VIRTUAL CLASSROOMS — A REALITY

Mukund Moorthy
Dept. of Electr. & Comp. Engr.
The University of Arizona
Tucson, Arizona 85721-0104
U.S.A.
Mukund@ECE.Arizona.Edu
http://www.ece.arizona.edu/~mukund/

François E. Cellier
Dept. of Electr. & Comp. Engr.
The University of Arizona
Tucson, Arizona 85721-0104
U.S.A.
Cellier@ECE.Arizona.Edu
http://www.ece.arizona.edu/~cellier/

ABSTRACT

The impact of the World Wide Web on our lives is increasing day by day. The various applications supported by the World Wide Web is growing every minute. This paper looks at one such growing culture namely education via the World Wide Web and in particular Web-based teaching. The paper looks at Web-based teaching from an instructor's perspective. The efforts of this project are twofold, the first part involves imparting the knowledge to the students, and the second part pertains to evaluating the understanding by the students.

Keywords: Education, World Wide Web, virtual teaching, multimedia, presentation model

1. INTRODUCTION

The *World Wide Web* may easily be the most important development in human history since the invention of the book press by Gutenberg over 600 years ago. It may have deeper implications on our daily lives and societal structures than any of the other technical marvels that the 20^{th} century has produced. More than telephone and television will the Internet, and its most modern child, the World Wide Web, bring humanity together, make this planet one tightly linked global society.

Viewed by many as just another "nice toy" in the beginning, the World Wide Web has already conquered its place in history. Commerce begins to realize its potential. The *virtual shopping mall* has become a serious contender for customers to the traditional stores, and this is only the beginning. It can be predicted without too much farsight that soon, more goods will be traded on the Internet than across shop counters. After all, why should customers contend themselves with the limited choices that any individual store can keep on its shelves, if they can shop in seconds for the best products sold at the lowest prices all over the globe?

Yet, the most fundamental impact that the World Wide Web will have in the future is on the educational system. No longer will kids growing up in far-off rural communities be disadvantaged by a "provincial" education that offers limited perspectives and even more limited choices. No longer will they stand before the meager bookshelves of a third-rate library. No longer will their world end at the end of Main Street, where pavement turns into gravel, and nature is only interrupted by the occasional farm house, each one an island, isolated and self-contained.

Each child will have a *true choice* of where and what to study, only limited by his or her own capabilities, energies, and imaginations. Educational institutions will have to compete for students on a national and possibly even international scale. Only good institutions will survive this competition, a struggle that will invariably lead to an overall improvement of the educational system and its institutions. Educators will not be able to escape this challenge. Either they deliver quality education, or they will face an empty (virtual) classroom.

First "products" start to appear on this new market. The *Internet Academy* [Internet Academy], a web-based K-12 school, made global (virtual) news this month, when articles about it appeared on ZDNN [ZDNN] and MSNBC [MSNBC]. To mention another example, at least two Ph.D. long-distance learning programs in psychology appeared on the Internet during the last two years [Graduate School of America, Walden University]. Both of these schools are nationally accredited by now. These are only two –quite different– examples of new and innovative initiatives in long-distance learning, both successfully competing with the more traditional schools for students. Both of these initiatives have in common that they have emerged in fields that are not traditionally at the forefront of technology.

Whereas the use of the World Wide Web across the Internet is quite trivial, publishing on the Web is not as easy, and without proper tools, can be very time-consuming. Since there are many more students than educators, the market for services directed at students is much more profitable than that directed at educators. Consequently, industry has created more, and more elaborate, tools for students (Web

browsers, plugins, etc.) than for educators (Web publishing tools, Web page organizers, etc.).

