Centralised data management in the demining world : The Tiramisu Repository Service

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1. Introduction

Information systems play a more and more important role in modern demining actions. They enable effective, collaborative and secure management of demining actions. They also improve the human interface for more and more complex tools like sensors and detectors and enable the usage of new technologies like Geodata, GIS mapping and sensor fusion or modular toolkits. But these systems also have to be usable in remote areas with poor infrastructure and without expert knowledge available. This brings new challenges for data management, data communication and data security.

Several cooperative tools have been developed by the EU funded project TIRAMISU, that can help to solve these demands. These tools give support for the demining workflow starting with pattern recognition on satellite or aerial images, support for sensor data management enabling sensor fusion, infrastructure for precise navigation and flexible data communication even at remote places of demining up to support for decision makers, report generation and documentation.

The tools for these purposes will be presented and also the cooperation between them on the basis of a demining workflow scenario:

* The Tiramisu Repository Server (TRS) acts as a data repository that serves either through internet or by a rugged field server device the data storage and retrieval needs. It is based on open standards and popular internet technologies. Through MA-XML, data exchange with actual demining data systems like IMSMA is under development.
* Infrastructure for precise positioning using multi satellite navigation systems like GPS, Glonass and Galileo, flexible ad-hoc data communication infrastructure including connecting to the internet through satellite communication can be provided by the TCPbox. The TCPbox also supports vehicles like robots or drones with position and communication capabilities and also enhances demining sensors and detectors with a genuine interface for automatic data transfer into the TRS data repository for further evaluation.
* For interaction with humans there are several tools cooperative. A QGIS based system with support for more detailed sensor and image data processing cooperates with the TRS. The Decision Support Client DSC can be used for easy information queries and presentation of the data involved. The T-IMS system can also be used for generating reports and supports also interfacing to IMSMA based systems.

To demonstrate the actual developments, an integration of the TEODOR robot vehicle, equipped with a Vallon sensor array and a TCPbox delivering data to a TRS server system, detailed analysis and computation of sensor data through the FDS, display mission data on the DSC and reporting with T-IMS is planned to be demonstrated during the conference.

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2. General description

More than a software, what we actually propose is an operational standard for data storing and exchange between all the contributors and parties of a local demining organisation. The objective is to address all the needs for data sharing, and to improve the security on the field by providing accurate and exhaustive information, as well as the overall efficiency of the management.

Practically, the Tiramisu Repository Service (TRS) is a database with geographical capabilities, working in a client-server architecture, in which different tools store and read data. The inner structure is made of data tables allocated to divisions (the schemas) covering each a specific main functionality. It will be hosted in an office on a desktop computer or as a server in a computing centre and will have its robust, battery-driven lighter version for accompanying the field missions. So the TRS centralises the information and makes it available to all the tools whenever and wherever they need it.

As in the usual IT world what we call a standard is *a normative specification of a technology or methodology,* applicable here to the IT demining operations. Its objective is to guarantee an universal compatibility between different systems developed independently.

In the text below we will distinguish two different versions of the TRS:

- the National-TRS hosted in the national demining headquarter,
- and the Field-TRS which is hosted on a rugged Unix-box and used outdoors on the demining site.

The figure below gives an overview about the basic software and hardware components of the Field-TRS. All the software components are based on popular open source programs and give a comprehensive computing environment. even if no (or a very limited) internet connection is available. The hardware components are assembled in a single ruggedised metal box, which can operate independent of external power supply and internet connection.

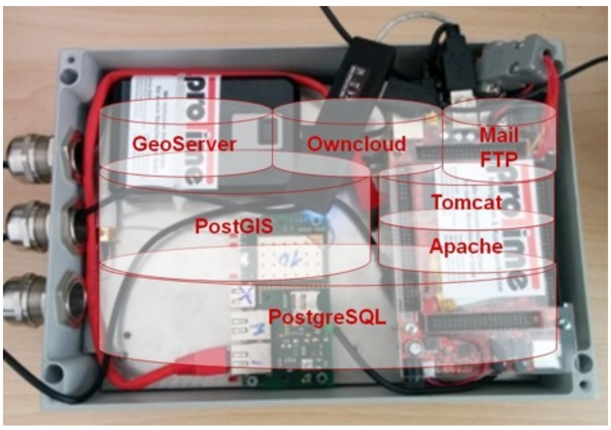


FIG 1. THE FIELD TRS

3. The final user first

The demining world is currently evolving with the release of many software tools aiming at supporting the whole chain of operations. Tiramisu and D-Box projects are illustrating perfectly this tendency. Hence, many software are proposed to the demining community with an ever growing redundancy, which can be seen as a better chance for the final user to find better solutions. Yet, it is seldom easy for the demining actors to switch from one solution to a new one even if the latter fits more their needs, because this switch would mean either the loss of previously collected data or a difficult and expensive effort to transfer them to the new system. This transition stress could be lowered if the different software were sharing some standardisation, and this is possible by the adoption of free standards, such as those on which the TRS and its current partner tools are based, i.e. the OGC protocols, Openlayers, HTML5, ODBC, SQL, PostGIS, …. If the different proposed systems share the same elementary building bricks that don't belong to any specific company, then the final users will always find solutions to eventually transfer their precious data between different systems, and escape from a probable captivity where they become gradually more and more dependent on a single actor. And forward-looking it is a question of sustainability to think about solution, which keeps the growing number of data accessible and usable for other people or companies next month, year or even in ten or twenty years.

