THE REVISION OF IRANIAN 1:25000 SCALE TOPOGRAPHIC MAPS BY KVR-1000 IMAGE USING RATIONAL FUNCTION MODEL

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ABSTRACT:

Nowadays, due to improvements in satellite technology, remote sensing data is applied 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, KVR-1000 image, have been used in applying (revision) to a 1:25000 scale base map. Successful exploitation of the accuracy potential of KVR-1000 depends on good panoramic model for the sensor modeling. But the camera information and interior orientation parameters were not available. Therefore the rational function model has been used and its flexibility and its good accuracy is demonstrated. Based on obtained results, KVR-1000 images, while having required planimetric accuracy at scale of 1:25000 (about 7.5m), provides the required information contents for such maps.

1. INTRODUCTION

In Iran, production of 1:25000 scale topographic maps has been started over ten years ago. At the moment about 7000 sheets are produced and more than 3000 sheets is under production. These maps are produced by photogrammetric method using aerial images taken at 1:40000 scale. One of the big problems that NCC is now facing, regarding these maps, is the changes on the features during these years. As a result nearly all these maps have to be revised and up to dated as soon as possible. Satellite images may offer the fast and cheap solution for this problem. This paper tries to show the capability of the KVR-1000 Russian satellite photograph for revision of Iranian 1:25000 scale topographic maps.

After the introduction, Sections 2, 3 discuss the theoretical aspect of map revision including: the time of revision and the places to be revised (Figure1). In section 4, the methods of revision explained. Section 5 outlined the capability of KVR-1000 for revising of 1:25000 scale topographic maps. It also discusses different types of the mathematical models for geometric correction of KVR-1000 images and describes the potential of KVR-1000 images for providing qualitative information that is necessary for 1:25000 scale maps. The paper will concluded in section 6.

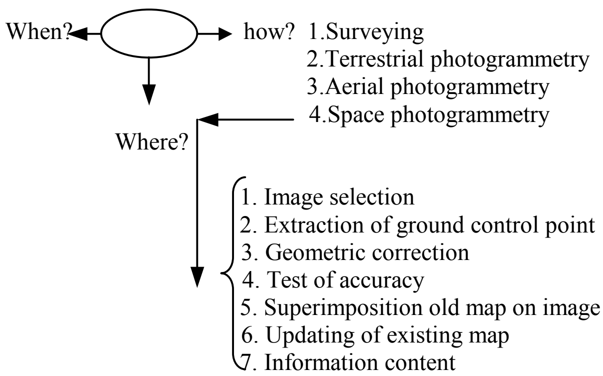

Figure1. Revision process

2. PLANNING REVISION (WHEN?)

There are three main alternative ways in which the revision of mapping can be planned. These are:

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

In Iran, for planning revision blocks of 1:25000 scale maps, the features of each blocks are classified to three main classes: the features which change rapidly (urban areas), the features which change slowly (rural areas) and the features which change more slowly (natural areas with little or no cultural development). The blocks that have more urban area, every 5 years, rural blocks every 10 years and natural areas with little or no cultural development every 15 years be revised.

3. PLACES OF CHANGES FOR MAPS REVISION (WHERE?)

After the planning revision, each block must be revised based on the plan. Replying to questions the following will determine our task:" where to apply the changes?" and " How many changes have occurred?".
For this purpose, satellite images acquired in the date of mapping are compared with images used for map revision.

4. THE METHODS OF REVISION

There are alternative ways for revision. These ways are: surveying, terrestrial photogrammetry, aerial photogrammetry and space photogrammetry. The use of remotely sensed data acquired by the satellite images has various advantages comparing to the other methods: regular repeat coverage, the possibility of adding GPS/INS to remote sensing satellites, the possibility of %100 overlay and base: height greater than one (B/H>1), recording data from the same geographic area at the same time of day, extensive coverage area, lower costs compared to other methods. The case of image selection, many of parameters is noted, as follows: the possibility of stereo imaging, providing planimetric and altimetric accuracy and information content with respect "detection" and "identification" of features, availability of images in emergency and etc. In this paper, the because of availability and acceptable resolution, is used to KVR-1000 images.

5. PRACTICAL TEST

In this section, capability of KVR-1000 images in planimetric accuracy and information content aspects is investigated. For this task, is used to KVR-1000 image acquired in 2000 with 1.7 m pixel sizes.

5.1. GEOMETRIC CORRECTION OF KVR-1000 IMAGE

The typical basic map accuracy specifications in Iran at 1:25000 and 1:50000 and 1:100000 scales are shown in Table 1. These apply to all maps at these scales whether they compiled from aerial photographs or satellite images. Therefore, plan accuracy 7.5 m is need to 1:25000 scale topographic maps.