One of the authors of this paper publishes all of his class material: homework problems and their solutions, midterms, etc. on the Web [Cellier 1998]. Since there still are no good tools available to typeset mathematical formulae on the web, he uses LaTeX to write his formulae, then uses a screen capture program [Screen Capture] to cut out each formula and save it in a bit map (a ".bmp" file). He then uses a conversion program [IrfanView] to convert each of these files separately into a compressed image file (a ".jpg" file). He then creates a Web script file (a ".html" file) that invokes the image files containing these formulae. Each homework solution consists, in this way, of many small files, one for each formula, and preparing one such solution for publication on the Web consumes somewhere between three and four hours of his time. This clearly is unsatisfactory.

There exist first attempts at overcoming this problem. A standard committee is now looking at the problem of writing mathematical formulae directly in HTML by defining *MathML*, the *Mathematical Markup Language* [MathML]. However, the new language definition isn't stable yet, and until it is, using it may cause more problems than it solves. There exist alternate routes, such as converters from LaTeX to HTML [TeX2HTML], and Adobe's PDF format, but all of them exhibit shortcomings of their own.

Yet, posting homework problems and their solutions on the Web is by no means the only way, in which the Internet can be used for teaching. It can play a role in many different facets of the educational system. Historically, the first use of the Internet was to improve communications between the student, his/her classmates, and the instructor. For about 10 years now, it has become customary among educators to communicate with their students by means of e_mail. The next step was to provide supplemental class information such as reference material through FTP sites as well as Gopher and, more recently, Web pages. As mentioned earlier, the tools for doing so are not yet user-friendly, and therefore, many educators still shun away from making extensive use of these capabilities. Yet, the authors of this article are convinced that such efforts have now become pivotal to successful teaching. The next stage of Internet usage, which is shaping up right now, uses video conferencing, chat lines, and related tools. It has recently become feasible to conduct classes over the Internet. While the Internet is not expected to replace the conventional classrooms altogether, it can provide an easy and improved learning methodology. Many educators now prepare their class notes in Powerpoint, and teach by bringing a notebook computer into the classroom. Tools exist already that enable educators to convert their class notes and Powerpoint presentations to Web-based presentations in an almost automated fashion.

All that the student needs in order to take full advantage of these possibilities is a multi-media computer and access to the Internet. Students can then access lecture notes and attend classes on the Internet if the resources are made available to them. It no longer matters where the students and educators are physically located — an educator in Tucson can teach simultaneously students living in Detroit and in Barcelona; a student in Berlin can attend back to back classes taught in New York and in Tokyo. The ramifications of such *virtual* class rooms are almost unlimited.

A number of educators have already embraced this new technology [Barnet and Burton 1996]. The virtual classrooms currently in use vary from sets of simple static HTML pages to much more complex pages that offer a wide range of services to the students [Huelsman and Schooley 1996]. Web pages can be dynamically generated, and may offer a high degree of interactiveness, allowing even computer programs, such as simulations, to be executed on the server in response to student input. Web pages that allow a student to take quizzes on-line with provisions for electronic submission and grading of homework assignments have recently been developed [Oakley 1996a, Oakley 1996b]. A number of descriptions of Web-based learning environments and methodologies have been published [Lockledge *et al.* 1996, Lancor *et al.* 1996].

This paper looks at developing tools that support the instructor in creating *virtual* class rooms. The project aims at making available computer packages that will enable instructors to develop fairly complex Web pages without having to be versed in Web technology; without ever having to master HTML and CGI programming. Details of how the Web pages are constructed are hidden from the user of the software. The software interacts with the instructor using form protocols, and making use of the provided inputs, generates HTML files and their accompanying CGI scripts in a fully automated manner.

2. VIRTUAL LECTURING

Microsoft already addresses this issue to a fair extent in its current version of Powerpoint 97. It is straightforward to create a Powerpoint presentation. Many researchers, managers, and educators already do so on a regular basis. It has become common practice to carry a notebook computer to a meeting, plug it in, and use Powerpoint instead of the traditional slides or transparencies during an oral presentation.

Powerpoint offers the capability to export the presentation to HTML. Powerpoint uses three HTML frames for this purpose. The frame on the left, a rolling window, contains an automatically generated *table of contents* of the presentation. The *Titles* of all the slides are collected into this table of contents. Each title is a hotspot that points to the corresponding slide. It is therefore important to place meaningful titles on each and every slide.

