THE UNIVERSITY of EDINBURGH
informatics

GVIZ -- Geometric and Mathematical Visualization
Software Prototype Documentation

P00189: Interactive Sound Environments
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1. Introduction:

1.1 What is GVIZ?
GVIZ is envisioned to be a Geometric Visualization Tool for use in applications such as artificial vision or primary school education, and is especially suited for the visually impaired.

GVIZ enables the visually impaired to visualize the geometry of either a virtual picture or a real object placed in front of them. It also is equppied with a sonic numbering system to aid in numerical measurements.

2. Contributions and motivations:

The goal to achieve the complete functional realization of GVIZ has presented an opportunity to pursue academic research, as some of the components involve automated sketch understanding and visual cognition.

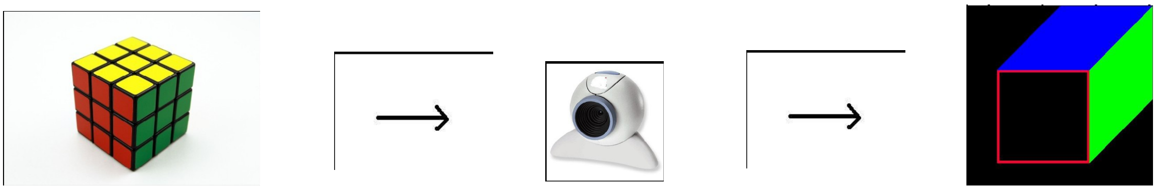
Further, the minimal sound based numbering system used for geometric measurements in GVIZ, is an idea which could possibly stem off as an efficient numbering system in user-interfaces for the visually impaired, which till date has not been installed in everyday consumer appliances that depend on a numeric input.

3. Design Overview:

GVIZ enables the visually impaired to move a physical device along the contour of a virtual representation, to visualize the geometry of either a virtual picture or a real object placed in front of them.

For real objects, edge detection is performed using a webcam and then transferred as a regular matrix based image onto the computer.

The next step is to define sonic fields which represent positional errors (lateral and vertical) from the desired outline path to be visualized. This may be done manually by an assistant of the visually impaired subject or automatically by the software, although automated sketch understanding can be quite challenging for arbitrary geometries.



Real object/ Digitized picture) **computer vision (edge detection/noise removal/ segmentation)** **Outline Geometry to be sonified**

Ref: Picture of visually impaired user Courtesy: IPSIS-TLB project.

In the present standalone, acquisition of real objects has not been included. However,the positional errors from the desired contour have been defined for a primitive object (cube) using sounds to constrain the user onto the desired path, so he/she may visualize the shape of the geometry from the corresponding 2D movements of a computer mouse on the horizontal plane.

4.Implementation and Description of Interactive Sound Design:

The sound interface and control interface were designed in separate units in MAX MSP. The control interface in GVIZ is coded in a Javascript object and the interaction with the graphics uses the openGL library.

4.1 Representation:

The geometry chosen for this simulation is one of the faces of a cuboid. This was represented in a Javascript object in the local coordinate system of the graphics window. The desired path to be visualized by the user is the outer edge of the cube, and positional errors (lateral error and vertical errors) were defined accordingly, to provide sonic corrective feedback to the user's movements.

4.2 Control Interface:

The current version of GVIZ uses a regular computer mouse to map the movements of the user with interactive correctional sonic feedback. The mouse interrupt code contains the primary decision loops involved in communicating and controlling the sound related objects.

4.3 Sound Design:

Various factors were considered during the choice, design and synthesis of sound, which is the primary feedback in the user-interface of GVIZ.

4.3.1 Position Feedback and Control:

There are four possible errors in 2 Dimensions when a visually impaired user is trying to sketch along the desired contour of a represented geometry. These are 2 lateral position errors (left and right) and 2 vertical position errors (top and down).

a) Lateral Errors and Panning :

A sound consisting of one short pulse followed by a 'springy' long pulse. This selected sound *seemed to represent an 'error'.Further a long pulse followed by a short pulse suggested a condition of 'displacement/movement' to a new position, thereby hinting the user to make a lateral correction.*

The same sound was cross faded (based on mouse position) to achieve panning between right and left ears. (Lateral error in the right ear urges a corrective movement to be made towards the right).

b) Vertical Errors :

Vertical panning is challenging as auditory representation in the y-direction can not be perceived accurately. A sound consisting of rapidly ascending frequencies produced by running a pen across the resonating rods of a piano ---
and a reversal of the same sound file representing 'descend' was used for signalling vertical (+/-) errors. respectively. These sounds were repeated at a higher frequency to suggest emergency/immediate response.

c) Texture Sound:

This is the sound heard by the user when he is moving along the correct path of the object. Ideally anything suggesting movement in free space (such as bubbles in water, or the atmospheric airy motion effect used here) could be instilled to contrast the constraining error sounds. Clicks and pops for all sounds were removed by inserting a trapezoidal ramp prior to the start of play.

4.3.2 Sonic Numbering System to represent geometric measurement:

GVIZ allows a visually impaired user to visualize, say the length of a line, by converting the conventional decimal system into sounds. Basically just 3 sounds are used to represent any number from 1 to 1000 with ease:

a) **A long beep (dash)** : (to denote 5)
b) **A short beep (dot)** : 1 beep for number 1, 2 beeps for 2, etc until 4.
Number 6 to 9 are represented by combination with a long beep.
For instance, number 7 would be a long beep (5) followed by 2 short beeps.
c) **A bell like tone**: To signify the 10s place or 100th place.

(Beeps were generated using a phasor and appropriate line signal ramp.)

For instance the number 69 would be firstly dash(5) + dot dot dot dot = 9 for units place, followed by a dash(5) +dot =6 , synchronized with a 'bell' to signify 10s place.

The above discussed sonic numbering system is intended to represent numerals to the visually impaired and could have many other applications such as in credit card PIN entry devices, ATMs and other devices using just 3 to 4 buttons.

5.Conclusions and Future Developments:

More efficient haptic interfaces such as a vibratory Wiimote with headphones maybe used to constrain the user's gestures onto the vertical plane that does not require a surface and provides a more intuitive feel to the geometric understanding.

Further research is currently in progress to include vision based techniques to incorporate automatic sketch understanding of generic geometries to extend the use of GVIZ by the visually impaired to a range of different objects in their environment.More sounds representing shape of the object must be researched to provide realistic visualization.

6. References:

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