

DATA FUSION OF AERIAL IMAGES COLLECTED BY MATRIX CAMERA AND LINE SCANNER OF DIFFERENT RESOLUTION

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ABSTRACT:

The information collected through the airborne remote sensing are useful for many scientific and practical works. In order to use collected information and existing knowledge of the observed object in the most efficient way for the purpose of solving specific problems, we have to examine their characteristics and if possible fuse them. This article is motivated by the existence of two operative digital sensor systems in Croatia that collect information at different wavelengths and with different methods of taking images. The first sensor is the digital matrix (staring) camera, for three visible channels (V: 0.4–0.5 μm , 0.5–0.6 μm , 0.6–0.7 μm), for near infrared channel (NIR: 0.7–1.0 μm) and the second sensor is the longwave thermal infrared (TIR: 8–14 μm) parallel scan camera. This paper will analyze the possibility of fusing information provided by above sensors, of one not very accessible area (mountainous terrain, with large differences of heights). Digital sensor systems yield multispectral images with different spatial and radiometric resolutions, geodetic and photogrammetric data (geographic maps, GPS data, orthophoto maps, geocoded mosaics), the insight in the field situation (ground truth) and other accessible sources provide inputs for fusion. It will also consider influence of the fusion on the results of classification of mosaics developed on multi-sensor, multi-spectral and multi-resolution digital images from above mentioned two sensor systems. The mosaics made on the basis of the above-mentioned sensor systems have been separately made, and later on the multi-spectral mosaics containing the information from all 5 channels will be created. Spatial and geometrical quality of multi-sensor and multi-spectral images and mosaics were analysed in earlier works, so this article will not deal with this matter, but will use the results of those earlier analyses. The work is an integral part of the research conducted in the scientific project ARC funded by the European Commission.

1. INTRODUCTION

The operative system, which consists of two sensors, two digital cameras, DuncanTech MS3100 and Thermovision THV 1000, is in intensive operational use in Croatia for remote sensing of minefields. The first sensor is the digital matrix camera, for acquisition in three visible channels (V: 0.4–0.5 μm , 0.5–0.6 μm , 0.6–0.7 μm) and near infrared (NIR: 0.7–1.0 μm) and the second sensor is the parallel scan camera which collects data in the longwave thermal infrared (TIR: 8–14 μm) area. These two cameras are different in many ways, they collect data in different wavelengths and they have different principle of collecting data. DuncanTech MS3100 is the digital matrix camera (sensor resolution 1392x1039 pixels) and it produces images in central projection. Thermovision THV 1000 collects the data by scanning 5 parallel lines at the time in 80 rows with resolution of sensor 5x400 pixels. The reason for this particular camera to be used instead of matrix camera (available on the market) is the sensor resolution. The matrix TIR cameras have resolution of 320x240 pixels and for that reason the parallel scan camera is in use. The flights for collecting the images for the purpose of humanitarian demining in Croatia took place at the height of 130 m and higher above the ground. Because of small flight height, the small surface of each image and a large number of images, the orientation in space has become difficult. This problem can be solved by mosaicking the selected images of the an area and geocoding of the whole mosaic. Therefore, for practice use of mosaics, it is necessary to know what can we expect from it in geometric and radiometric way. In the previous work (Krtalić, A., Fiedler, T., 2003.) we considered the spatial quality of both (TIR and VNIR) mosaics. In this article the results of data fusion from this mosaics and other available information was done and later on analyzed. This is important especially for TIR mosaic (data fusion at pixel level) and its influence on multispectral image in order to

achieve better understanding of scene and for better interpretation of the terrain.

