection of the new data. A tile approach was used for the revision process, where the operator steps through the data set in small virtual map tiles, revising all the features before moving to the next tile. The task of visual change detection was aided by relying on photo-prints from the field verification for classification of roads, noted additions, deletions and changes to features. The zoom in/out capabilities were applied for data collection. Image interpretation was improved/assisted by employing interactive contrast enhancement using either histogram equalization or user specified histogram. During revision the selective display of features was applied for best results. In conjunction with the display on screen, the operator used a stereoscope and the aerial photographs with field information to view the area's relief, identify features such as watercourse, permanent snow and ice (glaciers) and collect them with greater ease. Figure 2 shows the "old" and the revised "new" vector data of the Athabasca River features.

The data set for Jasper map sheet was vectorized cartographic data and required a slightly different approach for revision than a positional data set. When revising a positional data set, the exact positional data would be collected. In the case of the revision of a cartographic data set, features that were not positionally correct due to cartographic displacement are not re-positioned. Repositioning these features would only result in additional work at the cartographic editing stage, although it may be considered to improve the accuracy of the NTDB vectorized "old" data. To determine if a feature was positionally incorrect or just cartographically displaced, the cartographic utility WYSIWYG was found very useful. The WYSIWYG capability allowed the operator to turn feature symbology on and view the feature with its cartographic representation. For example, a railroad that was positionally displaced, but shown to be cartographically correct with it's symbology displayed, was not edited.

Attribute changes in the data were applied based on information collected during the field work. The height information of the planimetric features can be derived from the DEM used to produce the orthoimages either in real-time or in post-processing mode. For the revision of this map, new contours were automatically generated from the DEM for evaluation purposes only, and the existing metric contours were maintained.

The revised data was time-stamped. This enabled the revision operator to identify all the features that have been revised and separate them from the original data for quality control.

