The Internet Chair

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Abstract

A pivot (swivel, rotating) chair is considered as an I/O device, an information appliance. The input modality is orientation tracking, which can dynamically select transfer functions used to spatialize audio in a rotation-invariant soundscape. In groupware situations, like teleconferencing or chat spaces, such orientation tracking can also be used to twist iconic representations of a seated user, avatars in a virtual world, enabling social situation awareness via coupled visual displays, soundscape-stabilized virtual source locations, and direction-dependent projection of non-omnidirectional sources. For audio output modality, the system can present unencumbered binaural sound with soundscape stabilization for multichannel sound image localization. The Internet Chair, manifesting as personal LBE (location-based entertainment) is potentially useful in both stand-alone and networked applications.

Keywords: audio windows; {augmented, enhanced, hybrid, mixed} reality, information furniture, networked appliance, soundscape stabilization.

1. Introduction

There are more chairs in the world than windows, desks, computers, or telephones. According to a metric of person-hours used, and generalized to include couches, stools, benches and other seat furniture, the chair is the most popular tool on earth, with the possible exceptions of its cousin the bed, and eyewear. The Internet Chair [Coh98a] begins to exploit such ubiquity, as an instance of information furniture. It determines which way a seated user is facing, adjusting dynamic maps and soundscape presentation accordingly.

1.1 Related Systems

This research belongs to fields variously described as or associated with "calm technology" or "ubicomp" (for **ubi**quitous **comp**uting[1]), which containment hierarchy can be proposed as in Table 1.

Regarding the form of the interface, several researchers and many game developers have explored the utility of exotic chairs. For example, the Operating Cockpit [WSDU98] is an augmented chair, meant for surgeons doing remote surgery, equipped with hand-driven input devices and visual, kinesthetic, orientation, and motion feedback via a hydraulic hexapod robot, giving limited motion in a six degrees of freedom. [TLP97] explored using pressure-sensitive transducers and vibrotactile stimulators in a seat-back to classify user postures and augment the range of display media. The ImmersaDesk [DSD$^+$98] is a personal tele-immersion device that offers a VR interface through a drafting table-sized desktop. The Matsushita Momo Chair [NS98] features feedback control systems for relaxation. Matsushita has also developed a VR horseback riding simulator, inteded for therapeutic applications. The Joy Arm system, shown in Figure 1, integrates a joystick into a desk chair.

Many game arcade attractions feature active chairs. Disney Quest Mighty Ducks Pinball Slam[2] allows networked players to use their seats to bounce off each other. The Rolling Thunder and Thunder Seats[3] use sub-woofers to enhance simulation. The Namco Prop Cycle, shown in Figure 2, simulates a flying bicycle, driven by pedals and controlled by a 2 DoF tiller and the driver's leaning weight. The Sega R360, shown in Figure 3, is a flight simulator game whose gimbals provide three rotational degrees of freedom, and can completely invert the pilot. Sega's Rail Chase II features a two-rider motion platform bench. The Sega Virtua Racing attraction, shown in Figure 4, uses air-driven suspension bladders along the seats and/or tail sway in some of its deluxe editions to simulate driving acceleration. The Namco Galaxian 3 attraction, shown in Figure 5, arranges 32 'star-fighter' pilots in a circle, facing outward to a shared 360° panoramic screen; as enemy warships attack, the mother ship pitches and rocks against the the interactive onslaught.

1.2 Soundscape stabilization

The direction one's body is oriented differs from which way one's head is turned (a primary parameter for auditory directionalization), which in turn differs from which way one's eyes (and also often one's attention) point. Nevertheless, a chair tracker, which senses and transmits the orientation of a pivot (swivel, rotating) chair, provides a convenient first-order approximation for all of these attributes. Informal experiments suggest that seated body tracking alone provides adequate parameterization of dy-

