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A Study on the Development for 3D Audio Generation Machine

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ABSTRACT

The production and authoring of digital multimedia contents are most important fields in multimedia technology. Nowadays web-based technology and related multimedia software technology are growing in the IT industry and these technologies are evolving most rapidly in our life. The technology of digital audio and video processing is utilizing rapidly to improve quality of our life. Also we are more interested in high sense and artistic feeling in the music and entertainment areas by use of three dimensional (3D) digital sound technology continuously as well as 3D digital video technology. The service field of digital audio contents is increasing rapidly through the Internet. And the society of Internet users wants the audio contents service with better quality. Recently Internet users are not satisfying the sound quality with 2 channels stereo but seeking the high quality of sound with 5.1 channels such as 3D audio of the movie films. But it might be needed proper hardware equipments for the service of 3D sound to satisfy this demand. In this paper, we expand the simple 3D audio generator developed and propose a web-based music bank by the software development of 3D audio generation player in 3D sound environment with two speakers minimizing hardware equipments. Also we believe that this study would contribute greatly to digital 3D sound service of high quality for music and entertainment mania.

Keywords: 3D, Audio, Multimedia

1. INTRODUCTION

The present age is multimedia era. A various fields are affected by multimedia technology. The multimedia technology is also developing rapidly. The digital video among multimedia factors is essential and it is very important that the sound can amplify the effects with the development of video these days.

When you wait a bus at the bus stop, the engine sound of a passing car from remote parts makes a most big sound in front of the station, and dies away in the distance. For the implementation of real sound like this, mono, stereo and surround sounds are converted into 3D sound which is defined as "the sound given space information that allows a listener to sense a direction, distance, and space when he doesn't exist where the sound resources occur". 3D audio area is playing a significant role in making users have a same experience to watch videos as in a real situation and feel reality.

This 3D audio needs a place which is equipped with the sound system like a theater and high-priced hardware equipment. There are few products which were implemented as software access. A simple 3D Music Studio, a 3D audio player, was developed to implement the 3D audio, and loaded

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into a web server named music bank to provide 3D audio to users in real time by support of Technology Innovation and Development Project on 2001 of the Small and Medium Business Administration Agency.

Therefore, in this study, we expand this simple 3D audio generator to provide more variable selection of types of 3D Audio according to sound directions. This expanded 3D audio generator also developed some algorithms to access the 3D audio as software and can be adjusted in low-priced two speaker systems in PC. It makes the greatest application in rapidly demand-increasing fields, such as games, music bank of web-based, multi-media contents and so on. Also, We consider it cut down hardware investment resolutely and provide high quality services to sound system which is the important part of the multimedia field.

2. 3D AUDIO AND 3D AUDIO GENERATING SYSTEMS

2.1 3D Audio

3D audio means audio that enables a listener to perceive a direction, distance, and space when he doesn't exist where the audio resources occur.

In general, audio is not stereo but mono in real life. But people think it is stereo with 2 channels because they have two ears. When the audio reaches to people's ears, their brain and ears distinguishes the audio source. That is to say, the shape and position of ears, shoulder and body is interacted with audio source. Based on this, one's ears combine with a brain and it knows the position of audio source exactly.

2.1.1 Distinction between Left and Right

Assume that a door on the right side closes when people stand on the center of a long corridor. And audio is generated and it reaches faster to the right ear than to the left ear. We call this as "Interaural Time Delay, ITD". Also, the intensity of audio is stronger at the right ear than the left ear. We call this as "Interaural Intensity Difference, IID. Based on this information, the brain decides that the right door was closed, not the left door.

2.1.2 Distinction between Front and Back

People's pinna functions as filter of audio which reaches to ears and makes brain distinguish between front and back of the audio.

2.1.3 Distinction between Up and Down

Audio changed by a pinna plays an important role in distinguishing audio pitch. Audio pitch is distinguished by patterns of a frequency showed on audio reaching to the ear drum. Interference patterns depending on original pitches are created by un-symmetrical resolute reflection of a pinna. And interference patterns are changed depend on the audio pitch. A brain can distinguish audio pitch by analysis the interference patterns.

2.2 3D Audio Generating Systems

2.2.1 HRTF (Head Related Transfer Function)

Existing 3D audio system played three dimension effects with more than 2 speakers around. But it is hard to have this kind of system in the PC environment. One way to solve the problem is using HRTF.

