Taking digital Notes in the Field: the Archeo tool-set

M.Ancona, G.Dodero, M.Mongiardino.

DISI, Dept. of Computer Science, University of Genova.
Via Dodecaneso 35, 16146 Genova. Italy.
E-mail: ancona@disi.unige.it

A.Traverso

ISA, Institute for Archaeological Science, Univ. of Genova. Italy.

Abstract

We describe a software tool, which is executed on a mobile, pen-based computer, intended to substitute handwritten notes and sketches, in the field. Such a tool substitutes computer post-elaboration of field notes, by means of real-time connection to a mobile, local-area network.

Introduction

Due to recent advances in computer technology, the term, "mobile computing", presently indicates the possibility of using computer resources in a mobile environment, i.e., not being constantly in the same place. This term is contrasted to the use of laptop computers, which may support a stationary working environment, at different locations (such as both home and office); the term refers to different kinds of devices, usually called, hand-held palmtop computers.

Like all new technologies, mobile computing provides new challenges to hardware and networking, and most of all, to software design. The reduction in size, and the need to be operational in outdoor environments, have important consequences on user interfaces and packaging. True mobility needs wireless communication, such as radio or infrared connections. High costs and low bandwidth/ reliability tradeoffs have important consequences on traditional networking support, like client/server program execution, distributed file systems, data bases, and so on. Software challenges lie both in adapting and redesigning existing software, and in designing of novel applications, especially addressing the needs of mobile users.

One such application is the outdoor field: earth sciences are natural candidates, to benefit from this new technology. Applications like wildlife monitoring, in Kenya's natural parks, have already been operational for a while, though still in prototypal phases. Other experiences are now being collected in the archaeological sector, where field survey and excavations are just starting to make use of mobile devices. Field archaeology is an extremely hostile, computational environment. A computer must be able to operate in the field, in the open air, under any possible conditions, including heat, dust, or perhaps rain, and laptops are often non-operative, under such conditions. The palmtop computer, then, may well substitute the diary, where notes and sketches are taken hour-after-hour by each archaeologist as excavation proceeds. In contrast to what might happen in urban areas, electric power supply and telephone cable connections are seldom possible on the site: no wires can cross the site, but perhaps there could be a nearby building (where archaeologists live during the campaign), where such facilities could be found. A fixed workstation can be placed in such a building, thus providing networking facilities, to mobile systems in the field, and could also be connected to the Internet.

This paper describes Archeo, a software tool, which is executed on a mobile, pen-based computer, intended to substitute handwritten notes and sketches, taken in the field, thus eliminating computer data entry and post-elaboration, by means of a mobile, local-area network. The mobile computer hardware is shockproof, waterproof, and resistant to dust, rain, heat, and in general, to open air operation. It does not need a keyboard for textual input, rather, a magnetic pen is used, to touch inside menus (like a mouse or trackball pointing device), and to draw on the screen. Handwriting recognition software is used for insertion of text.

Archeo was developed as a part of an integrated project, aimed at supporting field, archaeological work with real-time communication and data-logging facilities. A companion software system, Ade, supports fieldwork cooperation, on the site object store: it runs on a fixed work station and connects to the mobile systems. The whole project is financially supported by CNR, the Italian National Research Council, with a three year initiative (Finalized Project on Cultural Heritage).

First, we will present the novel features of wireless communication and pen-based computing, then, we will describe the fieldwork environment, which we foresee. Then, we describe Archeo's facilities, for data entry, both as drawings and as textual information. Details on the present prototypal implementation will be given, and we will conclude, by indicating the future direction of our work.

Wireless and pen based computing

Advances in cellular communication, wireless LAN and satellite services, will soon support an increasing number of *mobile users,* as described in [1]. In the near future, millions of people will connect to information sources, while moving, for their jobs, by means of their *personal, digital assistants.* These devices provide the computing power of a workstation, in a smaller, lighter package, called a *palmtop* or *hand-held computer.*

Palmtop computers cannot input from keyboards, for reasons of space and weight; instead, user interface is based on a pen. A pen replaces a mouse (or other pointing devices) in menu-driven software; when a complex command or text has to be input, some handwriting recognition software must be used. Such software should recognize, at least, block letters; of course, advances in recognition techniques are always welcome by users.

