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Minefield Indicators and Analytical Mine Contamination Assessment in Scientific Projects and in Practice

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Abstract

The key factors of the application of the airborne remote sensing technology for humanitarian demining are the minefield indicators [1] or the indicators of mine presence and the indicators of mine absence [2] and the analytical assessment of the contamination by the landmines [3]. The basic simple concept of the minefield indicators was given in [1], where it was related to the ordinary physical features of the artificial and natural objects in the mine suspicious area. Similar concept was used in other works, while in [2] were introduced signatures of the minefield indicators and additional contextual features. The signatures depend on the sensors used for the remote sensing and this aspect was thoroughly considered in [2]. The contextual features can be derived by the analytical assessment of the terrain contamination by the land mines [3], addition of the formalized knowledge enables efficient use of the indicators for the support of the decision making and for suspicious area reduction [4].

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1 Introduction

The key factors of the application of the airborne remote sensing technology for the humanitarian demining are the minefield indicators [1] or the indicators of mine presence and the indicators of mine absence [2] and the analytical assessment of the contamination by the landmines [3]. The basic simple concept of the minefield indicators was given in [1], where it was related to the ordinary physical features of the artificial and natural objects in the mine suspicious area. Similar concept was used in other works [4], while in [2] were introduced signatures of the minefield indicators and additional contextual features. The signatures depend on the sensors used for the remote sensing and this aspect was thoroughly considered in [5], [2], and [6]. The contextual features can be derived by the analytical assessment of the terrain contamination by the land mines [3]; addition of the formalized knowledge enables efficient use of the indicators for the support of the decision making and for suspicious area reduction [2]. The development of the concept of the minefield indicators is the main topic of the paper, aimed to encourage further development and advancement. We consider the time period from 1999 to 2009, e.g. from [1] to [7], [8]. In [7] was for first time applied the operational project the concept of the minefield indicators and the analytical assessment of the contamination by landmines, whereas the formalization

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of the expert knowledge was for first time introduced in [8]. The experience and the lessons learnt are briefly commented in following text.
The phases of the development of the minefield indicators from initialization to the application are:

- definition of the initial list of the indicators, expected to be suitable for the considered environment, mine contamination status and the war history,
- estimation of the expected detection characteristics of the minefield indicators in dependence on the applied sensors and wavelengths of the airborne or space borne acquisition of images, [5],
- collecting the minefield indicators in the ground truth field missions, [9], [10], [11], [12],
- processing of the imagery and extraction of the signatures of the minefield indicators, [6],
- estimation of the confidence of the minefield indicators,
- definition of the strong (military) minefield indicators of mine presence (IMP),
- definition of the non military minefield indicators of mine presence (IMP),
- definition of the indicators of the mine absence (IMA),
- estimation of the confidence of the minefield indicators,
- definition of the relative importance to each class and to each particular minefield indicator, in dependence to the context, made by expert,
- definition of the membership functions to each class and to each particular minefield indicator, in dependence to the context, made by expert,
- evaluation of the influence of the minefield indicators on the results of interpretation, mainly by the confusion matrix and its derivatives (commission and omission errors), [14],
- validation of the project results by the comparison with the results obtained by the conventional mine action technology, [15].

2 Minefield indicators in the scientific projects SMART and ARC

In the frame of the project SMART was realized a whole process of the development of minefield indicators and at the end was used two groups of them: the indicators of mine presence (IMP) and the indicators of mine absence (IMA). Four regions in Croatia were analyzed, a total area was 48 km^2: Glinska Poljana, Pristeg, Čeretinci and Blinjski kut. Both groups of the minefield indicators were identified, checked by ground truth mission, approved by experts, furnished with attributes (confidence, relative importance, membership function), and used in the interpretation. Although the goal of SMART project was decision support for the mine suspicious area reduction, only two classes of the indicators of mine absence (IMA) were identified and approved. Thus, in the future application of the minefield indictors more efforts should be focused on the IMA due to their importance.

Indicators of mine presence (IMP)

Mine records – polygon or line or points of minefield.
Confrontation zone reconstructed analytically.
Dominant slopes and heights at location that enable visual surveillance and gun fire protection of minefields.
Houses used by the military, between first lines of warring parties.
Bunkers.
Concealed paths to trenches or bunkers.
Damaged, destroyed houses.
Shallow river and creek locations, suitable for crossing.
Irrigation, drainage channels.
Shelters for tanks, heavy weapon.
Trenches (T) and man-made embankments (E).
River shores, at mean water level.
Bridges, inclusive destroyed bridges.
Tracks not longer in use.
Agricultural areas no longer in use.
Crossroads, crossings of main roads with tracks no longer in use.
Forest edges.
Power supply poles.
Soft edges of hardtop roads.
Mine accidents and incidents.

Indicators of mine absence (IMA)

Cultivated land.
Asphalt roads.

Strong minefield indicators

The minefield indicators can be further divided into two classes:
- the land cover and the land use,
- the strong indicators (indicators related with military activities and mine laying process).

The identification and detection of the land cover and the land use minefield indicators can be made by various methods of the unsupervised or supervised classification and processing, at the pixel level or at the region level, [2]. The success of the detection of these indicators depends on subtle differences of the vegetation that should be determined. Therefore for this type of minefield indicators are needed different sensors and wavelengths. In SMART [2], [5] were used multispectral scanner with eleven channels, four wavelengths SAR (two bands with full polarization, interferometry) and color infrared aerial photography. The strong minefield indicators are remnants of the war activities and their contribution to the success of the project is more significant than the influence of the land cover and the land use minefield indicators. The identification and the detection of the strong indicators require high spatial resolution and the most important is the time lag between the emergence of the object that is strong minefield indicator and the time when it was detected. In accordance to experience in first operational project in which the minefield indicators are used, Deployment of the Decision Support System for Mine Suspected Area Reduction [7], the combined time and spatial resolution are more important than the spectral resolution. In [7] was analyzed area of nearly 150 km^2 in the regions of the communities Gospić, Bilje and Drniš. Types of the minefield indicator are similar to that in SMART but new indicators of the mine absence were identified. They are: water areas (in mine suspected area in community Bilje) and the very steep terrain of the mountain Velebit.

Analytical mine contamination assessment

The use of the minefield indictors is meaningless without the understanding of the actual status and the history of the process contamination by landmines in the particular region. While the ordinary practice in the mine action centers has weak this aspect in their project planning, we have introduced analytical assessment of the contamination by landmines [3], as an important part in the scientific projects [2], [4]. At the current status [16], the analytic assessment of the contamination by landmines has reached an advanced level if compared with [3] and [8]. The new kinds of outputs of the analytical assessment in [16] are general requirements and special requirements for the acquisition and providing the data and the information of the considered mine suspected area.

Conclusion

The ten years history of the minefield indicators that started by [1], was advanced by [2], reached in 2008./2009. the operational use for first time.

The indicators of mine presence, indicators of mine absence, strong indicators were recognized as useful paradigm and they are in further use in operational projects.

Further development of the concept of the minefield indicators is expected.

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