

**CONCEPTION OF AN INTEGRATED 3D-GIS  
FOR PRIMARY DATA ACQUISITION AND DATA MANAGEMENT;  
APPLIED TO AN INVENTORY OF HISTORIC MONUMENTS**

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## **ABSTRACT**

On the example of the inventory of the historic monuments of the south of Morocco, one shows up 3D data acquisition and 3D modelling. The work is part of an inventory of these monuments and the information is integrated in an information system allowing flexible management of the data. The tools used concern also the management of photographic views with the special 'Engineering Link' and the management of detailed descriptive files beside the extensive use of a relational database.

## **1. INTRODUCTION**

The application of Geographic Information Systems to various inventory tasks based mainly on photogrammetric data acquisition is becoming a routine work. However most GIS are 2D organised and do not allow an extension to 3D object modelling. Whereas an inventory of a built-up area, including information on the facades is difficult to imagine on a system based only on 2D. These applications require rather 3D modelling, the inclusion of elements of virtual reality and the visualisation of facades and of various other photographic documentation. The article presents the conception of an integrated 3D-GIS including elements of virtual reality and Netscape elements beside the organisation of attribute data in a relational data base. The concept of this 3D GIS was developed for the inventory of the historic monuments of the Drâa Valley of Southern Morocco. This project represents a collaboration between the Institute of Photogrammetry of the EPFL, in Switzerland, the architect Hans Hostettler, Bern, Switzerland, and the "Centre de Conservation et Réhabilitation du Patrimoine Architectural des zones Atlasique et Subatlasique" (CERKAS) of Morocco.

## **2. 3D MODELLING AND VIRTUAL REALITY**

In order to obtain a high degree of vividness, one urges more and more that information systems present beside flat maps also 3-dimensional presentations. However, the incorporation of the virtual reality requires the use of 3D-capable information systems. AutoCad, MicroStation or ArcView show certain possibility in this respect. Of course, the possible effects remain still limited like the use of avatars (artificial human beings) and the independent movement of one or several objects which would require the use of specific software products like SoftImage, 3D-Studio and others. However, these specific products of virtual reality cannot be connected with a relational database. It is however always possible to make use of software of virtual reality by using special interfaces. Another possibility in order to work with the effects of virtual reality is the use of the Virtual Reality Modular Language (VRML). Also in this case the data have to be exported from the information system and are then presented by a simple browser. However, all modifications of the basic set of data requires a repetition of the data transfer and the data visualisation. Consequently, it has great advantages to limit themselves to a 3D-capable CAD system which also allows a possibility for 3D visualisation which is possible with the above-mentioned systems like AutoCad, MicroStation or ArcView.

### **2.1 Integration of raster data**

Beside geometric representations, there are also images like photographic views, aerial photographs and orthophotos but also hand-drawn sketches which play an important role for vivid presentations in architecture and civil engineering. As for the presentation of the information, but also concerning data acquisition, one requires in general that these images can be combined with geometric presentations.

**2.1.1 Visualisation of raster data.** The easiest task when using raster data is their monitoring. In order to point out some features on maps or plans or for modelling one uses with great advantage vivid presentations which can be monitored permanently or selectively. The image can be digitised on a simple office scanner and can then be presented as a simple image matrix. A permanent monitoring rises however quickly problems as they require considerable place in a map. Much more efficient is it if special reference points or even better links are placed in the geometric presentation by which these images can be called when needed. The CAD software MicroStation disposes on the so-called 'Engineering Link' which establishes the reference to raster data but also to more extended descriptions in the form of html-files. This link goes even beyond these possibilities and allows also to refer on data over the Internet. In this way we get very interesting possibilities concerning the opening of an information system to other resources.

**2.1.2 Integration of orthophotos for visualisation and data acquisition.** An important standard for geographic information systems is today the monitoring of digital orthophotos together with the vector information of the system. Most information systems offer today this possibility. The combination is on the one hand important in order to complement vector information. On the other hand, we realise that the information content of the map can be heavily reduced when using orthophotos without reducing the readability. Furthermore, the orthophoto gives to ordinary people the feeling of reliability in the map data and makes it easier to understand a project.

