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Feature

Report on the DeTec-2 Testing in Cambodia November 18-21, 1997

Jean-Daniel Nicoud, Frederic Guerne, LAMI-DeTec, John Brooks, BIT-Alabama

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General Objective

The 2-year DeTec-2 project started at the end of 1995 as a continuation of our 1994-95 work on the Pemex demining robot [1] to evaluate an antipersonnel mine sensor that is based on a combination of a metal detector (MD) and a ground-penetrating radar (GPR) [2]. The ERA radar was selected in early 1996, and we used the Schiebel, Förster and Ebinger metal detectors. We built a laboratory sandbox to evaluate the sensors under controlled conditions [4], with the ultimate objective of conducting tests on a real minefield before the end of the project.

A preparatory visit to Cambodia in early November 1996 convinced us to concentrate our efforts on a GPR used with a MD, rather than on a combined system. The problem with GPR is that the humanitarian demining community has little knowledge of or experience with its suitability, especially because virtually no data is available publicly. We therefore decided to focus on this aspect (data acquisition, portable system engineering). We also made our data files available on the Internet and on CD-ROM to allow image and data processing specialists to test and improve their algorithms.

Tests with live mines were carried out in our sandbox [3] and at a military field in Karlovac, Croatia [4]. This report explains how the last tests were conducted in Cambodia in November 1997. Further relevant files are available on our Web server: http://diwww.epfl.ch/lami/detec/detec2data.html.

Collaborating with a Demining Team

Demining teams are quite familiar with the MD. They are understandably reluctant to believe in anything else, and a given demining company does not change easily for a new model. All the Standard Operation Procedures (SOP) have to be respected, and any new equipment in the field must be operated by the deminer himself, with the design engineer at least 50 metres away for safety reasons.

To get data from a real field, the GPR had to be used without omitting any SOP step. This meant adding two operations:

- when a MD alarm had been localized, before the prodding was done, a GPR scan of the spot had to be performed, over an area of 40x40cm.
- when the object has been dug up, its identifying characteristics and position had to be accurately recorded.

The only added risk to the deminers was the use of the additional radar equipment, still too heavy and bulky, on the narrow 1 meter wide demining lane.

Preparing for the Project

We decided to work with HALO Trust in Cambodia because they are supported by ProVictimis, the Geneva-based NGO that funded part of our project. HALO Trust planted several inactive mines for us in a field next to a village before the rainy season (5 months before we arrived). We planned to use this field for initial testing of the equipment and training of the deminers and to acquire most of the data in a real minefield.

The Equipment

The discussions with HALO Trust in Cambodia in November 1996 led to the design of a hand-operated antenna used by a kneeling or prone-positioned deminer. The DeTec-1 system [5] was tested in Karlovac, Croatia, in July 1997, in a military field containing live mines that were planted the same morning. The tests demonstrated that the head of a hand-held device must not weigh more than 1 kg. Scanning by hand on lines spaced by about 1 cm, as required when doing imaging, is possible, but needs too much concentration. The distance to the ground is spontaneously increased when the operator knows that a live mine could be below. This increased distance reduced the quality of the GPR images we obtained, given that the antenna we used had been optimized for civil engineering applications (i.e. touching the ground and sliding on it). The system was

Figure 1: DeTec-2 System

redesigned with all equipment inside the same box, supporting a moving arm that included a simple mechanism for doing the regular scanning [5], resulting in much improved data quality. DeTec-2 weighed 25kg and was reasonably easy to carry and position (see Figure 1).

Arriving in Cambodia

We arrived at HALO Trust in Cambodia on November 16th, 1996. The HALO Trust compound consists of two barracks to accommodate one or two permanent expatriates and about 10 Cambodians in charge of organization and equipment maintenance. The demining field is located 15 km away, close to the border with Thailand. The demining platoons, 200 people, have a nearby camp. They live there for three weeks, and then return to their villages for one week.

