PARADIS: GIS Tools for Humanitarian Demining

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ABSTRACT

Landmines and UXO (UneXploded Ordnance[1]) represent a constant and long-lasting threat to the life of millions of individuals. Moreover, these weapons have a strong socio-economic impact on contaminated countries as they involve serious effects as the loss of agricultural fields or access to water. Demining is a critical issue since contaminated areas are large and their clearance often requires investing much time and money into it. It is then fundamental to manage demining activities in an efficient manner. PARADIS[2] is a tool dedicated to Mine Action and helps demining campaigns planners take rational decisions. It fits the needs of all campaign actors, as it is based on the tasks assigned to both the campaign planner and the field operator. The tool is built upon GIS technology and uses satellite imagery as a substitute for background maps, in order to represent all data involved in demining in their most explicit form: a map.

Keywords

PARADIS, humanitarian demining, GIS, Remote Sensing, satellite imagery, landmine, UXO

INTRODUCTION

A dedicated tool must be provided to the Mine Action Community to help planners taking rational decisions in the framework of a demining campaign. The tool must be designed to solve several problems inherent to demining. First of all, a demining campaign represents a huge amount of data. This may lead to irrational scenarios, such as deminers going to a cleared minefield in order to clear it again because the data stating that the minefield was cleared has been lost. The data must then be efficiently managed in order to guarantee data integrity and avoid data loss; they must also be represented in their most explicit form so that the user can easily understand them and take pertinent decisions. Moreover, as demining campaigns generally take place in developing countries, there is often a lack of recent and accurate maps for the region of work. However, maps are key elements to demining activities management and satellite images may be proposed as a solution to this second problem. The tool must also be adapted to the users' specific needs and allow the planner to follow the evolution of the campaign from beginning to end, browsing through the identified scales of work, from global (country) scale to local (field) scale. These requirements are the development guidelines for the PARADIS system.

STATE-OF-THE-ART

Several information systems have been developed in order to solve the problems discussed above, and are now widely used in countries affected by mines and UXO. IMSMA (Information Management system for Mine Action, [2]), the UN-standard information system for Mine Action, mainly consists of a database located at the Mine Action Centre (MAC) of a specific country or region, into which all Mine Action related data are centralized. It also contains planning tools that process the information in the database in order to help decision makers. EOD IS (Explosive Ordnance Disposal Information System, [3]) focuses on the problem of data integrity. This system provides a GIS interface to the field operator to ensure that the data collected on the field is safely conveyed to the IMSMA database. Both systems are able to exchange data using the emerging standard protocol maXML (Mine Action XML, [4]). The idea behind data exchange is that one system may benefit of the data stored in another system; that way, different systems may complete each other while pertaining their own characteristics and strengths.

[1] "munitions that have been used but which have not exploded as intended…" [1]

[2] PARADIS (a Prototype for Assisting Rational Activities in Demining using Images from Satellites) is funded by the Belgian Defense

ORIGINAL IDEAS

Mine Action information systems usually propose one interface to enter the data (merely in their textual form) and another secondary interface -the GIS- for viewing the data on a map. Hence, the user may have to switch from one interface to another in order to enter geographical data (e.g. a minefield) and its associated metadata (e.g. the minefield status). On the other hand, PARADIS considers the GIS as the central element of the system; hence all the data can be entered from one single interface - the GIS.

Moreover, PARADIS aims at filling certain lacks in existing information systems by proposing original tools. Indeed, in order to satisfy as many users as possible, the quoted information systems mainly propose tools that fit the common needs of most users, without integrating those more specific ways of working that vary from one demining organization to another. On the other hand, PARADIS proposes a modular approach that enables each user to have his own specific needs integrated into the interface. One may then see PARADIS as a tool complementary to other information systems.

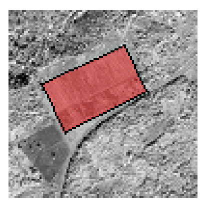
PARADIS: A TOOL FOR MINE ACTION

The aim of the PARADIS project is to improve the planning of Humanitarian Demining campaigns using Remote Sensing data and GIS (Geographic Information System) technology. The system addresses the different problems discussed in the introduction. In order to prevent data loss or corruption, in the planner's office a geographic database (or GeoDb) centralizes the whole set of data related to the demining campaign; on the field, a GIS interface provides a secure channel to convey data to the GeoDb. At each working step the system guarantees the integrity of the data.

