Self-Paced Instruction to Introduce Traffic Engineering in Virtual City (Sooner City)

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Abstract

This paper presents the results of one portion of a larger program conducted at the University of Oklahoma to introduce students to engineering and design through the use of a virtual city called 'Sooner City'. This particular module is used to introduce the students to traffic engineering through an easily-understood, internet-based learning environment. Since most freshman engineering students have little knowledge about engineering, it is helpful for them to learn through the use of interactivity and visualization. Also, because the module is web-based, the students were able to interactively control their learning pace. Through this approach, the students were required to design practical engineering cases and then visualize the design in a virtual world. The definitions for the level of service of traffic engineering were also presented through the use of text, pictures, sounds, simulations, animations and video in an integrated, web-based learning environment. Through the web, the students were able to set the basic design variables of the freeway section in the virtual world of Sooner City. The design variables included the traffic flow rate, the number of lanes, the length of the acceleration lane, and the on-ramp configuration. To help better understand the effectiveness of the learning environment, a survey was administered to all students using the module. The results of this survey are presented in the paper.

Introduction

The World Wide Web

Initially, the Internet was designed for just text-based data transfer and applications, such as telnet, ftp and e-mail, which were used to exchange information and data. With the development of the World Wide Web (WWW), or just web, the functionality of Internet was greatly expanded due to its easy-to-use graphical interface. This helped generate a large interest in posting information on the Internet that anyone could access. In particular, higher-education institutions are leading the push in adopting the web as a new tool for education because of the ease of use, quick access, and the low cost of access. Some universities, such as University of Oklahoma require freshman engineering students to own an individual laptop for use in the classroom. To help with the network,

they are supplied with a wireless network card so that they can be connected without the distraction of a network wire. At Rensselaer Polytechnic Institute, about 300 of the 1,163 incoming students were issued new IBM ThinkPad 600s with essential software [1]. In addition to the hardware advances, the campus-based networks have seen both their capacities and speed increase. The next generation Internet will even be faster, more reliable, and more secure, which will further accelerate the use of the web as a key learning tool. It is expected that future generations of the Internet will operate at 100 times faster (end-to-end) than the present Internet [2]. With this increase in speed and capacity, true multimedia applications, such as interactive video, can be fully realized and used in all forms of education.

The web is also changing the way people learn since it can provide new methods for presenting course material interactively all over the world. The web-based learning environment can be available 24 hours a day without the limitations of location and schedule. It is also flexible in letting students choose their own learning paces and in explaining the concepts, theory and applications. Furthermore, immediate feedback can be given in an interactive learning environment, which can deepen the students' understanding of basic concepts and theory. Students are also able to enroll in courses that are offered anywhere in the world instead of just on their own campus. The web-based learning environment also has the advantage of being accessible on most all computer platforms so the make or model of a particular computer will not prohibit the user from learning.

Sooner City and the Web

Sooner city is a program initiated at the University of Oklahoma in 1998. The students involved in the program are asked to build certain segments of a virtual city on completion of appropriate undergraduate courses in civil engineering. The end result is a complete virtual city that includes designs from all their coursework. The completed city will be viewable on the web at the end of four years. The web is also used to deliver the course material and simulations.

One of the first portions of the virtual city that the student needs to construct is a basic road system. Traffic flow is first introduced through the Introduction to Engineering course, which exposes engineering freshmen to basic engineering analysis and design. The Sooner City section of Introduction to Engineering requires the students to apply the learned design process to create city components, e.g., transportation corridors, fire station placement, wind farms. The traffic module discussed in this paper involves the design of a transportation corridor linking Sooner City to metropolitan Oklahoma City. Students were required to design the number of lanes and on/off ramp configurations of the corridor considering a 50-year life. In addition to the lanes and on/off ramp design, students were required to forecast population growth throughout Sooner City. The web-based traffic learning environment was developed and adopted (1) to help students visualize the design project and (2) to help students understand the underlying traffic design principles. There are three parts in the learning environment [10], namely, explanation, simulation, and field video (Video and sound in the module were not available when the students used the learning environment). A survey was performed to

evaluate the effectiveness of the learning environment. Data collected from the survey was interpreted. Finally, the paper concludes with a discussion of the advantages, and disadvantages of the Web-based interactive learning environment.

