Real Time, *in situ;* Computerized Graphic Documentation in Archaeological Excavation

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Abstract

This paper discusses survey methods and computer applications, that have been used, for the last few years, in archaeological field work .

Artifacts data analysis and matching processes are traditionally performed at the end of the excavation season, at the lab. We are able, with a combination of portable computers and common software, to start this process , at the field, in situ, and in real time. We have found that combining EDM (Electronic Distance Measurement) and DEM (Digital Elevation Model) system with a CAD\CAM (Computer Aided Design\Mapping) software, during the excavations, significantly improves archaeological work on three major levels:

1. controlling graphic recording processes for strata, structural elements, and major exposed finds.

2. examining data collecting, linking and matching, in real time, in order to prevent a lack of information, or possible errors.

3. facilitating introduction to different methods of access, for the analysis of archaeological finds, during the excavation process.

This paper will describe the way have applied this technique, to three different kinds of archaeological excavations: at a small scale excavation, at Yodefat, at a large and extended excavation, at Beth-Shean - Scythopolis (both in Israel), and finally, at the unique case study, in Pompeii .

Yodefat Excavations

Consecutive use of on-site computer applications was established for the first time at Yodefat, during the 1991 excavation season. This project was carried out by the Israel Antiquities Authorities, the Bar-Ilan University, and the University of Rochester (Adan-Bayewitz D. et al, 1995). Yodefat - a small, Jewish, fortified village in Lower Galilee, was founded during the Hellenistic era and was destroyed by the Romans, in the great revolt of 67 - 70 AD (Josephus Flavius :War III: 308-405).

Because of the poor preservation condition of the site, we decided, prior to excavation, to perform a general survey, with the QuickSurf DEM system (Schreiber Instruments Inc.). The aim of this survey was to carefully study the topographic landscape of the site, and its surroundings, and to record the major archaeological remains, that were visible on the ground, e.g., apparent walls, pits, caves, and architectural elements. (fig. 1) This information was processed by AutoCAD R12 (Autodesk Inc.). Each of the major remains was assigned a different layer designation on the program system (Messika N. 1996).

This preliminary survey was essential, to understand of the complexity of the site, and its fragile condition, prior to any irreversible interference, with its nature. Over the general plan, we laid a 5 x 5 grid, that marked the excavated areas, and squares, on an absolute coordinate, reference system. Once the digging started, we used CAD software, as a central data source. The slow and careful excavation process enabled us to digitize, on a daily basis, most of the top plans, and the sections, that were drawn at the site. This information was automatically linked to the topographic and the overall survey maps, and received accurate 3D values. The plotted plans, that we provided daily to the supervisors, the survey teams, and the pottery specialists, served as a unified and reliable document, for various needs (fig. 2). Some of the digitized data was combined with other data sources, such as pottery tables or special artifacts lists. In other cases, the data was simplified, in order to obtain a general overview, of the strata development for the city.

During the next excavation seasons (1993-1995), we improved our digital recording processes, that became, with time, easier and simpler to use, due to the establishment of interlined, classified directories. These directories allowed us to develop the system further, by adding new functions and details.

Beth-Shean - Scythopolis

Beth-Shean -Scythopolis, located at the junction of the Jezreel and Jordan valleys, contains settlement strata from the Late Neolithic to the Late Iron Age, at the Tell, and a Hellenistic to modern time city, at its southern, downhill side (fig.3). During the Decapolis period, the city expanded to its largest size, covering close to 100 hectares. During the last twelve years, the main, colonnaded streets, baths, shops, amphitheater, odium, theater, temples, and other monumental buildings, were exposed by two expeditions : one from the Israel Antiquities Authorities, and the other from the Hebrew University of Jerusalem (Foerster G. et al 1993).

We introduced an electronic survey map, with a CAD work station, during the 1996 excavation season. The plans were delivered to the archaeologists, from both expeditions, the restoration and conservation teams, and the Beth-Shean Tourism Development Company. The use of computer application, at the site, was therefore, in this case, a "rescue action", rather than a fundamental study process.

One of the major problems, that we had before starting the project, was how to unify old, manually measured drawings, that were not accurate enough for our needs. Since the recorded elements had changed, during the long excavation and restoration processes, we were unable to re-measure the entire, excavated site. We therefore, fitted the old plans, using EDM and CAD software. First, we added reference points to the plans, and then, we measured their exact location at the site, with a survey program application (Tripod Data System, Inc.) (fig.4). The data, that came from the survey, was used as a refitted grid, for digitizing the old plans, with an Auto CAD R13 for the win95 system. We used the "Affine" option, in the tablet calibration command, for getting a RMS (Root-Mean-Square) measurement, when the acceptable range, that we fixed, was limited to a maximum 5 cm error. In this way, we succeeded in combining the new plans, that were measured with electronic facilities in prior, recent years, with the old ones that were drawn, according to the manual measurement technique.