The user-friendliness of the system provides easy access to the data centralized in the GeoDb. As it uses GIS technology, the system represents geographic data in the form that fits them best: on a map. Indeed, the user works in a more natural and effective way with map representation than with textual representation (see Figure 1). As an example, an error in the encoding of X and Y coordinates of a geographic point will immediately show on a map, while it will not appear so clearly on a paper form. Encoding errors may then be prevented by representing geographic data on a map rather than a form.

X	Y
574,659	1,608,404
574,700	1,608,450
574,602	1,608,360
574,563	1,608,306

Textual representation



Map representation

Figure 1. Different representations of a minefield

Moreover, to solve the maps problem, high- and very high-resolution satellite images and their interpretation constitute the system's background data and provide accurate and up-to-date maps of the region of interest to the user. This topic has been fully addressed in [5]. Finally, in order to fit the needs of the users the system is built upon four scales (global, regional, local and advancement) and actually follows the tasks assigned to the deminers from global to local scale; to each of these scales correspond dedicated tools, distributed in two separate -but complementary- interfaces: the Planning Interface designed for the campaign planner, and the Field Interface built for the field operator. The system is still being developed. It is being designed in close collaboration with the end-users of the SEDEE-DOVO (Belgian Armed Forces Bomb Disposal Unit), who will use it during their campaigns in countries affected by mines and UXO.

DESIGNING TWO DEDICATED INTERFACES

The needs of the campaign manager differ from those of the field operator. While the manager needs a full-featured GIS interface to access the central GeoDb (geographic database) and make decisions at country and regional levels, the field operator needs an easy-to-use, lightweight GIS interface to bring data to the field and collect new information while there. This is the reason why two separate interfaces are being developed.

The Planning Interface is located in the central office also called Mine Action Center (MAC). As it needs to access the central GeoDb and may execute complex processes while manipulating the data, it is installed on a desktop computer and built on a full-featured GIS. The Field Interface is dedicated to the field operator for collecting and managing information. This interface is designed on a lightweight GIS running on a PDA (see Figure 2).

Figure 2. A Personal Digital Assistant (PDA)

Figure 3 shows the typical scenario for data exchange between the two interfaces. The first step (point 1) is to export geographic data such as maps, satellite imagery and its interpretation, tasking orders, etc to the PDA, in order to support the activities of the field operator. Note that the PDA user only needs data for the zone where he will be sent, so only a reduced set of geographic data needs to be exported. In the Planning Interface, the manager reduces the set of data to the region of interest by drawing a bounding rectangle on the map. He then exports the enclosed data set to the PDA. On the field (point 2), the PDA is used to collect new data including locations of UXO, perimeter of minefields, etc. The user may also edit the existing set of data and enter information that cannot be known a priori; as an example the only way to know the state of a road is to go to the field, because it cannot be seen on the satellite image. When the field operator comes back to the office (point 3) the manager gets the data from the PDA, verifies their integrity and puts them into the central GeoDb. As more and more data comes into the GeoDb, the whole region gets covered by the data brought in by the different field operators, which enables the manager to make decisions at regional level.

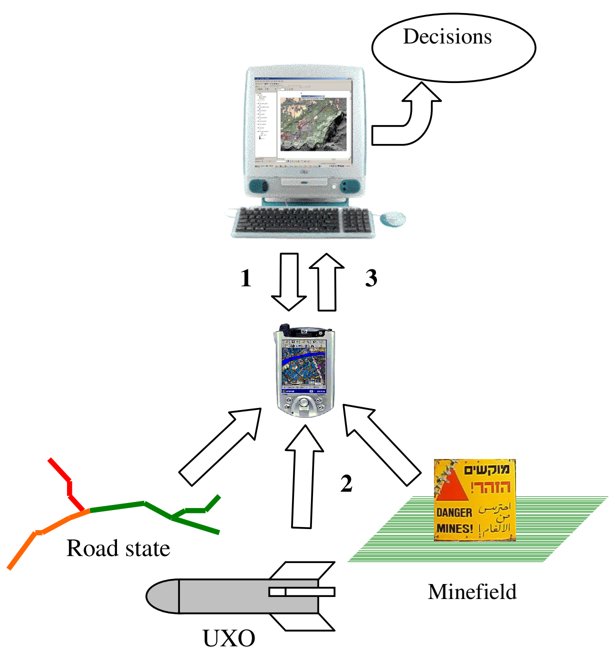


Figure 3. Field Activity Procedure

DESCRIPTION OF THE PLANNING INTERFACE

The Planning Interface works at the global (~1:1,000,000) and regional (1:250,000 to 1:50,000) scales. It provides a global overview of the demining activities to the planner, which enables him to set priorities on the different zones. The planner can also manage teams location, logistics and tasking.