Table 1. Iranian topographic maps specifications

Scale	Plan Accuracy (0.3 mm)	Height Accuracy	Contour Interval
1:25000	7.5 m	3 m	10 m
1:50000	15 m	6 m	20 m
1:100000	30 m	6 m +	20 m+

Russian KVR-1000 image taken by a panoramic camera. This camera utilize sequential line-by-line exposure of the frame using either a moving slit across the photographic film or a scanning mirror rotating in front of the camera lens. This gives rise to a cylindrical imaging surface and complex geometry with a new exposure station for each line of the image. Successful exploitation of the accuracy potential of KVR-1000 depends on good panoramic model for the sensor modeling. But the camera information and interior orientation

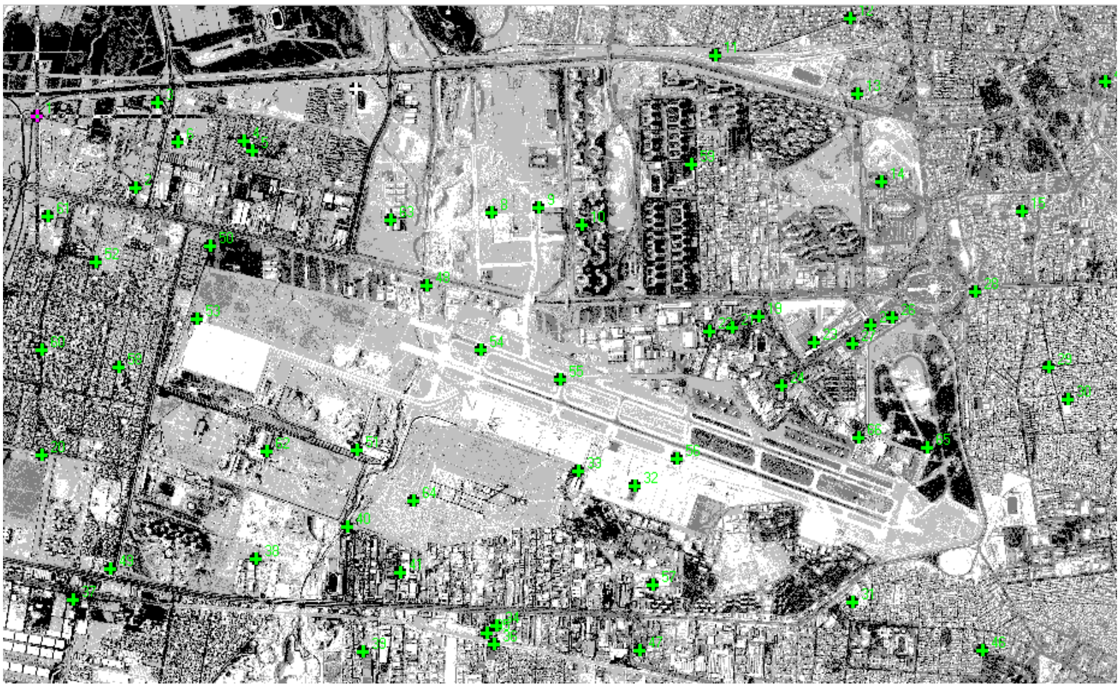

Figure2. GCPs is shown of test area of Tehran acquired by KVR-1000 camera

parameters were not available. Therefore the rational function and polynomial models have been used.
In this step, a set of 54 well-defined and distributed ground control points (GCPs) was collected simultaneously on the 1:25000 scale topographic maps and in the KVR-1000 image (Figure2). This task was achieved using to existing 1:25000 scale map.
These GCPs was applied in 3 set that has been changed number of GCPs and independent check points (ICPs) in every set (Table 2). The 1:25000 scale existing map, used to provide ground control points coordination.

Table 2. Applying GCPs and ICPs in geometric correction

Set	No. of GCPs	No. of ICPs
A	54	0
B	37	17
C	24	30

5.1.1. Polynomial approach: The polynomial transformation that is commonly used takes the form:

$$
\begin{aligned}
X = {} & a_0 \quad (a\ constant\ term) \\
& + a_1x + a_2y \quad (linear\ terms) \\
& + a_3xy + a_4x^2 + a_5y^2 \quad (quadratic\ terms) \\
& + a_6x^2y + a_7xy^2 + a_8x^3 + a_9y^3 \quad (cubic\ terms) + \ldots \\
Y = {} & b_0 \quad (a\ constant\ term) \\
& + b_1x + b_2y \quad (linear\ terms) \\
& + b_3xy + b_4x^2 + b_5y^2 \quad (quadratic\ terms) \\
& + b_6x^2y + b_7xy^2 + b_8x^3 + b_9y^3 \quad (cubic\ terms) + \ldots
\end{aligned}
$$

Where: X and Y are the ground coordinates; x and y are the image coordinates; and $a_i\ and\ b_i\ (i = i, \ldots n)$ are the transformation parameters. The results of using different terms of polynomial showed in Table 3. As can be seen from the table, result of using polynomial with degree 4, that have minimum RMSE ICPs is better for geometric correction.

5-2. INFORMATION CONTENT

The other major problem which effects the use of satellite images for revision topographic maps lies in the shortfall in the 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. The required information content may be divided into five main categories, as follows:

a. Lines of communication (roads, railways, etc.) and associated features (railway stations, bridges, etc.);
b. Cultural features including building block, stadium, airports, electrical and water supply features (power lines, pipelines, etc.);
c. Hydrologic, including rivers, canals, reservoirs;
d. Land and relief forms including hilly areas, sand dunes, gravel beds, etc., and
e. Land cover and vegetation, including cultivated areas, woods, orchards, etc.

