# Web-based Applications for Virtual Laboratories

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## ABSTRACT

Web-based applications for academic education facilitate, usually, exchange of multimedia files, while design-oriented domains such as architectural and urban design require additional support in collaborative real-time drafting and modeling. In this context, multi-user interactive interfaces employing game engines as well as Virtual Reality (VR) environments offer a framework within which web-based applications for virtual laboratories have been in the last decade successfully developed and tested within Hyperbody at Delft University of Technology (DUT).

**Keyword:** e-Education Technologies, Virtual Learning Environments, Virtual Laboratories

## 1. Introduction

Web-based applications for academic education in design-oriented domains such as architecture require more then exchange of multimedia files. The need for interactive 2D drafting and 3D modeling tools has been addressed within Hyperbody at DUT by employing game technology: As a web-based multi-user game, Protospace enables real-time design development and data exchange in the domain of urban and architectural design and has been tested in the Internet-based postgraduate program, E-Archidoct, that was offered by DUT in collaboration with 14 European universities. Such an Internet-based platform required consideration on two levels: Definition of means for web-based data exchange, and definition of data to be exchanged. Both influence each other intrinsically: While textual data exchange requires text-based software, image-, draft-, and model-based data require multi-media as well as Computer-Aided Design and Fabrication (CAD-CAM) programs. This paper presents and discusses the development and use of Protospace as a compound of soft- and hardware applications for virtual graduate education in architecture and urban design.

## 2. Software Prototypes

In addition to the Internet-based individual and collaborative exchange between students and teachers facilitated by the open-source Modular Object-Oriented Dynamic

Learning Environment (Moodle) which was incorporated in the E-Archidoct website (http://www.arch.pw.edu.pl/moodle/) Protospace software applications were as well integrated. These applications were drafting and modeling tools with shared database capabilities allowing, therefore, access to common project data as well as real-time exchange between design team members. By sharing the project data amongst each other, changes made by one participant are visible in all other views; this allowing for design, evaluation, and dialogue to take place in real-time (www.protospace.bk.tudelft.nl).
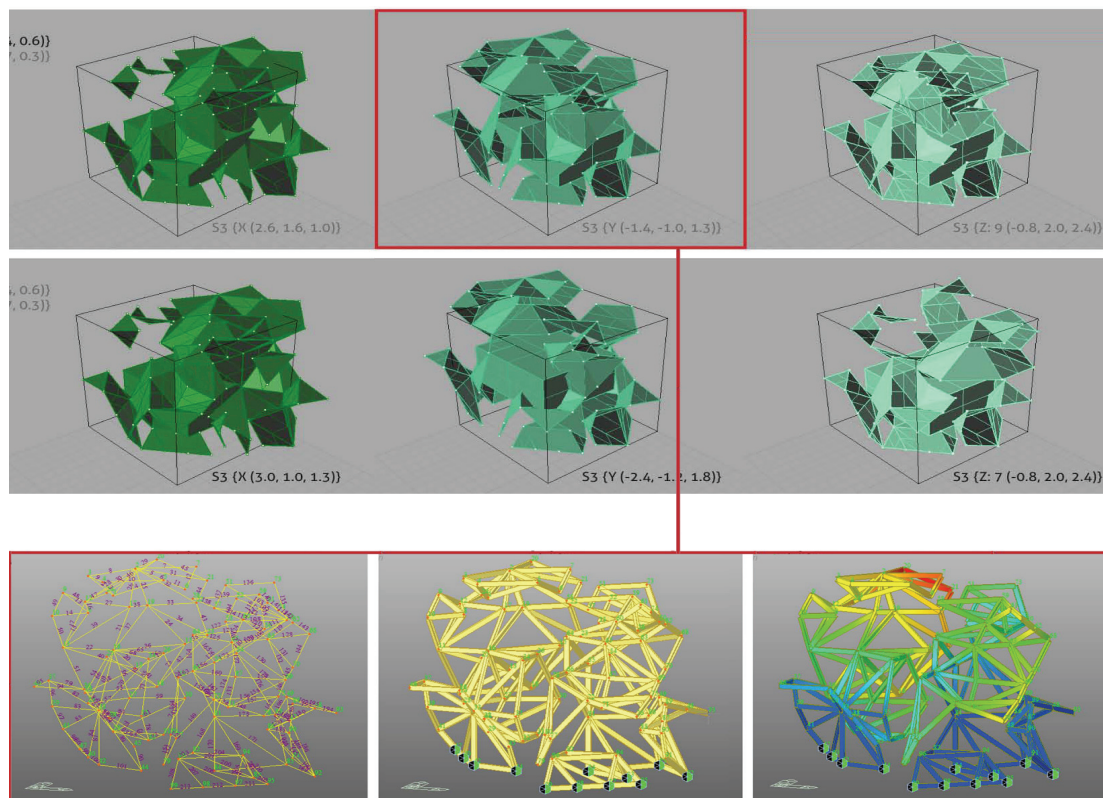


Figure 1: Liu's project showing multiple design and evaluation phases employing design and structural engineering software.

