ArchaeoCAD, ArchaeoMAP, ArchaeoDATA
An Integrated Archaeological Information System

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Abstract. The recent advances made in 3D surveying technologies and documentation techniques have given rise to a host of new software applications for processing the acquired data. Information systems have been around for quite some time including geographical information systems which link digital points on the Earth's surface with additional information. The potential uses of this technology for archaeology and heritage are apparent but the complexity of the subject matter in these fields makes developing specialist information systems necessary. ArcTron Ltd. has been developing a specialist archaeological information system for over a decade. This paper looks at some of the possibilities faced by archaeological information systems and briefly introduces the ArcTron system.

1. Introduction

There are presently many different varieties of 3D documentation used on archaeological and heritage projects, from total stations and photogrammetry to high-tech procedures such as 3D laser scanning. During the last few years, these documentation methods, particularly the use of total stations, have established themselves as standard procedures.
However, no matter how advanced the documentation methods are, they are of little use to scientists if the hard and software used to process the results are not of an equally high standard.
At ArcTron Ltd. we have dedicated ourselves since 1992 to developing an integrated and comprehensive software package which can cope with the diverse demands of archaeology and cultural heritage projects.

2. Information Systems

Computer information systems are a method of administrating and managing data of any kind. They have become almost ubiquitous in the worlds of business and finance.
One very well-known type of system is the geographical information system (GIS). These are computer information systems that allow the user to record, evaluate, store and display geographically referenced information. The systems also contain records of the data acquisition methods used, personnel involved, coordinate files, spatial relationships and so on. A GIS allows the user to pick a point on the globe or an object on the computer screen and to gain immediate access to further information concerning that point or object from linked files.
An information system of this kind would obviously be of great use to scientists working in the fields of archaeology and cultural heritage.
The problem with creating an information system for archaeology is the extremely wide range of information that it must be able to cope with. From personnel details to planning data, finds and feature descriptions, plans, drawings, photographs, survey data, reconstructions, finds labels, classifications, stratigraphy, physical contexts and relationships: all of these and many more are essential for the comprehensive documentation of an archaeological excavation or heritage project. In addition, no two excavations or heritage projects are alike, but to develop a whole new system for each project is unfeasible.
A further problem is the sheer quantity of data that is often produced during excavation. This data must be stored and archived in such a way that it is easily manageable and accessible both for the administrators and for possible future researchers. The solution to this problem would seem to be to create a standard system.
This conflict between the need for a flexible system which can adapt to the requirements of each project and the need for a standard solution to ensure efficiency and comprehensibility makes the development of an information system for archaeological purposes a difficult task.

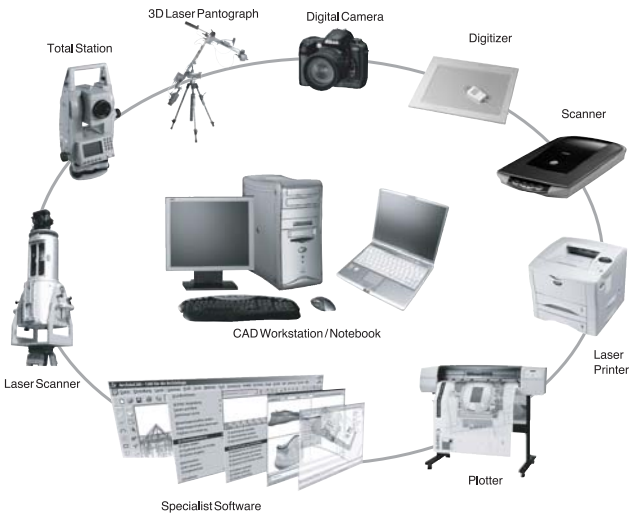

Fig. 1. Components of the ArcTron archaeological information system.

3. The ArcTron Archaeological Information System

The ArcTron archaeological information system has been in constant development for over a decade.
It is built largely out of standard components (Fig. 1). These include a high-capacity CAD station with peripheral equipment, laser scanners, digital cameras, our own specialist software as well as software from other manufacturers and a total station for use in documentation and surveying.
Further components such as GPS or digital pantographs can also be incorporated into the system if they are required.
The ArcTron system is modular but its components are standard, which means it can be individually tailored to meet the ever-changing demands made upon it by projects of varying complexity and size whilst losing none of the advantages of standardisation.
Our own software solutions (Fig. 2) can be linked directly to the electronic surveying instruments ensuring that data can be efficiently transferred. Our various programs can be combined in many different configurations to ensure optimum efficiency and flexibility. The programs interact both with the instruments and with each other, exchanging, matching and comparing information.
This cross-application analysis allows new connections and conclusions to be made, which may otherwise have gone unnoticed, and simplifies the investigation and research phases.

