Semi-Automated Detection and Extraction of Unexploded Ordnances using the Object Based Image Analysis Approach

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ABSTRACT: This paper describes application of methodology for semi-automatic interpretation of digital multisensor images for the purpose of detection and extraction of unexploded ordnances developed within the EU FP7 TIRAMISU project on the site of exploded ammunition depot in Padjene, Croatia. Process relies on combining the advantages of the both radiometric and object based image analysis using the statistical tools where lessons and rules learned on the test image are then applied on other images of the same scene but different location. In this case methodology has been applied on aerial images acquired by consumer DSLR camera mounted on helicopter flying at average height of 300 meters above ground level. Prior to this application perspective preliminary result was achieved for aluminum objects. During the further application, image processing for improved detection and extraction of corroded objects was defined and evaluated. Achieved results of methodology application on different scenes at same location (exploded ammunition depot). At the end, perspective of further research and analysis of this methodology is stated.

Key words: Remote sensing, Image processing and analysis, OBIA, UXO

1. Introduction

In September 2011 severe forest fire caused the explosion of ammunition storage depot in Padjene, Figure 1. For addressing these situations, ground teams of demining experts are engaged for clearance and recovery tasks. In scope of ongoing EU FP7 TIRAMISU project an idea of research and development approach to this problem was initiated. This idea resulted in deployment of data acquisition module of TIRAMISU Advanced Intelligence Decision Support System (T-AI DSS) – multisensor imagery acquisition system (Bajic, 2010) for aerial survey of wider area of ammunition storage.

Density distribution of the scattered ammunition and parts was estimated by the Task force of Croatian Ministry of Defense for recovery: inside the radius of 800 m form the ammunition storage center 70 % of the pollution was expected, while additional 20 % in the radius of 1000 m (Bajic, 2012). The results of this catastrophe were scattered unexploded ordnances (UXOs) varying from rifle ammunition to the cluster bombs. Nonetheless, due to the explosion UXOs were found in various forms: intact, slightly or significantly deformed, burned, corroded or with the original paint preserved.

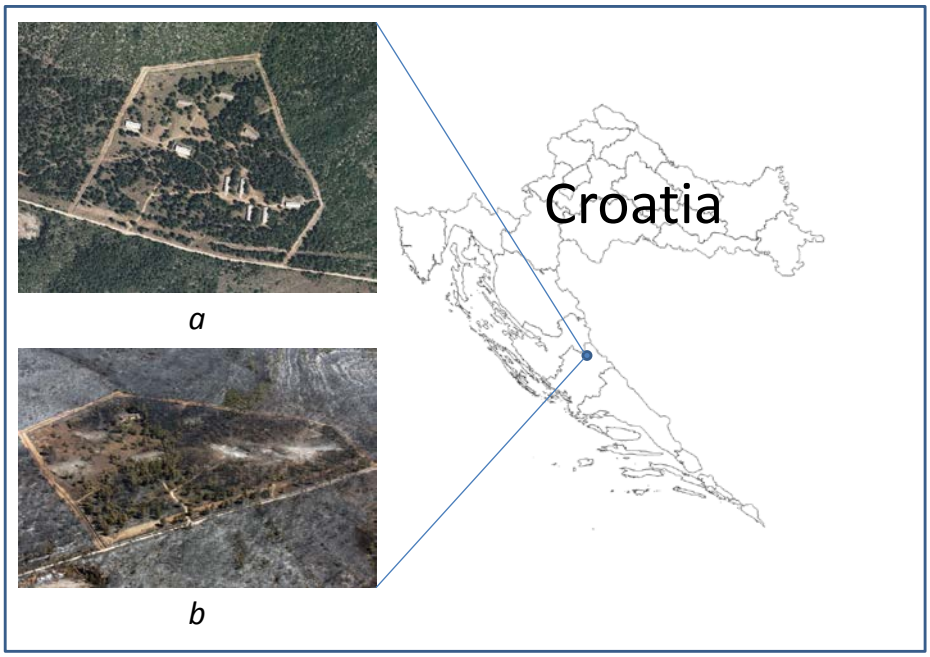

Figure 1 Images of ammunition storage depot Padjene: a) digital orthophoto before the explosion (available at URL 1), b) oblique aerial image after the explosion (available at URL 2)

2. Methodology

Data used for UXO detection and extraction at the exploded ammunition depot were aerial RGB images made by commercial Nikon D90 camera. Methodology used for data processing is methodology for semi-automatic interpretation of digital multisensor images for the purpose of detection and extraction of unexploded ordnances (Racetin and Krtalic, 2014), Figure 2. Process relies on combining the advantages of the both radiometric and object based image analysis (OBIA) using the statistical tools where lessons and rules learned on the test image are then applied on other images of the same scene but different location.

