A Haptically-Enabled Dental Simulator

Kevin Montgomery PhD, Paul Brown DDS, Eric Herbranson DDS

Background: Traditionally training in dentistry has used a combination of group classroom lecture with laboratory exercises. With the huge growth of computer technology, and particularly computer simulation technology as teaching tools, it is increasingly clear that this traditional method is costly and time consuming. Assessing skills acquisition difficult; furthermore, simulation of procedures is inexact resulting in some students reaching clinical practice without adequate skills.

There is currently a movement in medical/dental education to change the curriculum to include the principals of adult learning where students can adjust their learning experience to their own time frame and learning style. Computer based virtual reality simulation allows for unlimited on-demand access to "deliberate practice" sessions and provides immediate feedback on the level of skill acquisition achieved. Computer generated virtual hand pieces can be used an infinite number of times. Studies indicate that this approach can increase the efficiency of skills acquisition, retention, and has "carry over" to clinical performance.

Methods: The aim of this project is to put a computer-based simulation system to work. We have developed a tooth treatment planning system that integrates information derived from different imaging techniques and accommodates the intrinsic three-dimensionality of the resulting data set. The planning environment presents a stereo 3D computer-generated reconstruction of the imaging data in a 3D space and allows the operator to interact directly in 3D in a natural, direct and easy manner. The system allows for a believable simulation of a wide variety of tooth preparations that clinicians could encounter.

Specific Aims:
1) Develop methods for automated acquisition of tooth data
   - Surface imagery- automated stage control with integrated image acquisition
   - MicroCT volumetric data- segmentation and model generation
   - Microgrinding volumetric data- automated CNC milling and integrated image acquisition

2) Register multimodal tooth data
   - Registration of computer model with volumetric microCT and microgrind data
   - Texture mapping of surface imagery onto surface of resulting model

3) Develop haptic-based interactions
   - Distributed simulation engine using Spring with real-time haptic feedback

4) Develop evaluation metrics

Solution: A sensor resembling a dental hand piece appears as a computer generated virtual hand piece on the computer screen. It can be used to perform tooth preparation procedures. The position of the virtual instrument in the user's hand is calibrated in such a way that the user perceives it to be in the same orientation and spatial position. Through the use of haptic force-feedback it is possible to simulate the sensation of actual tooth preparations.

Acknowledgements: This work was supported by a generous grant from the National Institute for Dental and Craniofacial Research (NIDCR/NIH, R43-DE15232-01A1)

References