

EVALUATION OF THE POTENTIAL OF SPOT 5 HRG, HIGH RESOLUTION SATELLITE IMAGERIES FOR 1:25000 SCALE MAPS REVISION

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ABSTRACT:

Nowadays, due to improvements in satellite technology, remote sensing data is used for mapping at different scales. In Iran, there is a necessity to utilize satellite imagery as a complementary data source to aerial photographs. One of the main reasons for this, aside from the usual advantages of this technology, is the ability to map and revise border areas having aerial access limitations due to security reasons. This is especially true for Iran's 1:25000 scale base maps. In this paper the revision process of 1:25000 scale topographic maps will be discussed and explained.

Generally, the satellite images can be applied either in the change detection phase or in applying the changes to the maps. In this research, SPOT 5 HRG images have been used for revision of 1:25000 scale base maps. Successful exploitation of the accuracy potential of SPOT 5 HRG depends on well defined and distributed GCPs and using of precise orthorectification process. Therefore Toutin's spot model has been used to orthorectify SPOT 5 HRG image. Based on obtained results, SPOT 5 HRG images, while having required planimetric accuracy at scale of 1:25000 (about 7.5m), provides the required information contents for such maps.

1. INTRODUCTION

Conventional mapping techniques in Iran are still pegged on the use of black and white aerial photographs and extensive fieldwork exercises. This method is slow and cumbersome and is also very costly to the extent that continuous national mapping remains far beyond the realms of affordability for the countries. No wonder, most national maps in Iran are very old and out dated and thus unsuitable for planning and navigation purposes. Therefore there is an urgent need to produce new maps or update existing ones.

At National Cartographic Center of Iran (NCC), production of 1:25000 scale topographic maps have been started since 1991 and each map has 7.5' × 7.5' dimensions. Each block contains 96 sheets and dimension of each block is 1.5° in longitude and 1° in latitude (figure 1).

As mentioned, these maps are produced by photogrammetric method using aerial photographs taken at 1:40000 scale.

One of the big problems that NCC is now facing is the changes on the features during these years. As a result nearly all these maps have to be revised and up dated as soon as possible.



Figure 1. Index of 1:25000 topographic maps of Iran.

In general, main source of changes that make map revision and topographic databases updating a necessity consist of:

- Changes in data characteristics: when standard of data characteristics is changed, every production must be revised;
- Topographic changes: every change in topography must be considered in databases;
- Changes in description and structural information of features: such as changes in name, type and structures e.g. features merging or feature dividing;
- Errors and mistakes during map production or revision stage.

Because of the above mentioned factors, maps and topographic databases must be updated when at due time.

2. BACKGROUND

The theoretical aspects of map revision include: planning for revision (when), places to be revised (where) and method of revision (how).

There are three main alternative ways for planning revision or epoch of revision. These are:

- Cyclic revision, which would aim at the revision of the whole series over a fixed period of years;
- Selective revision, which would try to achieve revision of individual sheets by an order of priority that is governed by rate of changes or urgency of demand and not by fixed periods.
- Continuous revision, which relies on a continuous inflow of information, field survey and etc to maintain sheets in an up-to-date condition.

Continuous revision is ideal planning revision to achieve accurate and precise information. Cadastral maps and large scale ones are universally continuous revised. In this case, constant and certain resources such as municipalities are used to collect information. This is time consuming and costly method. Generally, for updating small and medium scale coverage maps, cyclic revision is used.

In the case of 1:25000 base maps of Iran, in planning phase for updating each block (96 sheets at 1:25000 scale), the features of them are classified to three main groups: features with rapid change (urban areas), features with moderate change (rural areas) and features with slow changes (natural areas with little or no cultural development). Urban blocks, every 5 years, rural blocks every 10 years and natural ones with little or no cultural development every 15 years should be revised. Based on this plan, each block must be revised. replying to following questions: "will guide our task or suppose revision method?" "where changes should be applied?" and "How many changes have been occurred?"

There are alternative ways for map revision. These ways are: ground surveying, aerial photogrammetry and space photogrammetry. Map revision using remotely sensed data acquired by satellites have various advantages comparing to the other methods which accessibility, lower costs and regular repeat coverage of the area of interest are the most important ones. For image selection, many of parameters should be considered, such as: the possibility of providing planimetric and altimetric accuracy as well as information content with respect to "detection" and "identification" of features. HRG mode of SPOT5 satellite images with 2.5 meter resolution and its geometric characteristics is considered to be suitable for 1:25000 base map updating.

3. OBJECTIVES AND METHODOLOGY

Objective of this study is to evaluate the potentials of SPOT5 HRG images and its information content, for extraction ground features in the context of updating 1:25000 base map series of Iran and associated topographic databases. Since 1:25000 topographic maps being typically targeted over the vast sparsely populated areas around the world, the results can be used in many developing countries. In Figure 2, map revision stages planned for this case have been depicted.