It is understood that orthophotos also allow the data acquisition. Many objects can be directly digitised from orthophotos. However, there rise quickly limits in visualisation and it is understood that stereo plotters have much higher performance as for the optics and the measuring accuracy. The stereo impression is of special importance in this context, especially when doing 3D modelling.

### 3. WORKING PROCEDURES OF VIRTUAL REALITY

Virtual reality has many aspects and most people might be familiar with this product in conjunction with film industry and video games. However, it is evident that planning and the protection of the landscape have other requirements than the entertainment industry. One needs a certain adaptation in order to find the monster of the film industry acceptable. However, if one wants to sell a project it must appear attractive and as realistic as possible. The simplest way to obtain this objective is to integrate photographic images of the region into the project. In an analogue way one can also proceed with video images. In this way very effectful film sequences or images might result, however the way of the camera must be predefined. Another possibility is a complete reconstruction of the environment with all its buildings and the generation of rendering. Then, of course, the way of the observer can be chosen freely and 'fly throughs' can be generated.

#### 3.1 Rendering and the introduction of texture

In order to present an object with the means of computer graphics, it is in general subdivided by finite elements which are then coloured (cf. fig. 1). This procedure is limited by the relatively important effort for object measurements and the subsequent object presentation. For the rendering of the surface elements it is an advantage if one does not use homogenous colours for the surfaces but one integrates also the texture which represent the surface as close to reality as possible. The next step after texturing is the consideration of the illumination. The easiest way is to choose the brightness of the surface as a function of the incident light. If one uses several light sources or a diffuse ambient light there results already quite favourable effects. Furthermore, one should take into consideration that also neighbouring objects influence the light energy and contribute to the brightness of a surface. In order to get even closer to reality one should also take into consideration the effect of the reflection of the different objects and finally distance object should be covered by a certain distance fog. All this effect should also be taken into consideration. All these effects change not only the surface as a whole of an object but should also be taken into consideration as for the texture. Although the computer capacity is constantly increasing one obtains soon limits as for a realistic object reconstruction.

#### 3.2 Draping and pasting of static images

In order to reduce the effort for modelling there are several possibilities in incorporating images and photographs. First of all synthetic model objects can be combined very effectfully with images. There are however limits when the angle of view has to be changed considerably. The next step is to drape this image on a simple object modelling. It is very effectful to drape orthophotos over a digital terrain model and the angle of view can be largely varied. Certain software products like Perspective Scene of Helava allows to introduce artificial 3D objects into the landscape in order to give also buildings a more or less realistic appearance. Even more effectful is it to use additional terrestrial photographs of the façades of houses in order to project these images onto the geometrically reconstructed objects.

