Upstairs – Supporting Peripheral Awareness Between Non-Colocated Spaces

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Abstract. *Media spaces* have been trying to create spaces over physically remote locations for decades. In the tradition of these spaces, *upstairs* supports peripheral awareness between non-colocated spaces but is following a different approach. *upstairs* is not built to tear down the physical borders, it is meant to weaken them. Instead of creating a large single space we use the metaphor of wall-diffused noises as they are known from neighbours living upstairs or next door. When sharing a space, we are subconsciously aware of other people's activities, mainly because of their interaction with the environment. To extend today's telepresence and social presence systems that mostly focus on the transmission of the conscious part of communication, *upstairs* is built to enrich these systems by supporting peripheral awareness.

1 Motivation

This work was inspired by the observation that noises diffused through walls, e. g., coming from the neighbours living one floor up, can give long-term insights about their behaviour and emotions. When sharing a space, we are subconsciously aware of other people's activities, mainly because of their interaction with the environment. This awareness can be recognised as a socially organised and contingent achievement which is often bound to artefacts in the users' environment [4]. Upstairs was built to study if a subconscious level of awareness and communication can be sustained while separating interactants into two remote places. Based on communication theory, such a system should consist of at least two parts for each space: a capturing device and a display for peripheral use i. e., "out of a person's primary focus of attention" [5].

Interpersonal interaction consists of many information cues that the interactants most often process in parallel. Roughly, these streams can be discerned into being either consciously (e. g., speech, sign language) or more implicitly used (e. g., prosody, facial expressions, proxemics) [4]. While the conscious part of a conversation might stop at some point, implicit streams remain indefinitely as long as people share a space. In other words, although people might not talk to each other, there is still communication going on. Today's telepresence and social presence research focuses mostly on the transmission of the conscious part of communication [1][6]. Thus, research on telepresence systems examines mainly

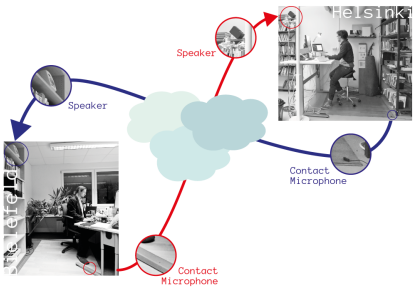

Fig. 1. The *upstairs* system connecting the work areas of two authors in Bielefeld and Helsinki.

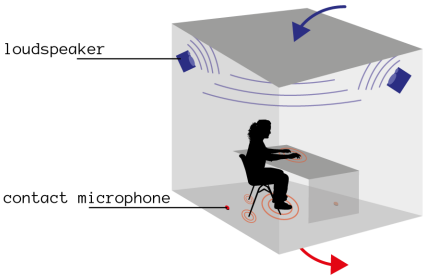

Fig. 2. The arrangement of the capturing device (contact microphone) and the ceiling-faced sound emitter (loudspeaker).

the transfer of speech and vision between two or more non-colocated interactants. But what are desired qualities for a connection between two spaces in the sense of the above motivation? What should such a system add in order to make places appear more close to each other? We considered these aspects in the design of upstairs:

Importance of context — The added implicit communication channel should not work as an exclusive cue over an extended period of time. Moreover, we suspect that there is a mutual dependence between implicit and explicit cues to support a balanced interpersonal relation. In this light, interpretation of content is highly dependent on existing knowledge which may have been acquired by other communication cues e. g., via verbal or visual communication channels.

Unobtrusiveness through illusion — Already existing environments should be altered as little as possible. Although the addition of visible technology or artefacts may heighten the dwellers' awareness of the system – a feature often considered positive – it is not intended here: We want to create the *illusion* of physical vicinity. Through augmenting objects that are present and already serve a specific function, we consider it more likely that the hardware of the system tends to fade into the background of people's attention.

