Wave Field Synthesis Holophony

First step towards Star Trek's Holodeck

0.1 Principal investigator

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0.2 Abstract

Using a large amount of loudspeakers, it is possible to reproduce complicated wave fields, that is to say to simulate acoustic waves produced by N and possibly moving virtual sound sources. This is based on the Wave Field Synthesis (WFS) paradigm originally developed in the University of Delft in early 90s. In the Smart-Room platform of Supélec and UMI 2958, two rooms have been equipped with respectively 72 loudspeakers (the acoustic holograms can be efficiently placed in and outside the room, and almost all around the center of the room from 0 meter to 20 meters) and 32 loudspeakers (200 degrees are efficiently covered). For a listener moving in one of these rooms, the perception of the sources localization would remain coherent.

0.3 Project objective

Four main points are concerned with this project :

– A portable and ergonomic graphical interface still needs to be build, in order to control efficiently the holophonic system. This interface will be written in GTK/Glade.

- The two rooms are also equipped with HD screens and with several arrays of microphones. Some techniques have been developed for 2D and 3D source localization using these arrays of microphones. They need to be extended and validated when several sources are present simultaneously, the number of sources being possibly larger than the number of microphones. Therefore, the development of acoustical antennas for efficient 2D/3D acoustical beam-forming is requested.
- It is envisioned in the continuity, for instance considering a visio-conference perspective, to build a system able to detect the source positions in one of the rooms and to reproduce the corresponding wave field in the other room, and conversely. This in order to emphasis towards sensations of immersion and presence in situations involving the participation of the listener.
- The rendering of virtual speaking agents. From a cognitive point of view, focusing on auditory and visual spatial cognition (that is to say on multisensorial integration processes), subject's performance, in terms of localization, should be studied.

0.4 Background literature

In order for the candidates to prepare themselves for the project, the backgound literature should concern these main domains :

- WFS Holophony
- Acoustical source localization
- Beam forming
- 2D/3D image rendering

0.5 Detailed technical description

The holophonic system in use at Supélec is based on the Wave Field Synthesis – WFS – technique.

Wave field synthesis is a spatial audio rendering technique, characterized by the creation of virtual acoustic sources (figure 1). It produces "artificial" wave fronts synthesized by a large number of individually driven speakers. Such wave fronts seem to originate from a virtual starting point : the so-called virtual source.

Contrary to traditional spatialization techniques such as stereo, 5 :1 and 7 :1, the localization of virtual sources in WFS does not depend on or change with the listener's position.

In the main room, there are 72 loudspeakers. Most of them are hidden behind two acoustically transparent screens. On these screens, 2D and/or 3D videos can be projected. In the second room, the holophonic rendering is much less efficient, as there are only 32 loudspeakers. Concerning the main room, there is only a small angle, around the door, where it is not possible to position a source. In

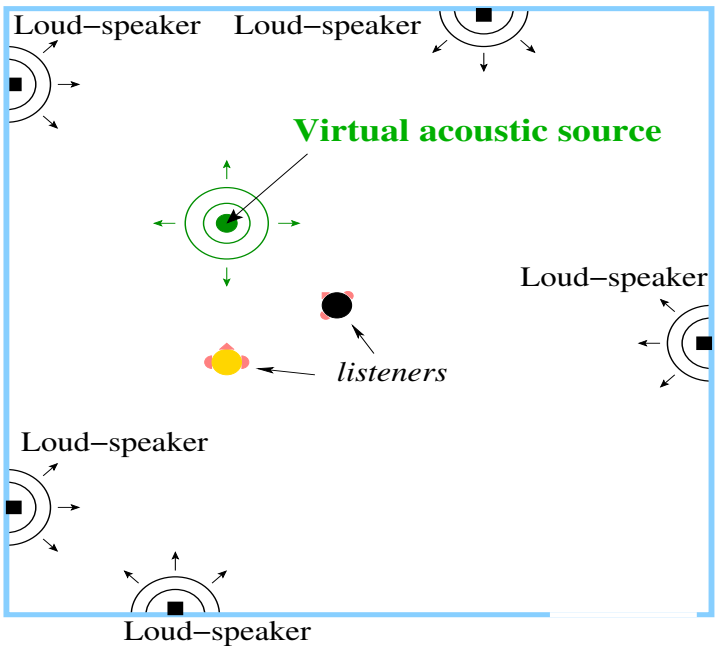

FIG. 1: Virtual sources

the other room, the "blind" angle is larger. It is around say 100 degrees.

It is possible to put sources outside the room, up to 20 m which corresponds to infinite distance ; and inside the upper left triangle. Notice that for a source inside the room, the listener must not be between the virtual source and the loudspeakers, otherwise the technique breaks out. When for instance the source is placed at the center of the room, people can place their head inside the source.

It is possible to simulate a non-holophonic 5 :1 and to compare the rendering to the holophonc 5 :1. What can be experienced is that the non-holophonic 5 :1 works well only for a small part of the room, contrary to the holophonic 5 :1.

Furthermore, acoustical panels are positioned on the four walls and on the roof. They modify the acoustic of the room. We can remove, move and change them.

Behind the wall, there are five computers, completely dedicated to the computation of the signals to send to each loudspeaker. We can not control the techniques used by these computers : everything is coming from the company which built the system (sonic emotion). Fortunately, it is relatively easy to connect to the server controlling the system and to send commands to it.

0.6 Work plan and implementation schedule

It will probably not possible to completely filfull the whole set of topics of interest for us. A possible time schedule could be :

- WP 1 (week 1). Become used to the system and choose the prominent topics.
- WP 2 (week 2). Implementation concerning the first chosen topic.
- WP 3 (week 3). Implementation concerning the second chosen topic.
- WP 4 (week 4). Implementation concerning the third chosen topic.

0.7 Benefits of the research

The work done will be used by our students, for their research projects ; students and PhDs from the École Supérieure d'Art de Lorraine are already collaborating with us and will collaborate more and more with us (museums, expositions applications) ; concert halls and movie theatres are being contacted.

0.8 Profile of the team

Over the last few years, Stéphane Rossignol has been designing and programming sound processing applications. Half-automatic and automatic indexing of sound signals are concerned. These works deal mostly with the temporal segmentation and indexing of speech and musical sound signals. Stéphane Rossignol works also on the design of dialogue systems.

Jean-Louis Gutzwiller works on image processing, speech processing, and on machine learning.

Jean-Luc Collette works on image pocessing, speech processing, and source localization.

Jean-Baptiste Tavernier is in charge of the Smart-Room platform to which the holophonic rooms belong.

0.9 References

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