2. MOSAICKING AND GEOCODING OF MOSAICS

For purpose of mosaicking there were 6 VNIR and 6 TIR images chosen which were collected in two strips in the same period of time. VNIR and TIR images covered approximately the same surface of the terrain. VNIR images are RGB images created from infrared (IR), red (R) and green (G) channels. The correlation between blue and green channel is over 92%, and for that reason the multispectral (RGB) image was created with only 3 above mentioned instead of all 4 channels. The first step was mosaicking along the strip and after that mosaicking between strips was carried out. After mosaicking, the both mosaics were geocoded. VNIR mosaic was geocoded according to digital orthophoto (DOF) of the same area and later on the TIR mosaic was registered to geocoded VNIR mosaic. The size of pixels are: 0.5 m on DOF, calculated spatial resolution of VNIR mosaic (according to flight height and used objective) is 0.2 m, and TIR mosaic 0.5 m. Geocoded mosaics, and every other outputs in this work have the same size of pixel and that is 0.1 m. This action has been done so as to facilitate the conversion of images of different resolution (multiresolution images) and different wavelength (multispectral) on the same size for further integrations and analysis (principal components, classification). After geocoding all geodetic basis (map of the scale 1:5000, DOF 1:5000, VNIR mosaic, TIR mosaic) was displayed on the screen one above each other (in layers), and cut in the same size. Now we have multispectral images with the same pixel dimension (but different spatial resolution!) which cover the same terrain and give us different pieces of information about the same objects on the scene.

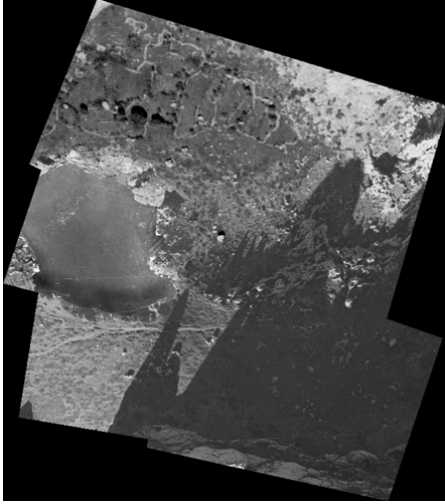


Figure 1. Part of DOF (with shadow)

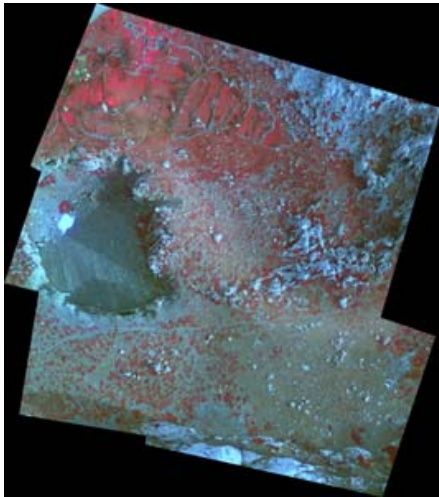


Figure 2. Geocoding VNIR mosaic over DOF

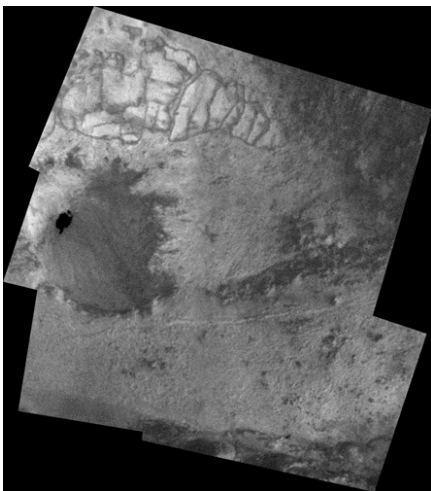


Figure 3. TIR mosaic registered over VNIR mosaic

3. ENHANCEMENT OF FEATURES ON IMAGES



Figure 4. Picture of terrain (used for ground truth)

Areas under vegetation, bare land, stones and rocks are blending on the scene. The only artefacts on the scene are stonewalls. In order to define the number of classes on the scene more easily, the existing images must be differentiating as well as possible.



Figure 5. Picture of terrain (used for ground truth)



Figure 6. Picture of terrain (used for ground truth)

3.1. Enhancement linear features and vegetation on scene

For enhancement of linear features on R and G channel of VNIR mosaic filters *Sobel* are used. Locally adaptive contrast enhancement was done with *Volterra/Unsharp* filter. Vegetation on the scene was treated with *Gram-Schmid* filter on IR and R components of VNIR channels, and filter TVI executed on the IR and R channel of VNIR mosaic. After those enhancements there were 11 different images of the same terrain produced (TIR, 3 VNIR components, 2 Volterra/Unsharp filter on IR and R channels, 2 Sobel filter on R and G channels, 2 Gram-Schmid filter on 3 VNIR components and TVI filter on IR and R channels).