This technology, to which an introduction can be found in [2], was introduced to the market some time ago, with great expectations on the users' side, followed by corresponding disillusion, for the limited possibilities offered by commercial systems. In retrospect, pen-based computer users now constitute a specialized market niche, that of applications (for which these devices cannot be substituted with laptops, etc.), in contrast to early forecasts, where palmtops were assumed to substitute keyboard-based input in all situations (business, as well as home). In other words, whenever a keyboard is sufficient for data input, no pen-based device is going to replace it. Ten years from now, voice input shall be the primary substitute for keyboards; thus, mid-term forecasts for pen-based computers, see their future in the communications field. Notes and sketches can be taken easily with a pen, and they will always represent a primary means for communication, among individuals. The application to field archaeology, which we are designing, is, thus, best suited to pen-based input, as opposed to trackball-mouse interaction.

A typical mobile network is sketched in Figure 1. Three different entities can be identified: mobile computers (labeled **mu**), mobile support stations (labeled **MSS**) and fixed hosts. **MSS** units are work stations with wireless, communication interface, towards mobile computers, and possibly another interface (wireless or cable), towards a WAN, such as Internet.

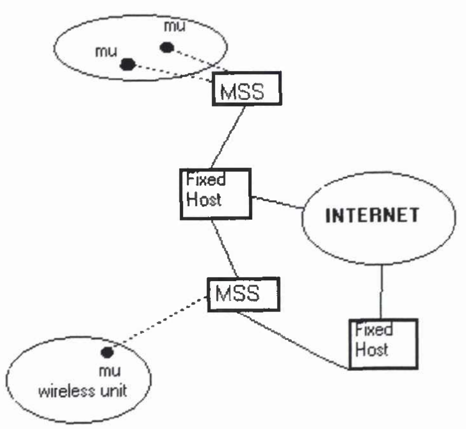

Figure 1.

These features, nowadays, make it possible to design innovative applications;1 for example, those combining mobile computing, and use of GPS inside what was called "context-aware" or "location-aware" computing [3]. The possibility of interconnecting palmtop computing, "in the field", is now being exploited in prototypal applications in urban archaeology (Seville), and for the localization of ancient rural settings in the mountains of Corse. In such applications, the possibility of contextualizing a find, for example, by use of historical maps, improves a critical interpretation of the territory.

However, there are other applicative scenarios in archaeology, where GPS supported localization is hardly significant, for example, when no previously localized information is available, or, when the scale of interest is different, such as localizing an object in the map of a room, or inside a building. The application, we are going to describe falls into the latter category.

A mobile computer for field archaeology

Location-awareness is present in field archaeology, at various scales of resolution. The largest topographical unit, to be considered, is the site, an area of interest, which has variable dimensions, usually very large ones, as well. A site cannot be excavated, at the same time on all of its surface; a selected portion of it, where excavation activities are operational, is called a test. If possible, an interpretation directs test selection, so that a unitary portion of the site, is treated at the same time, such as a single building. A test can be further subdivided, into smaller units, called sectors, whose size and shape may encompass further interpretation, e.g., a room inside a building, or it may just be convenient portions of an interesting area. Inside a sector, there may be several stratigraphic units, each of them being a convenient unit of archeological information, and the basis for cataloging. A stratigraphic unit may have a volume, by itself (e.g., a wall), or just be a profile or section (e.g., plain ground, where several bones were found).

As interpretation of finds proceeds, stratigraphic units may be aggregated to form a structure called, archaeological context, an example of which, could be a small building, composed of the four walls, delimiting it. Other relationships, among stratigraphic units, can be spatial (above, below, inside, etc.) sequential (referrings to the excavation time sequence: a wall excavated during the 1996 campaign, another in 1997), and stratigraphical (referring to dating finds: previous, subsequent, contemporary, etc.)

