"PHOTOGRAMMETRIST v.1.0": THE GREEK INTRODUCTION TO PHOTOGRAMMETRY

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ABSTRACT

"Photogrammetrist v. 1.0" is a Computer Assisted Teaching software package aiming to become a powerful tool for introducing the students of the Department of Rural & Surveying Engineering of NTU of Athens to Photogrammetry in the most comfortable way. During their five year study the above students come in contact with many different subjects ranging from Mathematics and Physics to Satellite Geodesy and Digital Photogrammetry, Highway Engineering, Concrete constructions and Hydraulic Engineering. The package has been compiled in such a way, to exploit the capabilities of the Personal Computer for better understanding and assimilation of the subject. In this paper the development of this package is described and the choices made are presented. The first result is discussed for its completeness and efficiency.
For the above purpose multimedia technology has been exploited to an extent that it will be easily accessible by everyone and portable to computers with varying capabilities. An extensive investigation of the market has been carried out in order to assess the potential and determine the most suitable package which would be used. The results of this investigation are presented and assessed for their validity. .
The material covered in *"Photogrammetrist v.1.0"* comprises the basics of Photogrammetry. It consists of seven books. In the first book and after a short introduction the general photogrammetric procedure is presented. This includes data acquisition, flight planning and basics of restitution. Consequently in the second and third books, the topics of interior orientation and the influences on the light ray are examined. This is followed by the presentation of the principles of monoscopic photogrammetry in the fourth book, including photo scale, rectification and orthophotography. In the next book the principles of stereoscopic vision are explained and the student is introduced into the relative orientation of two ray pencils. Finally, in the book concerning the orientations the collinearity equation is explained and its applications are presented. The absolute orientation and the stereoscopic restitution conclude the material covered in this first version of the package developed.
The package is completed with a series of simple questions and exercises, which will enable the user to test the knowledge assimilated so far. In addition a special installation program has also been developed in order to properly install the software in the MS-Windows environment.

1. INTRODUCTION

Recent advances in information technology and in Photogrammetry have influenced all aspects of application, including the methods and the instruments used. These changes have inevitably reflected on education at all levels. Computer Based Training (CBT), Computer Assisted Teaching (CAT) or Computer Assisted Learning (CAL) is a rapidly advancing field, where the above statement is realized.

Moreover, young students are far more familiar with technological gadgets nowadays, than only a few decades ago. They have grown in a world, where information is conveyed mainly in form of images, sounds and to a lesser extent in form of text. Hence, multimedia technology is a natural and profound means of transferring knowledge. Traditional lecturing has been dull right from the start, but there were no means of replacing it with anything else (Brown 1978).

Computer Assisted Learning is a bold move towards this change of scenery as far as teaching technical subjects like Photogrammetry is concerned. The considerable progress in computer hardware and software, offers alternative possibilities to the way Photogrammetry may be taught. The use of computers in teaching Cartography, G.I.S and Remote Sensing firstly appeared in 1987 (Stubkjaer 1994, Höhle 1994).

Since then several efforts have been realised to this end and ISPRS Commission VI has established a Working Group to develop and coordinate similar efforts. Such learning software packages, which have already been developed so far, include the following:

a. CD-ROM application of the open University of Netherlands for the teaching of remote sensing (Stubkjaer, 1994).
b. Introduction to Computer-Aided Cartography of Helsinki University of Technology (Stubkjaer, 1994).
c. Comprehensive approach to GIS techniques (Stubkjaer, 1994).
d. The Danish project of GIS that is divided in two parts CHORO (Stubkjaer, 1994) and ORTHO (Höhle, 1994)
e. ANALYT (Höhle, 1994)
f. LDIP (Höhle, 1994)
g. DiAP (Höhle, 1994)
h. ALEXANDER (Kostwinder, 1994)
i. Multimedia in GIS Education (Zhuang, 1992)

The above mentioned programs are incorporated in CAL, CAT and CAI, acronyms which correspond to Computer Assisted Learning (Stubkjaer 1994, Höhle 1994), Computer Assisted Teaching (Kostwinder, 1994) and Computer Assisted Instruction (Zhuang, 1992). These terms are constantly developed in a field where the innovative appears before the old disappears. Other terms such as Technology Based

Training (Barnicot, 1994) are often used. In this paper the term CAL has been adopted.