The HRTF is to get the response of both sides about each location with specific distances between 360 degrees of the azimuth angle and 180 degrees of elevation angle using Dummy Head Microphone modeled people's auditory organs[Fig. 0]. There are many studies on HRTF modeling, especially, MIT Media Lab. found HRTF of 463 spots around them using Dummy Head.

2.2.2 RTF (Room Transfer Function)

RTF is a Head Related Transfer Function measured at a particular space. Direct tone, early reflect tone, echo pattern and echo time to audio source are changed by size of space, structure, wall

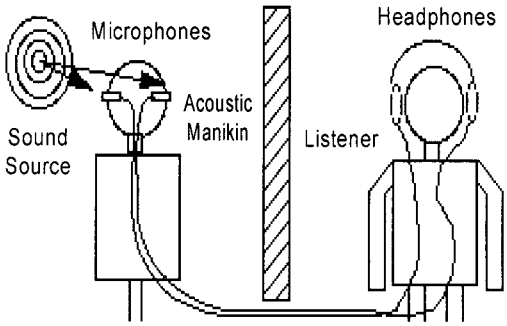


Fig. 0. Dummy Head Microphone Model for 3D Audio.

or the lumber of ceiling according to a place. Imaginative the space surrounding audio can be created with this.

2.2.3 RSX (Realistic Sound Experience)

The interface design which inserts audio effects in PC is an important factor for user's convenience and delivery of information on audio effects. The function of nonlinear editing, existing audio effect, additional function like Fade-in, Fade-out and the design of interface for 3D effect. It can provide effective function for users and perfect understanding for changed tone effect. It makes users easily select location of audio using 3-dimension graphic and check audio directly in this situation.

3. IMPLEMENTATION OF 3D AUDIO PLAYER FOR A WEB-BASED MUSIC BANK

A simple 3D Music Studio, a 3D audio player, was developed to implement the 3D audio, and loaded into a web server named music bank to provide 3D audio to users in real time by support of Technology Innovation and Development Project on 2001 of the Small and Medium Business Administration Agency[8]. To give more diverse selection of types of 3D audio we need expansion of selection function of 3D audio generator and also development some algorithms to access the 3D audio as a software system that it can be adjusted in low-priced two speaker systems in PC. So a expanded module of music bank can be consisted of following sub modules.

The 3D Music Studio is developed in module of 3D audio implement. It makes it possible to apply a cubic model and variables of the number of rotations variously so that users can feel effect of the 3D audio fully according to equation of an audio source.

In 3D Music Studio, a 3D character which place at the center means a listener. A moving ball, which means audio source, plays the music during play time and shows the position of moving audio source effectively.

3.1 Model Types

If you select one "Model Type" among the options in 3D Music Studio, the window will appears as follows. You can choose one of ten model types. In these menus, if you play the music without selecting the model type, the rotation

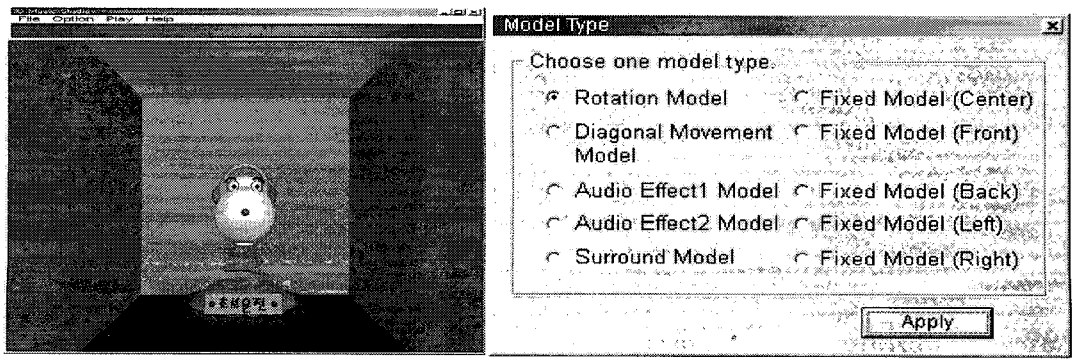


Fig. 1. Initial Mode of 3D Music Studio and Model Type Selection.