Teams Management tool

A tool has been developed in order for the planner to spatially distribute the different teams on the map. Moreover team equipment, attached personnel and tasks assigned to the each team can be managed efficiently; statistics can be processed to have a quick overview of the situation for each team. For example, this tool is useful to prevent a lack of gas for team ‘X’ or to know in advance how much explosives must be put in stock in order to follow the demand of the Explosive Ordnance Disposal (EOD) teams.

Reporting

Data in the central database can be automatically extracted and inserted on pre-defined reports conform to the OTAN standardized forms. As an example, for each task assigned to a team a report can be created and printed in nearly a mouse click. This feature is important as it drastically reduces the time needed to create a report, and the data on the printed form are more reliable that on a hand-written report.

DESCRIPTION OF THE FIELD INTERFACE

Several typical tools are described hereafter in order to describe the Field Interface.

Road Map tool

As it is said above, roads states cannot be seen on the satellite image and must be entered on the field. The Road Map tool enables the field operator to enter a detailed description of each road he goes along. This tool may be useful during several types of missions: ammunition disposal task, prevention patrol or roving (the activity of going from village to village to interview local populations about the location of minefields and UXO). The Road Map tool can also be useful to the planner, as the latter may want to assign a specific itinerary to be followed by the team of deminers he is sending to the field.

In the Planning Interface, the planner selects the roads to be attached to the itinerary and exports the resulting ‘road map’ to the PDA.

On the field, each road segment may be edited and is namely given a name, a state during dry and wet seasons (unknown, not practicable, poor or good), a type (tarred road, track), etc. As one goes along the road, the status of the road may change (e.g. from poor to good); in order for the Field Interface to reflect this information, the road segment can be easily split up into several segments of different status. Conversely, two segments can be merged into one single segment.

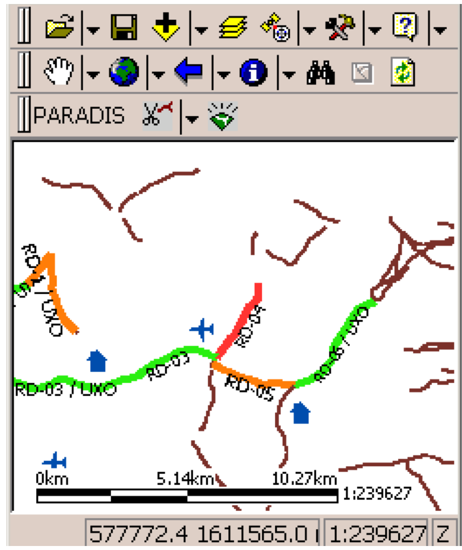


Figure 4. Reflecting the state of roads (brown= unknown; red= not practicable; orange= poor; green= good)

If mines or UXO were seen along the road (or reported by a local), a description of the ammunition can be entered on the road form. Note that this only gives a general information: some ammunition of type 'X' lies somewhere along the road segment. Generally one may want to enter precise location of the ammunition found; in that scope, a specific tool for ammunition reporting has been developed (not described here). When the team goes back to the central office, these data are imported into the central GeoDb; after grouping the road maps of the different teams, a regional road map is obtained.

Minefield Grid tool

This tool allows the user to follow the work on a minefield. After delineating the minefield, the user is able to draw a grid on the minefield. Each cell in the grid represents the small area -typically one square meter- that a deminer works on at a time. Then, each cell can be edited to show the ammunition found in it and the status of the cell (not worked on, ongoing, cleared). After a certain number of cells have been edited, the system is able to compute the time for complete clearance of the minefield, given an estimated future numbers of metal detectors working on the minefield. Conversely, one may want to ask the system how many working detectors are needed in order to finish the complete clearance of the minefield before a certain deadline.