[1] http://www.didi.com/sorcerersapprentice

[2] http://www.disney.com/DisneyQuest/Guide/Score/Ducks/Ducks.html

[3] http://www.thunderseat.net

- smart spaces and entertaining (aware) environments [CFBS97]
  - cooperative buildings
    - roomware (software for rooms) [Bro97] and reactive rooms
      - media spaces
        - immobots (immobile robots)
          - spatially **i**mmersive **d**isplays
            - *information furniture*
              - networked appliances [Lew98]
                - handheld/mobile/nomadic/portable/wireless
                  - wearable/intimate computing

Table 1: Saturated: pervasive, continuous, ubiquitous, transparent

Proxemic Context	architecture	Display: audio	Display: visual
intimate	headset, wearable computer	*eartop* headphones (ex: HWD, **h**ead-**w**orn **d**isplay)	*eyetop* goggles
personal	chair	nearphones	*laptop* display, *desktop* monitor
interpersonal	couch or bench LBE: **l**ocation-**b**ased **e**ntertainment home theater	transaural speakers, SDP (stereo dipole [KNH97])	HDTV
multipersonal	automobile, spatially **i**mmersive **d**isplay (ex: Cave^{TM}, Cabin)	surround sound (ex: Ambisonics)	projection
social	club, theater	speaker array (ex: VBAP [Pul97]) (ex: PSE with IMAX)	large-screen display stereoscopic cinema
public	stadium, concert arena	**p**ublic **a**ddress	(ex: Jumbotron)

Table 2: Audio and visual displays along a private↔public continuum

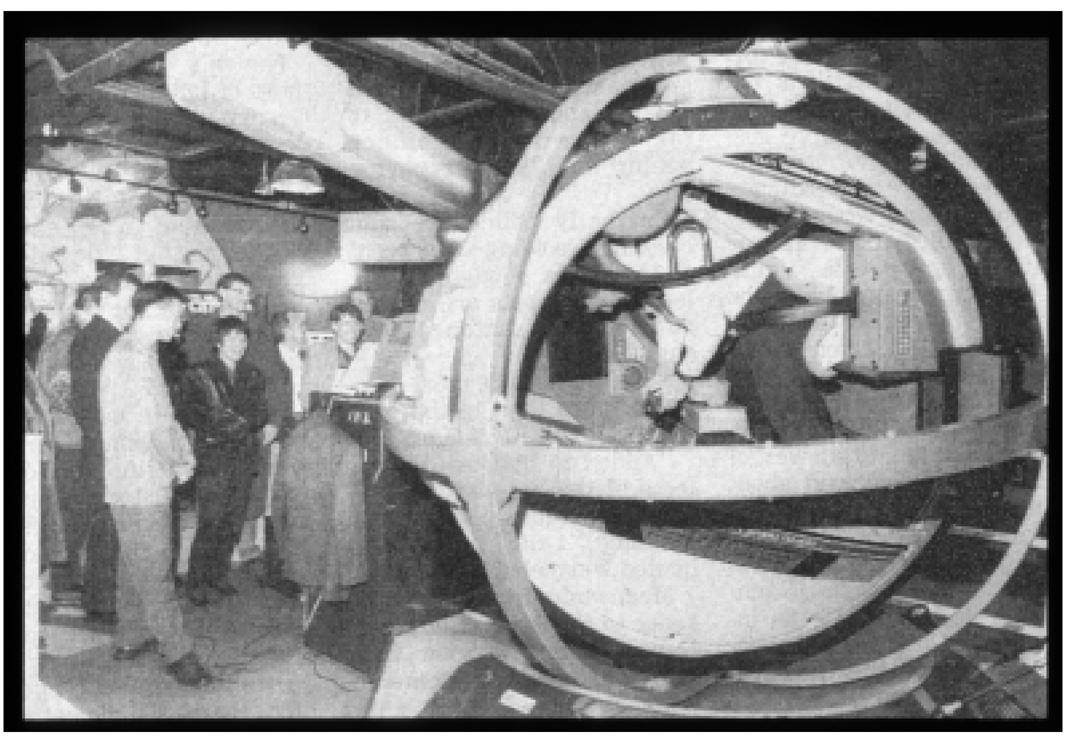

Fig. 3: R360 (SEGA): jet fighter simulator with gimbals providing three rotational degrees of freedom