Slides are shown in the top right frame. Powerpoint provides different options for how to partition the screen. It

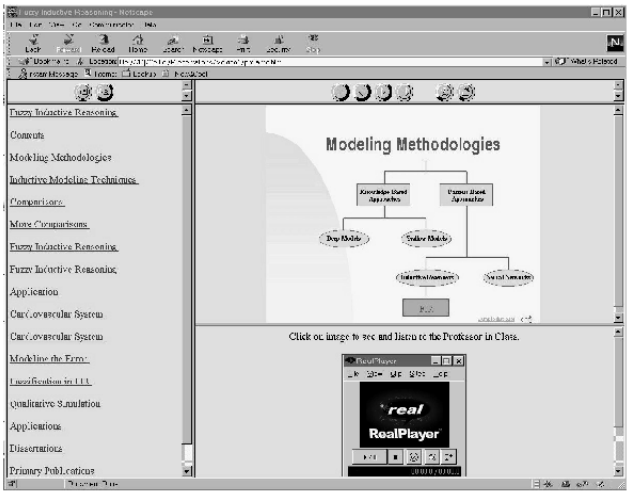

Figure 1: Screen Partition for Lecture Presentation

may be most practical to assign 50% of the screen to the slides. When doing so, the screen partition presents itself as shown in Fig. 1.

The lower right frame can be used to display notes. In the example shown in Fig. 1, this frame was used to invoke the *Real Audio/Video Player* [RealNetworks] to listen to and possibly view the professor, while he or she narrates the slide. Real Audio/Video is preferred over other audio/video players such as *Quicktime* [QuickTime] or *Media Player* [Media Player] because the Real Audio/Video Player allows for live broadcast. Also the streaming audio/video technology used by the Real Player occupies less memory space when compared to comparable .avi or .mov files.

The Powerpoint export facility only provides a framework. It automates those portions of the presentation that Microsoft felt comfortable automating, i.e., those portions that are expected to be common to *all* presentations. The export facility is easy to use. It is not even necessary to link the individual slides in the Powerpoint presentation. Individual slides will be arranged in the order in which they appear in the Powerpoint file, and linking will occur automatically as part of the export-to-HTML procedure.

However, the user of this facility is expected to be knowledgeable about HTML, frames, and possibly even Javascript, in that it is his or her responsibility to then edit the generated files manually to adapt them to his or her particular needs.

This is where the project comes in that is presented in this paper. Here, a standard *presentation model* is assumed. The software interacts with the educators, offering them either a form interface to gather the information necessary to fit the instructors' ideas into the framework of the standard presentation model, and then automatically edits the files that were generated by Powerpoint during the export-to-HTML procedure to implement these concepts.

The standard presentation model evidently limits the freedom of the instructors in how precisely their ideas are being realized, but it also frees them from having to be knowledgeable about the intricacies of HTML programming. Thus, this software should be ideally suited for K-12 teachers and psychology professors.

3. VIRTUAL TESTING

The second facet of this paper relates to *virtual testing*, i.e., testing the knowledge that the student has acquired by taking the class. Whereas Microsoft already offers quite a bit in terms of *virtual teaching*, the company doesn't address at all the issue of *virtual testing*. Also, the task is more demanding, because it requires interactive Web pages. In virtual teaching, the information flow is strictly from the educator to the student. The student is only in control of the speed by which the knowledge is imparted to him. In contrast, virtual testing requires flow of information from the student back to the instructor. This cannot be accomplished using HTML alone, because it requires a collaboration between the *client*, i.e., the machine on which the student's Web browser is running and the *server*, i.e., the machine where the educator's Web page is published. In HTML, the server is essentially passive. All it does is to provide the next Web page to the client, whenever the client requests it. In virtual testing, this approach no longer suffices. Now, the server needs to receive the answers of the students, and do something with them, such as grade the exam on the spot, or at least, forward the provided answers to the mailbox of the instructor. To this end, a CGI script needs to be developed that resides on the server, and that is responsible for the actions required as a result of incoming student submissions.

