IMAGE-BASED LANDSCAPE MODELING: ENVIRONMENT UNDERSTANDING AND VISUALIZATION WITH E-LEARNING FUNCTIONALITY

Dr. ATHANASIOS D. STYLIADIS
Department of Information Technology, The Alexander Institute of Technology & Education, (ATEI), Thessaloniki, Greece

ABSTRACT: *Computer graphics, CAAD, e-learning, visualization and virtual reality technologies are increasingly used to communicate the implications of environment understanding and management changes in landscapes and biological systems, well as in national parks and forests. Image-based and data visualization techniques can be used, not only by scientists but also by managers, the public, and desicion-makers, to comprehend massive databases, to interpret dynamic environmental changes, and to evaluate the range of outcomes likely from different management strategies. Recently, however, most developments have been fragmented, the links between different applications regarding learning, understanding and landscape visualization have been few and poor, and the validity and reliability of the visual representations regarding natural (landscape) phenomena have not been tested. This paper introduces (in an initial phase - as a discussion rather than as a well-definedmethod) a coordinated image-based e-learning environment with four modules:* ***landscape data collection, tree modeling, landscape database*** *and* ***landscape data communication****, for environment understanding, visualization, real-time interaction and management, and describes four relative goals for tree-based forest visualization with e-learning functionality.*

Keywords**:** *Image-based e-learning; Environment understanding; Tree-trunk modeling; Virtual reality; Forest inventory data.*

1. Introduction

Computer graphics, CAAD, e-learning, visualization and virtual reality technologies are increasingly used to communicate the implications of environment understanding and management changes in landscapes and biological systems in national parks and forests.

Data visualization has been widely applied to the inventory, evaluation, and management of environmental resources [1,2]. Visualization tools increasingly have been used to assist in the compilation of large and complex natural resource data sets [3], usually by natural resource scientists seeking to better understand their sciences [4], and by social scientists seeking to better understand human behaviors vis-a-vis those resources [5,6].

However, visualization users have identifiedseveralpressingneedsinthedevelopment of new Information Technology-based tools (like CAAD and e-learning) for photography-based 3D modeling [7], environment management and understanding and groupware collaborative e-learning and assessment [8,9]. Obviously, 3D tree models, and particularly tree-trunk models, are the basis for constructing 3D natural scenes for environment understanding and management [10,11]. Also, for a successful scene visualization the proposed methods are based on image analysis and computer (artificial) visiontechniques [12,13,14].

Recently, however, most development has been fragmented, the links between different applications regarding learning, understanding and visualization have been few and poor, and the validity and reliability of visuals representing natural phenomena have not been tested.

This paper introduces in an initial phase (as a discussion rather than as a well-defined method) acoordinated image-based and software-basede-learning environment with four modules: *Landscape Data Collection*, *Tree Modeling*, *Landscape Database*, and *Landscape Data Communication*, for environment understanding, visualization, real-time interaction and management, and describes four relative goals for tree-based forest visualization with e-learning functionality.

2. The coordinated image-based environment

2.1. Landscape Data Collection

The cost of ground-based data collection, as well as the increasingly time-sensitive demands of plant and tree management, have made image-based techniques (digital amateur photography, close-range photogra-mmetry, space or remote sensing imagery) a necessity.

Accurate classification and measurement of natural resource features, such as the trees, the tree-trunks and the shrubs, is made quite difficult by their variability in geometry (shape) and color.

So, the relative research has been focuses on software tools for an automatic or semi-automatic identification of individual features (components) of the natural resources (plants, trees, tree-trunks, etc.) from single or multiple images.

For this purpose, close-range amateur (photography) or remote sensing (imagery) techniques could be used.

The *landscape data collection* module of the introduced environment is based on amateur (tree) photography (Fig. 1a), (tree-trunk) skeleton selection (Fig. 1b), and then image processing (Fig. 1c) and analysis (Fig. 1d).

For this purpose, a simple low-cost digital camera and an image processing software (like Adobe's Photoshop CS2) could be used.

Fig. 1. Data collection: Photography and image processing and analysis

At the heart of the proposed environment is the *tree*. It is referred both as an *object* (in the real-world space) and as a *3D model* (in the software CAAD space). In order to calculate the tree size from single or multiple images, the delineation of the tree crown and then the calculation of the *tree crown - tree height* relationship, is required.

In low altitude close-range photography, the trees can be seen individually against a complicated background, and this is the case of the proposed environment.