Let us now introduce mobile computers into the above scenario. The system consists of a work station, and two, or more, mobile computers, connected to the work station, by radio devices. The work station is installed in some building, close to the excavation site, and it is connected to the Internet, by telephone cables or satellite. To give some figures, taken from specifications of existing systems, a mobile computer may connect directly to the fixed host, within a one mile radius; for longer distances, or to overcome obstacles, like hills, repeaters (i.e., antennas) should be installed. Mobile systems provide pen-based input, and support local computations (data acquisition and preliminary analysis), as well as remote computations, which result as transactions on the work station. Remote computations include data base queries, comparisons with previously entered data, contacts between mobile computers and scientists, in nearby or remote areas, and anything else, which can be done by means of the Internet. As remarked in [4], the mobile computer is, thus, a means to extend the archaeologist's diary, with real-time communication possibilities and automatic data base updates.

Transmitting a sketch or a snapshot of interesting finds, and comparing it to an image database of similar finds, in the same or a related area, or, sending it to a colleague asking for his/her opinion, it is possible ro receive almost immediate feedback: situations like these, may significantly reduce time delays, and make an excavation campaign significantly more productive.

Let us examine field work, in more detail, for a better understanding of how mobile, pen-based computers may support it. Archaeologists usually bring their diaries to the field, where they collect daily notes. These notes are later copied on standard forms (such as those supplied by the Italian Ministry of Cultural Heritage). Usually the site is not connected to computer centers, so all daily work is transcribed and elaborated, after daily work hours, or later, when the archaeologist is back in the lab. In case a database or a colleague has to be consulted, to collect additional information before a decision on how to proceed is taken, someone has to physically travel to or from the site.

Mobile computers, as said before, may perform two functions: on site data entry, as soon as finds are identified, and data processing, possibly by remote connections.

Data Entry: Drawings and Text

The test, in an excavation site, is usually marked by a regular, square grid (approx. 2-3 meters each edge), identifying areas to be excavated. Each square in the grid is separately considered, and in turn, it is subdivided into smaller sections (approx. 30 cm. each edge), by means of strings. This subdivision allows easy identification, of the exact position of finds, at the current level. The current level is inspected, removed earth is sieved, and finally, the fine grid is remapped, at the next lower level. When the current level is lowered, track is kept of the previous one, by marking its orthogonal projection to the vertical sides of the excavation: thus, we end up with a vertical grid, too, in order to be able to identify finds proximity, in 3D space.

Finds at each level are cataloged, and then separately stored in boxes (one, per square and level, in the large grid). Information to be kept for each find are:

- spatial information: its position in the tri-dimensional grid and its size;
- additional visual details (if needed): the shape, by means of a sketch or snapshot;
- classification: possible material, color traces, status, and so on;
- additional data (to be determined later): possible origin and period.

We then have to collect textual, visual and spatial information.

Textual information is locally collected on the palmtop computer, by means of selectable menus, or by handwriting (a few letters or numbers are often sufficient). Menu-based classification is, thus, strongly recommendable.

Visual and spatial information may consist of sketch creation and retrieval, find positioning on the 3D grid, spatial relationships to other finds (such as on-top-of), and association of a sketch to related textual information. The design of special purpose software, on top of a drawing system, is the first step in the development of our system. Each find can be sketched on the screen of the palmtop by means of the magnetic pen; it can then be measured and related to the grid, measuring its distance from grid edges. The sketch can also be automatically adapted to measures, once they have been taken (e.g., zoomed, rotated, stretched) for more realistic appearance. Attachment of a snapshot, taken by a digital camera, may be useful for the most significant finds.

