Report on the demonstration of ALIS in Europe, in April 2005

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1. Introduction

ALIS (Advanced Landmine Imaging System), is a novel landmine detection sensor system combined with a metal detector and GPR, which was developed at Tohoku university, Japan. This is a hand-held equipment, which has a sensor position tracking system, and can visualize the sensor output in real time on a head-mounted PC display. In order to achieve the sensor tracking system, ALIS needs only one CCD camera attached on the sensor handle. The new hand-held system ALIS is a very compact and do not require any additional sensor for sensor position tracking. The acquired signal from the metal detector and GPR is displayed on the PC display on real time, and the sensor trace can be checked by the operator. At the same time, the operator can visually recognize the signal on the same display. The CCD captured image is superimposed with the GPR and metal detector signal, therefore the detection and identification of buried targets is quite easy and reliable.

Field evaluation test of ALIS was conducted in Afghanistan in December 2004, and we demonstrated that it can detect buried antipersonnel landmines, and can also discriminate metal fragments from landmines. Then, in April 2005, was demonstrated at test sites in Europe, which include JRC (Joint Research Centre, Ispra, Italy), SWEDEC (Swedish EOD and Demining Centre, Eksjo, Sweden), and CROMAC (Croatian Mine Action Centre, Croatia, Sibenik) on 19th, 25th, and 28th April 2005, respectively. This report briefly summarizes these tests.

2. Test conditions

The test conditions of the demonstration sites, are summarized in Table 1. Only during the test at JRC, it was rainy when the data #2 and #3 were acquired. The conditions of each test are shown in Figure 1.

3. Test results

ALIS always outputs two figures, namely metal detector and GPR. In each figure, the left figure shows a metal detector response and the right figure shows a GPR horizontal slice (C-scan) at one depth, which is extracted from processed 3-D GPR dataset. The black asterisks shown in figures indicates the same position in metal detector and GPR images. Due to the offset of the sensor head of the metal detector and the radar antennas in ALIS, the location of the asterisk is also shifted by 20 cm in y-direction. Note that the units in all the images are “point”, not metric, and 1 point corresponds to approximately 5 mm.

(a) JRC
Figures 2-4 show the images of the data #1-3. We used landmine model, which were buried at known locations. In Figure 2, the image of a landmine is not so clear, because many clutters are appearing in GPR image. However it is possible to determine the buried location of a landmine by observing both the metal detector and GPR images. In Figures 3 and 4, we can see focused landmine images at the same positions of metal detector responses. Lane #3 has more vegetation and more inhomogeneity than Lane #2 and 5, thus there are less clutter in Figure 3 and 4 than Figure 2 and it is easier to

determine the buried locations of landmines. There is a response at left side in Figure 3, and it would be a response form a neighbor landmine.

(b) SWEDEC

Figures 5-8 show the images of the data #4-7. We used landmine model with a small metallic part corresponding to a fuse in real one, and we buried it before the tests. The soil in this test site is very soft, not beaten. Nevertheless the results have focused landmine images as shown in Figures 4-6. In Figure 7, the landmine is not so clearly imaged, because the landmine itself is big, about 30 by 30 cm, and it is too close to the radar antennas. It is difficult to get a well-focused image. However we can detect something from this image. In Figure 5, we can see metal detector response at left bottom. It would be a metal fragment.

(c) CROMAC

Figures 9 shows the images of the data #8. The soil in this site is local soil, and it is left after burying landmine models, more than 5 years. Landmine models are just inert real landmines by removing primary explosive. In this site, we tested ALIS at a location that had metal detector response without any information on buried locations and types of landmines, i.e., a blind test. As shown in Figure 9, we can determine the buried location, but it is not so clear. It is due to the error of the assumed velocity of electromagnetic wave in the soil and the configuration of the landmine.

4. Summary and future work

We conducted demonstration only in a calibration zone, but in all the test sites and all the conditions, we could determine location of buried landmines. However, we could not obtain clear image, immediately after the data acquisition, in some cases.

ALIS needs a few minutes for data acquisition fro a area about 1m by 1m. Then, all the acquired data is processed on the PC, immediately after the data acquisition. Typically data processing needs about one-to two minutes. In this data processing, we create 3-D GPR image, and outputs many horizontal slice images. If we need to create horizontal slices at very small depth separation, we need more processing time. In order to save the time, we created the horizontal slice about every 20mm. We think it is too rough and after we came back to Japan, we re-processed all the data and we created the horizontal slices every 5mm. Then, we could find clear landmine images in every data set. Therefore, we think this problem can be solved by improving the processing software.

At the same time, we could obtain many useful advises to improve the ALIS. We will continue the development of ALIS in order to improve its practical performance.

Acknowledgements

The ALIS demonstration could be conducted by the kind support of many colleagues. Dr. Adam Luis of JRC organized the demonstration in Ispra, and also invited ITEP colleagues. Dr. Curt Larrson invited us to SWEDEC facility. CROMAC gave us a chance to demonstrate at their site.