Obviously, any surrounding vegetation and dense, intersecting tree crowns, can make the tree modeling procedure even more difficult.

2.2. Tree Modeling

The opportunity to understand, model and visualize the environment and its components, in a user-defined desired modeling detail, has been missing for the lack of visualization techniques able to handle in real-time and in a networking environment the extremely large resulted traditional or spatial environmental databases.

To address these shortcomings, a simple CAAD- and image-based technique is proposed in order to develop a tree-by-tree visualization procedure.

At the heart of this technique is the tree modeling, which is completed in three phases: first,apixel-by-pixel analysis is performed (Fig. 2 left), then a vector 2D model is calculated (Fig. 2 right), and finally the 3D tree model is reconstructed (Fig.3) if at least two images are provided [18].

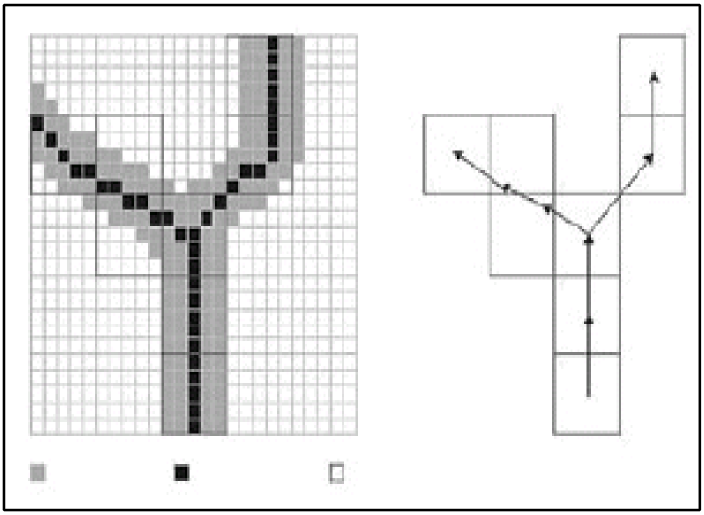

Fig. 2. Tree-trunk modeling: Raster-based analysis (left); Vector-based synthesis (right)

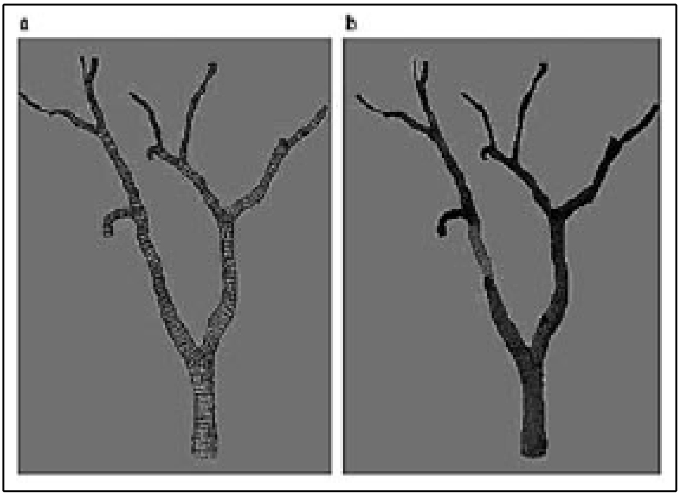

Fig. 3. A sample tree-trunk model:
A. Rendering view with materials; B. Rendering view with materials and texturing

For this purpose, a simple low-cost image processing raster-to-vector (R !>V) software, like Adobe's Photoshop or Intergraph's I/RAS, could be used. For a visualization with e-learning functionality, four relative goals are identifiedfor the proposed image-based environment:

- Sufficientspeed,inmodelingandrendering,mustbeachieved,inordertoallowusers to use the 3D scene as a real-time decision support tool rather than just as a decisions already made presenter.
- 3D tree and tree-trunk modeling must be supported in a simple and stratifiedway. Obviously, this will help the forest visualization development where individual trees and tree-trunks are represented by their 3D models. Also, this procedure because of its digital nature will take advantage of some contemporary (modern, digital, high-tech) methodologies available for single tree growth and population dynamics.
- A user-friendly interface (Graphical User Interface, GUI) must be developed, which will enable users to import data from a variety of sources, in order to deal with landscape databases of different kind (e.g. traditional or spatial, text-based or image-based), different resolution and different abstraction.
- 3D model and rendering parameters valuing must be supported. So, the modeling results could be viewed instantly (i.e. reaction & real-time visualization).