Students from Hyperbody's graduation lab are introduced to parametric software such as Virtools, Grasshopper and Generative Components. Liu's project (Fig. 2), for instance, applies parametric definition for the development of multiple designs. Parametric manipulation implied, among others, the use of the marching cubes algorithm, which constructs surfaces from numerical values; furthermore, programmatic considerations were parametrically defined with respect to function in relation to volume and orientation in 3D space, etc. Structural analysis employing MIDAS/Gen implied that data with respect to forces, moments and stresses was used in order to determine the placement and dimension of main and secondary structure.

## 2.1 Scripting

As one of the most relevant Protospace applications, Virtools allows development of web-based multi-user games and is based on separation of objects, data and behaviors employing an intuitive user interface with real-time visualization window and graphical programming. This allows programming with spatial arrangements of text and graphic symbols, whereas screen objects are treated as entities that can be connected with lines, which represent relations (Fig. 2).
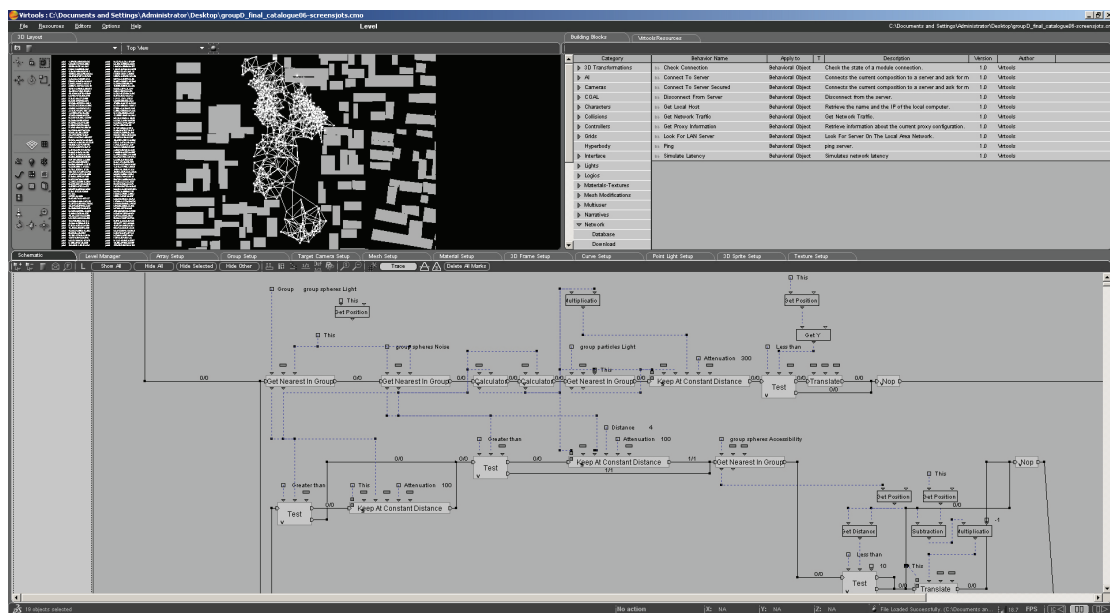


Figure 2: Hsiao's Virtools script showing graphical programming interface and behavior set-up.

## 2.2 Behaviors

Virtools' behavior engine runs both custom and out-of-the-box behaviors; Behaviors relevant for architectural and urban design are swarm behaviors [1] relying on self-organizing principles, which go back to Reynolds' computer program developed in 1986 simulating flocking behavior of birds [2]. The rules according to which Reynold's birds are moving are simple: Maintain a minimum distance to vicinity, match velocity with neighbors, and move towards the center of the swarm. While these rules are local establishing the behavior of one member in relationship to its next vicinity, global behavior emerges from local interactions. Similar to Reynolds' flocking rules, Protospace applications such as Virtools employ swarm behaviors in order to address issues such as the placement of programmatic units in 3D space either at city (Fig. 2) or at building scale.