Whereas Web browsers have been developed for many different platforms, servers are still primarily Unix machines. Although Windows NT offers Web server capabilities, these cannot yet live up to the standards of security (Web servers are vulnerable to break-ins by hackers) and software support that the (older) Unix servers provide. Essentially all CGI scripts run on Unix machines, and therefore, this phase of the project was developed and tested on a Sun/Solaris platform. The CGI scripts employed in this project run on UNIX script language on the C shell.

The philosophy behind this phase of the project is the same as for the other phase: protect the educator from having to be knowledgeable about HTML and CGI script programming. To this end, a standard presentation model was developed. The necessary programs that run on both the client (HTML) and the server (CGI) are automatically being generated from user input, protecting the instructor form the intricacies of Web programming, at the expense of limiting his or her freedom in how the information is being presented

on the Web. As before, the educator uses a form interface to provide the information necessary for automatically generating the quiz.

The form interface is itself a Web program, a client HTML file with an accompanying CGI script running on the server. However, the job of this CGI script is quite a bit more demanding. This CGI script generates dynamically new HTML files for the client and new accompanying CGI scripts for the server that then implement the form interface by means of which the student will take the test. The CGI script also interfaces with a database, in which the questions to be asked are being stored.

The "database," for now simply an ASCII text file, contains a number of questions, possibly together with a set of (correct and incorrect) answers. Questions for which no answers are provided imply that the student should send a text back in return. If the test contains such questions, then the test cannot be automatically graded. The student responses will then simply be submitted to the teacher for grading. Questions for which multiple possible answers are provided are interpreted as multiple-choice questions, and questions for which only two possible answers are provided are interpreted as true-false questions. Finally, there may be questions for which only a single one-word answer is provided. The interfaces generated for the four types of questions on the automatically generated quizzes are different. If a quiz only contains multiple-choice, true-false, and one-word questions, then it can be automatically graded. The instructor can choose, when generating the test, whether he or she wants the program to grade the test, what the grade scale should be, and whether the grades should be reported back to only the student (training test), only the instructor (blind test), or both. Also, the instructor can choose whether he or she wants the correct answers to be sent back to the student together with the grade.

The form that the instructor has to fill in when generating the test contains the following fields:

- Name of the HTML and CGI file.
- Title of the Web page.
- Header of the Web page.
- E_mail address(es) of those who should receive the submitted test.
- Deadline for submission of the test answers.
- Number of true-false questions to be picked randomly from the database.
- Number of multiple-choice questions to be picked randomly from the database.
- Number of one-word questions to be picked randomly from the database.
- Number of detailed-answer questions to be picked randomly from the database.
- Grading scheme to be used.

