Investigating the Effects of Satellite Data Fusion on the Accuracy of Forest Type Classification in Mazandaran Province

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ABSTRACT

Data fusion operation is referred to the combination of panchromatic band with multispectral data. This operation increases the ground resolution of multispectral data. In this study, the effect of fusion method on the accuracy level of forest type classification was investigated. The ETM^{+} multispectral and PAN data related to a forest district located at Azarrood forestry plan in Savadkooh were used in this study. The bands were controlled in terms of the radiometric and geometric errors, separately. Band one was omitted because of its radiometric error as well as its little importance in vegetation cover and forest type classification. Geometric correction was performed using 22 round control points associated with Digital Elevation Model (DEM), upto orthorectification level by a precision below half pixel. Fusion operation was performed by principal component analysis (PCA) method. The supervised classification was done using basic and synthetic bands (Ratio and PCA), with maximum likelihood, minimum distance, and parallelepiped algorithms. The highest overall accuracy and kappa coefficient were 34.12% and 23.15%, respectively, for six separate vegetation type. The result of data fusion operation showed the reduction of data accuracy in comparison with the accuracy resulted from forest type map production. According to the results of this study, the selected method for fusion operation was not appropriate to classify the forest types because of the heterogeneity of the study area. In conclusion, it is suggested that the same researches repeat for other places using other fusion methods.

INTRODUCTION

Data Fusion operation is to merge the panchromatic band (with high spatial resolution) and multispectral data (with high spectral resolution).This method can be used when both spacial and spectral resolutions are required. Due to some limitations in satellites capability to produce a combination of panchromatic and multispectral data, Fusion operation is applied to merge these kinds of data. Users usually expect a higher accuracy from this merged data. Forest type Classification and mapping are considered as the base data to provide forest plans. There are different methods to produce forest type maps ranging from field surveys to Arial photograph interpretation which are costly and time consuming. There have been a lot of studies, as this one, to find more simple methods in order to obtain higher classification accuracy.

Many researchers examined various types of data and data fusion techniques for the purposes including sharpening and enhancing the image as well as improving the classification result. Santosh & YusifAli, 2002, used the fusion operation to compare two classification methods in wet forests of Indonesia and obtained improved classification results. Researchers believed this improved result was due to the high spatial resolution of panchromatic band.

Hussin & Shaker (1996) used the fusion of TM and radar image. They obtained better results in classification and optical interpretation. Munechika et al. (1993), reported an improved classification accuracy by merging TM multispectral data and SPOT pan image. Hung et al, 2002, fused the panchromatic band with ETM+ multispectral data and obtained more acceptable classification results in geological studies. On the other hand, there are a few numbers of studies on using merged image for classification which showed low accuracy results.

Shaban & Dikshit (2002) reported low classification accuracy while using merged SPOT XS and pan data in an urban area.

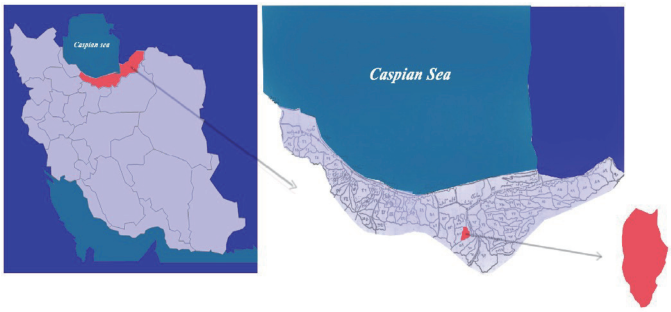
Van der Meer (1997) has also showed that fusion operation lowers the classification accuracy.

Since most studies revealed the positive effect of fusion operation, our hypothesis in this study is “fusion operation improves the satellite data classification results”.

Study area

The study area is located at the forest district in Azarrood forestry plan, in Savdkooh, Mazandaran province between the latitude of 36° 10' 29" to 36° 6 '54" E and longitude of 52° 50' 20" to 52° 52' 50" N on UTM coordination system (Fig.1). The total area covered 1737 ha. This mountainous area with a rough topography and an average slope of 50-60% is located at the height of 450m- 2117m. This forest is covered by uneven aged tree species including Beech, Alder, Scotch elm, Checker tree, Mazzard cherry, Hornbeam, Date plum, Tilled tree, and Yew.

Figure 1: Position of study area



Types of data used in this study

Landsat ETM+ data collected at August 18th, 2002 including 6 multispectral bands with 30 m resolution and one PAN band with 15m resolution as well as digital and paper topographic maps in the scale of 1:25000 were used in this study. These maps were named Galeshkola 6562 II (NW), Zirab 6562 II (NE), Lacoom 6562 II (SW). Used data were mostly processed by Geomatica 8.1 and Idrisi2 softwares. Other softwares such as microstation, Arcview 3/.a, Arc/info 3.5.1 were used for secondary processing.