2.3. Landscape Database

The tree and tree-trunk 3D models (produced by the *tree modeling* module) could be organized in a structural way forming a landscape (visual) database. The following Figures 3a and 3b are referred to a sample tree-trunk rendering model as the landscape database structural component, incorporating materials and texturing respectively [17]. Also, Figure 4 displays a proposed landscape database record related to a tree (field amateur photography and tree-trunk 3D modeling)[18].

2.4. Landscape Data Communication

For taking advantages of today's Internet and networking (intranets) capabilities, the *landscape data communication* module of the proposed environment must be Java-based and it has to be designed for dealing with *jpeg gif* images, *HTML* documents and *VRML* models.

The main streams of the proposed *landscape data communication* module could be definedasfollows(inaclient-server designschema):

- *The media stream:* This could be the main or server stream; the heart of the e-learning sub-system, for which a number of media servers are needed (e.g. a system or central server). These servers can provide data (landscape reports, architectural records, modeling details, etc.) for learners on real-time. Also, these servers can store material in repository (i.e. material palettes) which then can be searched by researchers or learners (e.g. students in landscape architecture).
- *The VR stream:* This could be a client stream; which includes virtual reality tools. It is the stage for the learner and it includes virtual and resource classroom, chat room, etc. This e-learning stream could provide walk-through functionality as well as chatting functionality on a learner-to-learner or learner-to-teacher basis.
- *The GUI stream:* This could be, also, a client stream; which can include a user interface based on 3D graphics [11,14]. After learner's logon to the system, he must be able to control the learning process by focusing on particular 3D modeling details of the tree, forest or landscape, using the keyboard or the mouse. Evenmore, using this stream the learner must be able to communicate on-

line with other learners (students).

- *The Web portal stream:* This could be, also, a client stream; which provides the learner with additional information like explanations, proposals, hypotheses and conclusions about the landscape environment and its context.

This stream operates as an integration platform for the entire digital image-based environment (incorporating: environment understan-ding, real-time user interaction and visualization, and management). Also, this stream could include system's operation manual and teaching materials.