4. *The data flow*

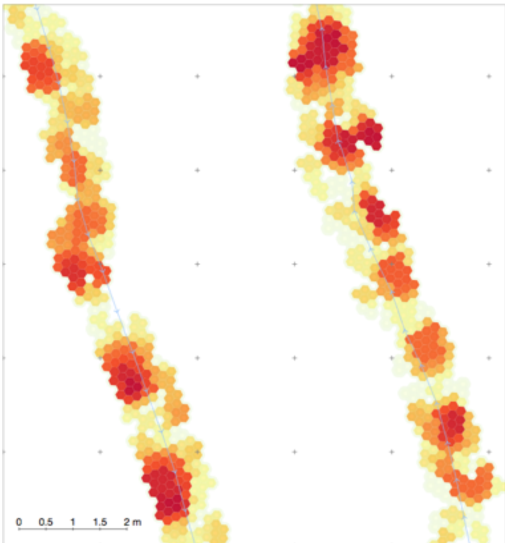
We consider that tools benefitting from the data repository can be seen either as data providers, as data users or as both. The data producers are the sensors, the remote sensing and consequent GIS operations, the surveyors, the general geographical regional data, the UXO databases. The data users are the decision makers, the deminers themselves, the MAC's management, the donors, the engineers developing new tools.

Internally the TRS has schemas devoted to the reception of data and others to present the data, with different access rights predefined and controlled by the server, so that a tool sees only what is necessary to itself. Automatic functions stored within the database and developed accordingly to the specific needs of some tool can perform additional tasks like add some metadata or achieve a complementary data processing. These stored procedures allow different tools to benefit.

5. *The current developments*

The development of the TRS is an extra task in the framework of the Tiramisu project and had to be done with a small budget having led to the limitation of the features currently available. At the moment we can propose the following:

- Support of a metal detector. Here the field TRS is connected to a TCP-box, which in turn is connected to a metal detector array mounted on the robot 'Teodor'[5], all tools are developed within Tiramisu. The array generates data (positioning and time stamps provided by a TCP-Box and detectors signals) that is fed into the TRS every minutes where a complementary process transform them into map layers that can be visualised in a GIS tool also connected to the TRS, such as the DSC[7] tool or QGIS[6]. The GPS tracks and all the geo-positioned detectors signals are stored in the database for further use.



Metal Detector signal intensity as viewed with the TRS. Test realised in July 2014 in DOVO centre, Belgium, with Vallon MD array mounted on robot Teodor. Intensity of the reds related to the intensity of the signal.

FIG 2. METAL DETECTORS SIGNALS

- The TCPbox implement a flexible infrastructure for a distributed ad-hoc data communication infrastructure and support for precise navigation using multiple satellite navigation systems like GPS, Glonass and Galileo (GNSS). Different versions of the TCPbox can act as communication hubs and equipped with different GNSS receivers they also support precise positioning using realtime kinematic algorithms (RTK). In areas without internet infrastructure they can serve as a gateway to a (satellite) internet connection and also act as a local reference station for correcting GNSS signals.

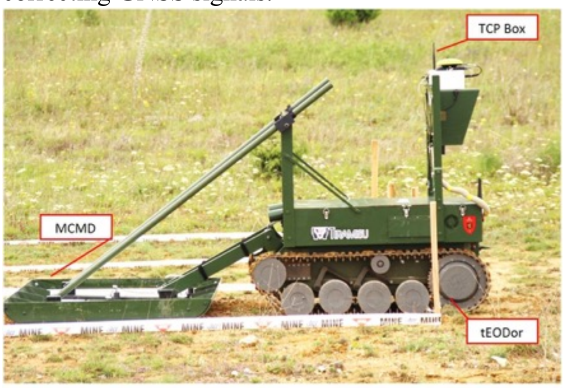


Figure 1 tEODor mobile robot platform with the MCMD and TCP box

FIG3. TEODOR WITH MD AND TCPBOX

- Survey data collected by T-IMS[2] are transferred by MaXML files. T-IMS is a mobile app used to collect data in the field and it uses MaXML (an XML formalisation of the Mine Action data created by the GICHD and enhanced during the Tiramisu project) as a transfer file format. The TRS has an input schema designed to receive the MaXML data loaded by a side module to T-IMS.
- Similarly a module developed in QGIS with a live connection to a TRS instance has been developed in the framework of the Non Technical Survey (NTS) for Mine Presence Indicators (MPI). It allows the user to identify on a ground image - obtained from public sources or from aerial engines such as UAV's - the MPI's that are used to describe the past war activities and consequently locate the possible mine fields. This module can be used in a semi-mobile way on the field with a laptop and a GPS positioning or in the office.

