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Low Cost 3D Visualization and Measuring "Tool" in the Service of Archaeological Excavations

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Abstract. Photogrammetry has been used quite a lot lately for the mapping of archaeological sites and for the registration and documentation of excavation findings. Photogrammetric software applications and Digital Photogrammetric Stations (DPS) have not been easy to use tools for any archaeologist since the knowledge and experience background needed for this purpose is very demanding. A DPS user should be familiar to the use of computers and should have specialized knowledge on CAD programs. However, in many cases the work that has to be accomplished using a DPS for the mapping of an excavation hole is just the recording of the site's ground-plan basic construction lines.

On the other hand the cost of a DPS is very high and considering its low duty in an archaeological survey, many archaeologists avoid to use photogrammetry for the recording of an archaeological site. A low cost software application providing all the high end features of a DPS and customized to be used for archaeological surveys would be the ideal tool for archaeologists and could give them all the advantages of photogrammetry. Such a handy low cost tool, that any novice user can handle, has been developed providing among others high operational capability, flexibility and 3D stereovision.

Key words. Stereovision, epipolar images, matching

1 Introduction

Excavation holes need to be mapped in order to document the work that has to be done during the excavation process, and to produce a thematic map that demonstrates the final chart of the excavation and the position of every finding on the site.

However this task is very difficult because of the continuous and rapid change of the excavation site. That's why high-speed processes have to be introduced so that the least amount of effort and time is dedicated to this purpose.

Another reason for doing this is to better organize the different kinds of artifacts that can be found during an excavation. Different layers of the same excavation site and their maps have to be combined on a single map sheet in order to produce a better visualization effect of the excavation progress.

Photogrammetry provides tools that use stereovision techniques and specialized computer systems called Digital Photogrammetric Stations. These tools can provide, with just a few measurements, (that are already taken from the archaeologists) 3D coordinates of every object that is presented in at least two overlapping images known a stereo-model (MIYATSUKA, 1996, POMASKA, 1999). Photogrammetry can be faster in the implementation of the classical surveying process and more accurate than classical techniques that have been used so far from archaeologists. The final product can be orthoimages, which are images that have the same precision, scale and orientation as a topographic map, and additionaly they provide the true situation of the excavation hole in a photographic form. Additionally they can give other kinds of products such as 3D models of the excavation site and combining the orthoimages with these models a Virtual Reality Model can be acquired and published on the Internet.

The problem of using a DPS is the extremely high knowledge of the photogrammetric techniques and processes that is demanded.

Additionally they are very expensive since they are accompanied with high tech 3D vision graphics cards that can reach the cost of 10.000€ or even more.

The accompanying software is very complicated and only experienced users can use it in an efficient way. The best quality of the final photogrammetric product is acquired when the DPS uses images taken from metric cameras such as the ROLLEI 6000 series and this makes the whole configuration even more expensive. In many cases archaeologists would like to spend less money for the imaging gear of the excavation; that's why they use non-metric film cameras. During the last years archaeologists began to use digital equipment such as commercial digital cameras (NIKON, SONY, OLYMPUS), which produce low-resolution images.

Using aerial photographic images (above the site from a balloon or helicopter) small-scale photogrammetric strips (which are continued stereo models) are produced and the whole excavation site can be recorded. In this case, the mapping scale cannot be over 1:500.

However this mapping scale of 1:500 does not provide the appropriate accuracy the researchers need. As a result close range images must be used in order to provide the appropriate accuracy of the final product (map or orthoimage). In this case, using the current digital cameras' technology (with a 3 Megapixel imaging sensor) the height of the imaging device should be less than 5 meters. Since the use of a Digital Photogrammetric Station does not provide the expected efficiency (time versus money) and is very hard to be handled by archaeologists, they are only used before the excavation is started and after the excavation process has ended. The intermediate phases of the excavation holes are not usually recorded at least using classical photogrammetric techniques and Digital Photogrammetric Stations (GEORGIADIS et. al. 2000).

2 Is Photogrammetry Not Applicable For Excavation Sites' Recording?

Is it appropriate to use photogrammetric tools to map an excavation site or is too expensive and time consuming to record the current situation of a distinct phase of an excavation site?

Of course, the mapping of any excavation site must be done anyway. Additionally, many measurements are taken using total station or any other measuring device. Why not take advantage of all those important information and try to use them for the sake of the recording of the excavation sites.

2.1 Our Proposal

A new tool oriented to the needs of archaeologists has been created in order to combine the amateur digital images they produce and the measurements they take. The purpose of the development of this software application is to introduce the efficiency of a Digital Photogrammetric Station in an easy to use tool. That means that the user can extract reliable 3D information from the imaged objects since they appear in at least two overlapping images.