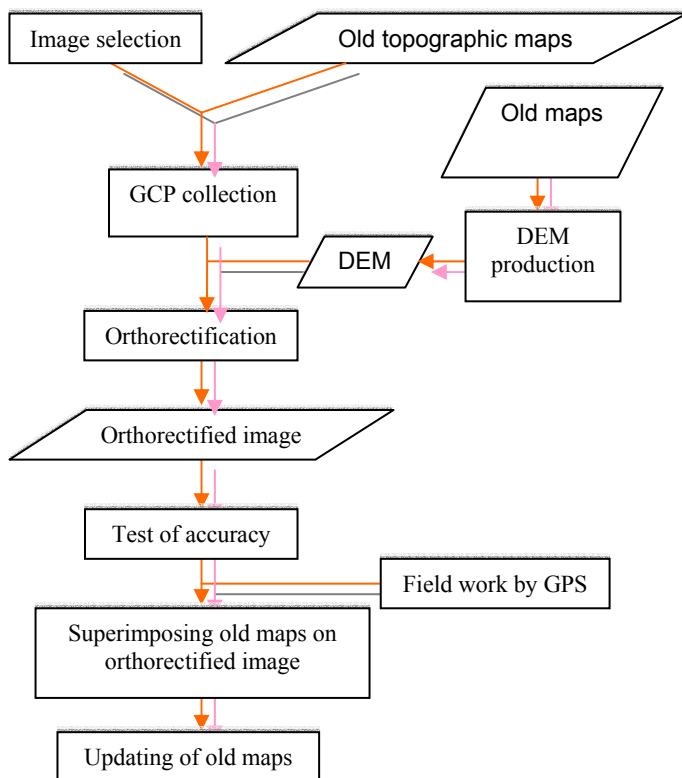


Figure 2. map updating stages using HRG images.

After planning the revision stage, data required for updating process including GPS measurements, new satellite images or aerial photos must be collected. Then, the collected data is processed to detect and revise changes. Finally, updated maps are produced.

4. TEST SITE AND DATA SETS

Khuzestan is a boundary province of Iran, and was badly damaged during eight years war between Iran and Iraq. Ahvaz (the center of province), is located between Longitudes 48°20' and 49° East and Latitudes 31°30' and 31° North. It is a flat area with slope lower than 3%. In figure 3, position of Khuzestan province relative to other provinces and digital elevation model (DEM) of Ahvaz city have been shown.

Maps of this city had been produced at the beginning of 1:25000 base mapping project in 1993. Since those maps are now quite outdated, they were selected for this study.

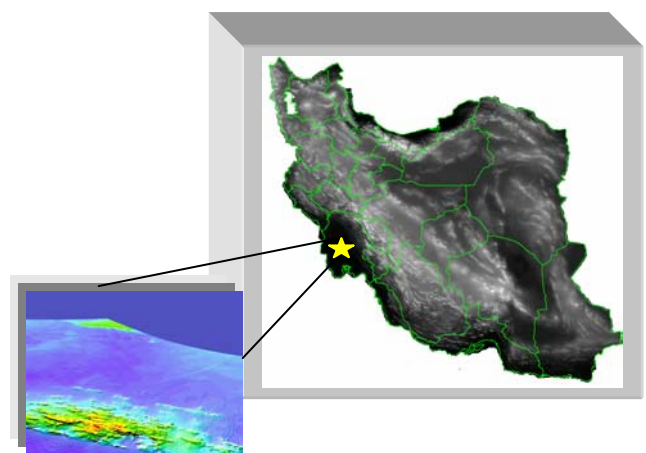


Figure 3. DEM and position of Ahvaz relative to other provinces.

Topographic vector maps at 1:25000 scale in UTM coordinate system, DEM with 10 meters resolution, GPS ground control points and Ahvaz SPOT 5 HRG image, acquired on 2003, were used as input data sets.

DEM of Ahvaz was produced based on spot heights, contours, water lines and water bodies if exist, which have been extracted from 1:25000 old maps.

5. PREPARATION STAGES

For orthorectifying of SPOT imageries, a set of 40 well defined and distributed ground control points (GCPs) was collected simultaneously on the 1:25000 scale topographic maps and on the SPOT HRG image. Figure 4 illustrates spatial distributions of these points.

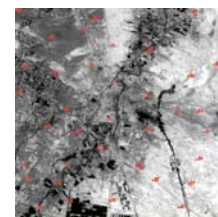


Figure 4. Distribution of GCPs.