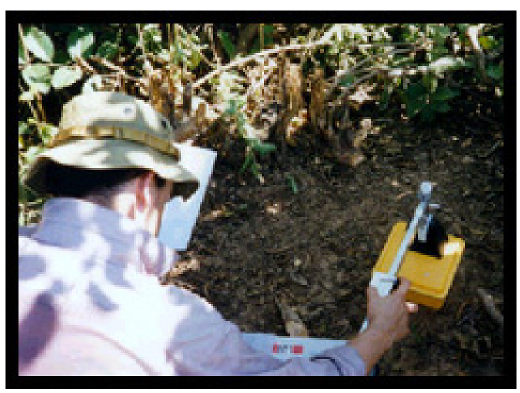
We were well received. However, we had expected different test conditions, and HALO Trust expected different sensor operations. The field with the deactivated mines had indeed been prepared but not quite the way we planned. We expected to be next to a real minefield; instead, we were next to the HALO Trust compound in a village. Several mines had been laid before the rainy season, but the vegetation had not grown in what had been a pond for several months. At first, we were not permitted to know where the mines were, which was fine given that we wanted to test the GPR under realistic conditions, similar to what a deminer would be exposed to. Our frustration with the number of false alarms gave us a glimpse of the everyday frustrations of the deminers in a real field-hundreds or thousands of false alarms for every real mine found. After two days of false alarms, however, we were given access to the site map which indicated the exact location of each of the mines. We then could concentrate not on distinguishing real mines from false alarms but on obtaining good GPR data of the mines.

Testing on the Dummy Field

The test field was a 40m x 40m square with an unknown number of mines. There were between two and five alarms per square meter, caused by several factors, including debris from villagers who had lived in the area and from past conflicts in the area. The field contained three major areas. One part was a former rice paddy composed of wet homogeneous silt with almost no grass because of remaining inundation with water two weeks before we arrived. A higher part was dry silt and already rather hard to prod. The third part surrounded and contained a tree surrounded by many roots, stones, and bricks.The dummy field was next to the Thmar Pouk HALO Trust facilities. This location was convenient, with electricity, table and chairs, fresh water, and coffee nearby as we conducted tests. On the last day, we asked to go with the deminers to an isolated place, within an area resembling more closely a real minefield. On this day, we abandoned work at noon. The extreme heat and inconvenience of the location wore on our equipment and on us. The DeTec-2 system withstood the trip without problems but experienced heat problems after 20 minutes of operation in the 40-degree Celsius heat. The processor cooling was improved with a field expedient, using a rod of aluminium and some toothpaste as glue. We then got reliable operations for more than two hours, when the equipment was not exposed directly to the sun. Two hours in such a hot environment corresponded also to the physical limit for the equipment operator.

1) Removing vegetation

2) Preparing the metal detector



3) GPR scanning

4) Prodding and removing soil

Figure 2: The Detection Process

The first day was mostly devoted to equipment set-up and check-out, solving our heat problems and explaining to the deminers how to proceed; we collected only 4 files. On the second day we conducted 7 hours of data acquisition (22 files). On the third day we obtained 21 files, including 4 mines. The last half-day took place on a field in the countryside (12 files). Power supply for recharging DeTec-2 was provided on this field by an additional car battery connected to a 220V converter.

HALO Trust had allocated a team of six deminers to assist us during our tests. The chief of the platoon spoke English quite well. One deminer was in charge of the equipment. Two pairs of deminers were doing the vegetation removal, metal detection and prodding (see Figure 2). Metal detector alarms were indicated on the ground by means of wooden triangles, and DeTec-2 was then put in position for the scanning. Positioning took 1-2 minutes, scanning 2-3 minutes. Then we, as engineers, were curious to look at the preprocessed files, showing B-scans (vertical cuts) and horizontal scans at different depths; DeTec-2 permitted such real-time readouts. These data previews were done frequently on the spot, before the deminers started to prod the ground.

The testing process was time consuming. Ground prodding was slow because the deminers used the same safety procedures that they use in a real minefield. Also, the engineers waited to see what the deminer removed from the ground rather than scanning the next prepared spot in the second lane. In any case, we had to take pictures of the object, both in and out of the ground. Consequently, we acquired only three or four mines per hour. Within normal demining activities, we estimate that the slow-down due to GPR data acquisition would be a factor of two. With software able to reliably recognize 90% of the false alarms and thus reduce the need for prodding by 90%, the GPR data should speed the demining process. But much experimentation remains to secure reliable, acceptable figures. We must now rely on the groups that will continue the development and experimentation building on our experience, and which will develop the sensors needed by the deminers. A long technical and experimentation road lies ahead.