The Laboratory of Photogrammetry of the National Technical University of Athens (NTUA), teaches Photogrammetry to classes of approximately 120 students of the 3rd and 4th years of the Department of Rural and Surveying Engineering. It occurs so that some of the basic functional problems of NTUA such as the large amount of students, or the insufficient instrumentation should be confronted with the introduction of new technological means for learning, educating, exercising and training the students with the help of computers.

The application developed is a multimedia educational program, whose target is to provide the student with the opportunity to assimilate basic photogrammetric theories and comprehend the various application fields. The presentation of geometrical concepts in modern audio-visual ways is mainly attempted, whereas at the same time it demands the active participation of the user through interaction and obligatory exercises. The application has been designed for self-studying and self exercising by the student and has been named *"Photogrammetrist v.1.0"*. A later modification of the existing program is expected to expand the potentiality of the system in researching or as a multimedia aid in classroom teaching.

2. MULTIMEDIA AND AUTHORING SOFTWARE

Computers alone cannot cause enthusiasm nor can they emphasise concepts. The messages should be transmitted in a way that causes and captures the user's attention, satisfying and stimulating his senses without misleading him. The concepts should be presented clearly, precisely and comprehensively. The power of information does not relate to the data but to the ideas, the senses and the actions of people who come into contact with it. The transmission of information can be executed efficiently, when it complies with four basic rules (Lindstrom, 1994):

a. It should capture the attention of the audience.
b. The messages should be precise and clear so that comprehension may be easily achieved.
c. The agreement of the audience with the messages must be absolute (scepticism can destroy the sequence).
d. The assimilation of messages by the user when combined with comprehension leads to knowledge.

Modern computing provides the capability of multisensory communication, a characteristic of which multimedia technology takes advantage. Operating systems have since several years adopted the Graphical User Interface (GUI) based on the of Windows-Icons-Menu-Pointer (WIMP) environment. Thus it was possible to develop interactive teaching programs. The communication between the computer-teacher and the student does not take place within a certain order of questions and answers, or like a monologue. The interaction helps the user focus on the desired theme, while the computer can answer his questions instantly. Furthermore, navigation can be done by the user at his own learning speed, while cross-references between different topics are possible. Interaction has a significant role in education: Learning by acting is an old and proven principle in education.

Multimedia applications are usually developed with the help of a suitable authoring software, which provides the necessary tools for integrating text, images, video, sound and animation. Multimedia provide communication with the user in many ways. Written text is only the 8% of communication. Sound and speech are the 36%, while the visual communication (graphics, images etc.) occupies the remaining 56%. Yet the integration of communication can only then be achieved, if it is close to human senses, i.e. to the natural way students interact. Interaction gives the ability to access information at the time and way the user desires.The great advantage of multimedia is that they combine the above mentioned features in a digital form, thus permitting their simultaneous use and direct access to information, provided by dynamic images with changes in shape, size, colour, use of sound, animation and video.

On the other hand, in hypertext applications information is related to appropriate text and can equally easily be studied. A multimedia system (text, graphics, images, animation, sound, video) is not necessarily Hypermedia. Only when the user, by interacting with the system, takes control of a set of dynamic links, the system can be characterised as Hypermedia. The contribution of hypermedia to the teaching and learning process, is that it offers the means to organise "knowledge" in a way, it can easily and effectively be accessed. The author offers to the user the opportunity to navigate through a certain subject, by dividing information into modules and determining a set of nodes and links between them (Argialas 1992). Hypermedia is ideal for non-linear programs and random knowledge searching (Figure 1).

Although hypermedia permits browsing through a vast amount of information, it is not the solution to efficient learning.The user can easily be misled and lost in a labyrinth of information. Freedom in accessing information has a price and the user can be lost in hyperspace. In a training, self-studying application, on the contrary, the interests that the program stimulates must be, in a way, unique.

