

# Mobile Data-Collection in the Field: the RDArcheo Application

Davide MERICO – Glauco MANTEGARI

University of Milan-Bicocca, Department of Informatics, Systems and Communication – NOMADIS Lab  
{davide.merico; glauco.mantegari}@disco.unimib.it

## Abstract

The availability of mobile technologies and the spreading of GPS for spatial data acquisition are rapidly changing the practices of archaeological documentation. This paper describes RDArcheo, a mobile data-collection application, its technical components and the results of the experimentations on the field.

## Keywords

mobile data-collection applications, RDArcheo, Dead Reckoning, Graphical User Interface

## 1. Introduction

The availability of mobile technologies and the spreading of GPS for spatial data acquisition are rapidly changing the practices of archaeological documentation. In particular, for what concerns the survey of large areas, several solutions have been developed during the last years, providing a good balance between accuracy and cost-effectiveness.

Nowadays a lot of applications – e.g. databases and GIS, commonly used by archaeologist – can run on small yet powerful devices like a Personal Digital Assistant (PDA). The main difficulty in using these applications is their general-purpose nature, which makes it difficult to configure them for the specific needs of a research project. This process often ends up with an arrangement/workaround solution in contrast with some research needs, because a desired functionality is not available and/or difficult to implement.

Different interesting experiences in the field of mobile applications for archaeology have been carried out, from the adoption and partial configuration of existing applications to the development of specific software (see, for example, the Field Map project: Ryan 2005). These experiences show that some programming work is necessary to fit the possibilities offered by technology to the needs of archaeological research.

Starting from these considerations, the NOMADIS lab in the University of Milan-Bicocca (NOMADIS Research Lab), which focuses its research in the area of the applications, methodologies and technologies for mobility and navigation, started the development of an application for archaeological surveys, named RDArcheo, which was tested in two survey projects, in

the island of Pantelleria (Italy) and in the Zeravshan Valley (Uzbekistan).

This paper aims at describing the framework of the application, its technical components and the results of the experimentations in the field. Particular attention will be given to the discussion of the critical elements that we noticed using RDArcheo, such as the problems related to the hardware and software components as well as the adequacy of this application to the needs of archaeological research.

## 2. The RDArcheo application

In the following sections we will discuss the hardware and software architecture of RDArcheo.

### 2.1. RDArcheo hardware

RDArcheo can be used both in Windows Mobile and in Symbian environments. We used RDArcheo both indoors and outdoors.

We have implemented the Windows Mobile version of RDArcheo using an HP IPAQ hx4700 PDA. This PDA includes an Intel PXA270 processor running at 624 MHz; 64 MB of RAM; a 4" LCD display with a resolution of 640x480 pixel and two expansion slots (Secure Digital and Compact Flash).

The Symbian version of RDArcheo has been tested on several types of Symbian phones.

In outdoor environments, we used a Bluetooth GPS module BT GPS X-Mini-Extreme produced by RoyalTek. This module supports up to 20 GPS channel and its batteries can last 17 hours.

Unfortunately, GPS-supported navigation does not work indoor even when the latest sophisticated receivers are used.



Fig. 1. HP HX4700 (left and center) and BlueTooth GPS Royaltek.

For this reason, RDArcheo could use the localization data of several indoor localization systems, for example UWB (Ubisense), WiFi (Ekahau; Aeroscout), Bluetooth (Kiran and Case 2003; Tahvildari 2001) or ZigBee (Sugano *et al.* 2006; Patwari *et al.* 2005).

These technologies make it all possible to build viable localization infrastructures, but require a substantial effort at the physical plant level. Trying to overcome this problem, we used Dead Reckoning Modules (DRM), a particular type of indoor localization system that does not require the presence of localization infrastructures, sensing its own rate and direction of motion.

Dead Reckoning (DR) is the process of estimating your position by advancing a known position using direction, speed, time and distance to be travelled. The usefulness of the technique depends upon how accurately speed and direction can be maintained on a given range of time. If direction and speed are evaluated with small error, very long and accurate navigation is possible. Otherwise, a periodic recalibration of the position is necessary.

In RDArcheo, we use the Honeywell GyroDRM (Honeywell). The GyroDRM uses the following sensors: a magnetometer and a gyroscope for heading, an accelerometer for speed, a pressure sensor for altitude, and a temperature sensor (it helps monitor



Fig. 2. The GyroDRM (Gyro-Stabilized Dead Reckoning Module).

environmental data and is used to calibrate other sensors). GyroDRM batteries can last up to 4 hours.