Operation Procedure

The DeTec-2 system is operated using the following steps:

1. Position the box and adjust the legs until the system is stable.

2. Keep the antenna 2-4 cm above the land area by placing the antenna in an upright position and extending the antenna arm in different directions. After verifying that the distance is even (8-10 cm) over the land area, lower the antenna to the correct height.

3. To scan, depress the start button. The screen shows the trajectory of the antenna and a beep signals excessive scanning speed.

4. To stop scanning, depress the stop button and then preprocess and save the data.

The final step is the most complicated; a sequence of actions with many options allowed to view the data and insert additional information in the data base, such as conjectures (based on the displayed data) about which object was found and descriptions of the retrieved object. Consequently, the deminers could learn steps one through three but not step four. We therefore could not bring the equipment to a real field, where engineers must remain more than 50m away from the deminer and cannot aid his operation of the equipment.

Saving the Data

Because of the high spatial density of data points, the local disk on the PC had sufficient capacity for 50 acquisitions. This capacity sufficed for four days of operation. However, to ensure no loss of data to equipment malfunctions, we copied the data onto a streamer tape and a laptop PC every evening. Recharging the DeTec-2 system was a problem because the charger did not operate well below 160V. The local 220V generator was frequently dropping below that value. The PC was 110V-220V compatible, so it posed no problem. John Brooks immediately checked the validity and quality of the acquired data. Because he will test several algorithms with our data files, it was extremely useful that he saw the method and physical conditions of acquiring the data. His observation of our tests also will help him better recognize the pictures.

Recommendations for Experiments in the Field

A paper, to be published by HDIC-JMU, in a compilation of demining research, will describe our understanding of testing and validating demining equipment. In this article, we provide important points and practical lessons we learned from our recent experience.

Prepare the trip as carefully as possible. It will be very difficult to imagine the situation you will live in, and you may not ask all the right questions in advance. One, possibly two, preparatory trips are essential. Be prepared for last minute changes and be flexible with the requirements of the demining team that accepts you.

Concerning the location, try to get as much information about how and where the tests will be done. Ask exactly where it will be. Verify that you can find the name of the village on the map. Try to ensure that the deminers do not give you the name of their headquarters but rather the name of your living quarters as well as the distance of the living quarters from the testing area. Try to get a picture of the spot (but do not insist too much, they may not have the facilities to do this as easily as we do in our high-tech countries). Inquire about the available methods of communication but do not expect to send e-mail or a fax every day.

Contact the person directly in charge of demining at your destination. General operations are coordinated from Europe, then from the capital of the country, then from a village close to the operations. Also, try to contact with the persons who will take care of you for several days, but this task may prove to be difficult.

Be prepared for physical conditions such as extreme weather (heat, heavy rain, cold, snow) or multitudes of insects. To protect yourself from disease, obtain all required immunizations prior to departing for the country. Also, do not expect to sleep well in the rustic living quarters.

Ensure that the equipment will survive under all conditions you might encounter. It might travel over rough roads, remain in the full sun, be exposed to moisture and even rain. The voltage might be much lower than your expectation and could disappear any time. Take instruments that measure voltage, heat, and humidity, add inside your equipment local heat sensors and simple-to-use diagnostic tools to determine whether the conditions correspond to the worst-case conditions you have created in the lab. Cambodia was extremely dusty due to the unpaved roads. In dusty conditions, carry your laptop and peripherals in air-tight plastic bags. Finally, because the local market carries no components, take plenty of extra data cables, connectors, and so on.

Do not expect to test in a real minefield. Safety procedures are very tight, and you will not be allowed to operate the system yourself. This means that the system must be easy enough for a poorly educated deminer to operate. You might test for days before finding a real mine. You might have to remain in a very hot and uncomfortable place while the deminer works, being ready to address equipment problems.

When the deminers' work is finished (usually about 3 p.m. but you might have additional time while experimenting), you likely will not have a comfortable place to do work. Moreover, when night arrives at 6 p.m., the light will be poor. Power plugs are unreliable, with an irregular voltage. Bring a flashlight and maybe a lamp with a long cable.

Acknowledgements

Besides the direct benefit for the project, being in the field is a wonderful human experience. We cordially thank the HALO-Trust team and the Pro-Victims foundation.

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