Fig. 4: **V**irtua **R**acing (Sega): networked driving simulator

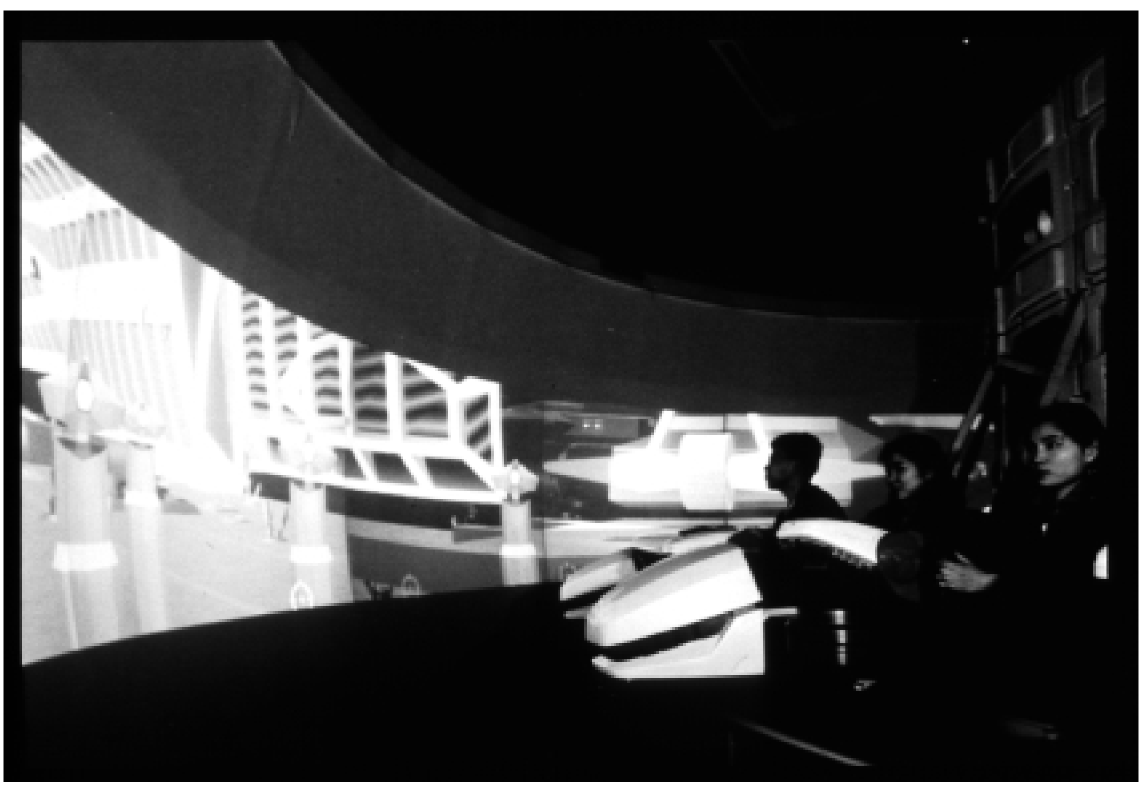

Fig. 5: Galaxian^3 (Namco Wonder Eggs): up to 28 users on networked motion platform attraction

Fig. 1: Joy Arm and coupled workstation (MES)

Fig. 2: Prop Cycle (Namco): flying bicycle (with pedals and fan-generated wind)

namic transfer function selection for auditory directionalization [KCA91] while serving as a cue to others in groupware contexts (virtual conferences, concerts, and cocktail parties) about directed attention. The propriocentric sensation is linked with soundscape stabilization, invariance preserving the location of virtual sources under reorientation of the user for world-referenced spatial audio. With suitably acoustically transparent audio display, such signals can be registered with the actual environment for alignment of real and synthesized cues.

human pilot	representative (projected presence)
carbon community	avatar
RL (real life)	electronic puppet
meatspace	synthespian (**synth**etic **thespian**)
motion capture	vactor (**v**irtual **actor**)

Table 3: User and delegate— projected presence. An avatar is the reification of an icon in a virtual environment.