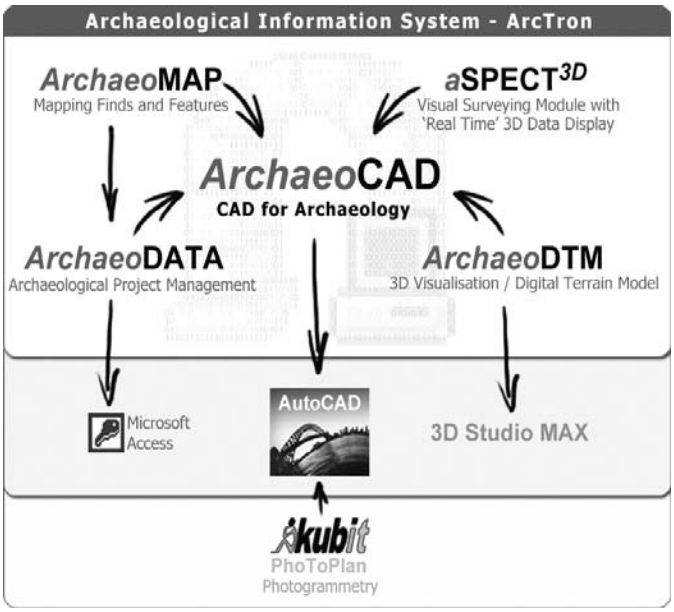

Fig. 2. How the information system software interacts.

3.1 ArchaeoCAD

ArchaeoCAD is an application for AutoCAD and is the cornerstone of our archaeological information system. ArchaeoCAD directly processes appropriately coded raw data from electronic surveying equipment (total stations, digital pantographs, etc.). The three dimensional data is automatically converted into scientifically pre-structured and largely print-ready plans (Fig. 3).

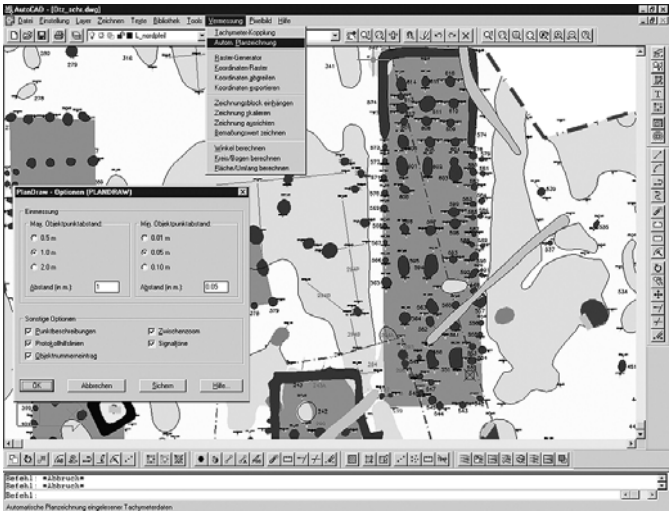

Fig. 3. Automated plan creation in ArchaeoCAD using the PlanDraw module.

The program contains numerous auxiliary modules which enable the user to edit plans up to the print-ready stage. The program also contains diverse functions for digitising and processing existing records (e.g. plans hand-drawn on graph paper). Various 3D modules enable the user to create isometric feature reconstructions. This is especially useful when reconstructing buildings, ditches, ramparts, walls, palisades etc.
In addition, and most importantly for the information system, ArchaeoCAD plans can be linked to any desired external data, e.g. written descriptions, photos, databases etc.
ArchaeoCAD contains many specialist functions and features for archaeologists including:

- Automated plan creation
- Archaeological layer management
- Archaeological drawing modules
- Digitisation and photogrammetry modules
- Isometric feature reconstruction modules

ArchaeoCAD can be used in conjunction with our mapping interface, ArchaeoMAP, and our excavation database, ArchaeoDATA, which will both be discussed a little later.
The combination of these programs creates an archaeological information system which is comparable to a geographical information system.

3.2 aSPECT3D

ArchaeoCAD contains an integrated 3D online module called aSPECT3D. This program enables the user to visually monitor incoming data from a total station in three dimensions whilst on site (Fig. 4). Incoming 3D coordinates from a total station can be controlled and structured using a connected laptop, a pen-based system or even a simple palmtop computer actually during the surveying procedure.
The coordinates are converted in real time into sequences of 3D vectors which can then be edited and processed using functions for triangulating, closing, copying, deleting etc. The vector polylines can be treated as object contours and allocated object numbers and descriptions. Finds measurements can be differentiated by find number and type and so on.