Examples of Web-based Learning Environments

In just the short span of three to four years, educational institutions have quickly realized the importance and capabilities of the web, have now started developing and using the web for almost all courses. The web is not only a tool for exchanging information between researchers, but also a mechanism to supplement traditional education and to provide nontraditional education. In the past, it was used to distribute the announcements and assignments, to collect assignments, to discuss related problems, and to search and access desired data. Further use of web technology was to present text and graphics based coursework [3].

New ways to use the web and its technology in education has now gone beyond the scope just mentioned. A good example is “Mallard” which was developed by Mike Swafford and Donna Brown at the University of Illinois at Urbana-Champaign[4]. The Mallard environment uses several Java Applets to teach a freshman electrical and computer engineering course at the University of Illinois at Urbana-Champaign. Within the environment, students can do homework, and get immediate feedback about their solutions. Students can also conduct the design of assembly code. Two interactive Web-based applications called Virtual FlyLab and Virtual Earthquake were developed for learning science [5]. An innovative use of Web technology for education is to employ Virtual Reality Modeling Language (VRML) to teach design over the Internet. The design module using VRML has been developed with the Practical Extraction and Reporting Language (PERL). Two design examples have successfully been implemented over the Internet [6]. These are but just a few of the many examples of highly interactive web-based learning environments.

David R. Wallace and Philip Mutton compared the effectiveness of web-based lecture and classroom-based lecture [3]. Their results showed that students who used the web-based lectures and learning system performed better than students who took the classroom-base lecture. Although the experiment was only on one topic, it rejected the hypothesis that the two groups should perform equally. Of course, this is just one example and more research is needed to identify why web-based or multimedia help learning, but it does show that the web needs to be taken seriously as a effective tool to help students learn.

Internet Technology used in the Learning Environment

As mentioned previously, most web sites originally consisted mainly of text with some graphics. In order to view videos, animations and perform simulations, various new technologies were developed to supplement basic HTML. These include Java, JavaScript,

Shockwave, QuickTime, stream video, and many more. The traffic engineering module described in this paper used many of these new web technologies to add user interactivity. The following paragraphs describe the different technologies that were used in the module.

The basic web pages were developed using HTML or Hypertext Markup Language. HTML is a scripting language which can be read by any internet browser. HTML pages are the basic vehicles of the World Wide Web. The simulations were done using Director which is a multimedia authoring program. Director files are saved as a compiled 'Shockwave' file that can be viewed and operated from a web browser. Shockwave is a general technology that puts Authorware, Director, and Flash files on a web page and that enables animation, audio, and interactivity to be added to static Web pages with text and graphics [7]. For Netscape-compatible browsers, Shockwave is a program plug-in. For Microsoft Internet Explorer, Shockwave is an ActiveX extension to the browser. The plug-in and ActiveX controls enable the user's browser to interpret and display the Shockwave movie. Since Shockwave was designed specifically for Internet use, it reduces the file size tremendously without loss of quality. It is also easy to write Shockwave modules using Director. If you only use the commands and features supported by Shockwave and keep the file size in mind, it is just like writing a multimedia application for CD-ROM.

The Shockwave plug-in is free to download for Netscape Navigator (version 2.0 or later) or Shockwave ActiveX control for Internet Explorer 3.0 and 4.0 from Macromedia's web site. For Windows 98, the Shockwave ActiveX control are now preinstalled in the Internet Explorer 4.0. For Netscape Communicator 4.5, Shockwave plug-in is also preinstalled.

Learning Environment Design

The topic selected for this interactive web-based learning environment was traffic engineering. Since the Introduction to Engineering course is for freshman students, only the basic concepts of traffic engineering are covered. There are three parts in the learning environment. The first uses text and pictures to explain the definitions. The second is the interactive traffic module. The third is the video section which demonstrates how the poor design of a ramp can cause traffic congestion. Figure 1 illustrates the main web page for the traffic engineering learning site.

