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Seeing Sound

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Abstract

This paper discusses the importance of animation in the study of sound.

1. Introduction

The nature and behaviour of Sound - the ways in which it is generated and propagated - are not easy concepts to grasp. Methods by which both experts and layman alike can gain a deeper understanding of physical acoustics are invaluable. Moving pictures, as in many other aspects of life, provide a powerful means by which such understanding can be achieved. This paper discusses methods of producing these *animations* and systems which use them. Clearly, illustrations of the benefits of the technique require a more dynamic medium than paper: the presentation will provide many examples.

It is generally true that '*a picture paints a thousand words*'. It is also generally true that moving pictures convey more information than static ones, even allowing for the increased amount of raw data required for the animation. Perhaps we should state that animations provide more information *per unit* of raw data?

Animations are becoming commonplace with the arrival of the Internet and certain standard file formats (see below), but their advantages have long been recognised in the world of acoustics. Celestion began using them (originally on an oscilloscope) in 1980 to display laser-scanned pictures of loudspeaker vibrations, and now also use them to show simulations by Finite Element Analysis [1,2]. Wavefront propagations are also well illustrated [3,4]. Complex physical phenomena such as diffraction are prime examples of the need and use of animation [5,6].

2. Method

Animations usually (but not exclusively) require a computer. They are generated by taking a short sequence of still frames representing different times or phases of the motion. In the context of sound this motion may be of a vibrating structure or of a wavefront (i.e. mechanical or acoustical). The frames are replayed sequentially, with the last followed by the first, forming a cyclic or 'closed-loop' animation. Many acoustical signals are cyclic in nature and therefore lend themselves easily to this display form. However, any signal which changes with time could be animated, including transients - impulses, ripples, etc. Figure 1 shows a typical frame-set of an animation.

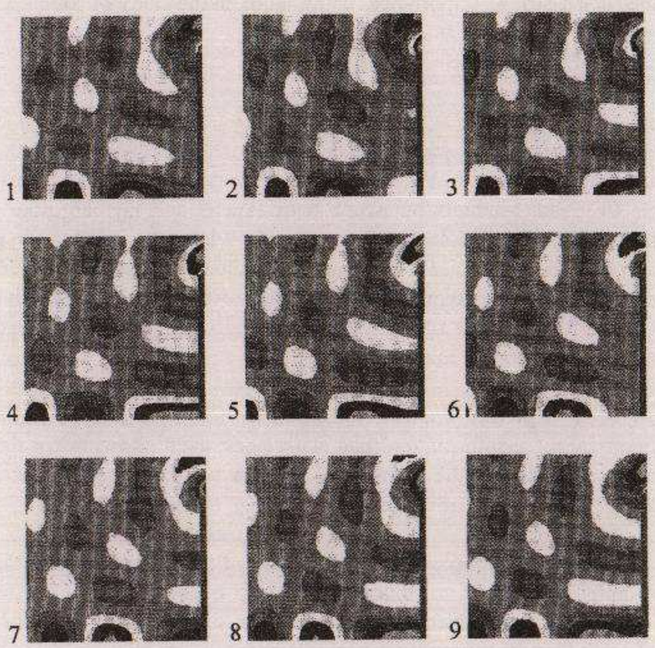

Figure 1. Typical animation frame-set. #1 follows #9 in a closed loop.

Care must be taken to ensure that there enough frames to convey an impression of 'smoothness' in the motion. The number can vary according to the parameters of the display - particularly the refresh or update rate - but usually 8 to 12 different frames will suffice. Obviously this number should be kept to a minimum, partly because of storage requirements, but particularly in view of the effect on 'download' times - either from a Website or even just loading locally from a disk. File sizes can be minimised using various techniques such as storing *only* the changes between frames instead of all of every frame, using fewer bits per pixel (reducing the number of colours), etc.

2.1. How to Create Frames for Animation

For a sinusoidal system the starting point will be a set of complex numbers representing properties of a surface. For example we may have m complex displacements x_m on the surface of a loudspeaker cabinet. To generate N animation frames calculate display points

$$d_{m,n} = \mathrm{Re}\,(x_m . e^{-j2\pi n/N}) \qquad \text{where } n=1,2..N$$

this simplifies to

$$d_{m,n} = \mathrm{Re}\,(x_m).\cos 2\pi n/N + \mathrm{Im}\,(x_m).\sin 2\pi n/N$$

To animate a transient, calculate $d_{m,n}$ at discrete time intervals nT/N where T is the total duration.

3. Animation Formats

The field of computer animation is still comparatively new and very dynamic. This section is provides only a brief overview. A vast amount of information is available on the Internet and some starting-point references are provided.

The prevailing file standard is Graphics Interchange Format (GIF) 89a [7]. There are royalty issues attached to this format, and this has led to the rise of the Portable Network Graphics (PNG) format [8], which does not yet support animations. Moving pictures are also supported by QuickTime [9], Microsoft's Audio Video Interleave (AVI) [10] and MPEG, but these are intended as multimedia (video *and* audio) formats and are not conducive to simple, fast animation.

The main PC GIF animation applications at this time are GIF Construction Set [11], JASC Animation Shop [12] and Microsoft GIF Animator/Image Composer [13]. All of these are relatively cheap and allow both assembly and playback of Animated GIF files. There are others [14].

4. Conclusions

The author has seen first-hand over many years the value of moving pictures in the engineering world. Any technique which illustrates complex technical concepts to the layman is by definition a valuable tool. Also, the ability to visualise the behaviour of complex soundfields or vibrations takes engineering comprehension to a new level. This simple tool called *animation* should not be underestimated.

5. References

1. G.Bank, G.T.Hathaway, *A Three-Dimensional Interferometric Vibrational Mode Display*, J. Audio Eng. Soc., 29 (5), 1981.
2. J.R.Wright, *Finite Element Analysis as a Loudspeaker Design Tool*, Proc. AES UK Conference, 1998.
3. O.Kirkeby, P.A.Nelson, H.Hamada, *Virtual Source Imaging over Loudspeakers*, Proc. Inst. Acoust., 19 (6), 1997.
4. www.isvr.soton.ac.uk/FDAG/vap
5. J.R.Wright, *Fundamentals of Diffraction*, J. Audio Eng. Soc., 45 (5), 1997.
6. S.M.Zhu, P.J.McKerrow, *Simulation of a Ripple Tank*, Acoustics Australia, 23 (2), 1995.
7. www.faqs.org/faqs/graphics/fileformats-faq/part3/section-57.html
8. www.boutell.com/boutell/png
9. www.cs.ubc.ca/spider/ladic/qtime.html
10. www.cs.ubc.ca/spider/ladic/avi.html
11. www.mindworkshop.com/alchemy/gifcon.html
12. www.jasc.com/psp5f.html
13. www.microsoft.com/imagecomposer/gifanimator/gatour.htm
14. www.dcs.ed.ac.uk/~mxr/gfx/3d-lo.html