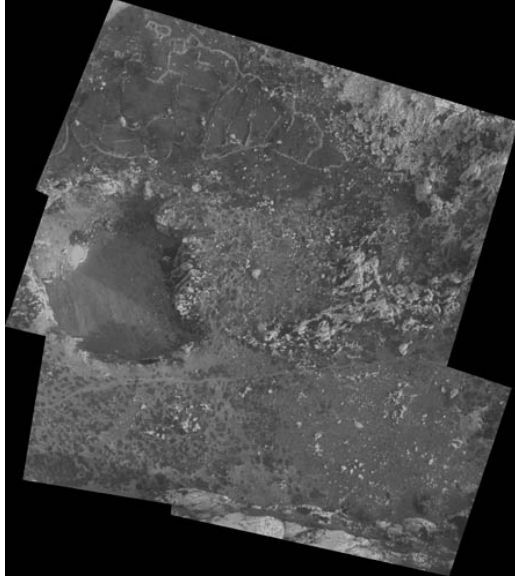


Figure 7. R channel from VNIR treated with Volterra/Unsharp filter

3.2. Principal components

From the above-mentioned 11 images of the same area, 11 principal components are produced. In this way, another information about specific area is produced, the first principal component which, in this case, contains 82% of information of the scene.

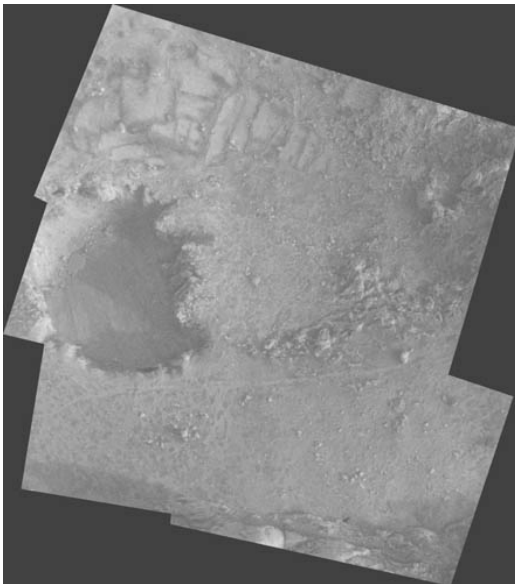


Figure 8. First principal components created of all layers

4. CLASSIFICATION

4.1. Sampling of scene

From the above-mentioned images of terrain the 10 combinations of images were done (5 with TIR mosaic and 5 without TIR mosaic). On these combinations of images, the recognition of class was carried out. The combinations were created with TIR and VNIR mosaic and their enhancements, and the same combinations without TIR mosaic for getting

conclusion of benefits of influence TIR mosaic (component) on final data fusion. The combinations are: all images; all images without TIR image; TIR and 3 VNIR components; just 3 VNIR components; TIR, 3 VNIR and 2 Volterra/Unsharp components; 3 VNIR and 2 Volterra/Unsharp components; TIR, 3 VNIR and 2 Gram-Schmid components; 3 VNIR and 2 Gram-Schmid components; TIR, 3 VNIR and 2 Sobel components; 3 VNIR and 2 Sobel components.

4.2. Class



Figure 9. Picture of terrain (used for ground truth)

After sampling of scene on above mentioned combinations of images of specific terrain and looking at the pictures taken from the ground (ground truth data) the following conclusion was made. We can recognize 5 classes on the scene and these are: bushes and high grass; low grass; rocks, separately stones and stonewalls; bare land and snow. According to sampling of scene on mentioned combinations, only the snow can be well defined without any doubt in all combinations with TIR component. For instance, in combination with only 3 VNIR components and combination with 3 VNIR and 2 Sobel components we can't do this. The second best class for recognition is bushes and high grass. The recognition of this class is also better in combinations with TIR component. The deviation in recognition of this class is bigger in combinations of images without TIR component. Shadows in the hole in the ground (named Kapljuv), as well as below the rocks, also present the big problem in determining the class because of the false information, which we have got from this part of terrain. The lower influence of shadows on differentiation of class is in combination of images with TIR component. The best example for this is the bare land in Kapljuv.