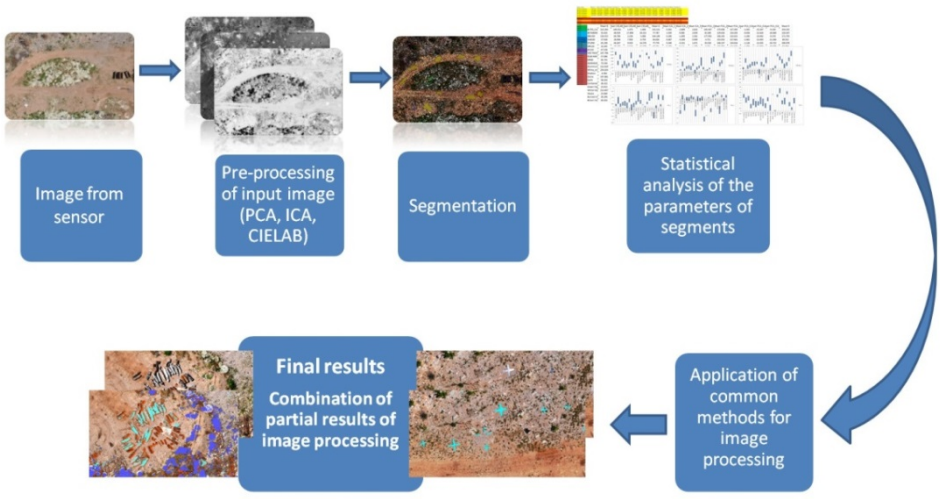

Figure 2 Shematic Representation of Methodology for Semi-Automatic Interpretation of Digital Multisensor Images (Racetin & Krtalic 2014)

3. Results and discussion

Prior to this application perspective preliminary result was achieved for aluminum objects (Racetin et al, 2014). During the further research, image processing for improved detection and extraction of corroded objects was defined and evaluated. Thresholds for pixel values in every layer (R, G, B, Principal components, Independent components) were defined for delineation between classes for the test image which contained most of the UXOs found in the ammunition depot. These thresholds are not something that is directly applicable on any image; they represent more a kind of guidelines to the interpreter. A simple classifier which ranked the highest possibilities according to the already defined thresholds was programmed. In the "Sample" column mean values of certain segment are inserted. If the mean value of segment in specified channel (Red, Green, Blue, 1st Principal Component, etc.) is occurring in the defined interval for some class (UXOs, Vegetation, Stone, etc.) value 1 is set, in opposite 0 value is placed. Upper and lower threshold values for class in specified channel are defined on the basis of statistical analysis (Racetin and Krtalic, 2014). Sum of row is the sum of occurrences of sample value in different classes which can be regarded as weight. Simple possibility of occurrence is calculated by dividing the one occurrence with the weight for that channel. Weighted sum is the sum of these probabilities. Higher values of this weighted sum for specific class indicate the greater chance of this sample belonging to it.

Table 1 Example of sample classifier, only few classes are presented here. Mean values of specific segment are exported from software supporting OBIA and then pasted in "Sample" column. Classifier then calculates the weighted sum of occurrences according to the thresholds calculated using the statistical analysis.

	Sample	BL755 Container	BETAB 500	RBK 250	SAB 100	STURM	MR 120	AS 130	R100 M69	WARHEAD OF S-24B	SUM
B	46.25	0	0	0	0	0	0	0	0	0	0
G	45.19	0	0	0	0	0	0	0	0	0	0
ICA_1	0.337	0	0	0	0	0	0	0	0	0	0
ICA_2	-1.177	0	0	0	0	0	0	0	0	0	0
ICA_3	-0.861	0	0	0	0	0	0	0	0	0	0
Lab_a	7.959	0	1	0	1	0	0	1	0	1	4
Lab_b	1.666	1	0	1	0	0	0	0	0	0	4
Lab_L	28.25	0	0	0	0	0	0	0	0	0	0
PCA_ICA_1	0.2162	0	1	0	1	1	0	1	0	1	5
PCA_ICA_2	-1.259	0	0	0	0	0	0	0	0	0	0
PCA_ICA_3	-2.052	0	0	0	0	0	0	0	0	0	0
PCA_1	-129.6	0	0	0	0	0	1	0	0	0	2
PCA_2	-4.47	0	0	0	0	0	0	0	0	1	1
PCA_3	-10.89	0	0	0	0	0	0	0	0	0	0
R	58.55	0	0	0	0	0	0	0	0	0	0
	W_SUM	0.25	0.45	0.25	0.45	0.20	0.50	0.45	0.00	1.45	