Table 1. Test conditions at JRC, SWEDEC, and CROMAC

	Test site	Soil	Target	Depth [cm]
1	JRC, Lane #3	White sand	M3B	5-10
2	JRC, Lane #2	Roam		
3	JRC, Lane #5	Cray		
4	SWEDEC		PMN-2	5
5	SWEDEC		PMN-2	10
6	SWEDEC		PMN	10
7	SWEDEC		TMA-5*1	5
8	CROMAC	Mineralized Soil	PROM-2*2	10

*1: Yugoslavian anti-tank blast mine

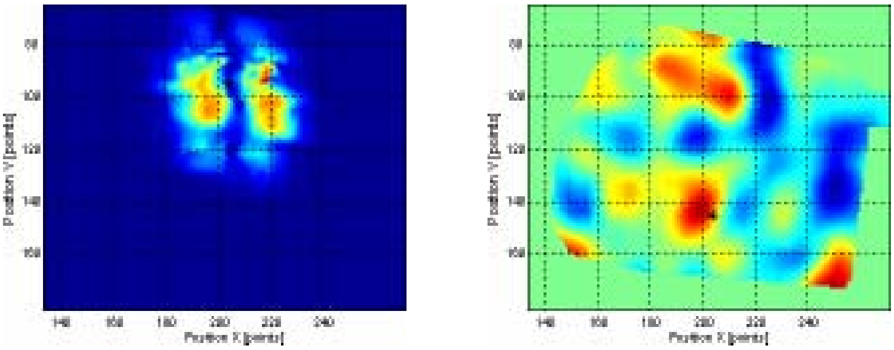
*1: Yugoslavian anti-personnel bounding fragmentation mine

(a) Test at JRC

(b) Test at SWEDEC

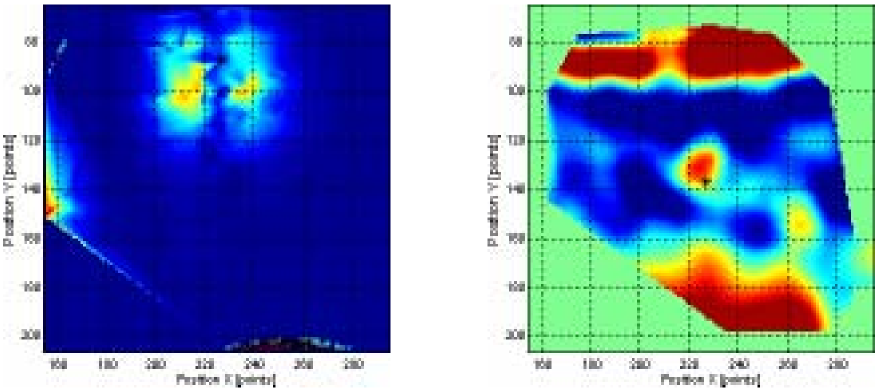
(c) Test at CROMAC

Figure 1. Experimental sceneries of the tests



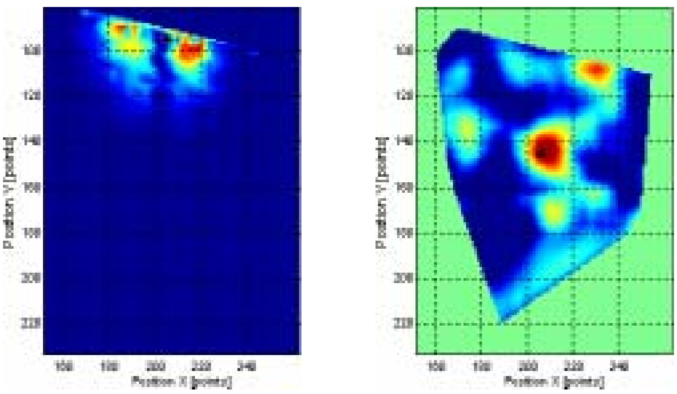
(a) Metal detector image (b) GPR image

Figure 2. Images of the data acquired in Lane #3 at JRC. The target is M3B buried at 5-10 cm.



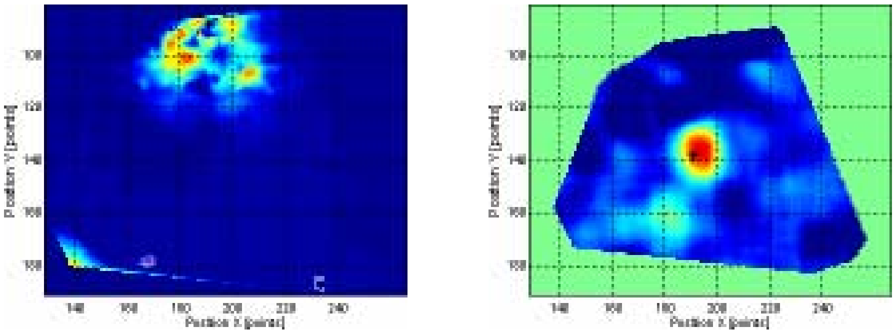
(a) Metal detector image (b) GPR image

Figure 3. Images of the data acquired in Lane #2 at JRC. The target is M3B buried at 5-10 cm.