Directness in information transfer — To support "a directness of the technological representation" [2], direct audio cues are favoured against more abstract approaches. A broad signal-near low-level information transfer as opposed to the computation of triggers based on analysis of sensor data postpones the chance of automated misinterpretation and failure to identify a possibly important event to the user, who is well-trained in interpreting everyday sounds.

Privacy — A peripheral connection between spaces should be constant and non-obtrusive yet informative. The aim for a constant connection does, however, immediately raise the question of privacy: even though we enjoy sharing a room with someone we like, at times we also want to close a door. A peripheral information system should therefore allow to adjust the kind and amount

of transmitted information. As trust into a system is considered crucial, a possibility to monitor what it currently transmits should be available as well.

Sense of community — A sense of community can only emerge from having a shared context, mostly drawn from a shared history. This particularly includes active and engaging communications over personal meetings or by phone and video chat. The upstairs system is purposefully not intended for such communications but heavily relies on their existence.

2 The Upstairs Setup

The upstairs system consists of four components: (i) sound capture, (ii) signal filtering, (iii) transfer over the network, and (iv) the display (i. e. sound projection, playback) on the other side.These components operate mutually as depicted in Figure 2.[3] We briefly describe these components in turn:

(i) The sound is captured with capacitive contact microphones. However, the capturing depends on the available flooring. We experimented with different kinds of floors and floorings. Concrete or stone floor and a very flexible and elastic floor material transmitted footsteps very poorly: footsteps could only be heard up to 40 cm away from the microphone for concrete and even less for the elastic floor. Carpeting, even thin one, worsened the situation considerably whereas wooden floor worked much better: the only real loss of energy seemed to occur at plank boundaries. Even laminate flooring worked quite satisfactory.

(ii) To create the illusion of sound travelling through the floor and ceiling, we used a combination of low- and a high-pass filters that cut off frequencies below 100 Hz and above 1–2 kHz. Signal processing is done in real-time using the SuperCollider programming language.

(iii) For the network transmission, we used the open source streaming software Icecast configured for low latency.

(iv) As the type of loudspeakers plays an important role for the perceived sound (frequency response and radiating properties), we adapted filter parameters accordingly. By facing the speakers upwards, the sound is distributed over and via the ceiling so that the first reflections are perceived as most prominent. The resulting large emitting angle increases the illusion of the whole ceiling to emit the sound.

3 Results and Future Work

At this point the system is fully operational. Our next step will be to conduct a long-term user study briefly outlined below. To spark some fruitful discussion beforehand, however, we confronted people from various backgrounds with the system, ranging from interaction design over interactive media art to photography

[3] For additional photos and a detailed technical description see `http://tai-studio.org/?page_id=808`.

and sound design. They were asked for their general impression of the system, their opinions towards it and how they think it could be improved.

In these discussions, one person reported that, although he rarely meets his upstairs neighbours, his knowledge about the daily routine of them is more detailed than that of his friends. Another person suspected that, when having this system installed in his home, he would be more self-conscious about coming home late.

A question that arose from the discussion was on how to differentiate between the system-induced sonic illusion and the sounds actually originating from the neighbours living above the user. Also, people mentioned that many environments already suffer from a lot of environmental noise and asked how we intended to deal with this. Along the same lines, people emphasised the importance to add self-monitoring possibilities and to let dwellers adjust the system in terms of overall amplification and filter parameters. Another suggestion that came up during the discussion was to augment only certain spots of places instead of covering the whole area. In conclusion, in this paper we presented the basic concept of a peripheral shared presence system called *upstairs* and described its design and development. Design and implementation of a convincing and unobtrusive system supporting peripheral awareness between non-colocated spaces turned out to be challenging. In future work, we seek to be able to more quickly and systematically adapt system parameters to given spaces and we want to add important features such as self-monitoring and interfaces that allow users to influence the strength of the connection. We also want to test our hypotheses that upstairs promotes co-presence [3] and satisfaction of separated dwellers with their relationship by carrying out a long-term user study that periodically queries participants for these factors. Our ongoing work can be found on our web page.[4]

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[4] `http://tai-studio.org/?page_id=808`