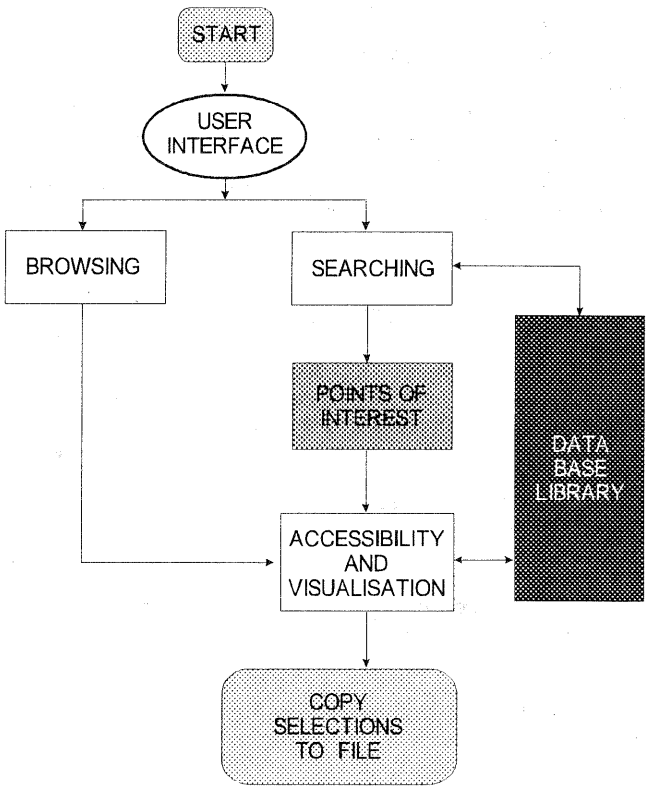

Figure 1: Structure of Hypertext non-linear browsing

As already mentioned, on the opposite side of Hypermedia stands Computer Based Training (CBT). A CBT application is structured in distinct educational units (Figure 2). Each unit consists of subunits which can be displayed as progressive steps of successive ideas with an increasing degree of

difficulty (Figure 3). When the user logs into the system, he may choose the module with which he wants to work. Before exiting the program, the computer saves the user's status (Luther 1994).