Field Surveys

Ground truth map was prepared through ground surveys in order to evaluate the image classification accuracy. Due to the rough topography and vast extent of the study area (1737 ha), it is practically impossible to prepare a vegetation type map for this area. According to Darvishsefat and Fallah Shamsi (1998), TM maps with the accuracy of 4-6% can be evaluated using a ground truth map of 2% of total study area. Regarding to the available facilities and time, it was attempted to prepare a ground truth map for a wider surface of the study area; finally we could provide it for 24% of the area via field surveys. To provide this map, the available data in forestry plans of the area were used and the tree types of the area were determined via total frequency method (Rashidi, 2004). This map was prepared simultaneous with acquiring satellite data of the region in late august and early October. Ground truth map of the area was provided by moving on the crests and borders of parcels and determining the beginning and the end of each tree type using natural topography, Altimeter and GPS instruments and via a random stratification method. Then, the results were conformed and registered on the topography map (available in the forestry plans) in the scale of 1:25000. The Classifications were carried out based on a qualitative method (percentage of frequency). The types were divided into 6 classes, including pure beech (class1), mixed beech (class2), mixed hornbeam (class3), data plum (class4), mixed deciduous (broad leaf) (class5), and road and non-covered area (class6).

Training areas were determined using Altimeter and GPS instrument simultaneously with land surveys for ground truth map preparation. Then, these areas were registered on the topographic map of the area with the scale of 1:25000 existed in the forestry plans. At least one hectare was considered for each vegetation type. Finally, the coordinate points of the training areas on the topographic map were precisely identified on the image.

Computer Based Data Processing

Preprocessing

To assess the probable errors, the data were studied in one band or combined bands after contrast enhancement and different exaggerations in size. The bands were separately controlled in terms of radiometric and geometric errors. Band one was omitted because of its radiometric error and its less importance in vegetation cover study. Geometric correction was performed by 21 Ground Control Points with DEM (1:25000), upto the orthorectification level using first class equation and nearest neighborhood interpolation, by less than half pixel precision (RMS=0.3). Results of studies on the corrected image and some data layers such as roads, rivers, etc. demonstrated the high accuracy of geometric correction.

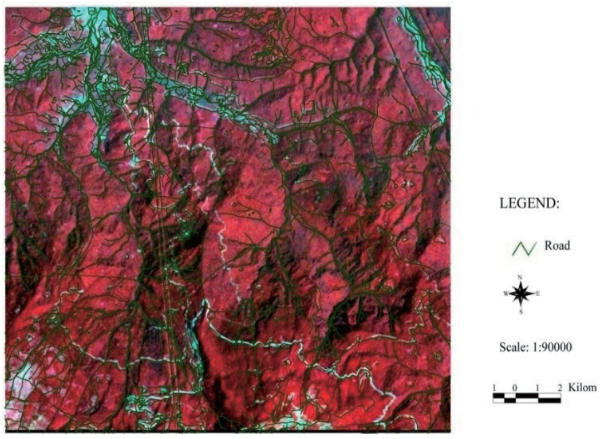
Data Fusion Operation

Fusion operation was used in order to increase the accuracy and ground resolution of multispectral data. This operation was performed using 6 reflective bands with spatial resolution of 30 m associated with an ETM+ panchromatic band with the special resolution of 15m. Fusion operation was completed by PCA method and Geomatica software. To do this approach, first we must get the principal component of the multispectral images (band one, band two, band three or R, G, and B). Then the first principal component, which contains the most information of images, is substituted by the panchromatic image. Finally, the inverse of PC transformation was done to get the new R, G, and B bands of multispectral images from the PCA (Dehghani,2002).

Classification

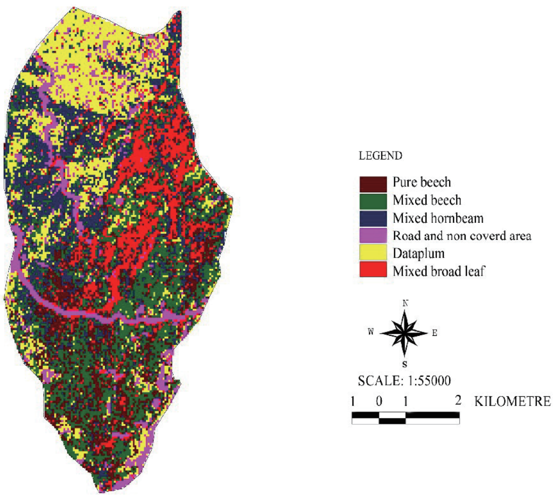
To classify the study area, training areas were chosen through field surveys. These selected training areas were evaluated in terms of separability and uniformity. The heterogeneous samples with overlaying areas, determined by studying the histogram of training samples, Bhattacharya Distance, and transformed divergence were corrected; then, the best samples with least overlaid areas were selected. To optimally separate the objects, we used spectral transformations such as rationings and pc analysis. It has been already proved that spectral rationings are more potential to separate the objects rather sensors' reflective bands.