Fig. 4. aSPECT3D is an online graphics interface for total station surveying.

Data from aSPECT3D can be directly imported into ArchaeoCAD via a special interface for further editing.

3.3 PhoToPlan

Multiple or single-image photogrammetry techniques are extremely advantageous for archaeology and heritage. We use and market kubit PhoToPlan as a photogrammetry interface for AutoCAD and ArchaeoCAD. It can be used to rectify digital photographs using accurately surveyed control points, resulting in seamless, scaled photographic documentation of even the most complex sites. The rectified plan can be printed out and checked whilst still on site.

3.4 ArchaeoMAP

ArchaeoMAP is a mapping module for use in conjunction with ArchaeoCAD. It is the interface between ArchaeoCAD and the excavation database ArchaeoDATA.
It allows various mapping and database queries to be graphically visualized in CAD plans. The results of database queries can be mapped by feature type, sector, dating etc. The graphic design of the mapping can be freely modified by the user.
Using ArchaeoMAP, CAD plans of an excavation can be structurally linked to the information in the ArchaeoDATA excavation database. This allows the user to switch from a feature or find in the CAD plan straight to the corresponding entry in the database. ArchaeoMAP simplifies the analysis of archaeological excavations. During evaluation, finds and contexts retrieved from the database can be automatically plotted to generate archaeological plans according to user-defined parameters and criteria.

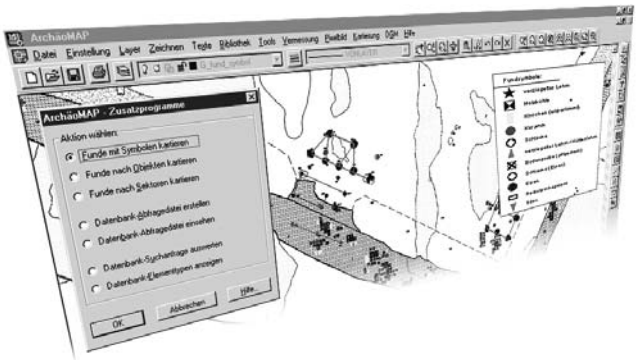

Fig. 5. ArchaeoMAP is the mapping interface between ArchaeoCAD and ArchaeoDATA.

3.5. ArchaeoDATA

ArchaeoDATA is an archaeological excavation management database based on MS Access.
Databases are indispensable tools for managing the enormous amounts of data which commonly occur on archaeological excavations. The more thoroughly the excavation data is managed, the more potential is unlocked for the efficient creation of excavation reports and their subsequent evaluation.
ArchaeoDATA can be used in conjunction with ArchaeoCAD and ArchaeoMAP. This combination forms an archaeological information system which functions in a similar way to GIS.
ArchaeoDATA is capable of recording all vital and secondary information arising from an excavation. Standard archaeological tasks such as printing finds and samples labels, recording finds and features, filing and referencing drawings and photographs or creating reports are organised into separate, standardised work phases.
Each phase is represented by a user-friendly input dialog which is interlinked to other work phases by corresponding information and entries and make it simple to navigate the database. Some of the most important dialogs include:

- Archaeological project management. Project management is standardised using fundamental excavation data such as location, title, type, date etc. The setup can be adjusted to suit the project.
- Finds management. The finds manager uses fundamental finds information such as finds numbers, find contexts, classifications and descriptions to organise large quantities of finds into a manageable collection (Fig. 6).
- Scientific finds classification. A classification database is included in the program which helps the user to define finds using scientific terminology.
- Feature management. The standardised feature management dialog allows the user to organise all the information concerning features or objects from an excavation using criteria such as feature number, field, sector, section, area,

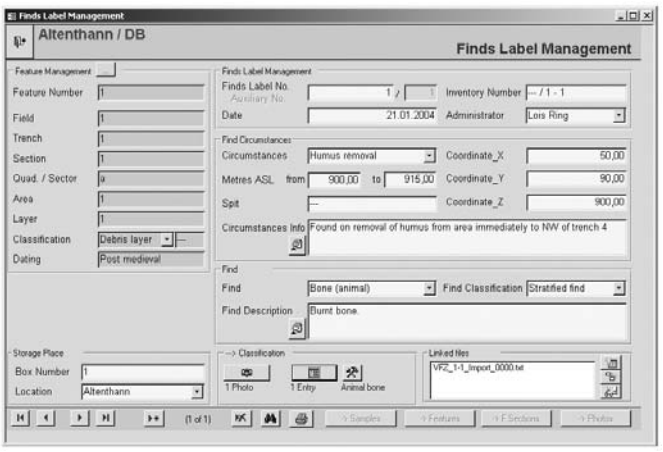

Fig. 6. The ArchaeoDATA finds label management dialog.

layer, feature description, classification, dating, pedological description etc.