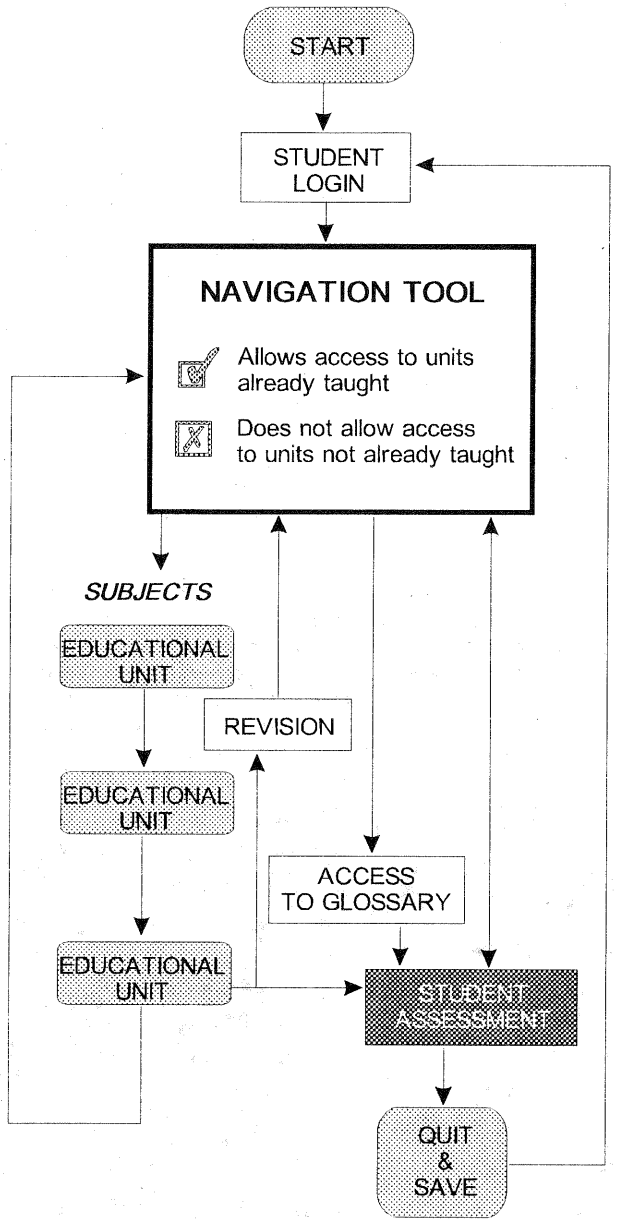

Figure 2: Structure of a CBT application

Within a subunit two different learning processes may be distinguished: the presentation of information and the testing of the degree of assimilation. In the first stage a certain topic is presented using multimedia features. In the second stage, the user has to answer questions put by the system. If the answers are correct, the subunit is marked as completed, and the user may continue. If the answers are wrong, the system gives the opportunity to the user to review the subunit again and be reexamined. Other more sophisticated systems respond differently in wrong answers. Finally, the system summarises the wrong answers and evaluates the user's effort and degree of knowledge (Luther 1994).

This structure, which demands from the user to fill in the questionnaire, ensures that the user will not be diverted from the specific educational interest.

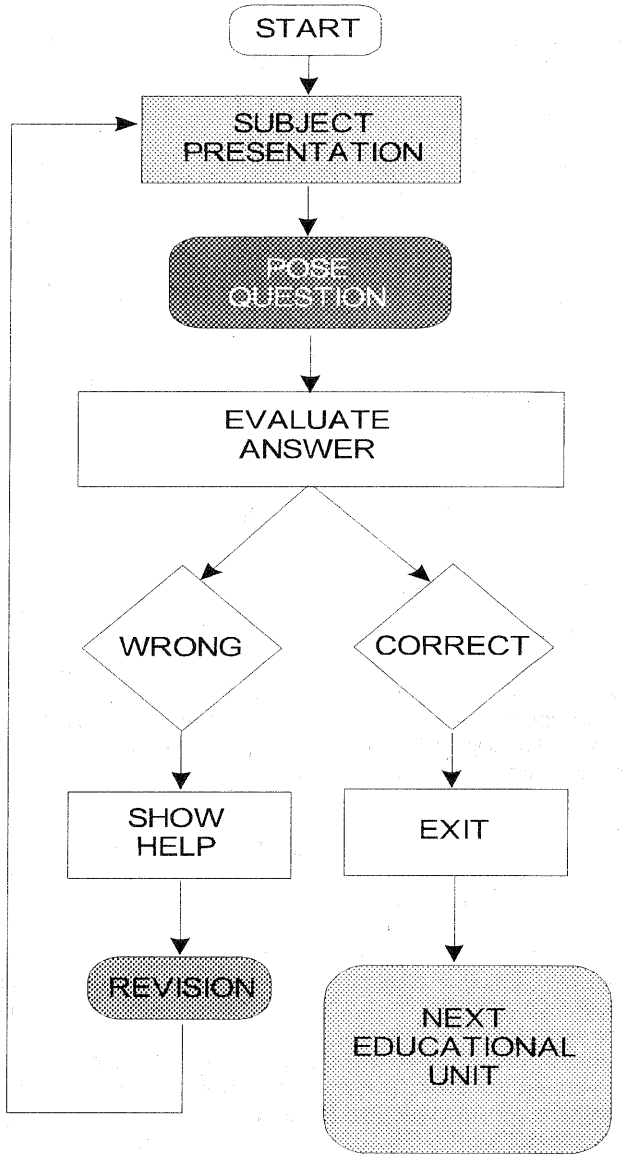

Figure 3: Structure of an Educational Unit

Such a learning program may be developed either with the use of standard programming languages (e.g. C, Pascal, Prolog), or with an application generator or with an authoring software (Höhle 1994). The use of such tools, makes the development of learning applications easier and faster. It is common place that "life is too short to program in Assembly".