Another very important feature of this tool is the low cost that is needed for its implementation, since a typical graphics game card that is used for the stereo viewing system, costs about 300€.

The user is not necessarily introduced to the complete theory of Photogrammetry and the only thing the user should do is press the left mouse button when the stereo viewing system provides a correct stereo image of the three dimensional object.

2.2 The Methodology

In order to provide the absolute coordinates from stereo model images, control point measurements should be acquired. These measurements can be taken using a Total Station or a GPS or they may be already implemented on a fixed frame (light metal construction) that can be photographed together with the excavation site. A pair of images has to be acquired for every object that is going to be recorded.

The images can be acquired either using a ladder or other simple metal constructions that places the camera at the appropriate height above the excavation hole.

The images on fig. 1 are taken in a stereo mode configuration. Their overlap is almost 60% and there are enough measured points to provide the absolute coordinates using photogrammetric techniques.

Fig. 1. *Left and right images of a stereo model and their overlapping region*

The images of the stereo model have to be relatively oriented, that means the user must identify the same –conjugate points–in both images. The technique that is used for the accurate collection of the conjugate points on the stereo-pair images is the Least Square Matching (LSM) technique. This technique has been used quite a lot in photogrammetry and is part of the software packages of many DPS (GRUEN and BALTSAVIAS, 1988). After the images are relative oriented, epipolar images are created. The epipolar images are transformed images of the original ones that can provide stereovision using a specialized hardware graphics card (TSIOUKAS, et. al. 2000). These images are then introduced in an interlaced mode in the stereo viewing system and they can be observed three-dimensionally (TSIOUKAS et. al. 2001). A minimum number of 6 points give some results for the relative orientation of the image pair but a minimum number of 10 points give a result that provides sub-pixel accuracy measurements for any pair of points. All these points do not have to be absolutely measured in ground space but only 3 of them are able to provide the absolute position of the images and can give the 3D model of the imaged objects.

Since relative orientation has been performed, the epipolar images of the previous stereo pair are created. They are actually rotated images of the originals and their main characteristic is that the location of a unique point on the ground lies at the same image line for both of them.The images can be combined in a single one. The new image is rather peculiar (fig. 2). The odd rows of the new image come from the left epipolar image and its' even rows come from the right epipolar image of the stereo model. When this image is presented from the interlaced mode stereo viewing system, a perfect 3D view of the excavation is generated. The user can scroll the odd rows relative to the even ones (using the roller mouse button) and in that way the user can bring into coincidence the idols of a ground point on both images. By clicking the left mouse button the user acquires the 3D coordinates of the specific point.

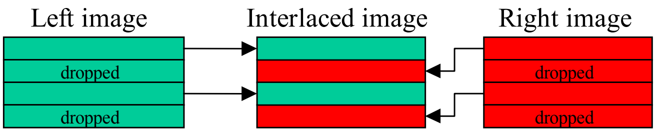

Fig. 2. *Creation of stereo image (SECHIDIS et. al. 2001)*

2.3 Hardware Configuration

The demanding cost is rather low (fig. 3). A typical personal computer running under Windows is appropriate for the software to run. The demanding hardware is a 3D graphics game card. We have used the ASUS V7700 model with stereovision capabilities and virtual reality glasses. An intellimouse compatible pointing device should be used in order to provide

the roller mouse button that performs the roaming of the images. The software has been created using Microsoft Visual C/C++ compiler and is running under any Windows configuration.

Fig. 3. *Hardware configuration*

3 A Simple Example

In the captured image (fig. 4) from the application tool three overview images of the excavations site are shown and by clicking the left mouse button on any part of them, a detail image is shown in the other windows. The bottom left widow is showing in interlaced mode the stereo image. By clicking the left mouse button the program generates the correct 3D coordinates of the point under the mouse pointer, only if the user has brought into coincidence the idols of this point from the left and right part of the epipolar images. In other words the user should be able to see in stereo the region around the mouse pointer.

The user can very easily draw the object in the stereo window. All he needs to do is observe through the virtual reality glasses the points under the mouse pointer and bring them into coincidence for both left and right images (by using the roller mouse button). By clicking the left mouse button the 3D coordinates of the points are inserted in 3D coordinates file that can very easily be transformed in CAD DXF format file.

To measure distinct points and distances is even easier. The only thing to do is produce the stereo image at the location of the point that defines the ending points of the lines' and click on the left mouse button. A special dialog box illustrates the distance between the current and the previously defined point and it can also give the total perimeter of the polyline that has been drawn.

The user is also able to produce a dense grid of points that can be used as a Digital Terrain Model (DTM) for the creation of the orthoimage.