Figure 2: Image after geometric and orthorectification correction.



The supervised classification was completed for 6 separatale classes, using basic and synthetic bands (ratio, PCA) with maximum likelihood, minimum distance, and parallelepiped algorithms. The best band combinations were determined using channel selection program in Geomatica software based on statistical criterions. Then, the suggested bands by software had been reviewed based on the best separability of training areas. The finally selected bands were used in the classification. Due to test the effects of fusion operation on data classification, satellite data with ground resolution of 30 m was classified by 6 classes without using fusion operation. To do this, all above mentioned levels were performed on data again (Fig 3).

Figure 3: Classification map with 6 vegetative types (with ground separability 30m)



RESULTS

In order to assess the classification accuracy, a comparison was made between the classified map and ground truth map via a pixel-to-pixel method. According to the results, the highest overall accuracy, 34.12%, and kappa coefficient, 23.15%, were related to ML classifier with 6 separatable classes and the best 8 -band combination (4/3+5, 4-3/4+3, 7, 4/7, 4-5/4+5, 4, 5, 4-7/4+7) and 17 input canals including sensor bands and synthetic bands. (table1)

This classified map was compared with ground truth map without performing any fusion operation. The best results ,with the highest overall accuracy of 38.29% and kappa coefficient of 27.7%, was related to the six-class classification with the best 8 band combination (3, 4, 4-3/4+3, 4/3+5, PC_1, 4-7/4+7, 5/4, PC_2)

Table 1: Error Matrix for 6 vegetation types (from ground resolution 15 m images)

	1	2	3	4	5	6	User accuracy
1	1924	79	64	54	104	652	66.87
2	2525	409	292	95	450	1686	7.49
3	1079	94	432	130	245	1167	13.72
4	504	39	83	1200	237	284	51.12
5	765	66	110	76	1689	434	53.78
6	547	97	33	131	87	671	42.84
Producer accuracy	26.19	52.16	42.60	71.17	60.06	13.71	

Overall accuracy:34.12%, Kappa coefficient:23.15%

Discussion and Conclusion

The results of applying the fusion operation for classification showed a reduced accuracy (overall accuracy of 34.12% and kappa coefficient of 23.15%) as compared with the result of forest type classification without fusion operation (overall accuracy of 38.29% and kappa coefficient of 27.7%). This result is in contradiction with Santosh & YusifAli, 2002**;** Pohl and Van Genderen, 1998); Munechika et al., 1993; Hussin & Shaker, 1996. A few studies proved by our results were Saban & Diksit, 2002; Van der meer, 1997.

As it is illustrated in table 1, the highest user accuracy (66.87%) was related to the pure beech class and the lowest user accuracy (7.49%) was attributed to the mixed beech class. This result indicates that the classifier showed the highest resolution for pure beech class, i.e. the pure types could be better separated rather mixed ones. Due to its lower density rather pure beech and its spectral interference with soil reflectance, pure kalhoostan could not be classified as accurate as pure beech. The highest, 71.17%, and the lowest, 13.71%, producer accuracies were assigned to road and non covered area classes and mixed deciduous class, respectively. The estimated overall accuracy indicates that 34.12 % of total pixels had been well classified through this classification method. Moreover, the calculated kappa coefficient, 23.15, showed the errors occurred in assigning pixels to their related classes.

Some of reasons for the lower accuracy of classifications using fusion method are as follows: type of data and fusion techniques, heterogeneity of the area (its rough topography, deep valleys and its resulted shadows) and vegetation type variety widely scattered throughout the study area. According to Zhang, 1999; Zhou et al., 1998, types of data and fusion techniques can contribute to reduce the overall accuracy in classifications using fusion operations.

Dehghani (2002) showed the spectral characteristics of image could be preserved via applying fusion methods such as Wavelet (AWRGB-AWL-SUBRGB).

Since the results showed a low accuracy even before applying fusion operations, it is not suggested to use this type of data to produce forest type maps. In conclusion, it is suggested to use other fusion operations for higher resolution satellite data such as hyper spectral data in the areas with a more homogeneous and uniform coverage.

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