The Abstract Video "Triangular Vibrations"

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Abstract

Triangular Vibrations is an abstract video with surround sound, based on the vibrations of an idealised drum (circular membrane). The vibrations of the drum generate both sound and image.

1. Modes of Vibration

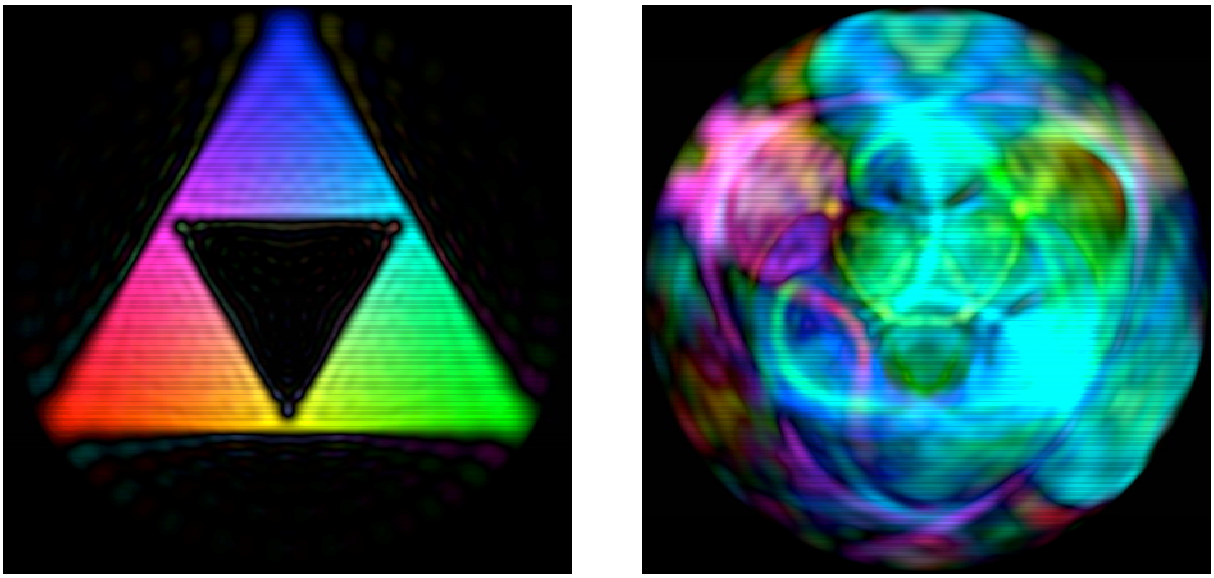
Triangular Vibrations is based on the idea that an arbitrary displacement of a circular membrane can be analysed as a sum of modes (Fourier-Bessel modes) [1,2]. If we hit a drum with a triangular hammer, for example, this triangular displacement can be expressed as a sum of certain modes, in a way analogous to representing a waveform as a sum of sine waves. To represent a triangular impulse exactly an infinite number of modes is needed; if a finite number of modes is used, the representation will be somewhat blurry.

In *Triangular Vibrations* three superimposed drums are used, coloured respectively red, green and blue. Nine hundred modes are used for each drum. The representation of the initial impulse at the start of the video is shown in Figure 1 (left); it appears a little blurry, and also a mottled pattern has been induced in it, as a consequence of the limited number of modes used for each drum.

Each mode of vibration has a natural frequency associated with it. The modes are not harmonic, that is they are not integral multiples of a fundamental frequency. For example, the red drum has lowest frequency 50 Hz and second-lowest frequency 79.7 Hz. The green drum has lowest frequency 100 Hz and the blue drum 200 Hz. The mode with the highest frequency has frequency 11 320 Hz.

2. The images

The images show the vibrations of the modes greatly slowed down, by a factor of approximately 18 000. These slow oscillations are quantised, in that each mode undergoes a whole number of oscillations during the video, with the lowest frequency mode executing just one vibration. This was done to provide a coherent stopping-place for the video, as otherwise, since the true frequencies of the modes are inharmonic, the modes never come back into any sort of synchronisation. The quantisation means that the video is symmetric about its midpoint.



. **Figure 1: The start of the video (left); a frame from the middle of the video (right).**

3. The sound

The sound consists of the various modes heard at their natural frequencies (not slowed down and not quantised). However, each audio mode is modulated (faded in and out) according to the speed of its slow video counterpart.

The slow vibrations are also used in the distribution of the sound in the surround space. There are two sorts of drum modes, those with circular symmetry and those with lower symmetry [2]. The sounds for modes with circular symmetry are treated as omni-directional signals. For the modes of lower symmetry, it is possible to associate an angle or direction to each mode. The sound corresponding to the mode is treated as a point source oscillating back and forth in the appropriate direction, something like a pendulum, with speed according to the video modulation of the mode. The sound is then distributed, treating the five speakers of the surround set-up as a quad array with an additional front centre speaker.

The glissando effect heard during the piece is an illusion, in that each mode has a fixed frequency. The effect arises from the way the different modes fade in and out.

4. References

[1] Strauss, Walter A. *Partial Differential Equations*. New York: John Wiley & Sons, 1992, pp. 251-256.

[2] Fletcher, Neville H. and Thomas D. Rossing. *The Physics of Musical Instruments*. New York: Springer-Verlag, 1991, p. 74.