## 2.2. RDArcheo software

RDArcheo is conceived as a special purpose data management system. The application allows collecting data in the field using some forms specifically developed for each project and to automatically

associate, by means of a Bluetooth GPS device, the geographical coordinates to each survey unit.

A few other functionalities include the possibility to link audio notes and images to relevant elements of the dataset and synchronization facilities to easily download and update data in a central database on a desktop computer.

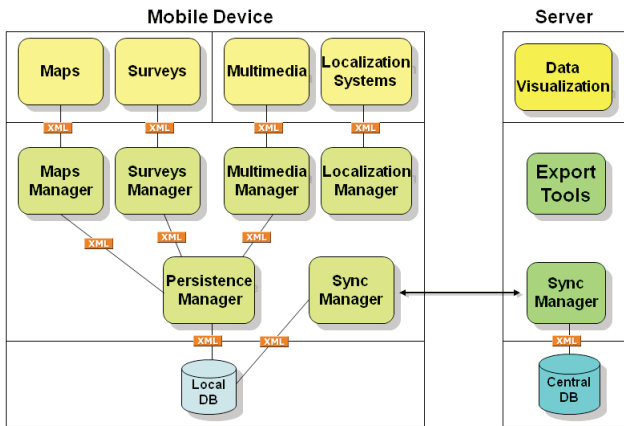


Fig. 3. The RDArcheo Software Architecture.

The entire system was designed to be very modular and reconfigurable; the entire application could be reconfigured adding or removing software functionalities adapting to particular sites or surveys.

Customizing RDArcheo for new surveys is very simple. In case of simple surveys, the graphical interfaces are automatically generated using XML templates. For more complex settings, the integration of customized graphical interfaces is also possible but requires additional work.

The integration of detailed geo-referenced maps permits constant feedback on position directly on mobile devices. Maps can also be used to support particular surveys, e.g. border tracking.

RDArcheo permits the visualization and the management of notes directly on the maps.

RDArcheo provides the following multimedia functionalities: vocal notes recording (a few minutes without additional storage cards); automatic speech recognition (ASR) of reduced and simplified dictionaries; video recording using geo-referenced cameras.

The system also provides playback and editing features of the collected data.

Large amounts of data can be saved directly into mobile devices. The database is based on XML, which makes it flexible and open to different applications, avoiding the need for complex customizations for adapting to various experiments.

RDArcheo includes specific tools that allow synchronization and backup of data on a centralized database in a very simple fashion.

Another function of the system is to provide different modules to export data ensuring the compatibility with several databases, GIS and statistical processing systems.

### 3. Evaluation

In 2006 RDArcheo was tested during two survey projects, in order to evaluate:

- hardware performance and the usability of the devices in the field
- software functionalities and the effectiveness of the data entry procedures

Two different projects offered an ideal test bed, because of their different goals and scope: the Middle Zeravshan Valley and the Pantelleria surveys.

The following sections briefly describe the projects as well as the results of RDArcheo use in the field.

#### 3.1. The Middle Zeravshan Valley survey project

The Middle Zeravshan Valley survey project aims at mapping the settlement pattern in order to understand the water landscape evolution in Samarkand Oasis (Uzbekistan). Archaeological sites (typically mounds or tells) are detected with the aid of Satellite Images, Aerial Photos and Topographical Maps through Remote Sensing techniques.

The most useful information is supplied by the Soviet Military Maps (1950s), in particular those at a 25,000 scale (contour lines every 5m) and a 10,000 scale (contour lines every 1m), produced before the extensive amelioration projects of the Soviet period, that caused the destruction of many archaeological sites. In fact, the territory surrounding Samarkand has been subject to major Soviet reclamation projects carried out between the 60s and 80s and these destroyed many archaeological sites by leveling the ground, creating artificial terraces and constructing new canals. Further damage has been done by the quarrying of sites for creating mudbricks.

The main aim of the survey project is then to create a complete, detailed catalogue of the supposed archaeological evidence in all the area using the

cartographic data as a basis and to check and verify the detected anomalies in the field.

RDArcheo was used to support data collection in the field and, in particular, the location and the main characteristics of the sites, which are traditionally described using paper-based files. Moreover, the evaluation took into consideration the possibility of automating the manual procedures of data uploading into the project's information system. In this way, everyday work would be supported in a more efficient way, e.g. avoiding all the problems that are usually related with handwriting, such as the difficulty to interpret someone else's writing correctly.