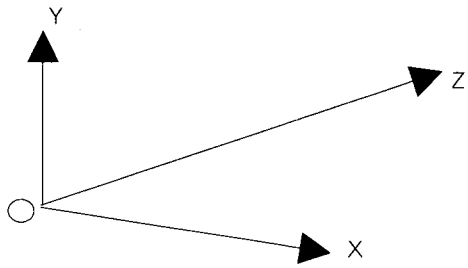


Fig. 2. Audio Source represented by values of X, Y, Z in 3D Coordinates.

model will be selected as a default value and played.

Model type can be defined as an equation of audio source which expresses a position of audio source as 3D coordinates or the position of audio source, values of X, Y, Z. The audio source moves repeatedly in a special pattern according to time in equation of audio source so we are modeling the movement of audio source and select a proper trigonometric function.

(1) Rotation Model

The Rotation Model is an audio source rotation type. It is the most basic form of the audio source rotating listeners around. The equation of audio source is as follows.

$x = \sin(t);$
$y = \sin(t);$
$z = \cos(t),$
where $t > 0.$

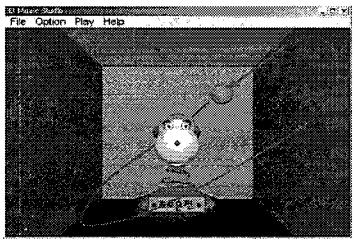


Fig. 3. Rotation Model.

(2) Diagonal Movement Model

In Diagonal Movement Model, the audio source moves from the front side of listeners to the back side and also conversely, which means a diagonal direction. The equation of audio source is as follows.

$x = \sin(t);\ y = \sin(t)$
$z = \sin(t) * \cos(\sin(t)^2)$

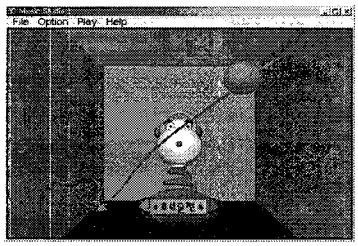


Fig. 4. Diagonal Movement Model.

(3) Audio Effect1 Model

In Audio Effect1 Model, the audio source starts at the right of front side of the listener, passes the listener face and then moves to the left of front side. And it starts again at the left of front side, passes the listener face and then moves to the right of front side. This model only moves in front of the listener compared with the diagonal movement model.

$x = \sin(t);$
$y = \sin(t);$
$z = 2 * \sin(t)^2$

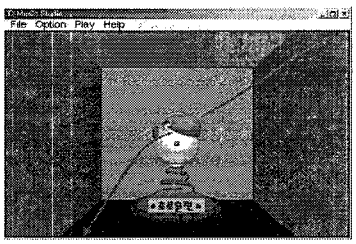


Fig. 5. Audio Effect1 Model.

(4) Audio Effect2 Model

In Audio effect2 Model, the audio source starts at the left of back side of the listener, passes the listener face and then moves to the right of back side. And it starts again at the right of back side,

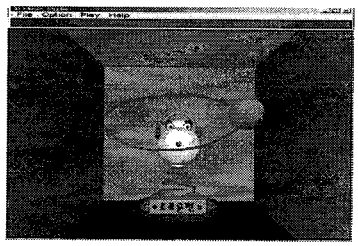
passes the listener face and then moves to the left of back side. The audio effect1 model only moves in front of the listener. On the other hand, in this model, the audio source occurs at back side and passes the listener's face and then moves to the back side again.

$x = \sin(t)$; $y = \sin(t)$
$z = -2 * \sin(t)^2$

Fig. 6. Audio Effect2 Model.

(5) Surround Model

In Surround Model, the audio source circles around a listener in the center in two-dimensions.

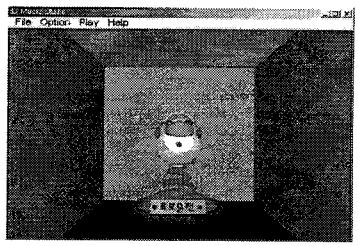


$x = \sin(t)$
$y = c$, c is a constant.
$z = \cos(t)$

Fig. 7. Surround Model.

(6) Fixed Model (Center)

In Fixed Model (Center), the audio source places at the center of the listener. In this model, the axis of X, Y, Z of the audio source is fixed to 3D coordinates, (0,0,0).

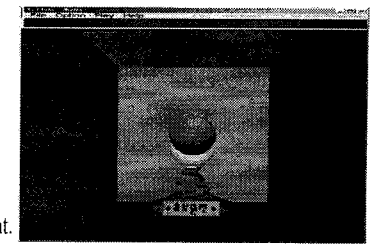


$x = 0$
$y = 0$
$z = 0$

Fig. 8. Fixing Model (Center).

