Interactive spatial sonification for non-visual exploration of virtual maps

Virtual map Non-visual (hearing + touch)

【Main Content】:

(Browsing the map through hearing + touch) This paper proposes a multi-modal interactive system for non-visual (hearing + touch) exploration of virtual map

【Paper Summary】:

1) We aim to verify the effectiveness and intuitiveness of the proposed tactile and auditory metaphors for rendering virtual maps. Second, we aim to qualitatively and quantitatively evaluate the relative contributions of these two models in virtual map exploration. These Relationships are related to how well subjects perform in simple exploration tasks and their ability to construct a coherent cognitive representation of the map being explored.

2) The first preliminary experiment is not specifically aimed at the acquisition of spatial knowledge: it achieves the target task through behavior and performance indicators, analyzes the intuitiveness of the proposed metaphor, and the complementarity of auditory and tactile information.

3) The second experiment focused on acquiring spatial knowledge of simple virtual environments, especially the ability of objects to form coherent spatial cognitive maps of freely explored maps.

4) Analysis results:

(1) The results of two experiments show that the system allows subjects to effectively utilize the complementary properties of the "near" haptic mode and the "distal" audible mode

(2) [Important] In Experiment 1, A. Analysis of arrival time and total travel distance showed that the subjects used two different exploration strategies under two unimodal conditions and successfully integrated them into Under bimodal conditions, where the exploration path travels at a faster speed. B. Compared with unimodal auditory conditions, subjects on average are more likely to reach the target under unimodal tactile conditions, but it also shows that auditory feedback to tactile feedback does not harm performance near the target.

【Contributes】:

1) The system can display the height outline of the map in a tactile manner with a tactile mouse. In addition, the spatial auditory information is provided in the form of a virtual anchor sound located at a specific point on the map and passed through the headset using a customized head-related transfer function (HRTF).

2) The proposed concept, design and implementation can make effective use of the complementary nature of the "near" haptic modal and the "distal" audible modal.

【HRTF】: (A pair of left and right HRTFs for each required sound source position) You can virtually find a noise cancellation sound source in space by convolving the noise cancellation sound source with the corresponding left and right HRTF pairs and presenting it as binaural.

【Experiments】: Through two experiments involving simple virtual space map exploration, the relative contributions of haptic and auditory feedback and their cross-pattern effects were evaluated.

Apparatus:

All the experimental conditions are managed in Matlab. Information about the current status (2D position on the tablet) of the TAMO is also managed in Matlab, and is used to drive both the tactile and the 3D auditory rendering. The latter is realized in Pure Data,2 an open source real-time environment for audio processing. Communication is managed through the Open Sound Control (OSC) protocol. Tactile feedback is rendered through the TAMO lever, while auditory feedback is rendered through headphones.

Experiment 1 : goal reaching

Main Purpose:

1) Prove the effectiveness of tactile + auditory browsing maps
2) Analyze the differences and complementarity of auditory and tactile information through the collected information

Three feedback conditions are provided:

TAMO: tactile conditions;

2D audio: hearing state;

TAMO + 2D audio: both.

Evaluation: From the starting point to the end of the map

Experiment 2 ： cognitive map construction

Main Purpose:

To what extent can a coherent spatial cognitive map be constructed

Three feedback conditions are provided:

TAMO

TAMO + 2D audio

TAMO + 3D audio