4.3. Automatic classification

The number of classes was defined and auto-classification, with 6 classes was done. The inputs for particular classification were combinations mentioned in chapter 4.1. with four addition combinations with following inputs: TIR, 3 VNIR, 2 Volterra/Unsharp and 2 Sobel components; 3 VNIR, 2 Volterra/Unsharp and 2 Sobel component; and second one: TIR, 3 VNIR, 2 Gram-Schmid and TVI component; 3 VNIR, 2 Gram-Schmid and TVI components; 3 VNIR, 2 Gram-Schmid and TVI components.

5. ANALYSIS

Statistical indicators of automatic classification (dendrogram, error ellipsis, co-occurrence matrices) make us aware of the fact that the combination of input data containing TIR component yield better results than those not containing it. It is obvious that the basic topological objects can be well differentiated in the field through automatic classification itself. Hence, the resulting presentation of the field with 3 classes illustrates very well the relationships in the field. Three presented classes are (given in the chapter 3): vegetation, rocks and stones, and bare soil. The best result is obtained through automatic classification of the following input data combinations: TIR, 3 VNIR and 2 Volter/Unsharp filtered presentations (VNIR-G, VNIR-R).

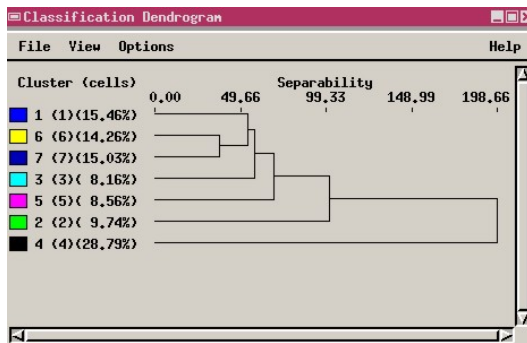


Figure 10. Dendrogram of the best auto-classification

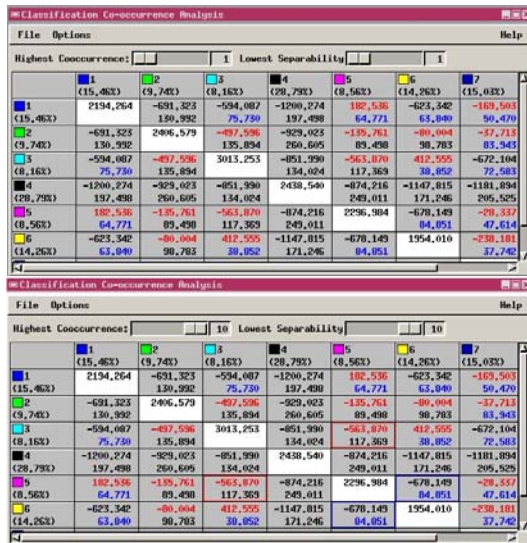


Figure 11. Co-occurrence matrix with minimum and maximum co-occurrence and separability of best auto-correlation with all classes

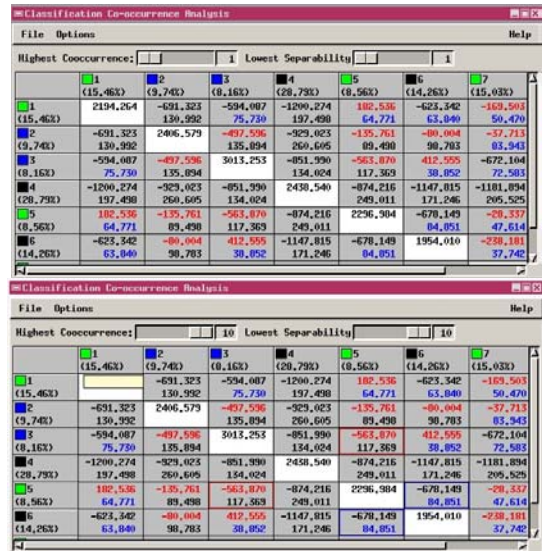


Figure 12. Co-occurrence matrix with minimum and maximum co-occurrence and separability of best auto-correlation with 3 classes (GREEN: vegetation, BLUE: rocks and stones, BLACK: bare land)