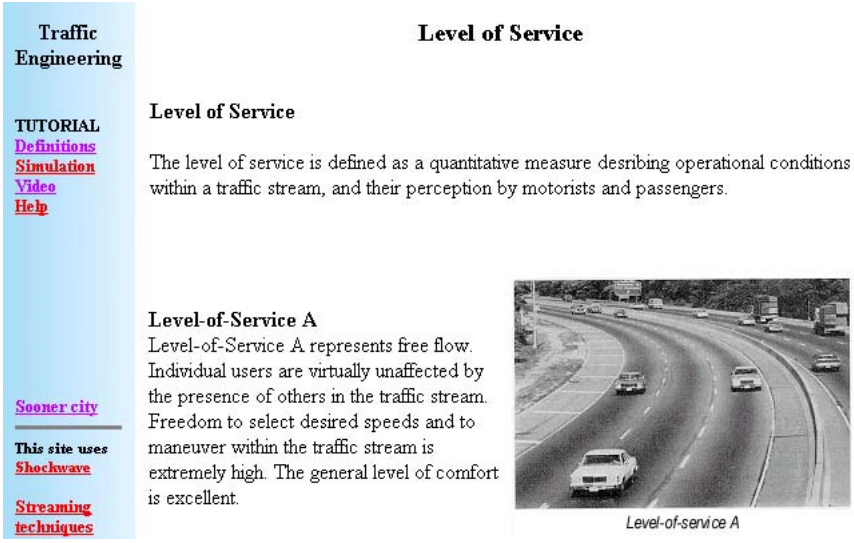

Fig. 1. Typical web page for the tutorial section

The first part of the learning environment covers the definition of the Level of Service (LOS) A, B, C, D, E, and F. Levels of service ranges from light vehicle traffic volume associated with unobstructed flow (LOS A) to extremely heavy traffic congestion(LOS F). Each LOS definition is accompanied with a picture to visually show the traffic volume corresponding to that level of service. Levels of service are defined by different levels of service flow in terms of vehicles per hour. In the vicinity of on-ramps, the highway maximum service flow values are reduced due to increased lane changes, weaving, and merging. For the sake of the module, the reduction in maximum service flow was made a function of the length of the acceleration lane at the end of the on-ramp. A table in the learning environment is used to give the reduced maximum service values for different acceleration lane lengths.

The second part of the learning environment consists of the Shockwave traffic module and explanatory text. As mentioned in the previous section, Director authoring tool was used to program the simulation. The exported Director file is a Shockwave movie which can be distributed across the web. The purpose of this module is to try to provide a interactive learning environment and to visually demonstrate the concepts of level of service.

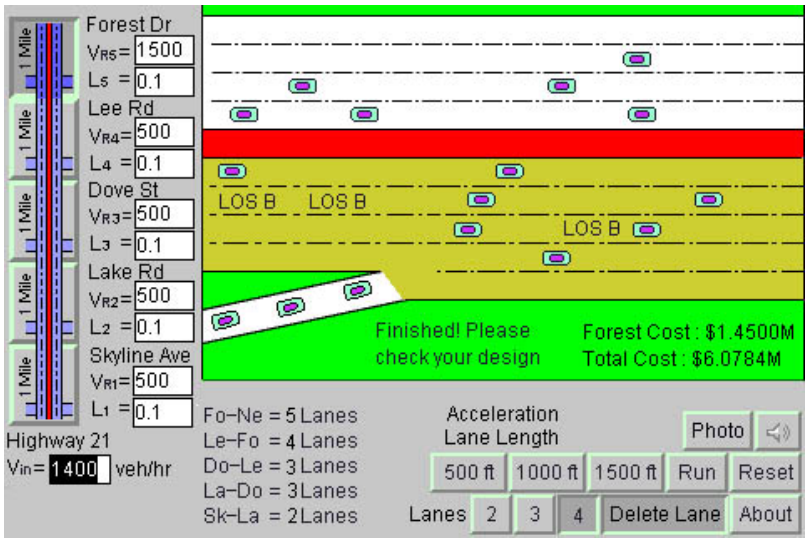

Fig. 2. Traffic Simulation Module on Web Site.

There are thirteen features in the module (Fig. 2).

1. There are three lane configurations, 2, 3, and 4 lanes which the users can select.
2. There are three choices for the length of the acceleration lane.
3. If the user wants to increase or decrease the number of lanes of the freeway, he can add or delete a lane.
4. There are five intersections available for design. Each intersection effects the design of the next one.
5. The level of service is illustrated using color shading based on the user's input of the traffic volume and the number of lanes. For example, if the current level of service is A, a green shading appears. If the current level of service is D, the red shading is used.
6. The cost of individual intersection and the cost of total five intersections are automatically calculated.
7. The number of the cars showing on the freeway is based on the user's input. In this module, each multiple of 500 vehicle/hour is represented with a moving car. The maximum number of vehicles shown on the freeway is 16.
8. The velocity of the vehicles on the freeway has a relationship with the level of service. The velocity with level of service A is the highest.
9. If the total maximum service flow with only two lanes is more than 5,500 vehicle/hour, the vehicles on the screen will crash with sound effects.
10. The user can turn on and turn off the sound switch.
11. A photo is used to show a real ramp.
12. The current design configuration is outputted to the user during the session.
13. A message is used to prompt the user when there is a problem with the design.