Thanks to the facilities offered by the application, it was easy to create a Graphical User Interface (GUI) reproducing the structure of the paper files (Fig. 4).

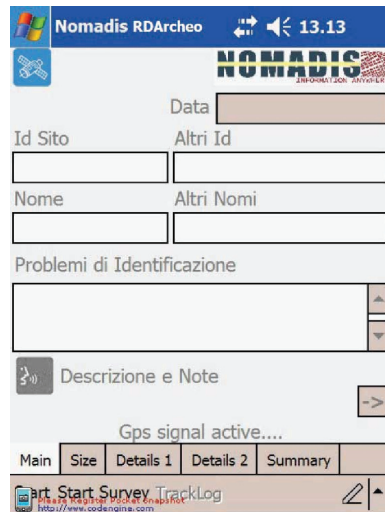
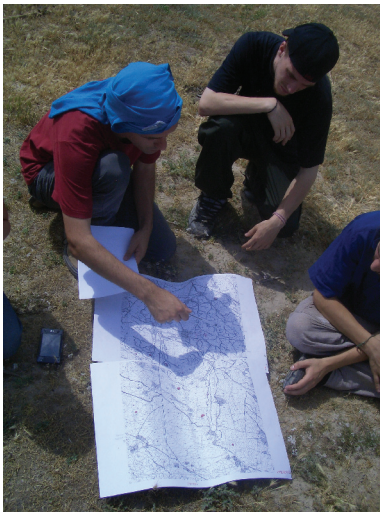


Fig. 4. The individuation of the sites on the cartography (left) and the RDArcheo GUI (right).

In this regard, several interesting add-ons were developed in order to better exploit the potentialities of digital technologies over the traditional ones and to ensure an easy use of the application during survey in the field. In particular, a module for vocal notes management was integrated, which allows the archaeologist to record all the elements that do not fit into the GUI's pre-defined fields and that are traditionally written as free text in notebooks.

Each note is automatically associated with the site record it belongs to. Moreover, other facilities were provided in order to use the GUI quickly and intuitively even on the small screen of a PDA: some examples are the grouping of the record fields into different areas denoted by tabs, or the drop-down lists that offer, where possible, pre-defined vocabularies, thus avoiding direct writing, which on a PDA may be time consuming.

Data transfer on the project information system is based on the coding of all the information collected each day in XML - thanks to another small application we developed (RDArcheoXML) - in Windows Media Audio. Data are then transferred using the standard application for syncing Windows Mobile-based PDAs with a Personal Computer (ActiveSync). The conversion of XML data into the Microsoft Access format can be then performed using a functionality of Access itself.

Some preliminary considerations can be drawn both for the hardware and the software components of RDArcheo. The PDAs and the Bluetooth GPS devices demonstrated to be sufficiently efficient, in particular for what concerns the battery duration, which was more than sufficient for a single day

survey. Moreover, the PDA screen was perfectly readable in natural light and the users felt comfortable with the devices.

The RDArcheo application, even at its first test, offered encouraging results. We did not experience any problems in data collection and management, even if, in some cases, support was required by users in the first approach to the system. However, after an additional and short training RDArcheo was used without difficulty.

However, some very useful suggestions came from the system users. In particular, they asked for the complete integration of a mobile

GIS application, which was not available during the evaluation in Uzbekistan, in order to better identify the sites without carrying the soviet maps when surveying the area. Another required improvement is the possibility of allowing a direct modification of the GUI, in order to make the application more flexible in all those situations that require an enhancement of the site description. In fact, in these situations vocal notes demonstrated their effectiveness, but the disk space that they require may be insufficient without a proper compression mechanism (e.g. mp3).

### 3.2. The Pantelleria survey project

The project aims at collecting data about the monumental prehistoric tombs (*sesi*) that are located in a vast area of the island of Pantelleria, between Sicily (Italy) and Tunisia. In fact, the

state of preservation of these tombs may be very heterogeneous, ranging from a relatively small number of stones to perfectly preserved and complex structures. Thus, it is fundamental to survey the area intensively to collect all the available information in order to have a complete picture of the remaining archaeological evidence.



Fig. 5. Mobile data collection on a sese.

The core of the RDArcheo application was the same used in Uzbekistan. However, several different features were developed, in order to make the system more effective for a completely different archaeological situation.