An extensive investigation of the market has been carried out in order to assess the potential and determine the most suitable of the available packages, which would be used. The following three, with examples as at the beginning of 1994, categories of software packages have been examined:

(a) Multimedia-capable presentation software packages (e.g. CorelSHOW, Charisma, Freelance Graphics, Harvard Graphics, Graphics Works etc.)

(b) Dedicated media integration software packages (e.g. ACTION 2.5, ASTOUND 1.5, Q/MEDIA, MEDIA BLITZ, HSC Interactive, COMPEL etc.)

(c) Professional multimedia development software or Authoring packages (e.g. Authorware Professional, Icon Author, Multimedia Toolbook, Hypercard etc.).

The potentials of each category relate to the level of the developer in programming. The first category is best for simple linear presentations, with no interactivity. To add some interactivity and to include video and animation the most suitable category is the second. Finally, for independent teaching - learning applications, with higher level demands, for the development of non-linear systems with great interactivity, only the third category is suitable. The results of this investigation are presented and assessed for their validity elsewhere in detail (Fotinopoulos 1995).

For the right choice of the package several considerations were taken into account, such as ease of use, user friendliness, ease of programming and, of course, possibilities offered. The market survey led to the choice of *Assymetrix Toolbook v.1.53*, as the most efficient package for the project in question.

3. STRUCTURE OF THE SOFTWARE DEVELOPED

An analysis was carried out as to how such an authoring package may be used to efficiently transmit knowledge to students. Special consideration has been given to the peculiarities of Photogrammetry and how multimedia may enhance the various points of interest. At the same time the contribution of Personal Computers in education has been examined and analysed, while the structure of a Computer Based Training (CBT) package, developed for this very purpose was also assessed and taken into consideration.

The design of the structure and the means that a teaching program uses, derives solely from the educational needs that such a program should cover. An application can cover one or more of the following educational needs:

1. Teaching: The program helps the educator while giving lectures. Using a projector or a projector screen all the classroom can watch the activities of the educator when using the program. This kind of applications have as objective to capture the attention of the audience by enriching the presentation of a certain topic with audio-visual means. Some programs provide capabilities for random access instruction by educators (Zhuang 1992).

2. Searching: Random and non-linear information searching by the student is provided. This kind of applications can replace libraries and data bases. The student can easily and efficiently access the teaching units of interest at a specific moment. A set of nodes must be predetermined by the developer of the application in order to relate common characteristics and information appearing in different chapters (Argalias 1992).

3. Studying, self-studying: These applications are useful for private study. On the contrary with the browsing programs where non-linear and random access is provided, self-studying programs can be accessed only in a linear way. The applications of this category have a CBT structure.

4. Exercising: The objective is to control the progress of students. This can be done either by using standard multiple choice forms or even by the integration of human speech into the computer; the student level may be evaluated automatically by the computer. Certain comments are given about the student progress, based on statistical data, in time and place where the teacher is absent. The only responsibility of the teacher is to achieve the right student management.

5. Training: The objective is to train the user on a certain topic. The topic is presented in different ways, and the reaction of the user is evaluated. This type of applications are the prototyping programs and the programs that simulate laboratory instruments.

6. Edutainment: This is a new category of software that combines entertainment with education. The concept is to entertain the user while learning. Virtual reality technology is often used (Perry 1994).

The structure of the software developed, *"Photogrammetrist v.1.0"*, is going to serve the various aims set out at the beginning. It adheres to the CBT principle. Care has been given to the fact that the user should interact with the computer through the software, in order to achieve efficient learning. The software has been developed in such a way, that the student should prove his/her knowledge of the material covered in each section, before proceeding to the next one.

While developing the program, the following three basic considerations were taken into account: (a) The application should cover the syllabus of the course *General Photogrammetry,* tought in the 5th semester of the Department of Rural & Surveying Engineering students. (b) As already mentioned, the application should address students who are not familiar with Photogrammetry. (c) The program should aim to help the self-studying process during private study time of the student.

