Interactive Multimodal Virtual Display of 2-D Coordinates Plane

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Introduction

Motivation

In Korean middle-school Math education curriculum, **coordinates plane or graph** is the visual representations, and it is not easy concept to understand for **visually-impaired students**, who commonly get their math understanding from aural explanation of the teacher.

Main Work of the research

Develop an Interactive virtual coordinates plane based on **haptic** and a**uditory** modules, in order to provide a studying aid for visually-impaired students to understand coordinates plane and graph (topics for 1st and 2nd grades in middle school)

Method

Results of Preliminary study on several aspects of education

Process of setting three guidelines from considering math, multimodal education

- **I.** Considering a characteristic of education for target curriculum "coordinates plane"
  - **Guideline 1**. Simplifying coordinates plane into grid plane is helpful to get started.
- **II.** Considering that general math education requires prerequisite process
  - **Guideline 2**. Accessibility to meaning of basic terms related to math concept is helpful for understanding.
- **III.** Multimodal interaction in education fields
  - **Guideline 3**. Active participation (bidirectional) is better than those only providing passive receiving (unidirectional).

Development of environment for program implementation

- ***Phantom force-feedback device*** is used for haptic accessibility to our tool. (Fig1,right)
- Program Design Language is **H3D API** which is a VR modelling language and enables haptic device using (Fig1. left)
  - H3D-provided haptic effects
    - Surface feedbacks - *Smooth Surface, Frictional Surface, Magnetic Surface*
    - Force feedbacks - *Position function effect, Time function effect*

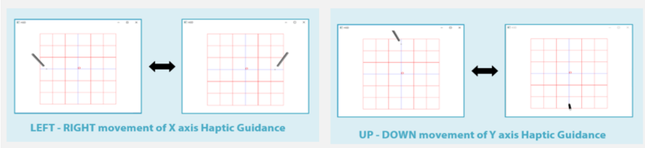
Figure 1: *(left) Touchable scene made using H3D API (middle) Phantom device (right) How Phantom device is used to touch virtual objects by a user*

Implementation and Results

Guideline1

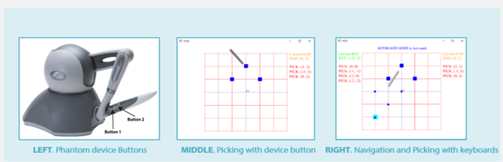
- **What to implement to Fulfil this guide**
  - Three main components of grid plane, ***plane surface***, ***grid lines***, *and* ***coordinates points***
- **Used Haptic technologies in H3D API**
  - *SmoothSurface feedback* for **Plane Surface**
  - *Magnetic force effect* for **Grid Lines**
  - Constraining effect, *Speech-sound feedback* for **Coordinates Points**.
  - Constraining force : F=[-10*(x-p.x), -10*(y-p.y), -10*(z-p.z)] ((x,y,z) : device position, p is a position of the coordinates).
- **IMPLEMENTATION**
  - While user holds *device* stylus user can receive each of three components either by Haptic or in Auditory feedback.
  - User can integrate the 3 elements into a one grid plane, by differentiation of emphasizing haptic effect of each components. (grid plane < grid lines < coordinates points)

Guideline2



- **What to implement to Fulfil this guide**
  - Haptic Guidances for X and Y axis
- **Used Haptic technologies from H3D API**
  - X, Y axis guidance : Constraining effect, Time function effect, speech-sound rendering
  - Constraining Effect : F_x=<0,-10*y,0> for **X axis**, and F_y=<-10*x,0,0> for **Y axis**
  - Time Function Effect : F_x=<sin(t),0,0> for **X axis** and F_y=<0,sin(t),0> for **Y axis** (t : time)
- **IMPEMENTATION**
  - If user triggers the guidance rendering for one of the axes, device stylus automatically vibrates on virtual space of that axis.
  - This vibration of the movement is a sinusoidal movement, which is a sin function of the time t.

Guideline 3



- **What to implement to Fulfil this guide**
  - Two functions, **Picking a Point**, and **Navigation with keyboard**
- **Used Haptic technologies from H3D API**
  - Picking point - Device main Button
  - Navigation - by keyboard input. It is executed by Left-Right, Up-Down keys. (Start point : (0,0)) While keyboard navigating it is possible to pick point with key 'End'
- **IMPLEMENTATION**
  - User picks a point by pressing a haptic device main button, and also can erase it with secondary button
  - User triggers the keyboard navigation by pressing some key, and moves between the coordinates with arrow keys

Conclusion & Future Work

- **We developed Interactive virtual grid plane to help receiving a concept of coordinates plane for visually-impaired students.**
- **The implementation follows several guidelines, considering math education and multimodal interactive education.**
- **We plan to have a user study and modify this tool to be an optimal multimodal design for coordinates plane education.**

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