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Development of educational software for beam loading analysis using pen-based user interfaces

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Abstract

Most engineering software tools use typical menu-based user interfaces, and they may not be suitable for learning tools because the solution processes are hidden and students can only see the results. An educational tool for simple beam analyses is developed using a pen-based user interface with a computer so students can write and sketch by hand. The geometry of beam sections is sketched, and a shape matching technique is used to recognize the sketch. Various beam loads are added by sketching gestures or writing singularity functions. Students sketch the distributions of the loadings by sketching the graphs, and they are automatically checked and the system provides aids in grading the graphs. Students receive interactive graphical feedback for better learning experiences while they are working on solving the problems.

Keywords: Beam loading analysis; Pen-based interface; Education software; Shape matching

1. Introduction

Shafts and beams are commonly used in mechanical components, building structures, and bridges. Many mechanical and civil engineering courses include the topic of analyzing the stresses and deflections of simple beams and shafts under various lateral loadings. [1-3] A simple beam is a straight beam with a constant section, and the analyses are relatively easy to solve by hand without complex digital computer simulations. An example of a simple beam-loading problem is shown in Figure 1. Students need to calculate the shear force, bending moments, and deflections along the beam, and identify the location and magnitudes of their maximum values.

Although the problems can be solved analytically on paper, the computational steps are usually tedious and prone to error. There are many commercial [4-6] and noncommercial [7, 8] software programs available for the analyses. There are also many systems [9-17] designed to be used as educational tools for the beam and structural analyses. Most of them are usually designed to generate solutions quickly and automate the processes for ease of use. Although effective in obtaining solutions, they may not be the best educational tools for learning the concept. Most of all, the user interfaces of the current educational software may not be ideal for educational purposes. They use the WIMP (Windows, Icons, Menus, and Pointers) based graphical user interfaces (GUI), in which users choose the loading conditions and parameters from the menus or icons or dialog boxes. This user interface deviates from the traditional learning mode that is using a pen on paper. Recent studies [18, 19] show that the students will learn better in their learning when the user interface is closer to the familiar work practice. According to Oviatt et al. [19], using a graphical user interface (GUI) increases students' cognitive load, causing distractions to learning. They conclude that learning performance is best with interfaces similar to the existing work practice of using pen-and-paper. In the traditional method, students learn by taking their time in drawing beams, marking loading symbols, writing and solving equations by hand. The magnitudes of loadings, shear forces, moments, and deflections along the beam are also drawn graphically by hand, based on the hand calculations. The

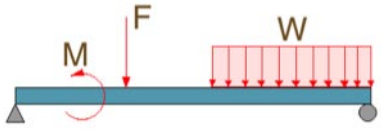

Figure 1. A statically determinate beam under loads.

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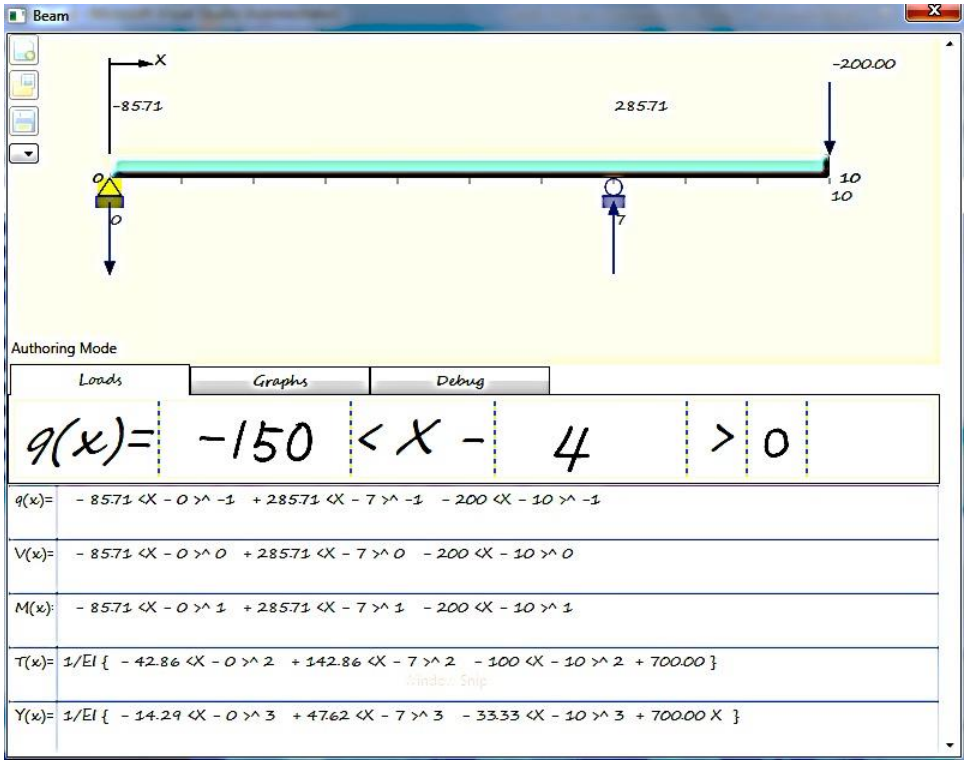

