3D Sound Wave Field Representation Based on Ray-Space Method

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1 Introduction

Sound can be recorded, computed and replayed by directed speakers, using the well-known sound processing methods, efficiently. Several approaches tried to generate arbitrary listening-point of sound; however there is not any model or representation of the sound sources in 3D space to have an efficient processing. Meanwhile, images are rendered by computer graphics algorithms and have become more attractive and more efficient and image synthesis hardware has come to existence [1]. The free viewpoint systems do not have a correct correspondence of sound and images in an arbitrary viewpoint. Considering the aforementioned problem, the main idea of this research is to propose a representation method of sound sources in 3D space using computer graphics and image processing techniques. This research addresses the problem of 3D sound representation without sound source localization and proposes a theory based the ray-space [2] representation of light rays, which is independent of object's specifications.

2 Ray-Space of SImages

In this method, an array of microphone-arrays (MAs), are set and each MA generates a sound-image (SImage) by scanning the viewing range, which can be captured by a camera in the same location of each MA. Each MA is beam-formed and generated a SImage with the same size of an image which contains pixels or blocks of sound wave with duration of one frame as shown in Fig 1.

Fig. 2 shows an example of the definition of ray-space. Let (x,y,z) be three space coordinates, and (θ,φ) be the parameters of direction. x and y are the intersection of the ray with XY-plane. θ and φ are the angles of the rays passing through XY-plane in horizontal and vertical directions, respectively as shown in Fig 2(a). After capturing all SImages with the array of MAs, the sound ray-space can be generated. Note that the u axis is a function of time. Therefore, the ray-space data of SImages is $f(x,y,u(t))$ as shown in Fig 2(b). f is the amplitude of the sound wave for a given t. After interpolation and having a dense sound ray-space (Fig 2(c)), any virtual SImage, which corresponds to an arbitrary listening-point, can be generated easily. Arbitrary SImage is generated by cutting the dense ray-space along the locus and extracting the section of SImage of the ray-space as shown in Fig 2(d).

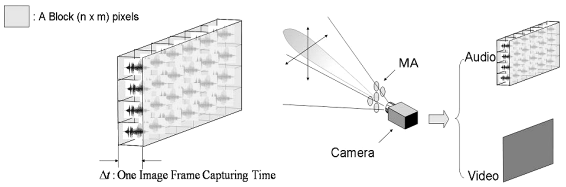

Fig 1: SImage Capturing with MA in location of a camera

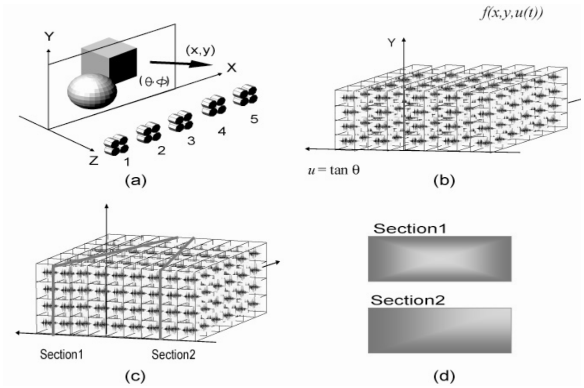

Fig 2: Ray-space method of SImages
(a) Ray space recording (b) Recorded ray-space
(c) SImage generation (d) Generated SImage

3 Arbitrary Listening-point Generation

To make a dense ray-space of SImages (Fig. 2(c)), interpolation between the captured SImages is needed. We propose to use the disparity map obtained by geometry compensation of corresponded images [3] in the location of each MAs. After obtaining the virtual SImage, the listening-point sound is generated by averaging the sound wave in each pixel or group of pixel of the SImage.

4 Conclusion

This paper proposed a method to represent the 3D sound field using ray-space method. The proposed theory can solve the problem of 3D media integration.

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References

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