VIRTUAL TESTING: WEBFORM FOR AUTOMATED WEB PAGE GENERATION

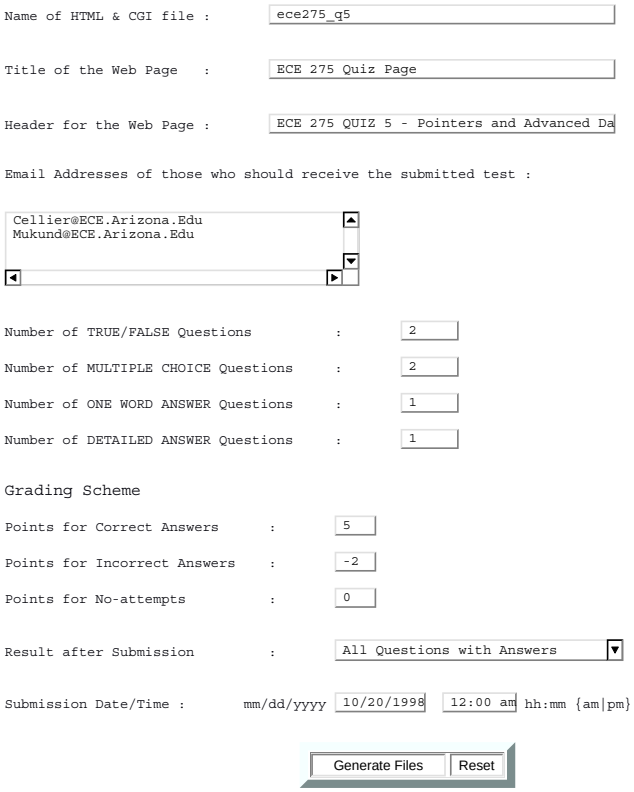

Figure 2: Form Used for Generating a Test

- Instructions for how to handle the test.

The grading scheme instructs the program as to how the tests need to be graded. The instructions for how to handle the test allow the educator to decide, how much information is to be returned to the student, and how much information is to be sent to the educator. The program offers a fixed number of choices, from which the educator must select one. The interface is straightforward. It is similar to that used by computer manufacturers who allow customers to configure a computer system on the Web.

A filled-in Web form used to generate the test is shown on Fig. 2.

Once the form has been submitted using the (static) HTML test generation page, the accompanying (static) CGI script automatically generates the requested quiz. The quiz again consists of an HTML file containing the form that describes the test, and an accompanying CGI file that contains information as to how the test needs to be handled by the server, once it has been submitted from the client by the student.

The quiz that has been generated using the form shown in Fig. 2 is presented in Fig. 3.

4. THE SOFTWARE

The complete software together with a user manual can be downloaded from [Moorthy 1998]. This Web site also includes links to a number of sample Web pages generated using the discussed tools.

5. DISCUSSIONS AND CONCLUSION

The project is in an experimental stage. The software has not yet been used for any classes. It was developed during the summer of 1998, and is being turned over to the ECE faculty only now. The two tools that are described in this paper, represent but a first step. To fully support the virtual classroom with appropriate software tools, many more tools will be needed, such as user-friendly tools for publishing mathematics on the Web, tools for keeping track of the progress of students during the semester (the *Virtual Assistant*), tools for monitoring students while they interact with the software (the *Virtual Tutor*), etc. Extra features, such as chat room facilities and/or bulletin boards can be added fairly easily. Also, students should be able to post their homework solutions on-line. The scores or results of the quizzes should be automatically uploadable into a database such as Microsoft Access. At this moment, the software does not allow yet for pictures to be included with the questions. This feature will be incorporated shortly. Yet limited as they may be, the two tools that are described in this paper, tools that are available for free to all educators who care to use them, are believed to represent a significant step in the right direction.

