COMPARISON OF SPOT5 AND LANDSAT7 FOR FOREST AREA MAPPING

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ABSTRACT:

The main purpose of this study is comparison of the potential of the Landsat7 ETM+ data and SPOT5-HRG image for forest area mapping at the scale of 1:25000 in northern of Iran. A Landsat7-ETM+ image and SPOT5-HRG in Pan and XS modes, with the spatial resolution of 5 and 10 meters, were analyzed. The images were almost simultaneous.
The investigation on the image quality showed that there was a non-systematic misregistration between SPOT5-Pan and SPOT5-XS. There were no other noticeable radiometric and geometric distortions. Orthorectifications of the both satellite data were implemented using ephemeris data and a digital elevation model. The geocoded images were checked for reliability in comparison with the digital topographic map. Diverse suitable spectral transformation such as rationing, PCA, and Tasseled Cap transformation were performed on the images. To generate effective multispectral bands with better spatial resolution, the green, red and near infrared bands, which lie in the spectral range of panchromatic band, were fused with Pan using DIRS method as a radiometric approach.
In order to estimate the potential of the satellite data precisely, a ground truth was prepared using aerial photographs. In this relation, 38 black and white aerial photographs at the scale of 1:7000 were taken especially for this project. These airphotos were orthorectified and interpreted.
Image classifications were performed using supervised and a new hybrid approach (digital and visual). At first, the images were classified using maximum likelihood classifier without any knowledge of a-priori possibilities. The best band sets were selected using Bhatacharrya distance criterion and the defined training areas. To get advantage of contextual information and expert knowledge, a forest/non-forest classification was also carried out using visual interpretation at computer display.
Based on comparison of the resulted maps and the ground truth, a better result had been achieved from the hybrid approach, up to 4%. The Landsat7 and SPOT5 data concluded an overall accuracy of 93% and 97 % respectively. It could be concluded that the SPOT5-HRG data is more appropriate than Landsat7 for forest mapping and updating at the scale of 1:25000. SPOT5 data permits fine and accurate forest/non-forest mapping. Revision of the forest road is also precisely possible trough SPOT5 image.

1. INTRODUCTION

Forests are one of the most important features in natural resources. Because of the valuable functions of the forests, public and political interest is directed toward progress in sustainable use of the forests. Sustainable planning and management of forests require some information about forest resources such as forest map. Mapping of forest in large areas is not easily through field survey or by means of aerial photo interpretation. In contrast, satellite data with their own characteristics such as being able to cover large areas, their revisit frequency, their constant spatial resolution and finally their possibility of automatic analysis has created a high potential in forest type mapping. Satellite data have been used to map forest resources since the lunch of the landsat1 in 1972 (Joffre, 1991; Brockhaus and Khorram, 1992; Darvishsefat, 1995; Kayitakire *et al.*, 2002). It has been suggested that more accurate mapping will be possible if satellite data with high spatial resolution, good spectral resolution and improved processing methods are used (Naseri *et al.*, 2003). The Landsat7 data has had a significant impact on the remote sensing society (Cheng *et al.*, 2002). It provides six visible and infrared bands (30m), one thermal infrared band (60m) and a new simultaneous panchromatic band (15m) with a wide coverage area (approximately 170 km by 185 km). Availability of SPOT5 data can be considered as a turning point in operational observation. Its HRG sensor can provide 4 visible and infrared bands (10m)

and a high resolution panchromatic band (5m). SPOT5 data are more expensive than Landsat7 data. This must be kept in mind if one would like to use it in an operational framework.

The main purpose of this investigation is comparison of the potential of the Landsat7 ETM+ data, the most widely used medium resolution images, and SPOT5 HRG data, set as newest operational high resolution satellite data, for forest area mapping at the scale of 1:25000 in mountainous deciduous forest in the northern of Iran.

2. MATERIAL AND METHOD

2.1 Study site

The study area consists in a continuous forest land in Gilan province in north of Iran, covering 2819 ha (Figure 1). The elevation varies from 170 m to 1350 m above sea level. The forest is relatively dense and the major forest species are Fagus orinetalis and Carpinus betolus.

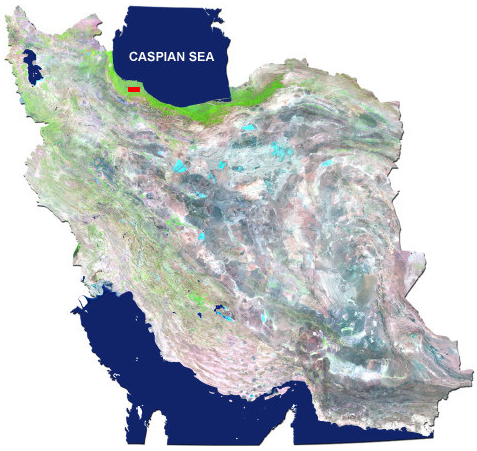

Figure 1: Study site localization in Iran

2.2 Data

Landsat7-ETM+: A subset of a map oriented scene 165/034 dated 31 July 2002 has been used (Figure 2). The image underwent level 1G processing (geometrically and radiometrically corrected). ETM band6 was ignored because of its thermal characteristics and low spatial resolution (60m).

SPOT5-HRG: A subset of a orbit oriented scene 147-276 in XS and Pan mods, acquired on August 14th, 2002 have been analyzed (Figure 3). They have been processed at level 1A (no geometrically and radiometrically corrected). The multispectral and Pan images acquired simultaneously. The two data sets were almost simultaneous. The SPOT5 data acquired only 14 days after Landsat7 images. The acquisition dates offer an optimal situation for proposes of this investigation. A fine digital elevation model and an accurate digital topographic map were also used for orthorectiefication.