Figure 2. UI for writing singularity functions.

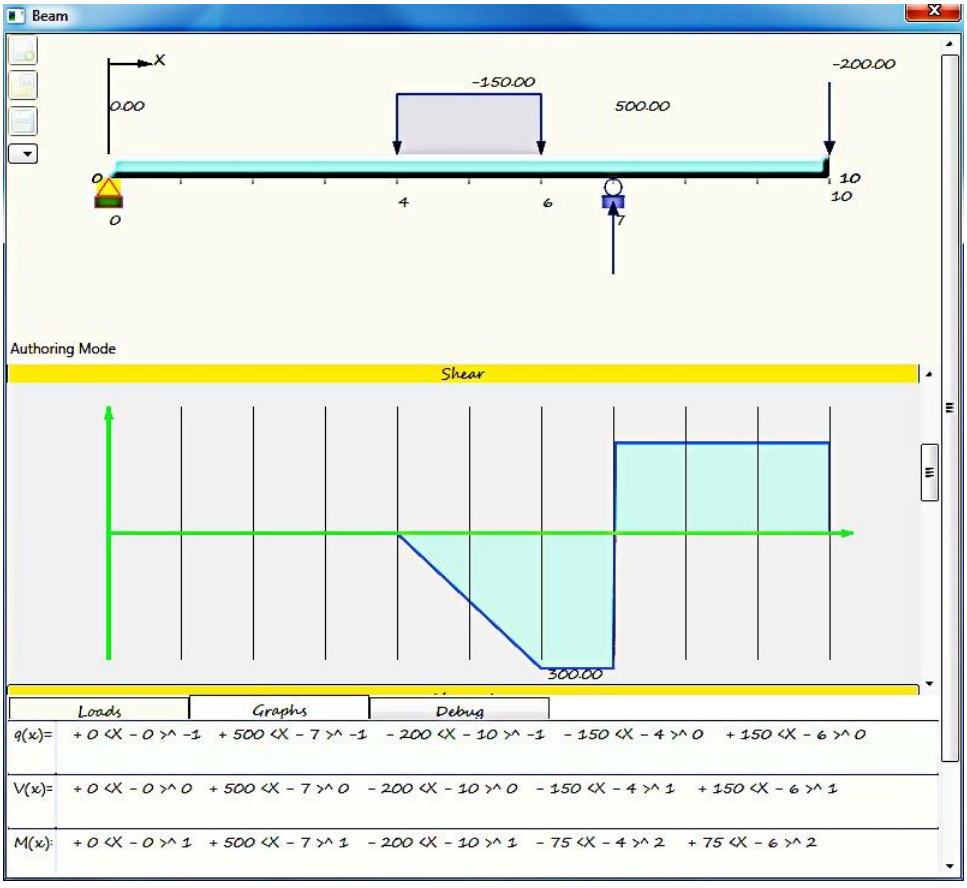

Figure 3. UI for sketching graphs.

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