The flexibility of the application allowed us to easily create a new and smaller GUI (Fig. 6), which offered new features, such as “sliders” to easily collect data. However, the major improvements regarded

the development of new modules and functionalities. In particular, a facility was added in order to use the GUI for the retrieval and evaluation of previously collected data. This functionality may be useful for the review of wrong data and for the addition of new data to already archived files.

Another module was developed for the consultation of the drawings and photographs that were made during previous surveys. This kind of documentation was incorporated into the system and is automatically retrieved when consulting the file pertaining to a particular tomb. The usefulness of this module is in the possibility of recognizing several structures that are today completely covered by the vegetation.

Finally, we started considering the integration of a mobile GIS application, which was considered to be fundamental by the users of the RDArcheo system in Uzbekistan. In this regard we tested ESRI ArcPad, which offers an effective set of GPS functionalities that help a user find each documented tomb. This was possible thanks to the availability of raster aerial photographs and vector shapefiles marking the position of the tombs in the area. It is important to stress that ArcPad was not integrated in the ArcGeo, but it was used in order to evaluate the possibility of creating a link between our application and a mobile GIS.

The experience in Pantelleria, even if it was conducted on a smaller area than in Uzbekistan,

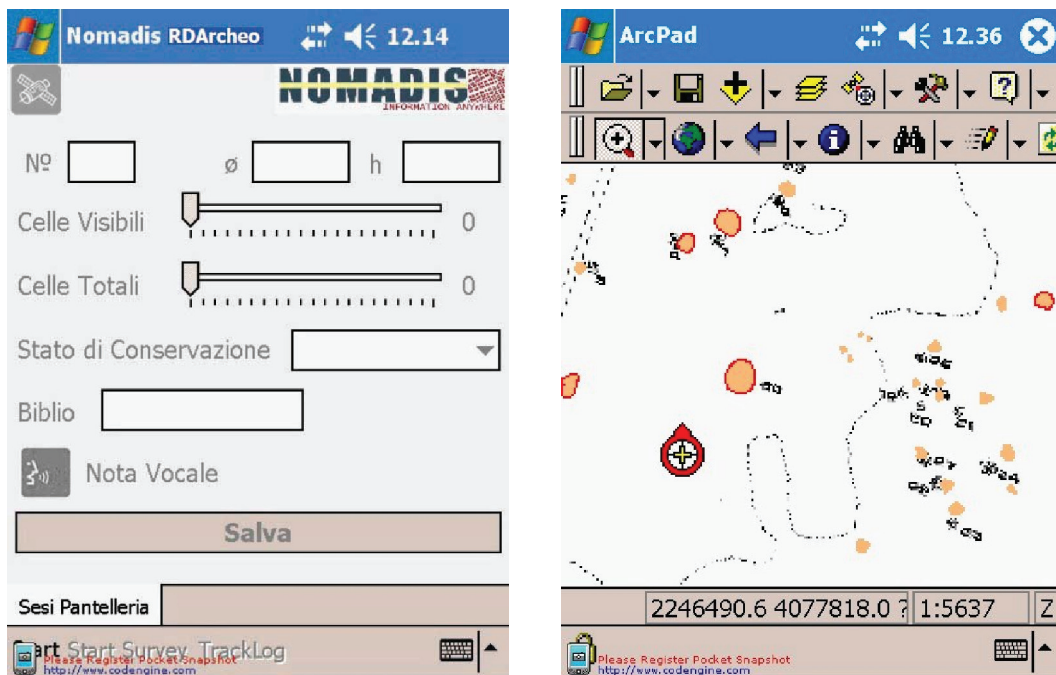


Fig. 6. The RDArcheo GUI for the Pantelleria Survey (left) and a screenshot of the evaluated mobile GIS application (right).

confirmed the efficiency of RDArcheo and opens for the integration of the above-mentioned new functionalities into the architecture of the application when used for archaeological survey purposes.

#### 4. Conclusions and future directions

In this paper, we described RDArcheo, a mobile data-collection application focused on reconfigurability, modularity and localization in every environment.

RDArcheo is very useful, but we want to further improve the software in several directions. In particular, we want to integrate RDArcheo with existing mobile GIS tools; improve the management of vocal and video notes and better integrate localization tools. Further work must be done in order to improve the quality of graphical user interfaces generated by RDArcheo.

In order to validate this data-gathering methodology a large-scale experimentation must be done.

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