Audio-visual means, carefully designed graphics and animation have been used in order to help the student understand a specific topic. The concepts in three dimensional space, and the geometrical conditions have been presented with attractive graphics, dynamic images, animation and interaction (Figure 4). The use of slides, the reconstruction of complex geometrical principles manually or on the traditional blackboard reduces the degree of comprehension of the students.

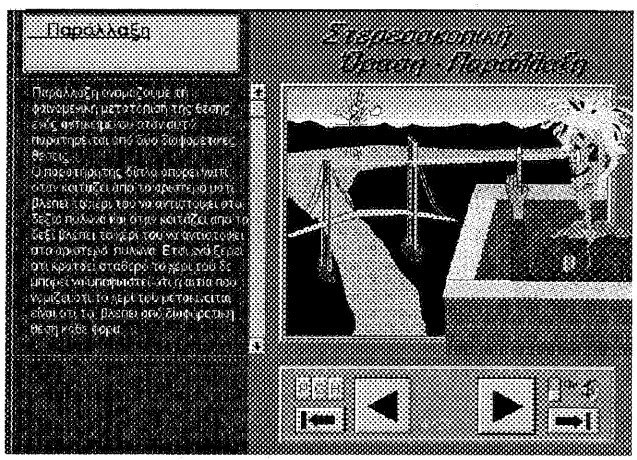

Figure 4: Stereovision and parallax

The layout of the project follows a strict linear structure, according to the CBT principle (Figure 2). The potential for searching, expands only to one layer, vertical to the direction of the representation process (e.g. for the explanation of a term). Thus the extensive use of links, that lead to further sublinks has been avoided.

"Photogrammetrist v.1.0" consists of seven different electronic books where each one has four to five subunits. Attention was given, so that the student focuses on the specific topic without being interrupted, thus the completion of each subunit will not demand more than 15min of study. At the end of each subunit there are obligatory questions, which the student must answer in order to continue with the program. The questions are of

multiple choice type and can be answered by simply clicking the mouse. Finally, it has to be mentioned that almost every page is interactive.

4. APPLICATION INTEGRATION AND MATERIAL COVERED

As already mentioned the authoring software used to develop *"Photogrammetrist v.1.0"* is Aymmetrix ToolBook 1.5.3. The object oriented structure of this software allows for the easy design of electronic pages including buttons, hotwords, menus, check buttons etc.

In *"Photogrammetrist v.1.0"* the basic concepts of Photogrammetry are covered in 150 electronic pages. Each electronic page consists of 50% of designs, graphics and dynamic pictures, 10% of a set of navigation buttons, 15% for the title of the units and subunits and 25% of text that embodies hotwords and hypertext (Figure 5). In addition a section with numeric exercises has been developed, where the user can study, by clicking the button 'Knowledge', the corresponding page of theory. Also by clicking the button 'Calculator', a simple calculator appears, which was included in the development to help the solution of simple arithmetic equations.

Figure 5: A typical electronic page of *"Photogrammetrist v.1.0"*

The seven electronic books include the following topics:

1. The Photogrammetric Procedure
   - Photogrammetric applications
   - Air survey planning
   - Data Collection (Figure 6)
   - Geometric model of Central Projection
   - Photogrammetric products
2. Examination of the optical ray path
   - Distortion due to earth curvature
   - Distortion due to atmospheric refraction
   - Distortion due to material shrinkage
3. Interior Orientation
   - Coordinate system of air photograph
   - Radial lens distortion
   - Displacement of principal point
   - Principal distance
4. Single image Photogrammetry
   - Object and photo coordinate systems
   - Scale differences of map and photograph
   - Factors affecting photo scale
   - Rectification
   - Orthophotography
   - Photomosaic and orthophotomap

Figure 6: Data collection and Photo scale

5. Stereoscopic vision and Parallax (Figure 4)
   - Natural stereovision
   - Stereoscope
   - Parallax (Figure 7)
   - Relative orientation
6. Orientations
   - Coordinate systems
   - Collinearity equations
   - Resection in space
   - Exterior orientation
   - Absolute orientation
7. Exercises (use of calculator)