By applying orbital parameter and using X, Y (extracted from planimetric vectors) and Z coordinates (extracted from DEM) of each point, Toutin's SPOT model was calculated with 0.93 pixel in RMSE

and finally HRG image was orthorectified. In figure 5, topographic vectors overlaid on the orthorectified image can be seen.



Figure 5. Overlay of vectors on the orthorectified image.

6. MAP REVISION STAGES

After preparation stage, such as orthorectifying satellite image based on old topographic maps and mathematical model, old digital map superimposed on the orthorectified image. Then 2.5m resolution panchromatic image and ground data collected from the field submitted to one image-interpreter. She worked with drawing software and carried visual interpretation on that image in a monoscopic way. Changes were defined and grouped in four codes in change detection phase (field work). Features that were deleted relative to the old topographic maps, added features, geometric changes and descriptive changes were reserved in the first, second, third and fourth code respectively.

The existing following features exist in the study area were considered and evaluated:

- Communication Lines such as roads, railways, etc and associated features e.g. railway stations, bridges, etc;
- Administrative features including buildings, walls, stadium, airport, Tunnel, Pool, Storage and fence;
- Power lines and pipelines such as electrical, gas and water supply features and associated features e.g. water well, oil or gas well;
- Hydrological features, including rivers, streams, canals and floodways;
- Land cover and vegetation, including cultivated areas, wet lands, orchards and etc.

The interpreted features were grouped by layer.

7. CONCLUSION

Major problem which effects use of satellite images for topographic maps revision lies in the low resolution of the satellite images and therefore in the information content of the resulting revision maps. The acceptable images should provide information content required for revision of 1:25000 scale topographic maps.

By using orthorectified images, updating old topographic maps is possible. Image processing software with the ability of superimposing vector on raster has been used to carry out this operation.

Results of feature extraction showed that there were no difficulty to detect and identify area features such as towns, smaller villages and isolated buildings. All linear features such as roads, tracks, railways, etc were extracted easily, except in some places where the contrast was relatively low. Finally, the point features such as water / gas wells, single trees were impossible to be detected and identified on the image. For each layer, quality criteria according to the interpretation results are defined as follow (total = 100%):

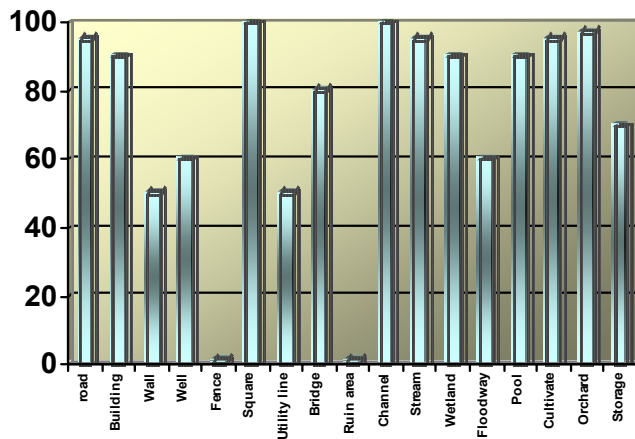


Figure 6. Results of detection and identification of features on SPOT 5 HRG image for 1/25000 scale map revision.

Changes can be detected based on comparison between aerial photo acquired on 1991 with SPOT HRG image acquired on 2003. River changes are obvious in the two aerial photo and satellite image.



Figure 6. Aerial photo acquired on 1991.



Figure 7. SPOT 5 HRG image acquired on 2003.

For each feature type, detected changes with respect to the old topographic map sheets are defined as follow (total 100%):

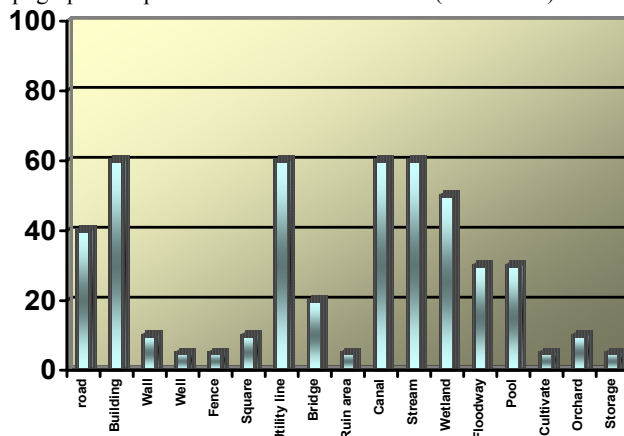


Figure 8. Detected changes from 1991 until 2003.

Regarding information content of SPOT 5 HRG images, more than 90 percent of the features were detected and identified successfully. Therefore, this study shows that planimetric accuracy and information content of SPOT 5 HRG images are good enough to be used for revision of Iranian 1:25000 scale maps.

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