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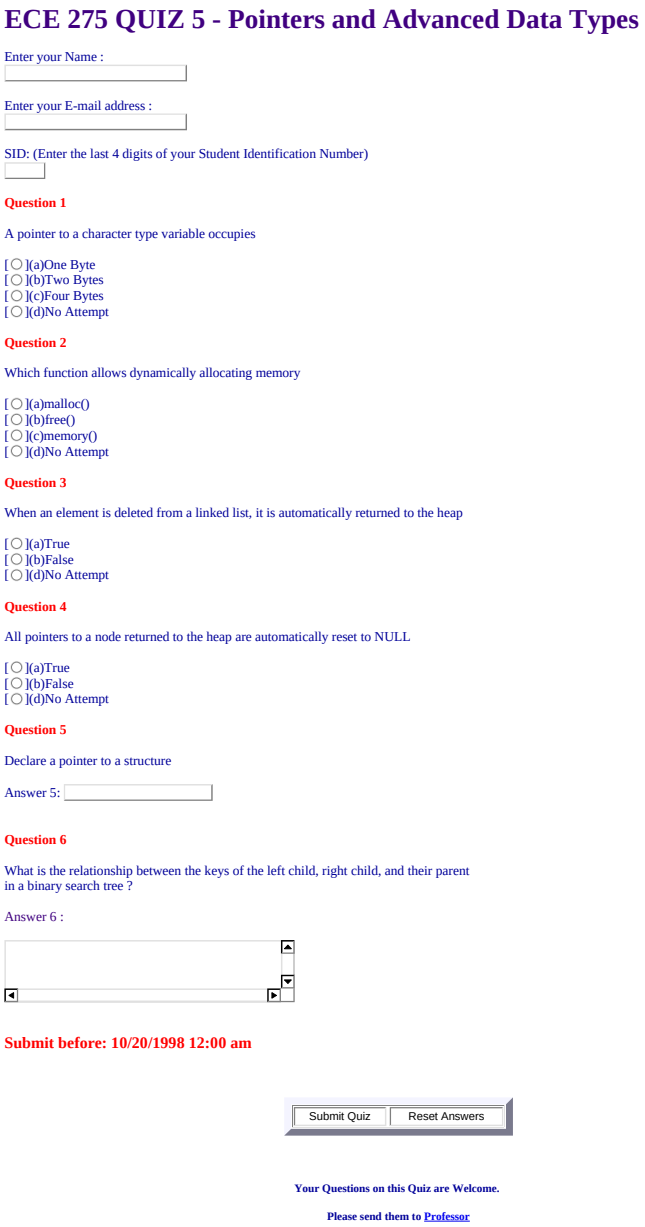

ECE 275 QUIZ 5 - Pointers and Advanced Data Types

Enter your Name :

Enter your E-mail address :

SID: (Enter the last 4 digits of your Student Identification Number)

Question 1

A pointer to a character type variable occupies

[○](a)One Byte
[○](b)Two Bytes
[○](c)Four Bytes
[○](d)No Attempt

Question 2

Which function allows dynamically allocating memory

[○](a)malloc()
[○](b)free()
[○](c)memory()
[○](d)No Attempt

Question 3

When an element is deleted from a linked list, it is automatically returned to the heap

[○](a)True
[○](b)False
[○](d)No Attempt

Question 4

All pointers to a node returned to the heap are automatically reset to NULL

[○](a)True
[○](b)False
[○](d)No Attempt

Question 5

Declare a pointer to a structure

Answer 5:

Question 6

What is the relationship between the keys of the left child, right child, and their parent in a binary search tree ?

Answer 6 :

Submit before: 10/20/1998 12:00 am

Submit Quiz | Reset Answers

Your Questions on this Quiz are Welcome.

Please send them to Professor

Figure 3: Generated Test

References

[Barnet and Burton 1996] Barnett, R.W. and C.A. Burton (1996), "Teaching and Assessment via the Internet - Experiences and Directions," Proceedings, IEEE International Conference on Multimedia Engineering Education, pp.355-360.

[Cellier 1998] Cellier, F.E. (1998), Class Notes, http://www.ece.arizona.edu/~cellier/syllabi.html.

[Graduate School of America] The Graduate School of America, Long-distance Ph.D. program in psychology, http://www.tgsa.edu/.

[Huelsman and Schooley 1996] Huelsman, L.P. and L.C. Schooley (1996), "Development of a World-Wide-Web/Multimedia Base for an Undergraduate Circuit Theory Course," Proceedings IEEE Frontiers in Education Conference, pp.355-360.

[Internet Academy] The Internet Academy, A long-distance learning K-12 school on the Internet, http://169.204.208.10/Ia/newlook.htm.

[IrfanView] IrfanView32 Version 2.60, Program to convert bitmaps to compressed image files, http://stud1.tuwien.ac.at/~e9227474/.

[Lancor *et al.* 1996] Lancor, L., K. Wurst, and K. Barker (1996), "A Methodology for Web-based Learning in Engineering," Proceedings IEEE Frontiers in Education Conference, Paper # 9a3.2.