### 3. Hardware Prototypes

In addition to software, Protospace incorporates Virtual Reality (VR) hardware (Fig. 3) consisting of large screens, wireless devices, and a multi-channel audio system. (www.protospace.bk.tudelft.nl). Wireless input devices allow implementation of specific tasks such as geometrical and behavioral manipulation. Additionally, Protospace is equipped CNC machines allowing for CAD-CAM production of 1:1 or scaled architectural prototypes.
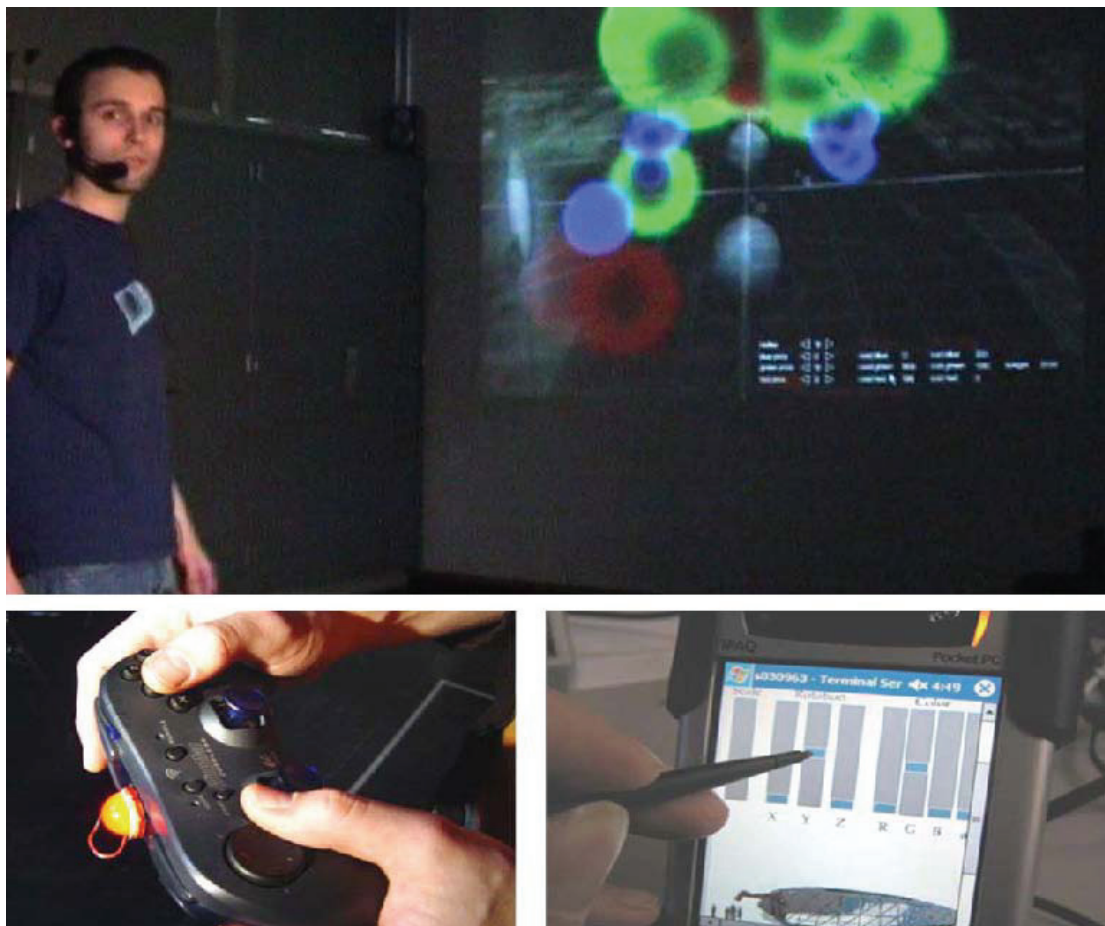


Figure 3: Wireless devices with varying characteristics are available as input devices for implementing specific tasks such as geometrical and behavioral manipulation.

These applications employed in the graduate program enable on the one hand development and CAD-CAM production of architectural prototypes, on the other hand they facilitate interactive presentations that allow physically and virtually present audience to attend and interact with the presenters and their presentations.

Non-linear screen presentations are set-up on multiple screens and the non-linear talk follows a paradigm in which the audience is enabled to select from predefined content clusters specific topics, images, and/or a movies and the speaker has to present and discuss them. From the multiple screen projections, only some of them can be

influenced by the audience: The physically present audience can alter the course of the presentation by using laser pointers, triggering light-sensors, and/or pressure-sensors, while audience from all over the world follows and interacts with the presentation via Internet-based interfaces. In this context, distinct clusters of content are marked with keywords, indicating when audience input is expected or required.

## 4. Conclusion

Software and hardware application compounds such as Protospace enable interactive design sessions and interactive presentations via Internet. In this context, the described Internet-based post-graduate program becomes a relevant alternative platform for studying and researching by connecting virtually students, researchers, and educators from all over the world.

Evaluation of the E-Archidoct program concluded, however, that more students started then in the end managed to complete the program. Reasons for this were found in students' limited access to software and hardware. For instance, some design assignments dealt with 3D modeling and students had no access to the required commercial software. Also, the program required Internet-based individual and collaborative exchange between students and teachers, for which the open-source Modular Object-Oriented Dynamic Learning Environment (Moodle) was offered on the E-Archidoct. However, communication with students via Google Wave, Dropbox and Skype has proven to be necessary. Furthermore, local technical support was required in order to ensure success of participation in the program.

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## APPENDIX