1.3 Social situational awareness

Gaze awareness is an understanding of the direction of another's attention [Ish92, IK92, IKG93]. A networked chair tracker can be linked to visual displays of virtual spaces which iconify distributed users as avatars. In general, both an icon/avatar's visual presentation and audio manifestation are directionally dependent— icons by having non-symmetric attributes, and sources and sinks by being non-isotropic (non-omnidirectional). The multicast spinning of an audio source communicates to other users in a chat space, both visually and acoustically, the loudness of non-omnidirectional sources changing as speakers face or turn away from sinks.

2. Implementation

As shown in Figure 6, the Internet Chair prototype software is a (thick) client bundling the chair tracker, graphical user interface (GUI), and sound directionalization, connected to a multicasting conference server for CSCW (**c**omputer-**s**upported **c**ollaborative **w**ork). The portable prototype computing platform is a Fujitsu MicroSparc S-4/Leia2 running NextStep. The prototype ("rear end") interface uses an ordinary swivel chair, like that found in a typical office, retrofitted with an azimuth sensor. The spinometer uses a Polhemus 3Space Isotrak II electromagnetic tracker [Pol97] deployed as a yaw sensor, but alternatives would be more appropriate for different simultaneous contexts, like GPS-based systems for vehicle-mounted seats, or factory-installed mechanical sensors.

An important feature of an interface for such a chair exploits forked presence, the ability of an individual user to have multiply instantiated avatars (vactors, delegates, ...) across arbitrary soundscapes. The Internet Chair allows a lone human to drive the orientation of multiple iconic representatives, as shown in Figure 8. Reality is separated into layers, which can be superimposed. Par-