Although the exact values of these thresholds are hardly a rules for direct delineation of targeted objects, the ratios between classes should stay preserved on whole set of images. Between the thresholds one showed great results and repeatability with the exact value. Values in channel ***α*** from

transformation to CIELab colour space which are higher than 15 strongly correlate with the corroded UXOs. Examples of achieved results are presented on following images (Figure 3), on black and white images white pixels represent object of interest.

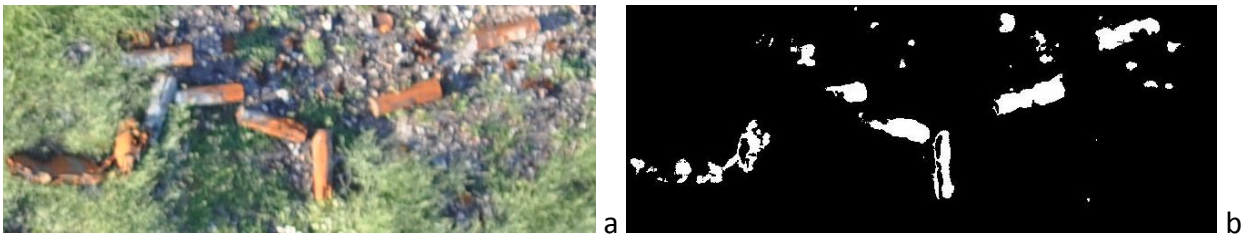

Figure 3 a) Input RGB image b) Result of processing

4. Conclusion

Implementation of procedures presented in this paper does not require any specialized knowledge or proprietary software to be applied. Although statistics behind it are complex, the procedure itself is not computationally demanding and it is easy to execute. This implementation is designed to be semi-automatic, meaning that it should serve as a help to the human interpreter rather than a replacement for him. It is clear that no matter what accuracy and reliability image processing and classification algorithms achieve, ground clearance teams will definitely watch their steps instead of walking directly to the coordinates exported from computer software.

Concerning the future steps, potential of object based image analysis has not yet been exploited to its limits. Because of the nature of the shape of targets – UXOs (some of them preserved their original shape, some suffered only minor damage and deformations, while some are in completely unrecognizable form) it is difficult to set geometry values for classification using the OBIA. Considering that one object can appear in different conditions (burned, corroded or with the original paint preserved), or it can be located in the sun or in the shadow additional resources will be invested in the research of textures parameters.

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References

Bajic, M., (2010): ***The advanced intelligence decision support system for the assessment of mine suspected areas,*** Journal of ERW and Mine Action, James Madison University, Issue 14.3, Fall 2010, pp. 69-75

Bajic M., (2012): ***Airborne wide area general assessment of the environment pollution due to the exploded ammunition storages***, The 9th International Symposium “Humanitarian demining 2012”, IARP International Advanced Robotics Programme 24th to 26th April 2012 Sibenik, Croatia, Book of Papers, pp. 117-183.

Racetin I., Krtalic, A., (2014): ***Methodology for Semi-Automatic Interpretation of Digital Multisensor Images for The Purpose of Detection and Extraction of Unexploded Ordnances***, South-Eastern European Journal of Earth Observation and Geomatics 3, No2S, pp. 567-572

Racetin, I.; Krtalic, A.; Candjar, Z. (2014): ***The concept of method for semi-automatic interpretation within T-AI DSS***, International Symposium "Mine Action 2014", Book of Papers, pp. 87-92

URL 1: State Geodetic Administration Geoportal**,** ***http://geoportal.dgu.hr/viewer/*** [accessed: 20.03.2015.]

URL 2: Image gallery of ammunition depot in Padjene after explosion, ***http://www.24sata.hr/galerija/news/ostali-temelji-i-krater-vojarna-u-paenama-vise-ne-postoji-235129/456359*** [accessed: 20. 03. 2015.]