The use of a graphic-based, object oriented tool [5], allows separate manipulation of each object (find), which encapsulates all relevant attributes, as defined by the archaeologist. Each object may also be spatially and thematically related to other objects, by linking them with distances and the same attributes, in order to be able to recall them on the screen. In a side window, textual information can be attached to objects as annotations. Specifically, two kinds of views are possible for each test, the map and the section modes. In the map mode, objects (that is, finds) can be inserted, by drawing them on the screen, or by inserting some points, and then interpolating a curve; they can be merged later, inside a stratigraphic unit, and stratigraphic units may be merged into contexts. The correspondence of screen coordinates to surface measures is immediate; depth is also available, on request. In the section mode, inserted objects are shown (if they belong to the selected section). Figure 2 shows a typical section, as it can be reconstructed, from some stratigraphic units, in the same test. Other functions are typical of drawing tools, like filling, zooming, gridding, etc.

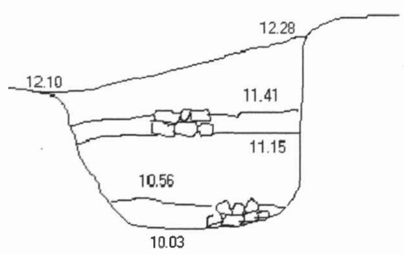

Figure 2.

At the end of each working day, and at end of the campaign, all acquired data is downloaded to the central work station, and automatically inserted into the site database (or better, into the site object store). Each new object is related to, and eventually linked to other existing objects. Further analysis is then possible: for example, thematic 3D maps of the site are automatically updated with new finds, as soon as they are cataloged.

Interaction begins by touching the `File` menu, and selecting either `NuovoTest` (new test) or `ApriTest` (open test): in the latter case, a previous session is retrieved. A global view of the test is always shown in a small side window so that the current active window, can be easily located. Once a test is chosen, a stratigraphic unit should be created, or a previous one should be opened. Such units are numbered from 1 on. Selection of stratigraphic units is a part of the GestioneReperti menu; once selected, stratigraphic units can be viewed or removed. In our object based philosophy, graphical information associated to a stratigraphic unit is composed of objects; that is, nothing can be drawn "wildly" on the screen; to enforce this philosophy, graphics is inactive until the AggiungiOggetto (add object) menu is chosen. Once drawn, objects are numbered within the unit; they can be moved and erased, their depth can be given, and they can be collapsed into a colored, numbered spot, in order to "clean" the screen and draw other overlapped objects in more detail. Textual information can be attached, by writing in a side window (the software recognizes block letters), a comment relevant to the object, the unit, or the context.

Graphic possibilities include a pen, a bin (to fill a closed area, with a given color), an interpolation algorithm, for drawing open or closed curves, the possibility to draw a section, and to add objects, inside a vertical section (or even to insert an object into the vertical section, in case the vertical profile is more relevant, than the flat one).

It should be remarked that the present tool must be considered prototypal, in that it does not (yet) contain many useful features, like the "undo"feature, which normally should be present in a complete drawing tool. Thus, in case an object is poorly drawn, it has to be removed first, from the stratigraphic unit to which it belonged, then it has to be added, and drawn again. On the other hand, some sophisticated features are already available for object manipulation: an existing object can be temporarily assigned to stratigraphic unit 0, until it is clear to which unit it belongs, or, if a new unit should be created. Also it is possible to collect a posteriori, of some stratigraphic units, into a context, like, for example, four walls in a room.

Two more problem specific functions are included: the Griglia (grid) menu allows automatic screen gridding, either at 1m. or at 10cm. distances. The Zoom menu allows the current window to be zoomed in on, by enlarging a given square in the grid.

Communication scenarios

The above presentation is centered on advantages given by a palmtop computer, on a site; we shall now examine, in more detail, what facilities are given by a mobile unit, that is by communication to the central work station, and through it, to other networked computers. The latter features become extremely important for "traditional" excavation campaigns, whenever work should be temporarily suspended, or slowed down, until new information can be collected, and new directions for further excavation can be derived from it.

