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Haptic Rendering for Blind and Severely Visually Impaired Children

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Abstract and objective

The prevalence of severely visually impairment (visus < 0,1) to the point of blindness (visus < 0.05) is in industrialised countries approx. 0.2%, i.e., in Germany approx. 160,000 people suffering from notable visual deficiency. 6% of the affected persons (approx. 8,700) are younger than 18 years, most of which attend school. The concept intuition is to provide visual information by tactile analogies. In the present study, a haptic device is used, i.e., a hardware device that helps present tactile information. A haptic device along with prototypical software (`make2Dhaptic`) is used to present tactile representation of geometric objects and physical bodies. First tests show that more than 50% of the blind and severely visually impaired students tested get an idea of the tactile representation when a haptic device is used. Approx. 25% prefer it over traditional „swell paper“.

Keywords:

hapticrRendering, phantom device, visual impairment

Introduction

Carl-Strehl-Schule (Marburg, Germany) is one of the few schools providing an opportunity for blind and severely visually impaired students to get a boundless University-entrance Diploma (“Abitur”). For blind and severely visually impaired students the visual components must now be transferred to be interoperable with other senses, preferably the acoustical and touching sense.

Methods

Using one of the main common haptic-devices we take the PHANTOM® Desktop™ Haptic Device (SensAble Technologies, Inc., Woburn, MA, USA) which possesses six degrees of freedom in its possibilities of movement (Fig. 1).

Figure 1 - PHANTOM® Desktop™ Haptic Device (SensAble Technologies, Inc., Woburn, MA, USA)

This haptic device can represent kinaesthetics and tactility to feel the surface texture. The computation of the forces fed back by the device is essential. We use the ability of generating physical powers to guide the user through the scene. Respective requirements have been met by developing the prototypical software `make2Dhaptic`

(applicable to chemistry, physics, biology and mathematics; Fig. 2).

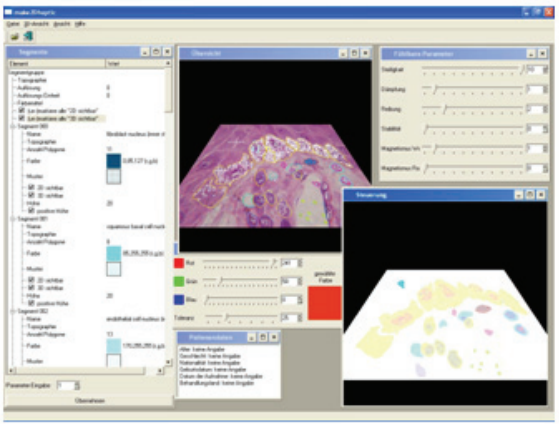

Figure 2 - The prototypical software make2Dhaptic (screenshot)

For a tactile representation of an output of a gas chromatograph (real time) the measured values are transferred into temporary or permanent forces. The values are represented as movements along the y-axis of the haptic device. In order to transform histological slides (medicine, biology) appropriately, the images were transferred into a 3D Surface Mesh, at which the spatial orientation (z-coordinate) is defined by the specific grayscale values of the image (Fig. 3).

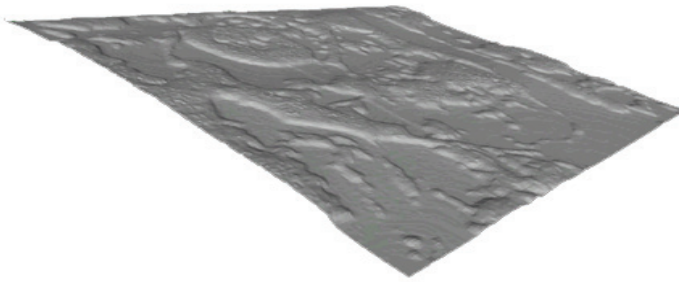

Fig. 3 - 3D Surface Mesh generated by make2Dhaptic

A gender mixed group of 21 sixth formers, who were partly blind from birth, were available for a trial. None of the group has ever used or touched a haptic device before. After the first

exploration of a standard parabola the users were asked to determine the form of the curve, and answered questions on the cells and the tissue samples presented to them. The replies of the users were mapped to a 1 to 6 Likert scale (1 = exactly right; 6 = absolutely wrong).

Results

For the graph, everyone answered directly "parabola". 60% of the test persons billed the statement "I can follow the line without loosing contact." with "1" and 40% with "2". All persons approve the statement "More lead time is wise." with 2 or higher. Approx. 25% prefer the haptic device over traditional „swell paper". The representations of histological slides (medicine, biology) were judged similarly.

Discussion and conclusion

The current surface mesh is generated by interpreting the greyscale values as the spatial orientation (z-coordinate). By this, an extreme closed surface mesh is given and as a consequence the memory requirements for the mesh is proportional to dimension of histological slide but independent from the level of detail of the slide. Using a meshing algorithm based on the delaunay triangulation a more efficient representation is given. Another drawback of the current mesh is that it is only a pseudo 3D mesh.

Therefore the next step is to integrate an algorithm for generating a volume mesh of the histological slides. The advantage of this is the option to "manipulate" the slide, *e.g.*, cell division could be represented. This allows teaching blind and visually impaired people dynamic processes. Another drawback of many haptic systems, as well as the current is, that physical properties are not correct arranged. This means that it is typically impossible to differ between different materials in the haptic scene in a realistic way, *e.g.*, soft rubber feels like metal. To avoid this undifferentiated feeling we intend to build up a data base for different materials and their physical properties to adjust the settings of the haptic engine.

Beside these drawbacks a first exploration implies that already today students may benefit from the application of a haptic device along with the prototypical software `make2Dhaptic`. Further studies are needed for systematic evaluation.