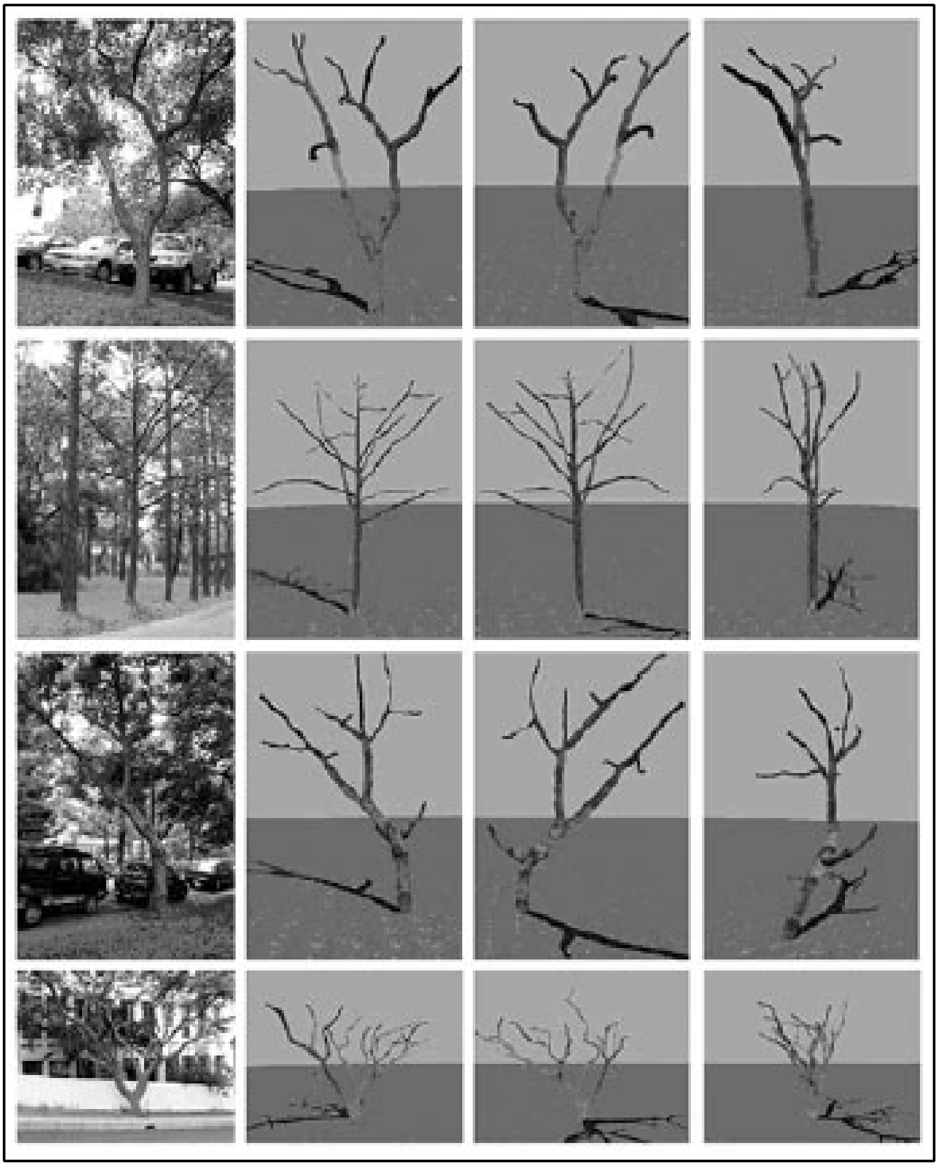

Fig. 4. A landscape database record related to a tree (field amateur photography and tree-trunk 3D modeling)

3. Learning requirements - Functional specifications

The basic requirements for the e-learning extension of the proposed image-based landscape environment, are related to tree and tree-trunk 3D models and they are as follows:

- ability to identify possible problems during the modeling (e.g. th tree or tree-trunk 3D model assembly) process and suggest alternatives (please see Figs. 1 and 2).
- ability to sustain the effort of students in understanting complex landscape structures by creating their 3D models.
- ability to maintain and test landscape architectural approaches on coloring, texturing, lighting and rendering the tree, tree-trunk, forest or landscape 3D models.
- ability to understand the emergent behaviour of complex environmental structures by modeling the structure itself and knowing the behaviour of their descrete subsystems (ecological, landscape, historical, etc.).
- ability to define the levels of objectivity with meta-data functionality as an approach to document landscape living systems (hierarchy of modeling records).

Also, on designing the proposed image-based landscape environment for e-learning functionality, the statistical analysis results from e-learning groupware courses in CAAD, collaborative modeling and visualization could be examined [8,9]. So, according to the ATEI of Thessaloniki students suggestions for the VRlab research project [15,16], the functional specifications for a 3D basede-learningsub-system could be defined as follows:

- Item-by-item 3D modeling functionality in an e-learning CAAD environment.
- GUI with drag-n-drop functionality.
- Multimedia functionality.
- Learning functionality incorporating landscape and semantic data.
- Virtual Reality functionality.
- Noting-board and shared-board functionalities.
- Non-stop study functionality.

In short, what the learner needs from an image-based landscape modeling environment (application) with e-learning functionality, is a synchronism e-learning sub-system which can interact in real-time with the tutor in class or through Internet. Also, in this domain, an asynchronous system can let learner to study the hosting landscape and the nested structures in his free time.

Obviously, such as system must let learners discuss with each other through media streams. Besides, they also need 3D virtual environments which can increase learner’s interest and attention.

4. Conclusions and Future Directions

This paper introduced in an initial phase -as a discussion rather than as a well-definedmethod -a coordinated image-based e-learning environment with four modules: *landscape data collection*, *tree modeling*, *landscape database* and *landscape data communication*. Also, four relative goals for tree-based forest visualization with e-learning functionality were described shortly.

The proposed image-based environment could be used for environment understanding, visualization, real-time interaction and management. Also, landscape multimedia learning material (DVDs) and e-learning or distance learning courses regarding environment understanding and management could be based on the discussed approach to image-based landscape modeling.

For future research, a detailed discussion and assessment of a camera pose recovery algorithm using multiple (tree and landscape) amateur images and archive photography must be described and examined [7,19,20]. Also, the relations between the image calibration methods, the collaborative Web-based architectural modeling, the collaborative groupware e-learning functionality and potentiality [8,9] and the landscape, environment and meta-documentation reverse engineering functionalities [1,6,12,14] of any (probably destroyed) landscape structure captured in an historic or archive photography, must be formulated and documented.

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