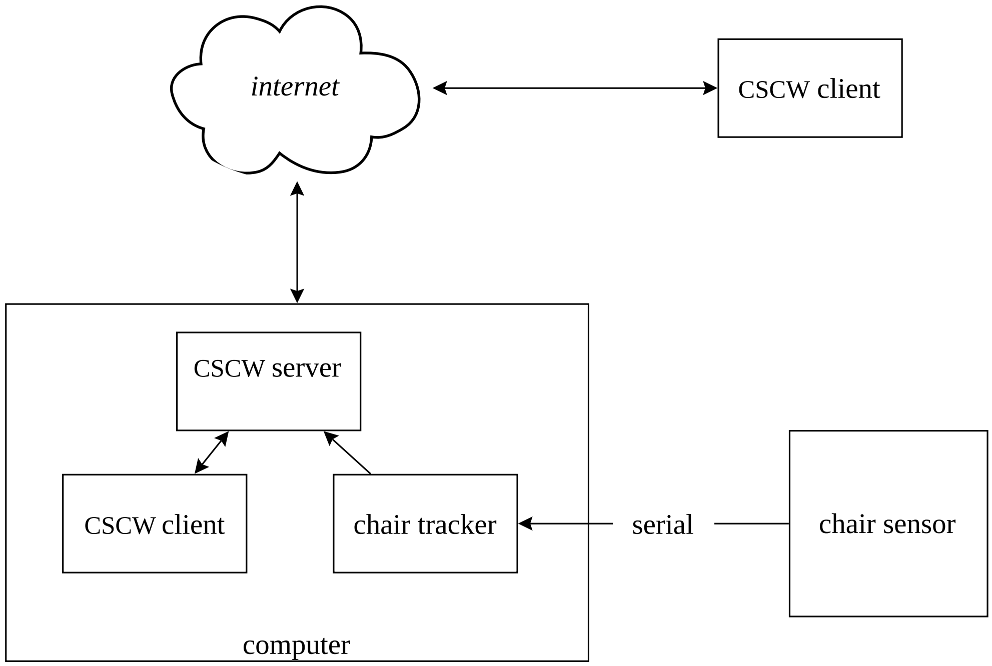

Fig. 6: Portable Prototype Implementation

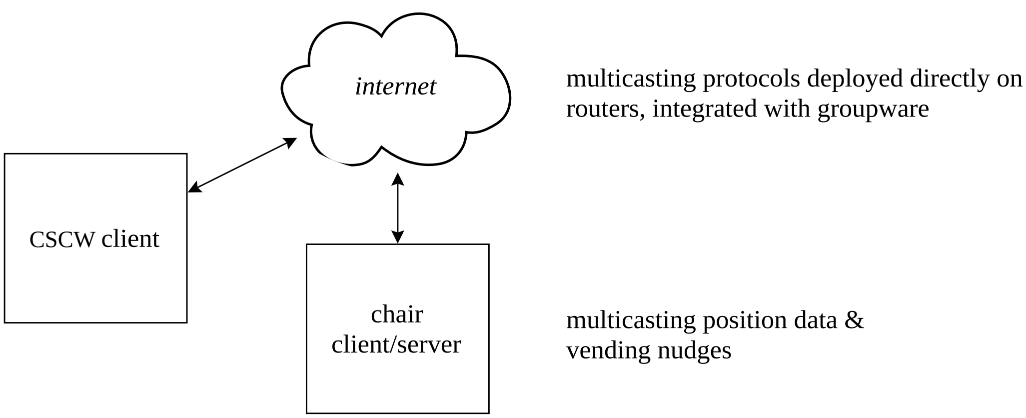

Fig. 7: Future Implementation

allel research explores the interface potential of multiple representations of a user in virtual spaces made explicit through an exocentric paradigm [Coh95, Coh98b] [CH98] [CHM99] [Coh00].

Sources can be disabled and focused upon with $\boxed{\texttt{mute}}$ and $\boxed{\texttt{solo}}$; the predicate calculus expression of such source activation is:

$$\texttt{active}(\text{source}_x) = \neg\texttt{mute}(\text{source}_x) \wedge (\exists\, y\ \texttt{solo}(\text{source}_y) \Rightarrow \texttt{solo}(\text{source}_x)),$$

$\boxed{\texttt{mute}}$ explicitly turning off a source, and $\boxed{\texttt{solo}}$ disabling the collocated (same room/window) complement of the selection (in the spirit of "anything not mandatory is forbidden"). For sinks, disabled or focused upon with $\boxed{\texttt{deafen}}$ and $\boxed{\texttt{attend}}$, the analogous relation is

$$\texttt{active}(\text{sink}_x) = \neg\texttt{deafen}(\text{sink}_x) \wedge (\exists\, y\ \texttt{attend}(\text{sink}_y) \Rightarrow \texttt{attend}(\text{sink}_x)).$$

Such controls find applications in which a user desires simultaneous presence in different contexts, monitoring, for example, an ongoing teleconference, a side-conference, an intercom connected to a nursery, ...

3. Future Development

3.1 Unencumbered audio presentation

In its current state, the spatial audio functionality of the chair tracker is no better (in fact, slower) than an off-the-shelf spatial sound system [Fos96] equipped with a head-tracker. As an alternative to transaural loudspeakers (crosstalk-cancelled binaural cues) or normal headphones, the prototype is typically demonstrated with an (cordless) infrared headset. However, the power of the ideas introduced leverages against completely unencumbered audio presentation— featuring, for instance, nearphones, external loudspeakers placed near but not on the ears, in the headrest of a chair, a hybrid of circumaural headphones (which block ambient sounds) and loudspeakers.

3.2 Embedded system

Graphics and audio updates on the prototype, and other unrelated processes, cause latency (delays) in the tracker updates. Neither the cost nor the realtime response of the prototype are suitable for consumer deployment, but a more streamlined implementation would be. An elegant deployment of the Internet Chair will embed its functionality in a thin server (polled) or client (not streaming, but updated when some threshold Δ is exceeded), with no dedicated keyboard or mouse, minimal or no display, minimal memory, and a Java/Jini software implementation [Mul98].