- Photo management for finds and features. Excavation and heritage projects often generate huge amounts of graphic data which can be laborious to manage. The ArchaeoDATA image manager allows all photos, slides and drawings to be incorporated and organised in the database. The images are numbered and linked to their respective entries in the finds or features managers.
- Automated report creation. Information from the database can be filtered, collected and printed as reports. The user can select which information they wish to include in customised reports or use the ready-made reports included in the program. The user can create individual reports for a specific item, detailed reports or overviews. The reports are printed in tabular form and can be easily modified by the user to adapt to the requirements of the current task.
- Finds and sample label management. Finds and sample labels can be easily created from the entries in the database. The labels contain all necessary definition and classification categories.
- Search engines. ArchaeoDATA contains three integrated search engines which make it simple to find excavation-related information of any kind. They enable the user to rapidly compose comprehensive database queries.

3.6 ArchaeoDTM

ArchaeoDTM is a software application for AutoCAD / ArchaeoCAD which was developed in collaboration with a partner firm. ArchaeoDTM is a high-capacity, digital terrain model program which works under ArchaeoCAD and allows the user to produce 3D models of an even greater complexity than when using ArchaeoCAD alone (Fig. 7).
ArchaeoDTM can generate three dimensional models from point clouds of up to approximately 500 000 points. The 3D points are meshed and interpolated using Delauney triangulation. The triangular mesh is created very precisely, remaining consistent within the X-Y plane and is generated independently of the location or rotation of the measured points. As well as landscapes, the program is able to model archaeological, topographical or geographical layers. The integrated functions allow the user to create contour line plans, labelling and colour evaluations etc. The generated model can be used to make accurate calculations of mass and volume and cross sections can be created through any point of the model. ArchaeoDTM also contains reconstruction modules which allow the user to create sophisticated visualisations of archaeological features. They include modules for drawing posts, walls, beams, windows, doors, roof structures and roofs. The latest version also includes functions for reconstructing masonry, ramparts, ditches and palisades. All reconstructions are created in three dimensions and can be automatically referenced to the corresponding topographical terrain relief map.

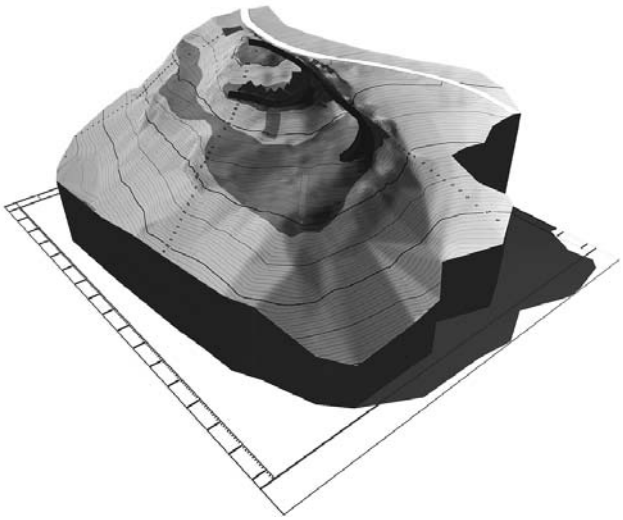

Fig. 7. ArchaeoDTM is an AutoCAD application for the generation of digital terrain models.

4. Conclusion and Further Works

We are standing on the verge of a sea change in the field of digital excavation documentation.
There is an enormous range of 3D surveying technologies and processing software available today and to not take advantage of these advances would be to waste an incredible opportunity to improve documentation standards.
Archaeological information systems which use a combination of innovative surveying instruments and specialist software have the potential to transform archaeological working processes. Systems which allow cross-application communication and comparison of data allow significant information to be analysed and evaluated more thoroughly and with a greater degree of insight. Our system is used by universities, heritage authorities and commercial excavation companies across Europe meaning that it is being constantly tried and tested by professionals. We are improving, expanding and simplifying our system all the time, for instance, we are presently developing a more extensive version of ArchaeoDATA as a client/server system MS SQL-Server.
We believe that the development of efficient archaeological information systems is of the utmost importance for the fields of archaeology and heritage.

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