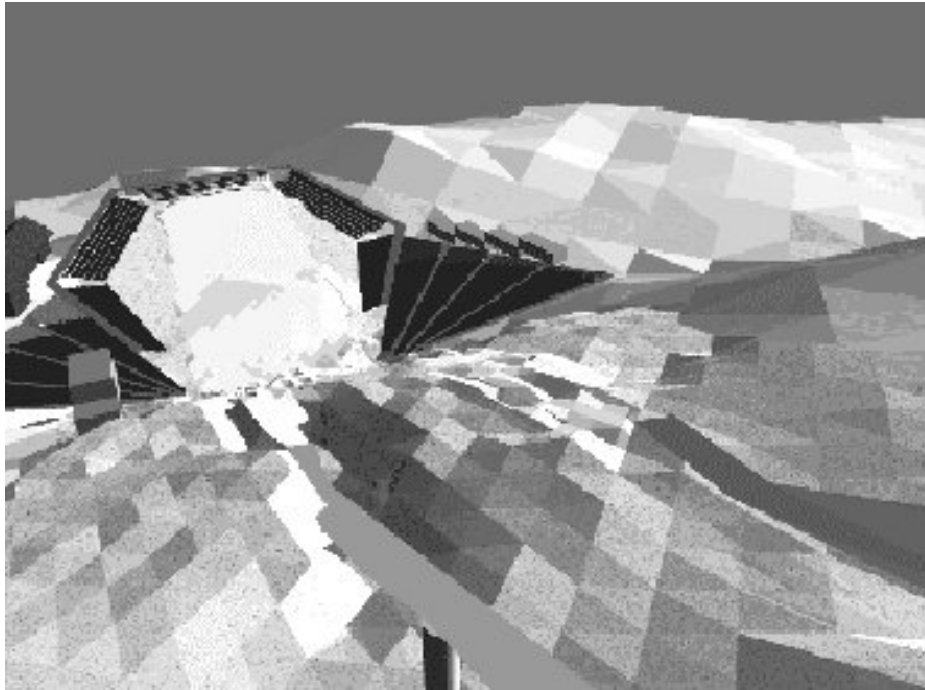


Figure 1

### 3.3 Integration of video sequences

The highest degree of reality is doubtlessly obtained with video sequences. However, the incorporation of artificial objects require a certain effort. The Institute of photogrammetry has specialised on this way of presenting objects. Special software products like SoftImage in connection with Eddi allow to combine video sequence with synthetic objects. This procedure is relatively simple : one tries to produce a video sequence of a synthetic object which largely corresponds to the angle of view of the video images. This means that the photogrammetric orientation elements of the video sequences have to be determined. If one determines these elements only approximately, then there can result disturbing image displacement between the 2 types of images. Relatively good experience have been obtained when using a video camera on a tripod which is slowly rotated.

## 4. PRACTICAL EXAMPLE : INVENTORY OF THE HISTORIC MONUMENTS OF THE DRÂA VALLEY

The presented working techniques are currently concentrated on a larger inventory project in the south of Morocco. Furthermore, various efforts have been made in the conjunction with the planning of the metro of Lausanne.

Morocco disposes on a great richness on historical monuments; in the first places there are of course the kingtowns : Fez, Marrakech, Meknès and Rabat. Beside this are a multitude of monuments with respect to the Islamic culture. Furthermore, a particular baked clay architecture remained in the south of Morocco attributed to the local population, the Berber; the origin of this architecture might go back up to 3,000 years.

The work is executed conjointly with an architecture office in Bern, directed by Hans Hostettler, his collaborator A. Tornay and with the competent instances in Morocco. There, the work is under the general direction of Mr Touri, director of the office on the 'patrimoine culturel', a section of the Ministry of Cultural Affairs. The local works is directed by the former manager of the CERKAS (Centre de Conservation et Réhabilitation du Patrimoine Architectural des zones Atlasique et Subatlasique) in Taourirt Ouarzazate Mr Faissal Cherradi and now by its successor Mr Mbarek. In the beginning it was planned to realise this inventory principally with the help of orthophotos and classical stereo-plotting. With the progress of the work, it showed very soon that the resulting information has to be properly collected and made available for further analysis which is only possible with the help of an information system. Another challenge resulted from the necessity of characterising the architecture. Is it already sufficient to document the typical architecture characteristics like façades, places or general view of villages by photographs and drawings or is it necessary to elaborate a library of typical characteristic elements ? Of course it was not easy to define the data model according to the various requirements of the architects.

#### 4.1 Considerations on the data model

As most important it appeared to elaborate the data model according to the necessary possibilities for analyses. If one considers the literature and especially of this region there are a considerable number of books available, one recognises that many analyses are based on drawn oblique views, drawings of the façades and drawings of overviews. Such views can be realised by the means of computer graphics in the easiest way on the base of a 3D-modelling (cf. fig. 2). Overview sketches and synoptic presentations of all ksour with their characteristics require the elaboration of a database in which are integrated the most important elements. Another important aspect is the requirement to present individual houses in a very detailed presentations and to establish a reference of these presentations with the original presentations. Furthermore, various photographic views and sketches and detailed descriptions have to be integrated into this information system.