4. Applications

Both the input and output modalities of the Internet Chair are expected to be useful to its users, separately or together. As suggested by Table 4, the Internet Chair interpolates between passive–vigorous poles.

As an input mode, a chair tracker can be used to monitor the position of the sitter. This data can be used to adjust the output modality, the presentation of spatial sound, or used by other software to track the user's visual focus and attention. Whether net-surfing, chatting, or shopping (or all three at once), the Internet Chair offers the possibility of passive exercise: therapeutic but not necessarily strenuous, like a distributed rocking chair.

5. Conclusion

Besides first-order utilitarian functionality, furniture has always had a psychological attribute [LS85] [Fie97]. To such expressive qualities, we must now add *impressive* qualities, the active receptiveness of the chair to the state of its occupant.

The Internet Chair blurs the distinction between egocentric and exocentric systems by integrating an egocentric audio display with ego- and exocentric control into personal LBE. An exocentric "desktop VR" interface lends itself to calmer interfaces than classical VR egocentric HWD-style interfaces. Emerging software architectures like Jini will make such organic-seeming interfaces "plug-and-play" for homes, offices, and schools.

An interface that includes such features, whether tracking is built into the chair or implemented by some other means (such as visually), encourages proproiocentric sensitivity while allowing rejection of the single perspective characteristic of immersive systems. Such multiple presence decreases the granularity of audition and allows the explicit overlay of multiple virtual environments.

6. Acknowledgments

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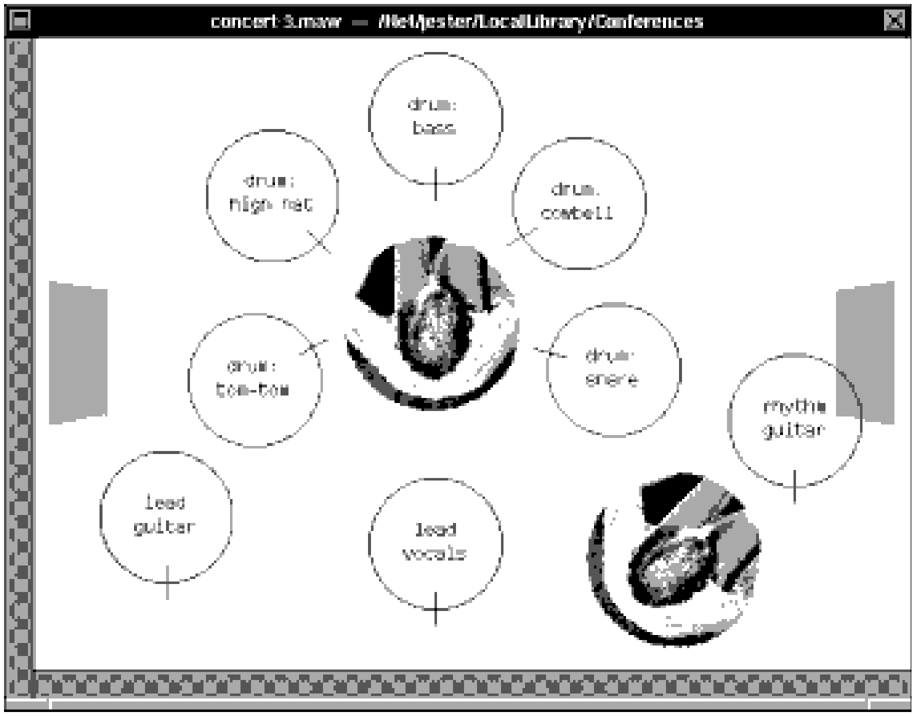

Fig. 8: Virtual concert: multipresence via multiply designated avatars, driven by a single client

	personal	social/public
pleasure	TV, movies, music, talking books games, dancing exercise	public entertainment spectator sports participatory team sports
business	browsing buying shopping	talking telemedicine, conferencing meeting

Table 4: Online applications: passive $\downarrow$ vigorous

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