Layers tool

In a GIS, geographic data are grouped into layers: each layer represents a specific kind of data. For example, towns are grouped into one layer, roads are grouped into another, etc. Using the Layers tool, the user can compose the map by selecting one or more layers from a list of possible pre-defined layers (ex: minefields, hospitals, towns, UXO locations, etc) and load them in the map (see Figure 5). The loaded layers are automatically assigned the appropriate symbology. The user may also choose to edit one layer directly, using the "Edit layer" box.

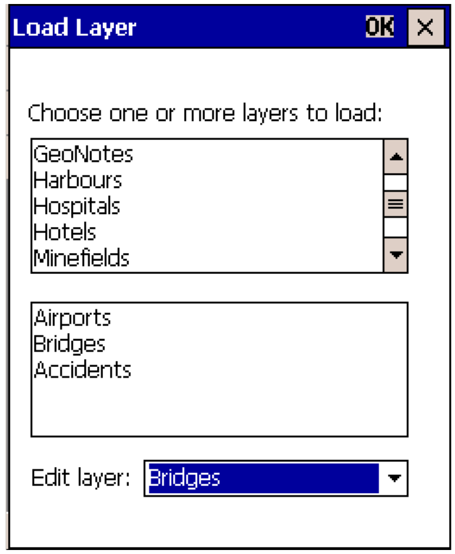


Figure 5. Layers tool form

Note that the way of editing a layer changes from one layer to another. For example, the Bridges and Minefields layers differ in that a bridge is represented as a point in the interface, while a minefield is represented as a polygon. Hence, to define the bridge point the user simply taps on the screen at the appropriate location. As the minefield is a polygon, the system behaves differently: when the user taps on the screen, the benchmark (reference point used to retrieve the starting point of the perimeter of a minefield) gets defined, then a form opens and lets the user define the other points. This is shown in the following figure:

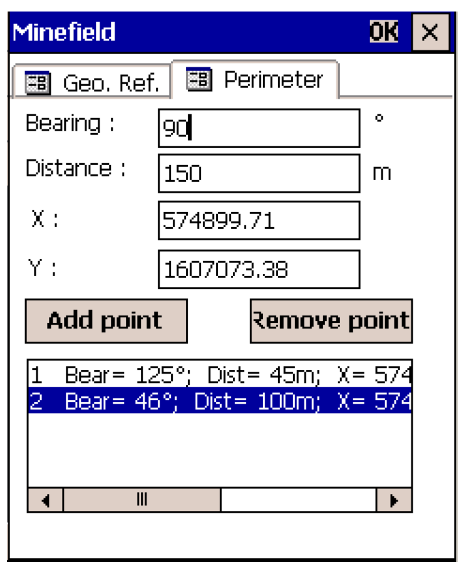


Figure 6. Defining the turning points of a minefield

The advantage of the Layers tool is that the system activates the appropriate editing method depending on the layer the user has chosen to edit.

GeoNote tool

Some data cannot be associated to any of the pre-defined layers defined above, but are interesting to enter into the system: heterogeneous information such as text, voice recordings, photos, videos, etc. In the interface these data can be associated to a single point on the map; this point is called a GeoNote. As an example, if the field operator interviews a local inhabitant about the position of a UXO, he would create a GeoNote by tapping the screen at the location of the interview. He would then associate the audio file of the interview to the GeoNote, along with a sketch showing the position of the ammunition relative to the village and a textual comment about the estimated size of the UXO.

TEST AND VALIDATION

Testing is a very important step in the development of such a system, as that phase sheds light on practical problems that cannot be seen from the developer's desk. The two interfaces are currently being tested in Afghanistan by the SEDEE-DOVO during their EOD missions in Kabul (as of the time of writing, the tests are still underway so that the results cannot be showed in this article). Moreover, other demining institutions are interested into the project and test missions are planned with them so that the system can be validated by as much end-users as possible

CONCLUSIONS AND FUTURE PROSPECTS

The current state of the Planning and Field Interfaces has been presented. These two interfaces are still in constant evolution, based on the ideas and methods of work of the end-users and on feedback from the field. Also, based on the request from end-users, different modules will be developed in order to fit their specific needs. Moreover, hands-on training sessions are being put in place, so that the system can be put in hands of as much people as possible. Finally, the system will soon be able to exchange data with other information systems using maXML.

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