4 Conclusions

The suggested low cost visualization and measuring "tool" for archaeological photogrammetric applications, is trying to bring photogrammetry closer to archaeological applications and namely to the excavation process. This effort is also supported by the reduction of hardware prices and especially of the special graphic subsystems.

We managed to develop a system that can fully support the capabilities of a graphics card with stereoscopic vision capabilities and the photogrammetric processes have been introduced to a simple software application that can easily be operated by a novice user.

The developers will try to embed more tools and automation in the application that can help the job of archaeologists. For that reason, the successful cooperation of the photogrammetric community with the other communities is essential.

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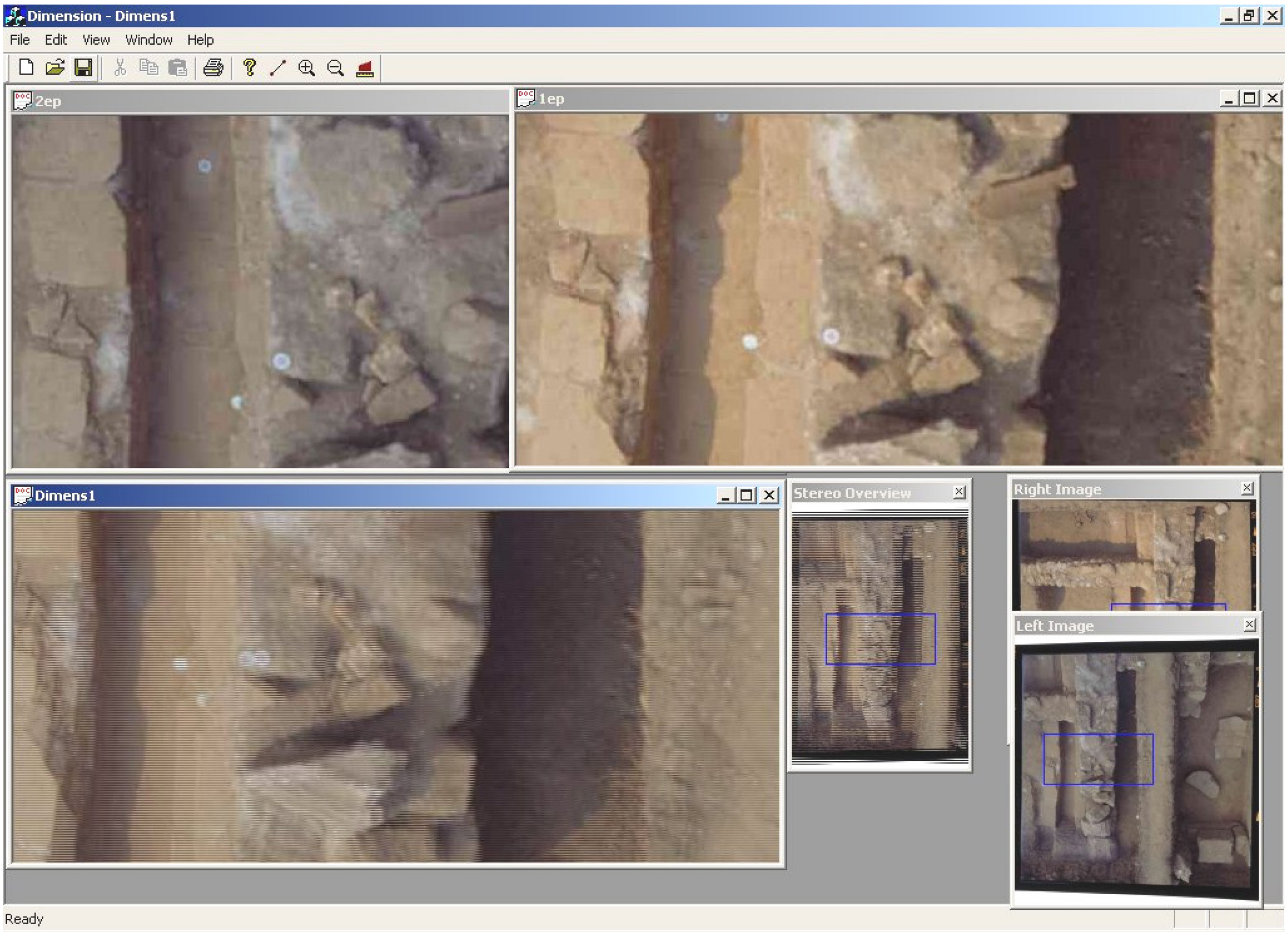

Fig. 4. *Demonstration image of the Low Cost 3D Visualization and Measuring tool*