Using produced corrected image (previous section), it is now possible to update the old topographic maps of Tehran. Image processing software with the ability to super-impose raster and vector data has been used to carry out this operation. The results of features 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 low. Finally, the point features such as water well, single tree and etc. were impossible to be detected and identified on the image. The results of detection and identification tests for cultural features are shown in Table 5.

The overall results showed that KVR-1000 satellite images can be used successfully with acceptable information content for revision of the 1:25000 scale topographic maps.

Table 4. RMSE values in ΔE (m), ΔN (m), ΔPl (m) using rational function model

Set	No. of parameters	RMSE GCPs			RMSE ICPs		
		ΔE (m)	ΔN (m)	ΔPl (m)	ΔE (m)	ΔN (m)	ΔPl (m)
A	3	2.34	2.70	3.57	-	-	-
	4	2.28	2.60	3.46	-	-	-
	5	2.28	2.60	3.46	-	-	-
	6	2.28	2.60	3.46	-	-	-
	7	2.27	2.45	3.34	-	-	-
	8	2.26	2.44	3.33	-	-	-
	9	2.17	2.37	3.21	-	-	-
	10	2.17	2.33	3.18	-	-	-
	11	2.17	2.33	3.18	-	-	-
	12	2.07	2.25	3.06	-	-	-
	13	2.06	2.24	3.04	-	-	-
	14	2.00	2.24	3.00	-	-	-
	15	1.99	2.20	2.97	-	-	-
	16	1.92	2.20	2.92	-	-	-
	17	1.92	2.20	2.92	-	-	-
	18	1.92	2.11	2.85	-	-	-
	19	1.92	2.11	2.85	-	-	-
	20	1.93	2.11	2.86	-	-	-
B	3	2.12	2.63	3.37	2.97	3.09	4.29
	4	1.95	2.44	3.12	3.21	3.16	4.50
	5	1.93	2.44	3.11	3.27	3.16	4.55
	6	1.91	2.42	3.08	3.29	3.22	4.60
	7	1.89	2.30	2.98	3.29	3.07	4.50
	8	1.89	2.27	2.95	3.27	3.46	4.76
	9	1.80	2.21	2.85	3.19	3.30	4.59
	10	1.80	2.16	2.81	3.20	3.36	4.64
	11	1.77	2.16	2.79	3.29	3.37	4.71
	12	1.77	2.08	2.73	3.21	3.73	4.92
	13	1.75	2.07	2.71	3.26	3.78	4.99
	14	1.68	1.95	2.57	3.03	4.17	5.15
	15	1.67	1.64	2.56	3.11	4.06	5.11
	16	1.53	1.87	2.42	3.38	4.39	5.54
	17	1.53	1.87	2.42	3.38	4.39	5.54
	18	1.56	1.94	2.49	3.37	4.44	5.57
	19	1.54	1.98	2.51	3.37	3.95	5.19
C	3	2.25	2.45	3.33	2.62	3.25	4.17
	4	1.97	2.08	2.28	2.97	3.24	4.40
	5	1.94	2.05	2.82	3.13	3.43	4.64
	6	1.92	2.04	2.80	3.05	3.43	4.59
	7	1.87	1.95	2.70	3.12	3.27	4.52
	8	1.83	1.95	2.67	3.29	3.25	4.62
	9	1.66	1.92	2.54	3.59	3.18	4.80
	10	1.64	1.87	2.49	3.63	3.05	4.74
	11	1.63	1.82	2.44	3.60	3.69	5.16
	12	1.62	1.60	2.28	3.44	5.12	6.17

Table 5. The results of detection and identification features on KVR-1000 image for 1:25000 scale maps revision (Cultural features)

Feature name	Features is detected				Features is identified			
	No	Sometime	Usual	Always	No	Sometime	Usual	Always
Stadium				*				*
Airstrip				*				*
Building block				*				*
Bridge				*				*
Tunnel				*				*
Gas station				*				*
Water well	*				*			
Oil or Gas well	*				*			
Fence				*			*	
Utility Line		*			*			
Wall			*					*
Single Building (To scale)			*				*	
Single Building (Symbol)			*				*	
Toll Gate				*				*
Delimiter			*				*	
Storage (To scale)				*			*	
Storage (Symbol)		*				*		
Ruin Area				*				*
Square (To scale)				*				*
Square (Symbol)				*				*

6. CONCLUSION

The overall results of the test reported in this paper showed that in planimetric accuracy and information content terms, KVR-1000 images is well qualified to be used for revision of Iranian 1:25000 scale maps. In both method GCPs were collected from available 1:25000 maps. For more hilly aerials, rational function models when applying DEM gives better results. Planimetric accuracy of 3.80 m and 4.17 m when using of 4th degrees polynomial and rational function model with 3 parameters respectively were obtained. Regarding information content, more than 90 percent of the features were detected and identified successfully.

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