The third part of this learning environment includes is an actual video of traffic flow which is used to show traffic congestion due to poor ramp design. Since the file size of the video is large, video streaming technology is used to play the movie over the web.

In engineering design, performance and cost need to be considered at the same time. Therefore, when a student selects different design strategies, such as different number of lanes, the cost is also estimated. This helps reinforce the relationship between performance and cost to the students. After the basic traffic engineering concepts are introduced, the students are asked to determine the best design of the freeway for the given conditions. The design variables include the traffic flow rate, the number of lanes, and the length of acceleration lane. Students can choose the design variables by themselves, but they are not allowed to exceed a reasonable range of values.

Evaluation of the Learning Environment

Survey

As a precursor to the corridor design, students were given the module and simple traffic volumes to design a sufficient number of lanes and acceleration lengths. They were asked to learn the module "on the fly" through the learning and simulation environments. To reinforce the underlying theory, traffic volumes that inevitably "crashed" the simulaion were provided (Module is limited to 4 lanes and 1500 ft acceleration lanes). Solution to the latter problem required hand calculation utilizing the theory provided in the module. Finally, the module was adopted by each student to design the proper corridor given projected Sooner City traffic volumes.

Table 1 Survey Results

	Definitely False	More false than true	Neither	More true than false	Definitely true	Average*
1. The module helped me understand the principles behind the transportation corridor design.	0**	4	6	18	8	3.8
2. The module helped me to better visualize the transportation corridor design.	0	0	1	11	24	4.6
3. The module helped me complete the design project faster.	1	1	4	9	21	4.3
4. The module allowed me to complete the corridor design without understanding the principles.	13	10	4	5	4	2.4

* Average score based on the following: 1 = Definitely false; 2 = More false than true; 3 = Neither; 4 = More true than false; 5 = Definitely true

** Number of students who responded " Definitely False". The total number of students that responded is 36.

A post project survey was conducted to evaluate the module's effectiveness. The questions asked and a compilation of the responses obtained from 36 students are presented in Table 1. Though the responses are subjective and do not provide a truly quantitative indication of the students' improvement in knowledge, they do provide useful insight. One of the objectives of the module was to help students visualize the problem. Student response suggests the module was successful in this regard (see question 2). The second main objective of the module was to help students better understand the underlying traffic principles. Student response indicated this, although not as resoundingly as for visualization (see question 1).

Discussion

For Web-based learning environment, there is no distribution problem. Users don't need to get the software through CD-ROM or floppy disk. Since the environment was web-based, there were no software or hardware compatibility issues. The special requirements for user's computer don't exist. It was also easy to update the module since only one copy of the simulation need to be updated on the server.

The Shockwave files are run on the client machine, so the speed of the program is quite fast. This is different from other learning environments which are programmed using Java and run on the web server [5].

Since the server is open for 24 hours, the students have flexibility when to access the web site. Furthermore, the students can control their learning pace according to their own preference, which is useful for different students. Through the interactive learning module, practical engineering concepts are easier to understand. The students can also visualize the problem in the learning module, which gives them a direct impression.

The learning environment requires the users to download the Shockwave plug-in or ActiveX for their browsers if they do not have the latest browsers. Some users are reluctant to do so because it requires some time and effort. The user has to have access to the Internet to use the web-based learning environment. Also, in order to play the video, the user must have access to the University of Oklahoma Intranet which can ensure the transfer rate required by the streaming technique.

Conclusion

According to student feedback, the learning environment was successful in helping students visualize the problem but only mildly successful in reinforcing the underlying principles. In future adoptions, more exercises will be developed to reinforce underlying principles.

Students can interactively control their learning pace according to their own interests since the learning environment is web-based, which is important to satisfy the pace requirements of different students.

Acknowledgements

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