Multimodal Wayfinding in a Driving Simulator for the $^{S}_{c}$ha$_{i}$r^{e} Internet Chair, a Networked Rotary Motion Platform

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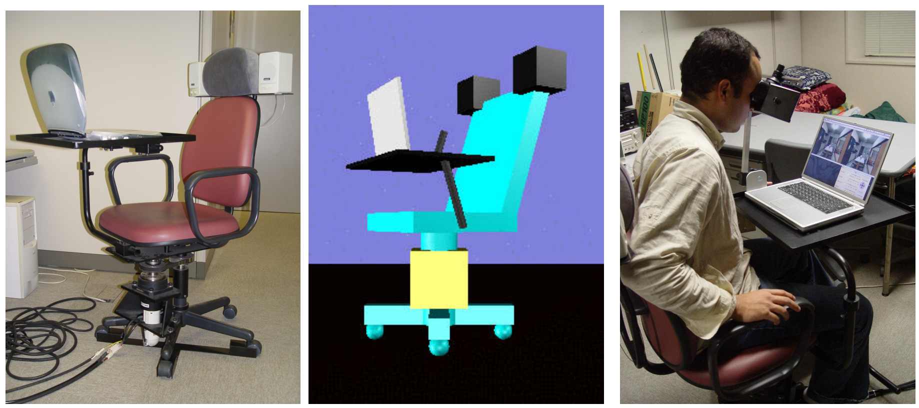
1 Multimodal Display/Control

We are exploring IDSS (**i**ntelligent **d**river **s**upport **s**ystems), especially including way-finding presented via spatial audio. ("Way-finding" refers to giving a driver directions, as via car navigation ["*Car-Nabi*"] GPS/GIS systems.) We have developed a networked driving simulator as a virtual-reality based interface (control/display system) featuring integration with the $^{S}_{c}$ha$_{i}$r^{e} rotary motion platform for azimuth-display, stereographic display for 3D graphics, and spatial audio (sound spatialization) way-finding cues.

As a haptic output modality, chairs with servomotors (shown below in Fig. 1) can render force-display, turning themselves under networked control, to respond to driving control. Our chairs are deployed with augmented reality visual scenes (via QTVR-enabled browsers, Swing-conformant dynamic maps, and Java3D) and sounds, using laptops integrated via wireless communication (using Wi-Fi, 820.11). As a visual output modality, a mixed perspective or stereoscopic rendering of a scene, fusible via special eyewear, allows spatial graphics. As an audio output modality, transaural speakers (without crosstalk), "nearphones" embedded in the seat headrest, can present unencumbered binaural sound with soundscape stabilization for multichannel sound image localization. These sensory modalities are reviewed in the following subsections.

1.1 Haptic Modality: Driving Control and Azimuth-Display

We developed a second-generation prototype of our Internet Chair [1] deployed as an output device, a rotary motion-platform information appliance [2, 3]. Dubbed "$^{S}_{c}$ha$_{i}$r^{e}" (and pronounced /schaire/, for 'share-chair'), our prototypes can twist under networked control, synchronized with visual displays and spatial audio for propriocentric consistency. We extended our $^{S}_{c}$ha$_{i}$r^{e} to support networked driving simulation, including a steering wheel controller and foot pedals (accelerator and brake).[1] The $^{S}_{c}$ha$_{i}$r^{e} Internet Chair motion platforms don't translate, but their rotation is synchronized with the turning of the respective virtual vehicle.



(a) Second Generation Prototype. (Developed with Dept. of Mechanical Engineering Systems, Yamagata University and Mechtec.)

(b) Java3D Virtual Internet Chair (Developed by Daisuke Kaneko, and extended by Shiyota Nakayama with Alam Bolhassan.)

(c) Stereographic viewer on the $^{S}_{c}ha_{i}r^{e}$ desk, used to fuse dynamic stereograms on the laptop.

Fig. 1. For its haptic output modality, servomotors render kinesthetic force display, rotating each $^{S}_{c}ha_{i}r^{e}$ under networked control. Note the nearphones straddling the headrest for binaural display without cross-talk.

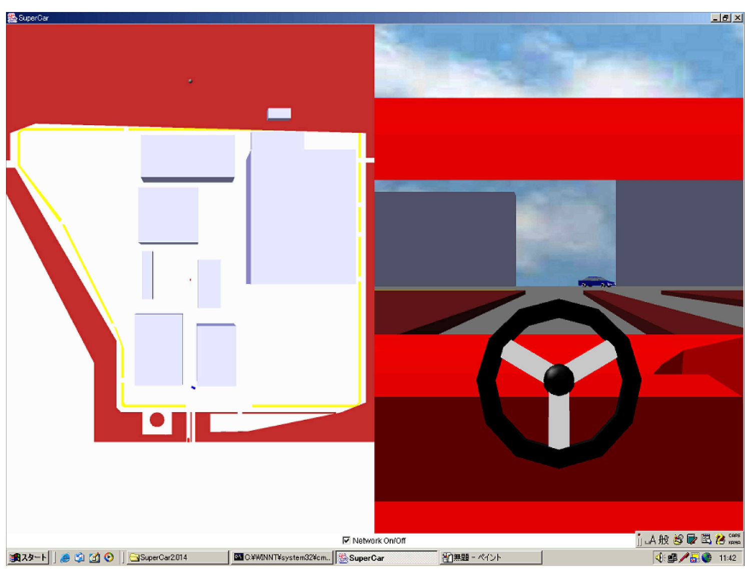


Fig. 2. Double-paned driving simulator window showing exocentric (left, bird's eye) and egocentric (right, driver's perspective) views. (Originally developed by Hideto Shimizu.)