[Lockledge *et al.* 1996] Lockledge, J., D. Geister, and P. Go (1996), "An Internet Based Learning Environment," Proceedings IEEE Frontiers in Education Conference, Paper # 6c5.4.

[MathML] MathML 1.0: Mathematical Markup Language, http://www.w3.org/Math/.

[Media Player] Media Player, Multimedia player, http://www.microsoft.com/windows/mediaplayer/default.asp.

[MSNBC] MSNBC (21 October 1998), "Internet Academy Finds School Niche," News article, http://www.msnbc.com/news/166989.asp#BODY.

[Moorthy 1998] Moorthy, M. (1998), Virtual Teaching and Testing Software, http://www.ece.arizona.edu/~moorthy/vclass.html.

[Oakley 1996a] Oakley II, B. (1996), "The Virtual Classroom: At the Cutting Edge of Higher Education," Proceedings IEEE Frontiers in Education Conference, pp.135-139.

[Oakley 1996b] Oakley, II, B. (1996), "A Virtual Classroom Approach to Teaching Circuit Analysis," *IEEE Trans. on Education*, **39**3, pp.287-296.

[QuickTime] QuickTime, Multimedia player, http://www.apple.com/quicktime/.

[RealNetworks] RealPlayer Plus G2 Beta, Multimedia player, http://www.real.com/.

[Screen Capture] Screen Capture 1.4.6, Program to capture portions of the screen and store them in a bitmap, http://www.nestsoft.com/.

[TeX2HTML] TeX2HTML, Program to convert LaTeX to HTML, http://www.tex2html.com/.

[Walden University] Walden University, Long-distance Ph.D. program in psychology, http://www.waldenu.edu/.

[ZDNN] ZDNN (21 October 1998), "Internet Academy Finds School Niche," News article, http://www.zdnet.com/zdnn/stories/news/0,4586,2152647,00.html.

AUTHOR BIOGRAPHIES

Mukund Moorthy received his B.E. degree in Electrical and Electronics Engineering from the University of Madras, India in 1997. He is currently pursuing his M.S. in Electrical and Computer Engineering at the University of Arizona, Tucson. His research interests concern modeling and simulation methodologies. He is currently working on macroeconomic modeling and its application to technology forecasting.

Dr. Francois E. Cellier received his B.S. degree in Electrical Engineering from the Swiss Federal Institute of Technology (ETH) Zürich in 1972, his M.S. degree in Automatic Control in 1973, and his Ph.D. degree in Technical Sciences in 1979, all from the same university. Dr. Cellier joined the University of Arizona in 1984. He is currently Head of its Computer Engineering Program within the Department of Electrical and Computer Engineering. Dr. Cellier's main scientific interests concern modeling and simulation methodologies, and the design of advanced software systems for simulation, computer–aided modeling, and computer–aided design. Dr. Cellier has authored or co–authored more than 100 technical publications, and he has edited four books. He recently published his first textbook on *Continuous System Modeling* (Springer–Verlag New York, 1991). He served as General Chairman or Program Chairman of many international conferences, most recently ICBGM'93 (SCS International Conference on Bond Graph Modeling, San Diego, January 1993), CACSD'94 (IEEE/IFAC Symposium on Computer–Aided Control System Design, Tucson, March 1994), ICQFN'94 (SCS International Conference on Qualitative Information, Fuzzy Techniques, and Neural Networks in Simulation, Barcelona, June 1994), ICBGM'95 (Las Vegas, January 1995), WMC'96 (SCS Western Simulation MultiConference, San Diego, January 1996), ICQFN'96 (Budapest, June 1996), WMC'97 (Phoenix, January 1997), WMC'98 (San Diego, January 1998), WMC'99 (San Francisco, January 1999), ICBGM'99 (San Francisco, January 1999) and ICQFN'99 (Warsaw, June 1999). He is currently Vice President of Conferences of the Society of Computer Simulation International. Dr. Cellier is Associate Editor of several simulation related journals, and he served as vice–chairman on two committees for standardization of simulation and modeling software.