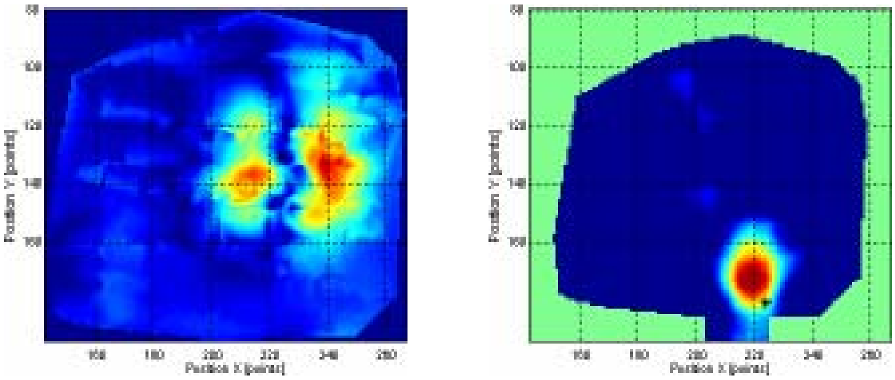
(a) Metal detector image (b) GPR image

Figure 4. Images of the data acquired in Lane #5 at JRC. The target is M3B buried at 5-10 cm.



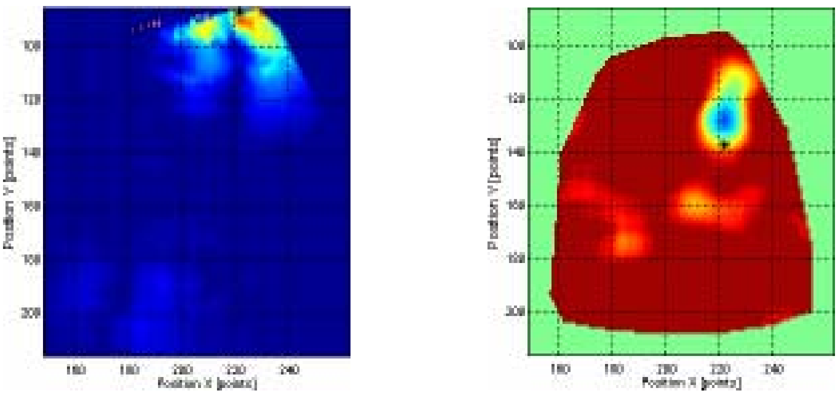
(a) Metal detector image (b) GPR image

Figure 5. Images of the data acquired at SWEDEC. The target is PMN2 buried at a depth of 5 cm.



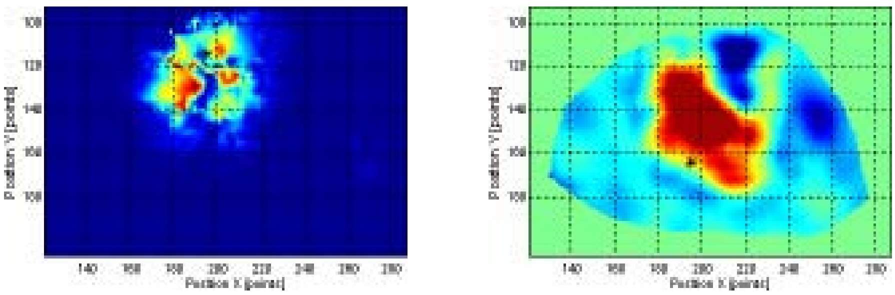
(a) Metal detector image (b) GPR image

Figure 6. Images of the data acquired at SWEDEC. The target is PMN2 buried at a depth of 10 cm.



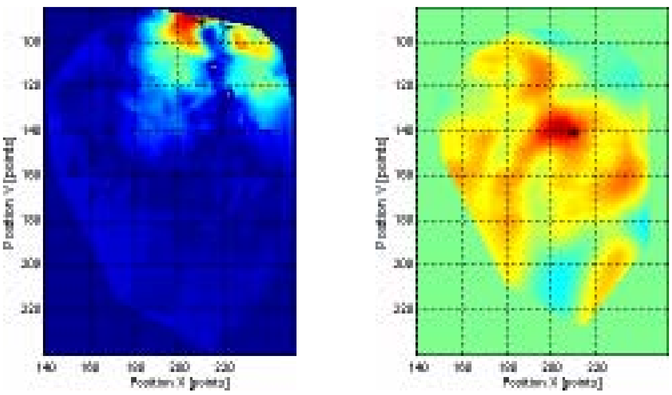
(a) Metal detector image (b) GPR image

Figure 7. Images of the data acquired at SWEDEC. The target is PMN buried at a depth of 10 cm.



(a) Metal detector image (b) GPR image

Figure 8. Images of the data acquired at SWEDEC. The target is a Yugoslavian anti-tank mine buried at a depth of 5 cm.



(a) Metal detector image (b) GPR image

Figure 9. Images of the data acquired at CROMAC. The target is a PROM2 buried at a depth of 10 cm.