1.2 Visual Modality: Mixed Perspective or Stereoscopic Display

Using Java3D[2] [4–6], we developed an interface for a driving simulator, shown in Fig. 2, featuring a model of our campus and controls for time-of-day (day- or night-time) and visibility (clear or foggy). Graphical way-finding is augmented by arrows that fly from each car's current position towards the goal. We have deployed a stereoscopic display, programming parallel windows presenting visual perspectives whose standpoints may be coupled, separated by an interoccular displacement, fusible with a viewer like the "Screen Scope,"[3] shown in Fig. 1(c).

1.3 Auditory Modality: Spatial Audio Wayfinding via Nearphones

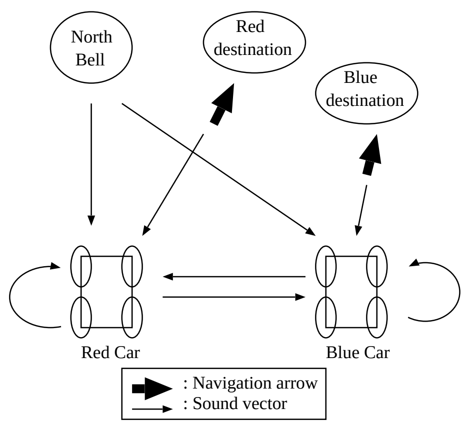


Fig. 3. Sound vector modeling

Anticipating a convergence of GPS/GIS and spatial audio [7], we are experimenting with audio cues for wayfinding. Besides each driver's own "driving music," various tones and sounds are emitted from other salient objects. As illustrated by Fig. 3, each driver may `attend` or `mute` four sound sources: one's own car's music, another's car's music, "North bell" (an audio compass), and navigation (way-finding) beacon.

A 'simplex' mode couples the local control and display, while an alternative 'duplex' mode disables such immediacy, relying instead upon returned network events to update the visual and displays. This scheme accommodates network delays and client latency, synchronizing the multimodal display. For particular instance, the $^{S}_{c}$ha$_{i}$r^{e} Internet Chair has significant sluggishness, a consequence of mechanical inertia (seatee payload) and user comfort.

[1] `www.logitech.com`, `www.logicool.co.jp`
[2] `www.java.com/products/java-media/3D/`
[3] `www.berezin.com/3d/screenscope.htm`

2 Conclusion

Our driving simulator application has been applied to a race game. A game manager program randomly determines a target in the field, and locates the audio beacon at that position. Drivers race to the goal— using a steering controller with foot pedals, keyboard, or both— with the encouragement of arrows flying towards and sound emitted from it. The first to arrive at the goal position is declared the winner.

In this entertainment computing research, three senses— touch, sight, and hearing— are employed. The duplex mode establishes that when the motion platform controller receives a target azimuth, it sends updates on a separate channel while twisting towards the target, coupling the proprioceptive, visual, and auditory displays.

Using spatial audio, our networked driving simulator is enhanced regarding both realism and augmented reality capability. In conditions of good visibility, the dynamic stereographic arrows are effective way-finding cues, but especially in conditions of reduced visibility— night-time and/or fog— spatial audio cues complement the arrows for way-finding and situation awareness.

References

1. Cohen, M.: The Internet Chair. IJHCI: **I**nt. **J**. of **H**uman-**C**omputer **I**nteraction **15** (2003) 297–311 `www.u-aizu.ac.jp/~mcohen/welcome/publications/ic4.ps`. Special Issue: Mediated Reality. ISSN 1044-7318.
2. Duminduwardena, U.C., Cohen, M.: Controlling the Schaire Internet Chair with a Mobile Device. In: Proc. CIT: Fourth Int. Conf. on **C**omputer **I**nformation **T**echnology, Wuhan, China (2004) 215–220
3. Adachi, K., Cohen, M., Duminduwardena, U., Kanno, K.: "*Kuru-kuru* Pitcher": A Game for the Schaire Internet Chair. In: Proc. ICEC: Third **I**nt. **C**onf. on **E**ntertainment **C**omputing, Eindhoven, Netherlands (2004) 35–45 ISBN 3-540-22947-7.
4. Matsubara, S., Monobe, K., Miura, S., Miyawaki, Y., Hattori, H., Kobayashi, R., Yamada, K., Tanaka, S.: Java3D Graphics Nyumonn. Tokyo: Morikita Syuppann Sha (2002) ISBN 4-627-84391-7.
5. Walsh, A.E., Gehringer, D.: Java 3D API jump-start. Prentice-Hall (2002) ISBN 0-13-034076-6.
6. Sowizral, H., Rushforth, K., Deering, M.: The Java 3D API Specification. Addison-Wesley (1997) ISBN 0-201-32576-4.
7. Holland, S., Morse, D.R., Gedenryd, H.: AudioGPS: Spatial Audio Navigation with a Minimal Attention Interface. Personal and Ubiquitous Computing (2002) 253–259