Spatial sound for casino game machines

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Abstract

Main focus of the investigations was on 3D-audio for game machines using binaural synthesis and cross-talk cancellation. It concentrated on the creation of a three-dimensional sound field, which is formed by solely using loudspeakers, which were already integrated in the game machine chassis. The player's position can be predicted accurately in case of standing in front of a game machine. Hence, a three-dimensional sound field can be produced using solely the integrated stereo arrangement with the aid of binaural synthesis techniques which requires a stable player's position. A specific algorithm was implemented without modifying the hardware of the game machine.

The results of listening tests highlight two things: A three-dimensional sound field can be formed by using a two-channel system (Prototype I) which is favoured over the conventional stereophonic sound field. Secondly, a frequency dependent angle of sound incidence provided by a four-channel system (Prototype II) is not well suited to create an enveloping sound field. Due to the added value of prototype I, this solution was immediately implemented in 'Fishing for Jackpots™' and distributed successfully in game machines of Atronic. As a second approach a concept for audio for linked gaming is introduced.

Binaural synthesis for single game cabinet

Aim of the first approach was the creation of a three dimensional sound field at a casino game cabinet without modifying its hardware configuration. Sound sources shall be positioned and moved freely in 3D-space as desired by the sound designer. Prior to that a conventional stereo configuration was used to playback game sounds.

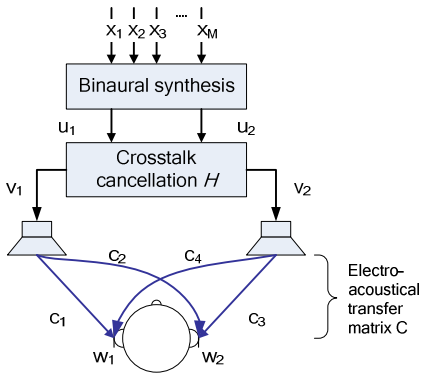

Figure 1: Block scheme of algorithm using binaural synthesis and crosstalk cancellation.

In figure 1 a block scheme of the employed algorithm, which uses binaural synthesis and crosstalk cancellation, is depicted. For the generation of the 3D-effect, KEMAR head related impulse responses (HRIRs) [1], which were measured by Gardner and Martin at MIT Media Lab, are employed. HRIRs describe how a given sound wave input (parameterized as frequency and source location) is filtered by reflection and diffraction properties of head, torso and pinna before it reaches the transduction mechanism of the eardrum and the inner ear. The application of direction-dependent HRIRs to sound sources is denoted as binaural synthesis.

The result is a two-channel signal (u_1 and u_2), which contain several sound sources (x_1, … , x_n) with applied HRIRs. Since it is not desirable to wear headphones at a game machine, the application of HRIRs only to sound sources and playing them back using a stereo configuration is not sufficient. This is because otherwise the signal generated for the left ear can be perceived by the right ear (c_2) and vice versa (c_4) by reason that the sound propagates through the air to both ears. Additionally the signal of the direct paths (left speaker to left ear and vice versa) is filtered again as the signal propagates through the medium (c_1, c_3). To overcome both effects a subsequent crosstalk cancellation step (v_1, v_2) must be applied to compensate the additional filtering of the signals through the path from the loudspeakers to the listeners ear (c_1, …, c_4). Aim of the crosstalk cancellation is that the signals at the listener's ears (w_1, w_2) are similar to the signals calculated after application of the HRIRs (u_1, u_2). As the calculations of the parameters depend on the gamers' listening point, enveloping 3D sound can only be perceived in the "sweet spot", which is a reasonably small volume around this location. However, the gamers' listening point can be derived quite exactly. Detailed information about the integration of binaural synthesis using crosstalk cancellation in game machines can be found in [2]. Specific information on the method itself is given by [3, 4, 5, 6].

The results of a listening test employing 31 persons highlight that a perceptible three-dimensional sound field can be formed which is favoured over the conventional stereophonic sound field by the test persons. A second prototype employs two supplementary loudspeakers to implement a frequency dependent angle of sound incidence [7]. The intention is to minimize the localization blur to ensure a more stable three dimensional sound field. The result of a second listening test highlight that a frequency dependent angle of sound incidence is not well suited to create an enveloping sound field for game machines.

Synchronized audio for linked gaming

Second approach is the synchronization of the loudspeakers for linked gaming. Linked gaming denotes a game machine cabinet array with additional signage (video monitor and audio loudspeakers), where a couple of persons can play together or against each other to win jackpots.

The intention of the approach is to synchronize the loudspeakers so sound sources can be positioned and moved in the area between them. A sound engine using multiple vector based amplitude panning (M)VBAP [8] for the horizontal positioning of sound sources between cabinet loudspeakers and VBAP for the horizontal positioning between signage loudspeakers and for the vertical positioning, fulfils this task (Figure 2). Prior to that signage and cabinet loudspeakers played back sounds individually.

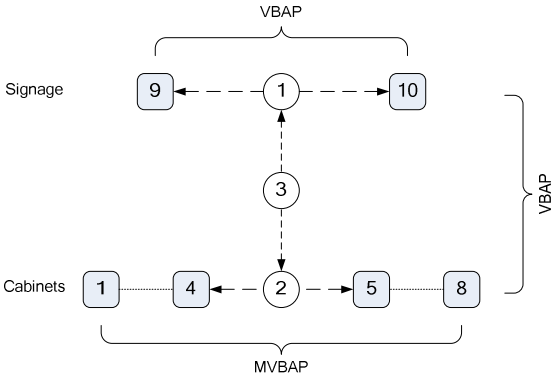

Figure 2: (M)VBAP-Engine using three VBAPs (circles 1-3) to position sound sources between cabinet (boxes 1-8) and signage loudspeakers (boxes 9-10)

VBAP [9] use tangent law to pan the desired phantom source between a pair of loudspeakers. Finally multiple sources can be positioned and moved within the area via superposition (Figure 3).

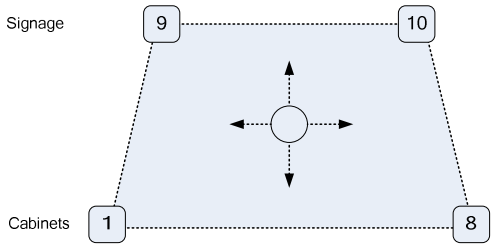

Figure 3: Range within virtual sound sources can be positioned.

Conclusions

In this paper we introduced two methods to improve the acoustical situation for casino gaming machines. First method uses binaural synthesis and cross talk cancellation to produce enveloping 3D sound for a single cabinet. The results of the listening tests highlight two things. A perceptible three-dimensional sound field can be formed by using a two-channel system which is favoured over the conventional stereophonic sound field by the test persons.

Secondly, a frequency dependent angle of sound incidence is not well suited to create an enveloping sound field for game machines. Due to the added value of prototype I, which is the creation of a three-dimensional sound field using a dual channel loudspeaker configuration, this solution was immediately implemented in 'Fishing for Jackpots^{TM}' and distributed successfully in game machines of Atronic.

The second method employs multiple VBAP to pan and move sound source within a large area which was determined by the loudspeakers of a linked gaming casino cabinet arrangement.

Acknowledgements

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