Figure 2a



Figure 2b

In order to cope with these requirements, the geometric information had been subdivided in 4 different levels :

1. Overview presentations in the approximate scale of 1:1,000,000 based on the Michelin Map
2. Regional presentations based on orthophotos 1:10,000
3. Local presentations of the ksour and 3D-modelling with the help of orthophotos
4. Detailed presentation of individual houses

The descriptive information had been linked primarily with the local presentations; nevertheless, reference had been established with respect to the overview presentations in order to allow the elaboration of synoptic presentation of all ksour (cf. fig. 3). This presentation concerned the whole Valley of the Drâa and allowed also the presentation of other architectural elements.



Figure 3

In particular, we can subdivide the descriptive information in the following elements :

1. Line and area symbols for geometric presentations
2. Point symbols which can be summarised in libraries (cell library), cf. fig. 4
3. Attributive information integrated in relational databases; this concerns mainly keywords allowing queries for the establishment of thematic maps
4. Descriptions, images and sketches in text format which can be monitored over special links whenever needed
5. Orthophoto as geometrically referenced raster images
6. Images of façades with geometric references
7. Geometric referenced video sequences

#### 4.2 Selection of the information system and technique of data capture

The preceding considerations made it evident that the CAD system MicroStation in connection with the information system MGE and facilities for the treatment of raster data will meet to a great extent the defined requirements. According to the various evaluations, it seems that ArcView in connection with ArcInfo is - at least for the moment - not able to meet all the requirements, especially as for the 3D referencing. Without any doubt it would also be indicated to evaluate AutoCad. However, up to now it appeared that the possibilities for the connection with a database and the possibilities for the treatment of raster data are not quite satisfying. As far as known, this problem seems to be solved meanwhile. For a good part the choice was also influenced by the means available at the Institute of photogrammetry and the relevant experiences. The CAD system MicroStation allows the use of special elements, however it showed very soon that it was important to allow the indexation of individual façades. For this reason, it appeared necessary to construct the buildings by surface elements. In order to make the 3D-modelling as efficient as possible, the stereoplotting was limited to the capturing of the surrounding of the roofs. Subsequently, a script file is produced with the help of a Pascal program which represents the individual façades of the houses and their roofs in the command language of MicroStation. The script file can then be read immediately by MicroStation and produces the 3D object. A manual editing is not necessary. In parallel, it was of course necessary to measure additionally the terrain model. This terrain model is however in any case necessary for the elaboration of orthophotos.

MicroStation can be connected with MGE (Intergraph) or with Geographics (Bentley). Tests with Geographics had been of quite some interest, showed however that system which is still in development has a great potential but at least

for version 2 it showed some deficiencies as for the reliability. For the final implementation we preferred therefore MGE. Within MGE there are modules available for the communication with the Internet like GeoMedia and GeoWeb. Furthermore, software products like SoftImage and Eddi have been used for special effects of virtual reality.

