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Hyperspectral Imaging for Landmine Detection

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Research context and motivation

- Third world countries have long suffered from the problem of landmines that threaten citizen.
- Unfortunately, the techniques that are used in the demining process such as metal detectors, trained dogs, and mechanical clearance using armored vehicles are generally slow, expensive and dangerous.
- Because of this and knowing that new technologies may provide effective alternatives, we propose to use the hyperspectral images.
- Hyperspectral imaging plays an important role in several scenarios involving target detection, among which landmine detection is a very challenging one. we developed a procedure based on pixel similarity measures to detect rare pixels present in a scene. The method can be combined with existing detection algorithms in order to reduce the complexity and improve the performance. The developed method was tested on various types of hyperspectral images where the spectra of the landmines were planted in different proportions in the scenes.
- The amount of data captured with hyperspectral imaging is very large. Moreover, the processing of this amount of data can be very complex and time consuming. Therefore, the need for dimensionality reduction in hyperspectral imaging motivated many researches in this field.

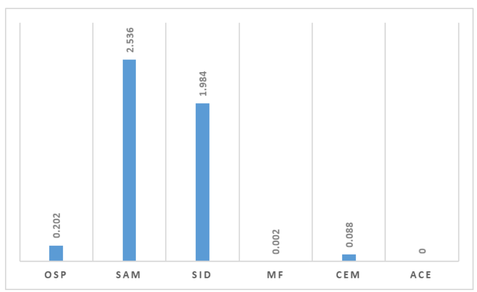
Addressed research questions/problems

- Which classification techniques are suitable for the detection of landmines using hyperspectral imaging?
- Can we decrease the complexity of classification techniques?
- How to decrease the dimensionality of huge hyperspectral imaging data at the pixel level?
- How to decrease the dimensionality of huge hyperspectral imaging data at the band level?

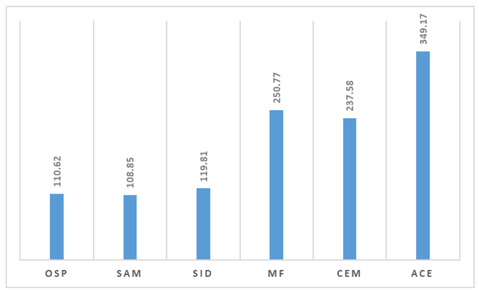
Adopted methodologies

- An analysis has been carried out to evaluate the performance of different classification techniques while trying to detect 6 types landmines. In this study, we compare the performance of the tested algorithms according to three criteria: Probability of detection (Pd), False Alarm Rate (FAR), and computation time (CT).
- We tested 7 classification algorithms on different images taken from AVIRIS (airborne visible/infrared imaging spectrometer). The spectrum of the 6 mines planted in the image was mixed in different percentages(between 0.9 and 0.1) with the spectra of a green leaf; the background material around the mines.
- The results show tha ACE are good algorithms for landmine detection. But it has the highest CT.

SAM: Spectral Angular Mapper
OSP: Orthogonal Subspace Projection
ACE: Adaptive Coherence Estimation
CEM: Constrained Energy Minimization
SID: Spectral Information Divergence
MF: Matched Filter



Average FAR for each detection method in all the types of landmines



Average CT for each detection method in all the types of landmines

Novel Contributions

- In order to foster the detection of all the types of mines in one scan, and to reduce the complexity produced by ACE method (has the highest performance) we proposed to detect 6 types of landmines using two similarity methods: pixel intensity(PI) and Relevancy. The idea is to apply pixel similarity methods in order to detect the rare pixel presented in the scene and then applying the ACE method to the resulting rare pixel. The process to apply the PI method is as follow: for each pixel, we compare the similarity methods of each pixel to the mean of 8 neighbors of this pixel, if the similarity is less than a certain threshold, so we can consider that this pixel is rare and then we store it in a new dataset. This procedure is repeated for all the pixels in all the bands. So, we obtain a new dataset containing only the rare pixel presented in the scene. Finally, we apply ACE method to the resulting rare pixel. Using the new method, the computational time has decreased up to 60% while conserving 100% Pd and FAR=0 when applied on original image.

Average Computational time and FAR for each method when the mine % between 0.9 and 0.14

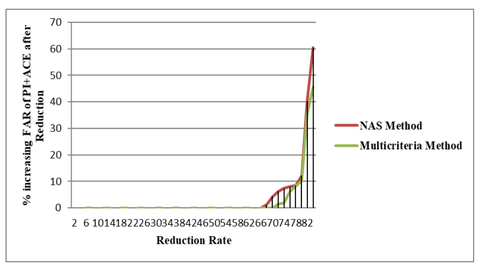
- When the mine % decrease to 0.1, the advantages of the developed method over the existing methods concerning the FAR are very evident.

