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Realizing the Vision of Immersive Communication [From the Guest Editors]

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ABSTRACT

We have witnessed tremendous progress in the buildup of communication networks in recent decades, driven by technologies that afford broad bandwidth and mobility to the user. While broadband and wireless technologies have greatly improved the delivery of information, packet-based connectivity promises the needed flexibility and efficiency for full dimensional remote collaboration. Delivery focuses on transporting information from one point to another, while full dimensional collaboration en-compasses experiences in generating, granting, and receiving the information, together with all the parties involved, as in a face-to-face interaction session. By full-dimensional collaboration, we mean sensory aspects such as sight, sound, and touch as well as enhancements to cognitive capacity. We are at the onset of a revolution in -telecommunication, from delivery of information to full-dimensional collaboration, as evidenced by the industry's strong push for the notion of telepresence (e.g., HP's HALO system or Cisco's Telepresence). In fact, there is an expe-ctation of change of mode in tele-communication, from telephony and telepresence, towards the ultimate goal of immersive communication (IC), in which users communicate, interact, and collaborate over a distance with immersive and lifelike experiences.

Audio Projection

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ABSTRACT

The ability to control sound radiation patterns in entertainment, gaming, communication, and personal messaging is becoming an important differentiating feature in many commercial products. A common feature in these systems is to -create a highly directional sound field to targeted audiences by forming a tune-in zone (or personal audio) for a group of -people. There are several ways to generate the directional sound field, which include i) using a sound dome that projects sound to a convex surface to focus sound wave to the listeners below the sound dome; ii) using a loudspeaker array that adjusts its phase-amplitude difference among the loudspeakers to spatially steer the audible sound beam in a horizontal plane; and iii) modulating an audible sound signal onto an ultrasonic carrier and projecting the modulated signal via special types of ultrasonic emitters to generate the parametric array through the air, in such a way that audible sound can travel in a column of sound beams. This latter group of loudspeakers is commonly called the parametric (or ultrasonic) loudspeakers.

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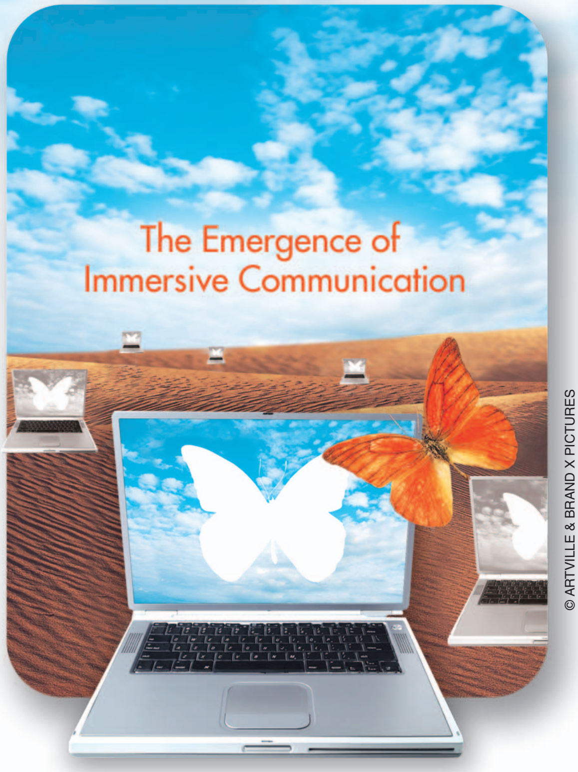
Audio Projection

Directional sound and its application in immersive communication

The ability to control sound radiation patterns in entertainment, gaming, communication, and personal messaging is becoming an important differentiating feature in many commercial products. A common feature in these systems is to create a highly directional sound field to targeted audiences by forming a tune-in zone (or personal audio) for a group of people. There are several ways to generate the directional sound field, which include i) using a sound dome that projects sound to a convex surface to focus sound wave to the listeners below the sound dome; ii) using a loudspeaker array that adjusts its phase-amplitude difference among the loudspeakers to spatially steer the audible sound beam in a horizontal plane; and iii) modulating an audible sound signal onto an ultrasonic carrier and projecting the modulated signal via special types of ultrasonic emitters to generate the parametric array through the air, in such a way that audible sound can travel in a column of sound beams. This latter group of loudspeakers is commonly called the parametric (or ultrasonic) loudspeakers.

When using loudspeaker array to steer the audible sound beam described in ii), the dimension of the loudspeaker or loudspeaker array must be significantly greater than the audio wavelength (i.e., more than a meter in diameter) to achieve good directivity at low frequencies less than 200 Hz. This approach of creating a focused sound beam incurs a high cost and cannot be generated by a small loudspeaker. In contrast, the parametric loudspeaker in iii) is able to generate a highly directional sound beam for a low-frequency sound wave whose wavelength is much larger than the parametric loudspeaker's diameter. Therefore, the small-sized ultrasonic emitter in the parametric loudspeaker is able to produce a highly directional sound beam with no vibrating cone as compared to conventional loudspeakers. Figure 1 shows two types of ultrasonic emitters used in parametric loudspeakers. The first type, which is shown in Figure 1(a), consists of several small piezoelectric transducers (PZTs) to form a bigger ultrasonic emitter. These small PZTs must be carefully matched in amplitude and phase near its resonance frequency. Typical resonance frequency of this PZT is around 40 kHz, and has a narrow bandwidth of 4–6 kHz. The second type uses a piezoelectric film ultrasonic material, as shown in Figure 1(b). A commercially available piezoelectric film-based parametric loudspeaker [1] is reported to have a bandpass frequency from 400 Hz to 16 kHz.



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However, conversion efficiency between electric power and acoustic radiant power of the above piezoelectric-based transducer is rather poor due mainly to the impedance mismatch between electric-acoustic domain. An impedance-matching solution proposed by Kamakura in [2] is to add in a coil (or inductor) in parallel with the piezoelectric transducers to achieve power reduction of approximately 30%.

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