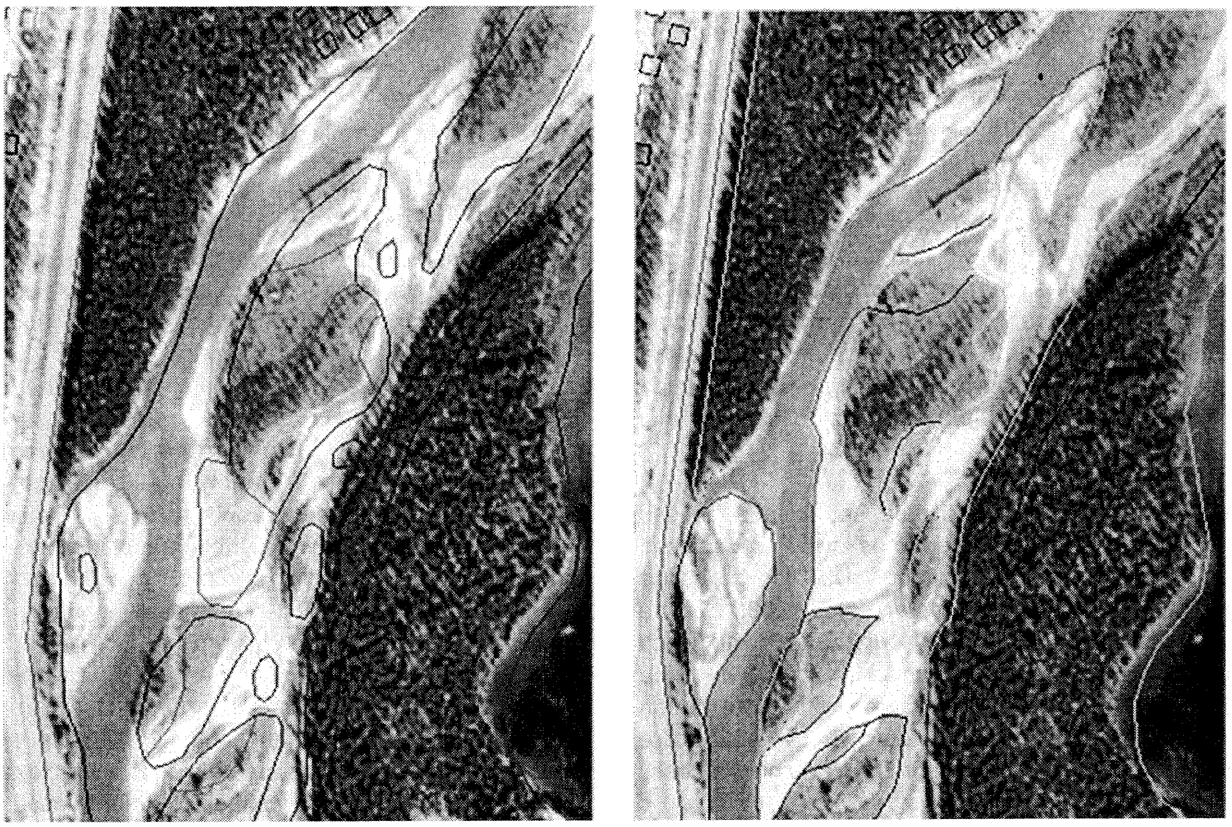

Figure 2: Athabasca River old and revised vector features (original in colour).

The existing contours for the Jasper map were compared visually by superimposition to the ones automatically generated by the DPW770. This comparison showed that the new digitally generated ones were acceptable in form and accuracy. The editing required for the DEM generated contours consists of adjustments for the re-entrance on streams, deletion of very small isolation contours and smoothing for cartographic presentation.

4.3 Quality control and time breakdown

The quality control of the revised vector data set consisted of four steps: a) verifying the feature codes with a statistical listing of the data set's content, b) inspecting a 1:50 000 plot of the data for content using the previous edition NTS map sheet and the field information, c) performing an inspection on the workstation of the revised vector data superimposed on the digital orthophotomosaics to check the horizontal positional accuracy of the data as well as the content, and d) creating topologically structured data.

The times shown below are estimates of the net production time required for the completion of the prototype revision of the 1:50 000 NTS Jasper map sheet, as the actual project time included such activities as training on and familiarization with the systems, defining the data requirements, and developing and implementing the procedures.

Description	Person Days
Aerotriangulation	5
- cross pugging	
Production of orthophotomosaics	10
Preparation	6
- system preparation	
- importing and preparing vector data set	
- importing and preparation of the digital orthophotomosaics	
Digital map revision	30
- revision/re-compilation	
Quality control	4
Total	55

These figures are specific of the Jasper map sheet and may vary depending on the relief of the terrain and the amount of revision required. Please note that the time for field work is not included.

5. CHANGE DETECTION

Investigation is in progress to introduce certain degree of automation into the identification of regions of possible changes and support a manual or semi-automated feature extraction scheme using multi-temporal digital orthophotos. The change detection operation can be further benefit by using multi-temporal digital orthophotos to further automate the identification of regions of possible changes and support a manual or semi-automated feature extraction scheme. For example, after performing histogram equalization and histogram matching on the temporal images covering the same area, it is possible to detect changes by edge detection, image subtraction and noise removal (Peled, 1994). These image variations are then examined by the operator as potential areas of change. It should be pointed out that simple radiometric differences between the temporal orthophotos do not necessarily represent areas of change. Digital elevation models and digital surface models will have a role to play in the radiometric matching process of multi-temporal orthoimages by providing geometric constraints. The spatial and attribute knowledge of the "old" database information can also support the change detection operations by matching the database objects, (Servigne and Laurini, 1994), with the image objects, semi-automatically extracted from digital orthophotos (Agouris et al., 1994).

6. CONCLUSIONS

The use of digital orthophotos for monoscopic revision of 1:50 000 database set has proven the potential and merits of this approach. From the technical point of view this approach facilitates the change detection and insures uniform and improved accuracy throughout the map data set. From the operational point of view this approach performs revision efficiently and effectively, allows time-stamping of the revised data and facilitates the quality control process. Further research is required towards improving change detection and feature extraction and classification techniques from multi-temporal orthoimages.

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