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Transportation Infrastructure Design and Construction – Virtual Training Tools

**Transportation Infrastructure
Design and Construction –
Virtual Training Tools**

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16. ABSTRACT <p>This project will develop 3D interactive computer-training environments for a major element of transportation infrastructure – hot mix asphalt paving. These “tools” will include elements of hot mix design (including laboratory equipment) and construction equipment and methods for building and maintaining asphalt pavements. These virtual tools are targeted towards university students and practitioners with the goal of providing a direct and realistic experience for learning about and interacting with both laboratory and construction equipment. This project builds on and complements projects that are supported by WSDOT and NAPA. This effort recognizes that hot mix design and construction in the U.S. is changing due to the development and implementation of the Superpave mix design system. A full implementation of the Superpave system requires several hundred thousand dollars of sophisticated laboratory equipment and trained technicians. This is not feasible for most universities and contractors. The proposed tools will significantly reduce the need for fully equipped laboratories and enable enhanced training for students and practitioners.</p>			
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Introduction

This project was part of a larger effort to develop next generation training tools for the pavement industry. The tools are envisioned to be interactive, media rich, available on demand for just-in-time and self-training activities, targeted to students as well as young practitioners, and encompassing design, material specifications, as well as construction activities.

As knowledge and technology grow at an exponential rate, today's engineers (as well as technicians, supervisors, inspectors and others) must increasingly rely on training as a means to stay current and acquire new knowledge and skills. A training strategy based on self-directed learning with the assistance of interactive tools is best equipped to address these increasing training demands.

In addition, due to economic pressures, engineers and technician trainees are expected to get up the performance curve fairly quickly. Computer-assisted tools have the potential of enhancing the effectiveness of novice training. Computer training environments have already shown their efficacy in a number of areas. Interactive manuals are used by aircraft technicians to learn about servicing and maintaining airplanes, flight simulators are used by pilots in-training to become familiar with basic procedures, surgical simulators are used to train medical students or paramedics to perform basic suturing procedures, etc. The computational capabilities of desktop machines as well as the video, 3D graphics rendering capabilities of modern graphics cards, now enable the realistic visualization and interaction with computer models of equipment, tools, and machines to produce compelling environments for training purposes.

The applications of this technology to the processes involved in designing, building and maintaining asphalt pavements is still in its infancy. This is despite the fact that 95 percent of the highway system is surfaced with asphalt concrete and represent a significant infrastructure investment. During 1998, for example, over 515 million tons of hot mix were placed in the U.S. Given typical costs of producing and placing this material, this amounts to over \$15 billion per year. Even small mistakes due to incomplete training of design or construction personnel can have enormous economic consequences.

Background

The methods, tools, and equipment for testing hot mix asphalt concrete materials have undergone significant changes during the last ten years and, with the advent of new design procedures and materials (such as the Superpave mix design system), continue to evolve, become more sophisticated, and play a critical role in obtaining reliable material designs. Yet, partly because of the costs associated with acquiring and running such equipment, most students and practitioners are not exposed to them in an effective manner.

On the construction and maintenance side, the need for personnel that can reliably build and maintain asphalt pavements using the latest monitoring tools and methods is increasing. NAPA estimates that there will be a shortage of about 15,000 paving industry employees in 2005 who are properly trained and can be effective on pavement construction sites. Computer technology can assist in the training of construction personnel by providing virtual environments where users can operate equipment, get feedback on the operations, monitor the quality of the hot mix asphalt concrete placed, and make decisions in a realistic setting.

Within the engineering profession, and in particular the pavement field, knowledge requirements are rapidly increasing and changing, while the workforce in general is becoming less experienced. The current employer-centered training environment is straining to meet the resulting training demands. While there are many existing high quality resources, they are primarily focused on the instructor-led classroom

Nationally available pavement training tools are essentially limited to textbooks, informational publications, and a few CD-ROM based tools (notably Caterpillar's *Mat Defects* CD-ROM). In the realm of pavements, evidence suggests that training needs may not be adequately met:

- As technology continues to advance, the knowledge engineers must have to remain competent both increases and changes. Without continuing training, engineers, in a sense, become obsolete. The term "knowledge half-life" is often used to describe this obsolescence. Most knowledge half-life estimates appear to be in the "few-years" range pointing out the need for continuous training.
- The average experience level of a practicing engineer is decreasing. Baby boom era engineers are beginning to retire. A 1996 survey of State Departments of Transportation (DOTs) showed that about 20 percent of pavement-related engineers, technicians, and management had retired in the previous three years. Furthermore, the same survey found that more than half of the pavement-related design engineers and technicians had less than five years experience.
- New engineers, in general, receive a minimal introduction to pavements while in college. Pavement subjects are often cursorily introduced within general courses on materials, transportation, and highway design. The dearth of undergraduate pavement-focused information points to the need for training after initial employment, particularly with respect to construction issues including the processes of material placement, the effect of environmental conditions of placement on quality and life of pavements, etc.

Problem Statement

As described above, there is a need for training tools to assist both novice and continuing education students. For practicing engineers and technicians there is a need for interactive, comprehensive, visually-rich, searchable presentation of pavement information related to both design and construction. For novices, there is a need for even richer and more realistic simulations of construction processes related to pavements, since construction practices have a significant effect on the quality and life of pavement systems.

Research Objectives

The objectives of this project are to develop prototypes for computer-assisted learning for pavement engineering using state-of-the-art computer delivery technology. Specifically, we seek to deliver a prototype pavement compaction simulation that allows a user to interact with a roller compactor in 3D, and a prototype “pavement guide” that contains state-of-the-art descriptions of pavement design and construction practices including animations of laboratory test procedures.

Results

The results of this work may be accessed through the TransNow website www.transnow.org: research section, final report TNW2002-05. The first result is The Pavement Guide Series. As developed, the Pavement Guide is readily customizable to the needs of various users to accommodate local practices that vary by geographic location, intended audience, and specific user goals (colored boxes distinguish such custom information). The Guide has been customized for various organizations (The Washington State DOT, The National Asphalt Pavement Association, the Washington Asphalt Pavement Association, and the Hawaii Asphalt Pavement Industry). The Guide can be accessed through a web browser (Internet Explorer 5+ or Netscape 6+, the Flash Player 6 plug-in, and Adobe Acrobat Reader, all of which are free.). These versions contain movies and animations of test procedures, interactive equations for some design equations, photos and movies documenting various constructions practices, as well as searchable hyperlinked textual information covering a broad spectrum of asphalt pavement engineering practice.

The second product, the Xpactor, can be accessed through a web link. It contains a prototype 3D roller simulation application that allows a user to drive a virtual roller to compact hotmix. The application uses the MultiCool program to compute, from given environmental conditions, the time variation of hotmix temperature. It asks the user to compact a given road section before the hotmix temperature decreases beyond the range where achieving proper density becomes very difficult. The user has to decide on a pattern for moving the roller, number of passes, speed, while trying to achieve proper and uniform compaction before cooling occurs. Feedback on performance is given to the user at the end of the rolling session. Because of its reliance on 3D graphics, the program requires a relatively recent video-card (any card with 3D acceleration should work). The program uses keyboard keys for user interaction.

The Xpactor simulation application are available on the TransNow website: www.transnow.org.

Conclusions

This project has shown that it is practical and feasible to develop and deploy on desktop machines highly interactive, realistic, media rich training material that can be used in a variety of training contexts. Our goal is to publish the CDs developed and distribute them nationally.