A typical example would be that, of a find, whose significance is given by contextual information (other finds from the same site), which may influence future excavation, on the site. For example, various pavement of the same kind, in different areas of the site, may suggest the existence of a road, connecting them, so it may be important to look at the intermediate grid positions, where the road may still be hidden. In this case, immediate communication (through the fixed unit), among people in different areas of the site, may allow an immediate update of a current situation.

Another example is the assessment of the relevance of an object, which cannot be related to other finds in the local site database. The opinion of an experienced person, whether at the fixed station, or remotely accessible at some museum, has to be collected, before making further decisions. A digital snapshot (taken with a digital camera) may also be sent with the message/query, or, just a pen-drawn sketch. Searching non-local databases may also be necessary: this latter feature, however, is limited by the availability of computerized data, and the compatibility, in the internal organization, of different databases. In the future, this problem, as well as that of making graphic queries, could well be solved.

Conclusions

This paper has presented how mobile computers, integrating suitable communication technology, as is available nowadays in the form of palmtop computers, may be used to develop field archaeology, support tools. Application scenarios in field archaeology have been examined comparing present with future situations.

Innovations of this project include:

- substituting handwritten notes, sketches, etc., in the field, and eliminating computer data entry and post-elaboration, by means of a single integrated system;
- real-time communication, by means of a fixed work station, located close to the site: communication to/from the work station, among mobile computers on the site, and, possibly, over a WAN;
- use of object-oriented technologies, for finds storage and retrieval, on the mobile computer, as well as at the fixed work station.

The tools we are presently using are:

- a palmtop computer Telxon PTC 11-X4 as mobile device; it runs Windows 3.x for Pen, and the drawing tool has been developed, using Borland C++ and the OWL libraries. The choice of such a development environment is motivated, by the need to optimize tool performance on small configurations, like the 16-bit one, we presently have, while preserving upward compatibility for future expansions, on 32-bit machines. The system is fully operational in stand alone mode, and prepares interface files, which can later be transmitted to the fixed work station.
- A Pentium based PC, running Windows NT and Lotus Notes serves as objects repository. Interfacing to the mobile system is presently based on textual information, to be exchanged on a serial medium (cable), when the two computers are closed (that is, after each working day). The radio communication hardware and software should be installed in the near future, and communication will be integrated, in both fixed and mobile systems.

This project is the result of a cooperation between DISI, the Department of Computer Science of the University of Genova, and ISA, the Institute for Archaeology and History of Ancient Arts in the College of Humanities, headed by Professor Santo Tine`. Researchers from both institutions

have been investigating the feasibility of an information system for field archaeology; as a result, the system described above was prototyped. The end-user for such a system is the Italian Archaeological School in Athens, which has been responsible for more than 60 years of campaigns, at Poliochni archaeological site, in the Greek island of Lemnos (see [6] for archaeological references). In the 1997 summer campaign, an almost complete version of the drawing tool was already field tested, on the site by the archaeological team.

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References

[1] IMIELINSKI, T. & B. R. BADRINATH (1994), "Wireless Computing", *Communications of the ACM* 37(10), pp. 19-28.

[2] JERNEY, J. (1994), "Mobile Insights: the Bright Future of Pen Computing", *Pen-based Computing, The Journal of Stylus Systems* (electronic version).

[3] RYAN, N.S., et AL., (e. p.), "Enhanced reality fieldwork: the context-aware archaeological assistant", in: *CAA97 Digest of Papers*, Archaeopress, Oxford.

[4] ANCONA, M. et AL., (e.p.), "Mobile computing for real time support in archaeological excavations", in: *CAA97 Digest of Papers*, Archaeopress, Oxford.

[5] MONGIARDINO, M., (1997), *A real-time software tool for archaeological excavations*, Master's Thesis in Computer Science, University of Genova.

[6] TINÈ, S. et AL. (e.p.), "Poliochni 1991-1995. I nuovi dati", *Monographs Scuola Archeologica Italiana di Atene*, L'Erma di Bretschneider, Roma.