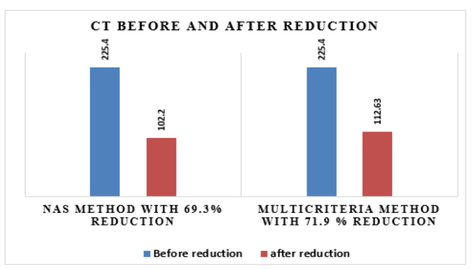
Algorithm/target	PMN	VS-2.2	VS-50	N°4	M411	TM-46
ACE	1	0.9975	1	1	1	1
MF	1	0.8757	1	0.9142	1	1
CEM	0.8858	0.5875	0.9043	0.8291	0.6660	0.8823
OSP	1	0.9121	1	0.9232	1	1
SID	0.9737	0.3254	0.7235	0.6632	0.7828	0.4583
SAM	0.9737	0.3864	0.7520	0.6979	0.8141	0.4830
MTCEM	1	0.8939	0.9782	0.7936	0.9530	0.9283
SumCEM	0.8828	0.9028	0.9939	0.8606	0.94114	0.9530
WTACEM	1	0.9333	0.8939	0.9217	0.9840	0.9936
Relevancy+ACE	1	1	1	1	1	1
PI+ACE	1	1	1	1	1	1

Algorithm/target	PMN	VS-2.2	VS-50	N°4	M411	TM-46
ACE	0.00001	4.58790	0	0	0.4300	0
MF	0.02122	6.24759	2.22157	1.58750	3.25400	5.58746
CEM	0.88584	5.58750	3.25780	2.22358	2.87569	4.56387
OSP	0	4.25460	2.01870	1.21557	1.87968	2.12736
SID	1.12546	1.85334	3.54278	1.05476	2.50173	1.99273
SAM	2.07365	6.66879	3.00015	2.22456	1.12456	4.73538
MTCEM	0.87327	5.55542	1.40783	3.78257	2.22145	2.16753
SumCEM	0.65371	5.79838	2.22278	2.51425	5.89347	4.12763
WTACEM	0.05600	5.22765	1.88875	1.16135	2.55214	3.224521
Relevancy+ACE	0	0.000042	0	0	0.000093	0
PI+ACE	0	0.00032	0	0	0.000058	0

Average Pd and FAR for each landmine type when the mine % between 0.14 and 0.1

- After verifying that PI+ACE method has the best performance concerning FAR, CT and Pd, we study the effect of net analyte signal (NAS) and multicriteria band selection methods on the performance of PI+ACE method.
- A highly reduced Hyperspectral image at the pixel and band level is obtained.
- Using NAS we can obtain a reduction rate of 69.3% without losing the performance of PI+ACE method, whereas Multi criteria method can obtain a reduction rate of 71.9% without losing the performance of PI+ACE.





Future work

- Prepare an area contain soil with vegetation and some types of landmines.
- Uses hyperspectral sensor to collect information about the area.
- Try to detect landmine in this area using the database signatures of landmins.

Submitted and published works

- . ***Mahdi Khoder***, *Serge Kashana, Jihan Khoder, Rafic Younes, "Multicriteria classification method for dimensionality reduction adapted to hyperspectral images" Journal of Applied Remote Sensing, Vol 11,No 2, 2017*
- *M. Zucchetti, **M. Khoder**, I. Makki, R. Younes, C. Francis and T. Bianchi, "Landmines," 2017 First International Conference on Landmine: Detection, Clearance and Legislations (LDCL), Beirut, 2017, pp. 1-6. doi: 10.1109/LDCL.2017.7976954*
- *Makki, I., Younes, R., Francis, C., Bianchi, T., Zucchetti, **M, Khoder** J., Rizk P.,"RBF Neural Network for Multitarget in Hyperspectral imaging", EUVIP conference 2018*
- ***M.KHODOR** et al "landmine detection in hyperspectral imaging based on pixel similarity" ," In progress"*

List of attended classes

- STIP 502 – Advanced Image Processing (15/06/2017,5 credits)
- STIP 504 – Advanced Signal Processing (05/03/2017, 5 credits)

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PhD program in
Electrical, Electronics and Communications Engineering