The self-studying character of the program posed several limitations. Firstly, the application should be able to run with minimum hardware demands. This was decided to be as little as a 386SX CPU, 2 MB RAM, SVGA monitor (640x480, 256 colours), no sound card, no networking. The problem of sound and speech was bypassed with the use of the PC Speaker driver, which is available free from Micrososft. The PC Speaker allows the computer speaker to output simple but recognisable sound and speech files (.wav files, 8 bit, 11 Khz, mono). Secondly, the distribution of the program in floppy disks prohibited the extensive use of images and the use of video. The majority of figures are drawn with the simple drawing tools, provided by ToolBook. In general, when dealing with multimedia applications the effort to reduce the space increases the time needed to develop the application.

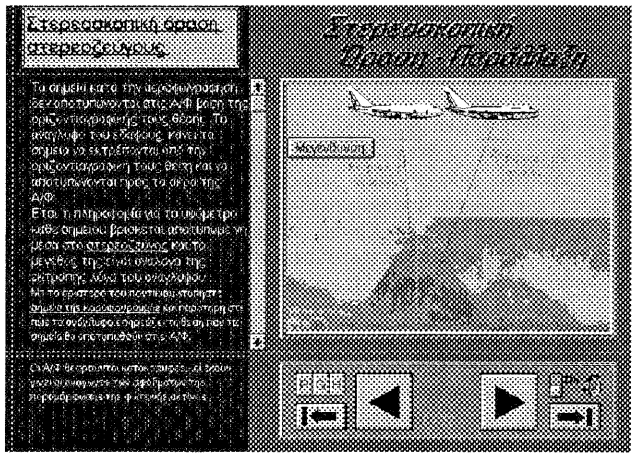

Figure 7: Steroscopic vision and parallax

The program requires 7MB of free hard disk space and it is distributed compressed in three floppy disks (1,44 MB) accompanied by a specially developed installation program and a 10 page manual. The manual gives answers to all possible problems that may appear when installing the program (e.g. fonts, sound driver etc.).

The operations provided by ToolBook, are expected to contribute to the integration of a hypermedia application, suitable for teaching and random knowledge searching (browsing). Each interactive page, which has already been constructed, can easily be transferred. Thus by determining the suitable set of nodes and links, a hypermedia application may easily be developed.

5. ASSESSMENT AND FUTURE OUTLOOK

The contribution of the application to the learning process can be summarised in the following points:

- Reduction of the time and increase of the effectiveness of teaching, via the audio-visual means that are used (sound, dynamic images, animation, graphics)
- Structural learning since the user cannot go on to the next section without proving to have absorbed the concepts presented in the present one.
- Availability and repeatability of training and teaching at all desirable times for the student.
- Reduction of teaching cost. The cost is reduced to that of integration and production of the application.
- Increase of motives for learning the particular subject. The response of the system to the student actions increases and stimulates his/her interest.
- Quick and easy access to information and transfer of teaching the process outside of the classroom. The application simulates instrument functions, which would be time consuming if presented to the whole group of students.
- Entertainment provision through the educational process, utilizing the interactive capabilities and takes advantage of their instant response.

Moreover, using *"Photogrammetrist v.1.0"* several problems such as the large amount of students, the lack of equipment and the way in which the students are examined, can be confronted. The integration of such applications is ideal for classes with more than 30 students since they considerably reduce the relevant cost (Stubkjaer, 1994).

It is considered as highly important that the package may be used as a self teaching tool, as a tool for supporting practical work and as a supplement to conventional teaching.

In the future it is planned to put the package to the test of the 3rd year students, who come in contact with Photogrammetry for the first time in the course of their studies at the Department of Rural and Surveying Engineering of NTUA. The feedback from the students, in form of an appropriate questionnaire, will be analysed in order to modify and adapt the package to their practical needs and requirements.

Finally the evolution of authoring tools and the great improvement of CD-I, CD-V, the vast spread of CD-ROM's, Photo-CD, Multisession CD's and the significant progress in networking, assure a brilliant future for similar applications of Computer Assisted Learning.

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