2.3 Image orthorectification

Since the study area was mountainous, it was essential to remove relief displacement. Image orthorectification were separately implemented using ephemeris data, ground control points and a precise digital elevation model and Toutin model (Cheng *et al.*, 2002) to a RMS error of less than of one pixel. An affine transformation and the bilinear resampling were applied. Landsat and SPOT data were resampled to 15m and 5m respectively. The geocoded images were checked for reliability in comparison with the digital topographic map.

2.4 Ground truth

To compare the potential of Landsat7 and SPOT5 images for forest area mapping an accurate and update ground truth is essential. Therefore a precise ground truth was prepared through interpretation of 38 black & white aerial photos at the scale of 1:7000. The ground truth covered entire of the study site. These photos were acquired from the study area especially for this investigation. The flight altitude was approximately 2300 meters above see level. The aerial photos were orthorectified and interpreted. The resulted forest map is used as a ground truth in this study.

2.5 Image enhancement

In order to improve information extraction from satellite image, suitable spectral transformations such as rationing, PCA and Tasseled Cap transformation were performed on the Landsat7 and SPOT5 data. The availability of the simultaneous panchromatic bands with the multispectral bands gives the best opportunity to generate effective multispectral bands with higher spatial resolution. In this study, the green, red and near infrared bands, which lie in the spectral range of panchromatic band, were fused with Pan using DIRS (Digital Imaging and Remote Sensing Laboratory of Rochester) method as a radiometric approach. This method preserves the spectral information of multispectral bands during the fusion process. It is based on the spectral response of every band used in the fusion process (Munechika, 1990). The blue and mid infrared bands were fused with pan using the common task, IHS method.

2.6 Image classification

Image analysis was performed using supervised and a new hybrid approach (digital and visual) classification method. At first, the image were classified in classes including forest and non-forest using traditional maximum likelihood classifier without any knowledge of a-priori possibilities. All multispecral bands (except thermal band), fused bands and synthetic bands such as those derived from PCA and ratios were used by classification process. Required training areas were defined trough fieldwork. The best band sets were

selected using Bhatacharrya distance criterion and suited defined training areas. To eliminate the isolated classified pixels, the resultant classifications were filtered with a majority filter in a 5*5 moving window. The forest/non-forest classification was also carried out using visual interpretation at computer display, a new approach called hybrid. The main advantage of hybrid interpretation is that contextual information and expert knowledge can be used in the analysis more easily. To perform hybrid classification, the most accurate map derived from maximum likelihood classification was used. This map was converted to vector format and then it was edited on the basis of various color composites, fused images.

3. RESULTS AND CONCLUSION

The main purpose of this study is comparison of the potential of the Landsat7- ETM+ data and SPOT5-HRG image for forest area mapping at the scale of 1:25000 in northern of Iran. The quality analysis of the satellite data indicated that the quality of the level 1 ETM+ was very good. In contrast, a non-systematic geometric misregistration between HRG-XS and HRG-Pan of SPOT5 data could be recognized. It ranges from 3 to 15 pixels. There were no other radiometric or geometric distortions. Both satellite images were orthorectified very precisely in comparison with the digital topographic map. The geometric misregistration of the SPOT5 bands could be corrected through the orthorectification. To assess the capability of the landsat7-ETM+ and the SPOT5-HRG data to discriminate forest area, the results of the classification were compared pixel by pixel to the ground truth. The maximum likelihood classifier concluded overall accuracies and Kappa coefficients equal to 89% and 0.84 for Landsat7 and 93% and 0.89 for SPOT5. Better results have been achieved from the hybrid classifications since this approach pays particular attention to texture and knowledge of expert. Similar conclusion was reported by Rafieyan *et al.* (2003). They achieved overall accuracies and Kappas through hybrid approach are equal to 93% and 0.89 for Landsat7 and 97% and 0.93 for SPOT5. The spectral data fusion technique, DIRS, which preserves the spectral characteristics of each multispectral band, had improved the classification results at 1% by both data sets. The performance of SPOT5 data is on behalf of its high spatial resolution, which permits to distinguish small forest and non-forest polygons. Revision of forest roads was also precisely possible trough SPOT5 image. Furthermore, determination of forest /non-forest boundary by SPOT5 data could be done more precisely than by Landsaty7 data. Three additional spectral bands of ETM+ (related to HRG), which lie in the blue, mid infrared and thermal infrared were not selected by the best bandsets for the classification. It indicates that the spectral resolution of SPOT5 is sufficient for such proposes.
The results of this investigation can lead to the conclusion that in such regions both Landsat7 and SPOT5 data are limited for forest mapping. But SPOT5 data meets specification of large scale mapping (1:25000) and offers forest managers valuable sources of data for fine forest mapping. Its potential with regard to forest stands mapping should be evaluated.

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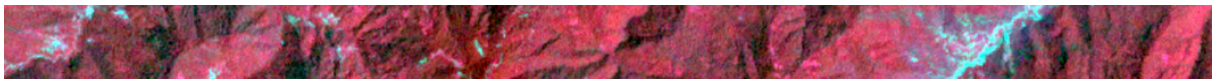

Figure 2: Landsat7 image of study area, ETM432 (RGB)

Figure 3: SPOT5 image of study area, HRG321 (RGB)

Figure4: Mosaic of the 38 black and white aerial photograph at the scale of 1:7000 which have been used for producing ground truth.