The general digitized plans, that we produced, enabled, for the first time, matching the different recording methods used, by all of the survey teams, that worked on the two expeditions. We established with the AutoCAD system, a rational logic structure for identifying building materials, stratigraphic sequences, and dating proposals. Our plans also served as an accurate base for 3D model representations, of the archaeological monuments, for the needs of the Beth - Shean Tourism Development Company. Lately, we have started to use AutoCAD R14, that has a stronger modelling and rendering performance, as well as other graphic programs, such as 3D Studio Max, PhotoShop 5, and Free-Hand 7, which provide us better rendering results. In some of the models, we were able to add actual photos to their bacground, in order to obtain an impression of the standing buildings, in the surrounding landscape (fig.5-6).

The Anglo-American project in Pompeii

The recent excavations, at the CASA DELLE VESTALI in Pompeii, were performed by the University of Bradford, as an archaeological field school, aimed towards recording and interpreting all of the standing buildings in Insula VI.1.

The project started with an initial survey, made in 1994 (Bon S.E. et al., 1996), and has been continuing successively since then. The combination of excavation and detailed, building recording, using digital imaging and an EDM station, with PenMap facility for Win (designed by Steve Dockrill from Department of Archaeological Sciences, Bradford), has revealed a complex sequence of building history (fig.7). In the 1997 season, we added a CAD system, in order to examine the surveyors' work, the walls analyzed and the drawing, recording processes of the excavated strata, *in situ*. With the use of the AME 3D, system of AutoCAD 12, we reconstructed house walls and floors, at different phases, according to their 3D, coordinated points, from the EDM survey (fig. 8). Over these models, we were able to add information, that came from analyzing the standing walls, i.e. reconstructed border lines, blocked openings, fresco remains, and construction methods, or materials (fig 9). In the coming season, we hope to extend the use of this method, in order to add more significant data, such as artifacts location, strata sequences, and dating proposals.

Methodological problems:

At the end of every excavation season, most archaeologists are concerned by two major questions:

1. How to insure the accuracy and completeness of the collected data.

2. How this data can be linked to other sources, in the simplest and quickest way.

Several years ago, these questions caused real dilemma, in many archaeological projects, since the possibility of having a system, for controlling and tracking the graphic recording process, *in situ*, and in real time, was an unreachable ideal. Today, when computers have become indispensable equipment, in most archaeological research, we are able to start using up-to-date CAD systems, to examine data gathering stages at the site. We have found that AutoCAD software can be linked easily to EDM and DEM survey data, and that its modeling possibilities, from Release 12 and on, are simple to operate, and are satisfactory for many basic field needs.

Equally important, as hardware and software choice, is the definition of the exact expectations, for our computer system, according to three main factors: the size and the complexity of the site, the duration of the excavation, and the specific character of the project. In the three examples presented, we showed how these factors have affected the making of a logical choice. When possible, as in the Yodefat case, it is very useful to establish, in advance, a fixed computing, recording method.

When this approach is inappropriate, as in the Beth- Shean project that started using sophisticated modern equipment, only after a long period of intensive, large-scale digging, the utilized system may be used as a quick, rescue solution. In the last example, the Anglo-American project in Pompeii, we used computing systems, to introduce to the students at the field school, new technical solutions, for matching different information sources, to the digging, surveying, and wall analyzing processes.

The presence of a well-functioning computer station, at the site, during excavation time, facilitates the information exchange, between working teams, and helps to centralize different kinds of data sources, under a unified language system. There is no way to point to one overall system, that will be suitable for all situations. The methodological solution must be made, according to archaeological and non-archaeological considerations, in each excavation project. Nevertheless, we suggest that the best way, to define the methodology of data collection, at the site, is to take into consideration, the advantages of high technology production, versus time and work force limitations, during the excavation period. For example, database input keying can be executed, without many differences in the lab. On the other hand,

skipping essential checking of important data, such as elevations and stratigraphic relations, may give rise to other problems, further on. Another recommendation is to try if possible, to simplify and unify the code system definitions, like the layer names, dates or subject structures in the DEM, CAD, and DataBase systems, that are used, in order to allow easy access and linkage of information, for the work in progress.

Review and prospects:

The results achieved in the excavation projects, that were described above, demonstrate the various possibilities for using DEM\EDM systems, with CAD\CAM facilities, during the excavation season. Even though those systems demand a certain investment, both in technical equipment and in proficient teams, we believe that the investment justifies it self as a worthwhile one, in time consumption, as well as in future research possibilities. It also guarantees that all the computerized data, that go back with the archaeologists at the end of the season, can be transferred, without too much effort, to different kind of GIS programs.

During the last few years, an increasing number of archaeologists have concluded that GIS programs are one of the best tools available for analyzing, manipulating, storing, and displaying information from excavation (Kvamme K. 1989, Savage S. 1990). The ability of these programs to describe general geographic, cultural and social phenomena in graphic form, and label them, makes them particularly important in the conclusion work process.

It is important to mention that the database in GIS is spatially linked to the world coordinate system, and therefore, we should verify information before starting to examine the buildings, according to their strata and finds, confirm that they are all equal, well-checked, discussed in the same determined and indicated language.

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