(7) Fixed Model (Front)

In Fixed Model (Front), the audio source places at the front side of the listener.

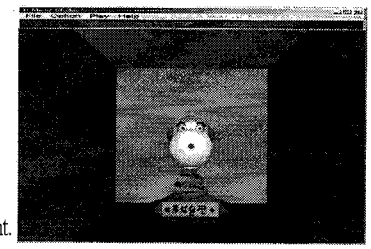


$x = 0$; $y = 0$
$z = c$, c is a constant.

Fig. 9. Fixing Model (Front).

(8) Fixed Model (Back)

In Fixed Model (Back), the audio source places at the back side of the listener.

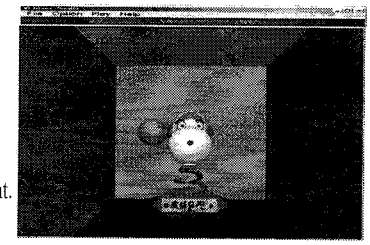


$x = 0$; $y = 0$
$z = -c$, c is a constant.

Fig. 10. Fixed Model (Back).

(9) Fixed Model (Left)

In Fixed Model (Left), the audio source places at the left side of the listener.

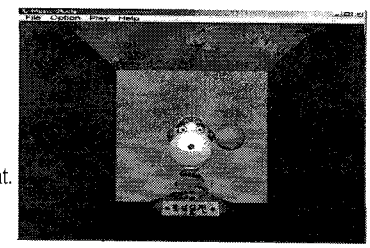


$x = -c$, c is a constant.
$y = 0$; $z = 0$

Fig. 11. Fixed Model (Left).

(10) Fixed Model (Right)

In Fixed Model (Right), the audio source places at the right side of the listener.



$x = c$, c is a constant.
$y = 0$; $z = 0$

Fig. 12. Fixed Model (Right).

3.2 The Number of Rotations

In 3D Music Studio, it is possible to adjust a relative speed of the audio source under the unit time by selecting the number of rotations of audio source according to each model mode like[Fig. 13].

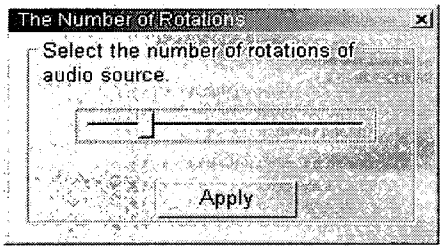


Fig. 13. The Number of Rotations of Audio Source.

3.3 The Scope of Module of Rotations of 3D Music Studio

In this study, the player of 3D Music Studio was developed to implement 3D audio as software method. The users can select the model type such as rotation, diagonal movement, audio effect1, audio effect2, surround, and fixed mode, which enable the user to feel the 3D audio in various environments. Also, 3D audio module, which can select the number of rotations controlling the relative speed of the audio source under the unit time, was implemented. The base development language to implement this module is Visual C++. Direct X Audio among Direct X API is used for 3D audio effect. Also, OpenGL API is used to create the 3D graphic and other visual effects.

4. CONCLUSION

In this paper, we expand the developed simple 3D audio generator to provide more variable selection of types of 3D audio according to sound directions. This expanded 3D audio generator also developed some algorithms to access the 3D audio as software system using low-price head-phone or two-speakers of general PC without additional hardware equipment. And it provides services to appreciate the multimedia 3D audio in real time through the web server, music bank whenever and wherever you want.

Let us see the feature of this research. First, 3D Music Studio Player was developed to implement the 3D audio as software. Second, existing researches and solutions are complicated to use because it is provided as contents production tool of digital audio and used for special purposes of experts. To improve this problem, 3D Music Studio, which is developed in this study, enables the user to select ten model types that help appreciate the 3D audio effect fully and the number of rotations that controls the speed of audio source. In addition, it made the largest utilization by servicing it on the web-page of internet that has the largest users now and is used easily whenever and wherever.

After this, the 3D Music Studio Player developed in this study will be added a function of real time streaming for the effective service on the web.

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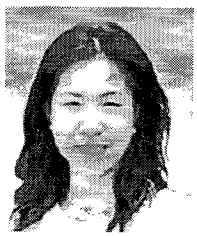

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