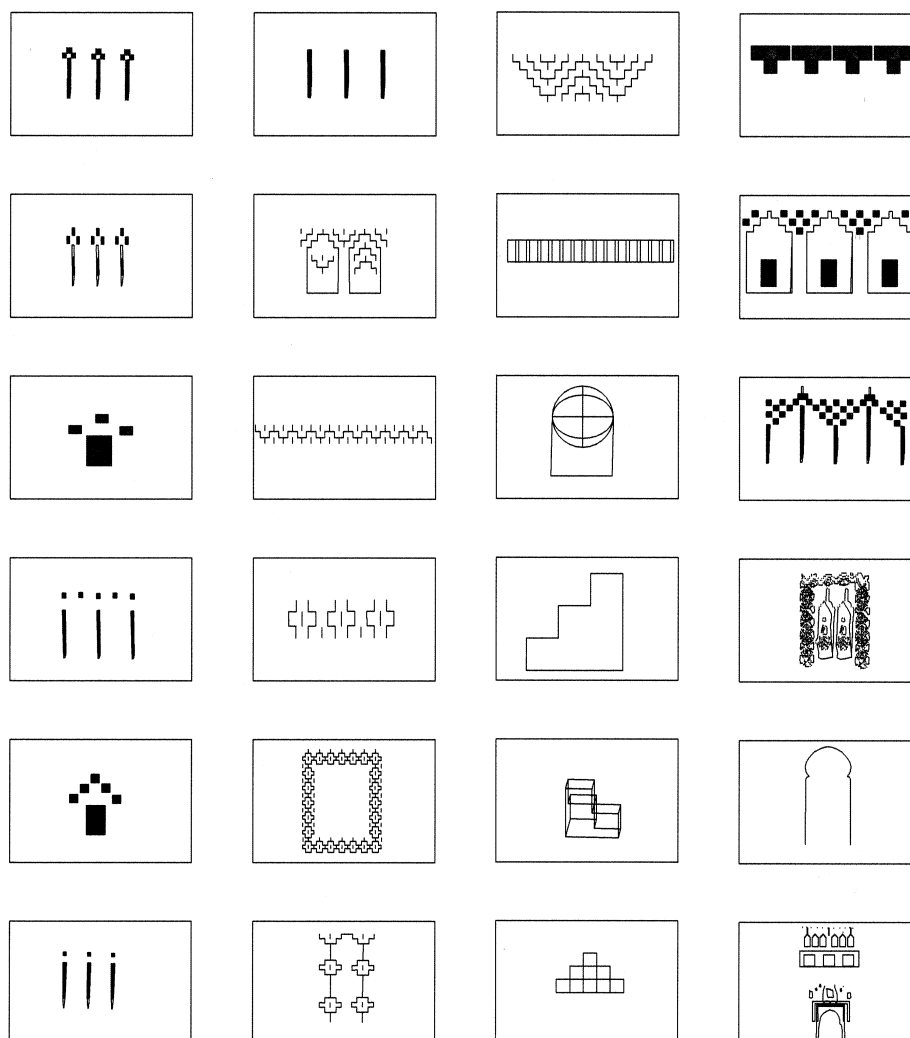


Figure 4

### 4.3 Presentation of the results

The information system presented here in connection with MicroStation and MGE allows to meet the requirements for the presentation of the results. The 3D-modelling and the generation of 3D presentations are standard routines of MicroStation. Scenes in action can be produced as video sequences in batch processes and can be stored. Another possibility is given by QuickView. In this case, the model scenes are stored and the movements are monitored in real time. It is understood that there are nevertheless limitations as for the graphic presentation.

Over the information system MGE one can generate various thematic maps over special queries generating arbitrary symbolic presentation. A particularity is the possibility of the generation of orthophotos coloured thematically (cf. fig. 5). Orthophotos are a very appropriate mean in order to show a region as realistic as possible. It is very easy to combine orthophotos with line and point symbols. The use of area symbols is however very limited and reduces heavily the readability of the photographic content. A way out is the use of pseudo colours. That means that the content of the image is not presented in the colours of the photo but thematically variable colours, for example the ksour in various hues of brown, new constructions in violet and the vegetation in green. In this case the photographic content remains readable but it is very easy to recognise its thematic attribution.



Figure 5

## 5. CONCLUSIONS

The following article shows up a concept for an integrated 3D GIS data management system including the primary data acquisition. It is understood that this system was only partially sketched, many elements are still in development and it will still take some time until the final system has been elaborated. For the practitioner it might be of interest that many aspects for such a 3D-system are now available. The CAD system MicroStation is largely used and allows to go very far in the conception of a 3D GIS system. It is also important to state that this product allows to realise many aspects of virtual reality. Limits are only met when several objects within a scene should be moved or integrated with video sequences which can be solved by exporting the scenes to other software products.

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