6. CONCLUSION

Out of the above given data it can be seen that no combination includes DOF. It has been done on purpose because the observed part of the field (due to large height differences) is largely covered with shadows that make a good insight into the field impossible and introduce anomalies into the radiometric processing. The contribution of TIR component can be seen already in the automatic classification and through simple connection of individual classes after the classification. While the result of the automatic classification of VNIR components only indicates the connection between the series of images making the mosaic, this line is not visible in the automatic classification of TIR and VNIR components. The influence of the terrain parts covered with shadows is also less expressed in the results of automatic classification with TIR components. The inaccuracy of the automatic classification can be noticed in the class snow that is attached to the rocks.

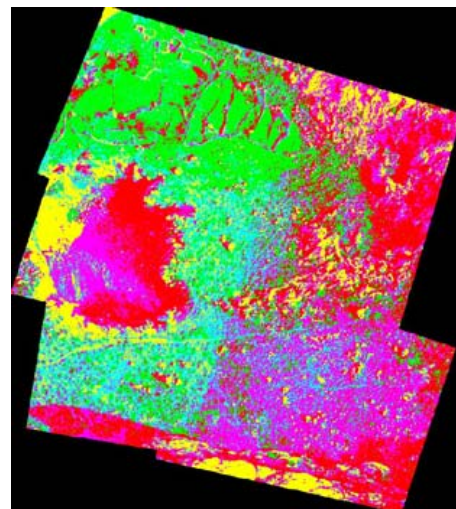


Figure 13. Result of auto-classification with all mentioned inputs except TIR component

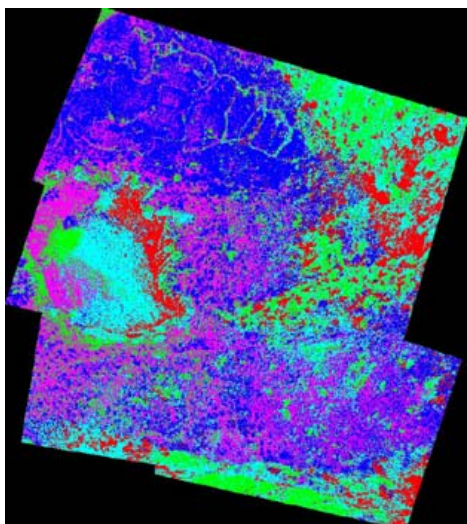


Figure 14. Result of the best auto-classification (with TIR, IR, R, G channels of VNIR mosaic and 2 images (R and G channels of VNIR mosaic) treated with Volterra/Unsharp filter

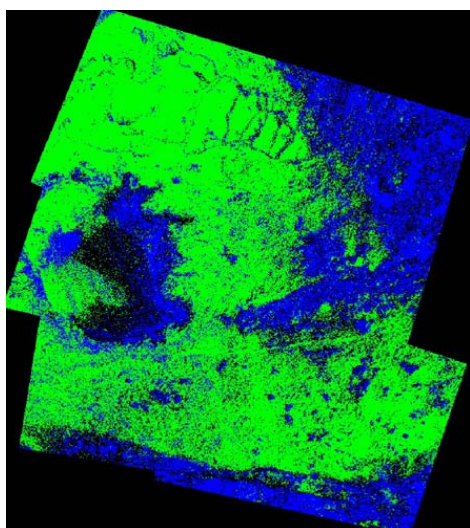


Figure 15. The best auto-classification result after class reduction (from 6 class to 3 different group of features: GREEN: vegetation, BLUE: rocks and stones, BLACK: bare land)

7. REFERENCE

DuncanTech, *MS3100 Digital Multispektral Camera*. Auburn

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