FIG 4. THE DSC USER INTERFACE

- The Decision Support Client (DSC) is probably the Tiramisu tool that takes more advantage of the TRS. It is a web-based interface fitted for a tablet that allows to display data from the TRS, such as the one generated by the tools described above, with a wifi connection to the TCP-Box field network. The DSC is based on HTML5 and can be used independently of the hardware. It is the TRS keystone for the decision makers, presenting on the same display the different types of data related to one area. It also provides access to collaboration tools like group calendar, task lists, shared documents and other management services hosted by the TRS.

6. *The next developments*

The Tiramisu project is still ongoing and even if the plans for the TRS are almost reached, we may have the opportunity to add some useful functionality.

The TRS has a modular structure and is progressively augmented with different tools developed inside the Tiramisu project. This allows us to consider the addition of other functionalities not yet implemented:

[5, 7] See project Tiramisu

[6] See http://www.qgis.org

- The TRS would be a perfect place to implement the T-Priority, a tool to compute the priorities among the different areas to care for.
- The T-PCH is a tool used to delineate the different suspected hazardous areas based on the indicators previously collected. A functionality designed to delineate PCH along linear feature like trenches or defence lines is already available but there is much more work still to do and we might integrate other algorithms already developed separately
- Additional sensors as data sources should be added to make the TRS a real universal data management tool. In addition to the storing of sensor data, functionality for setup and control of sensors to support mission planning is a helpful extension.

Obviously the more tools are integrated with the TRS the best.

7. Scalability / Openness / Adaptability

Because of the openness of the TRS and with attention to favour end-users, it is possible and highly desirable that other actors, among which the MAC, develop their own functionalities to enrich the TRS capabilities and to customise it to their specific needs. As it is said in last year's paper [1] there are different ways to interact with the TRS and as long as the authority in charge of operating the system allows it by defining the access rights, many things are possible. Moreover the add-ons developed by third parties could easily be shared between the different users in the HD community.

8. Demo scenario

To illustrate the role of the TRS for integrated demining data management, here's a simple scenario of hypothetic successive demining operations:

1. Limited-size satellite images or aerial photos over a mine contaminated suspected area and/or vectorial delimitations/characterisations of PCH (= Potential contamination hotspot resulting of the remote sensing analysis) are processed by analysts using Land Impact Survey Tools, and are stored in the **National TRS**. *[Result: A PCH is identified]*
2. The relevant PCH data are loaded on mobile field devices (tablet or laptop) of a Non-Technical Survey Team for on-site exploration purposes. Additional geo-referenced observations (photos, videos, notes) are collected via **T-REX.MPIC** (Mine Presence Indicator Collector) or **T-IMS** *[Result: A PCH is further validated by on-site observations and a field-report is generated (with **T-IMS**) and stored in **National TRS**.]*
3. The geographical material and the field report are used for further analysis at the MAC. The analysis result with the map(s) – now probably augmented with drawings/markings from the analysis staff – is stored in the **National TRS**. *[Result: Material for decision support is prepared and provided.]*
4. Based on the analysis result, decision makers from the MAC task a Technical Survey Team (TST) to enter the area. The task is defined in an order based on data stored in the **TRS** and it is also stored and shared on the TRS. *[Result: Decision is made and TST-Task is defined, stored and shared.]*
5. A "snapshot" with the data relevant for that specific area is transferred from the **National-TRS** to the **Field-TRS**. The **Field-TRS** will be set-up and connected to all **TCPboxes** installed on the different sensor platforms, and additional computers or mobile devices on site via the **Wifi Field Mesh-Net**. *[Result: Field-TRS, TCPboxes and Wifi Mesh-Net are up and running.]*
6. During Technical Survey, the sensor data of the mine detector(s) with position and timestamp are stored on the **Field-TRS**. *[Result: Documentation of geo- and time-referenced measurements]*
7. Map layers are generated to show a spatial visualisation of sensor measurements ('heat map') and the position tracks of the sensor platforms on the **DSC** tablet PC of the Head of the Technical Survey Team. (Previous measurements of other sensor surveys on the same area can be visualised as map overlays.) *[Result: Map visualisation of the measurements on the DSC]*
8. Periodical reports will be generated summarising the collected data and activities for the PCH. They are stored as PDF in the **Field-TRS**. *[Result: Shared PDF documents via the TRS-D owncloud service]*
9. When all the work in the PCH is done, the **Field-TRS** will be synchronised with the **National-TRS** *[Result: All data referring to that specific mine action site are backed up and available for further investigations – whenever needed]*

9. Conclusion

As more and more demining tools need input data from other tools and produce more data that might be input for others, a centralised data management gets more and more a urgent need also for deminers. During the Tiramisu project, the Tiramisu Repository Service TRS was developed and integrated with several other Tiramisu tools from sensor data to decision support to demonstrate an open approach for data handling along the demining workflow from satellite image analysis to technical survey and documentation. We are open to cooperate with further tools for a real comprehensive support along the demining process to make demining more efficient, results more reliable and well documented also for future use.