Notes on "Dissonant Particles"

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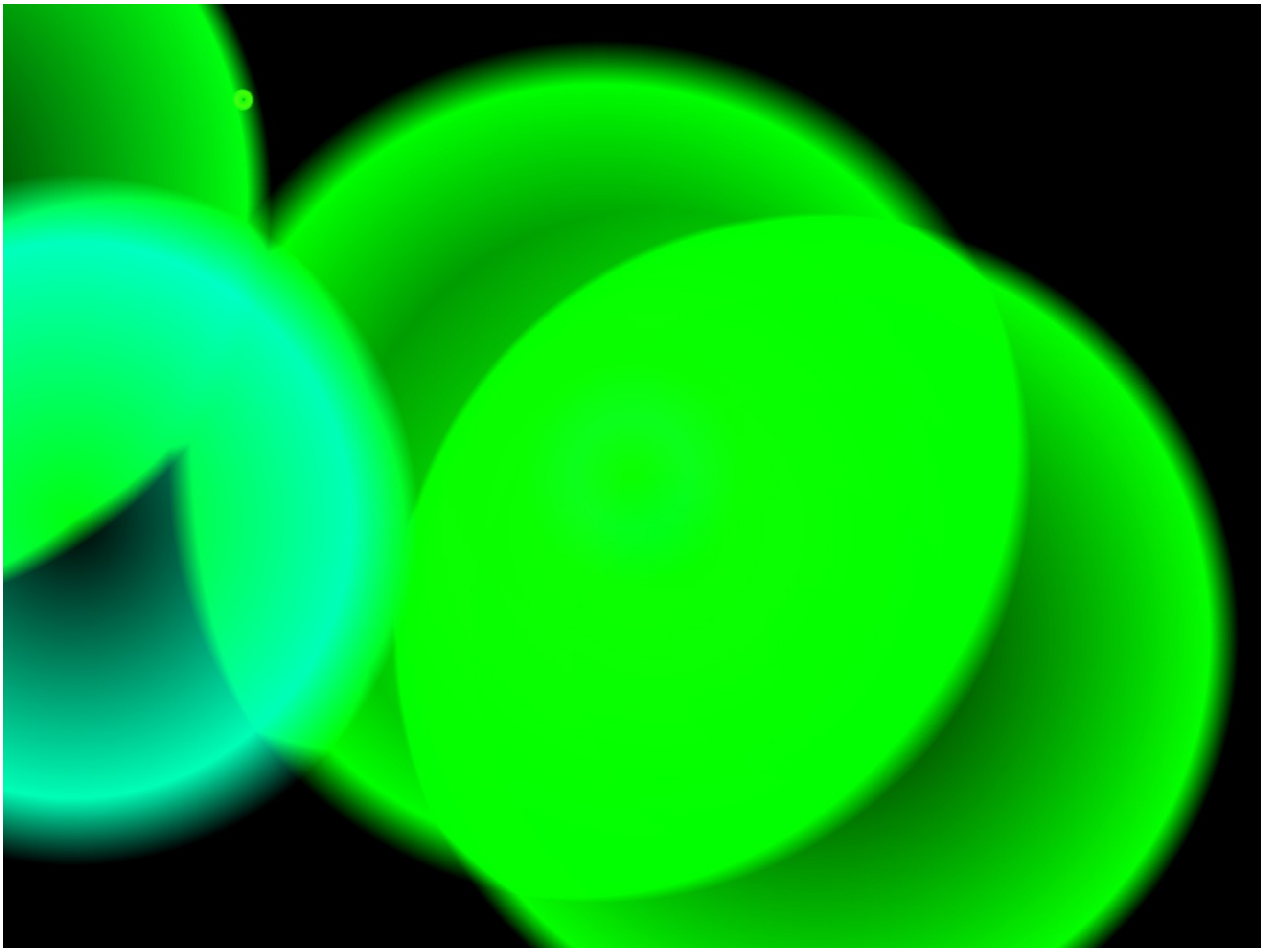
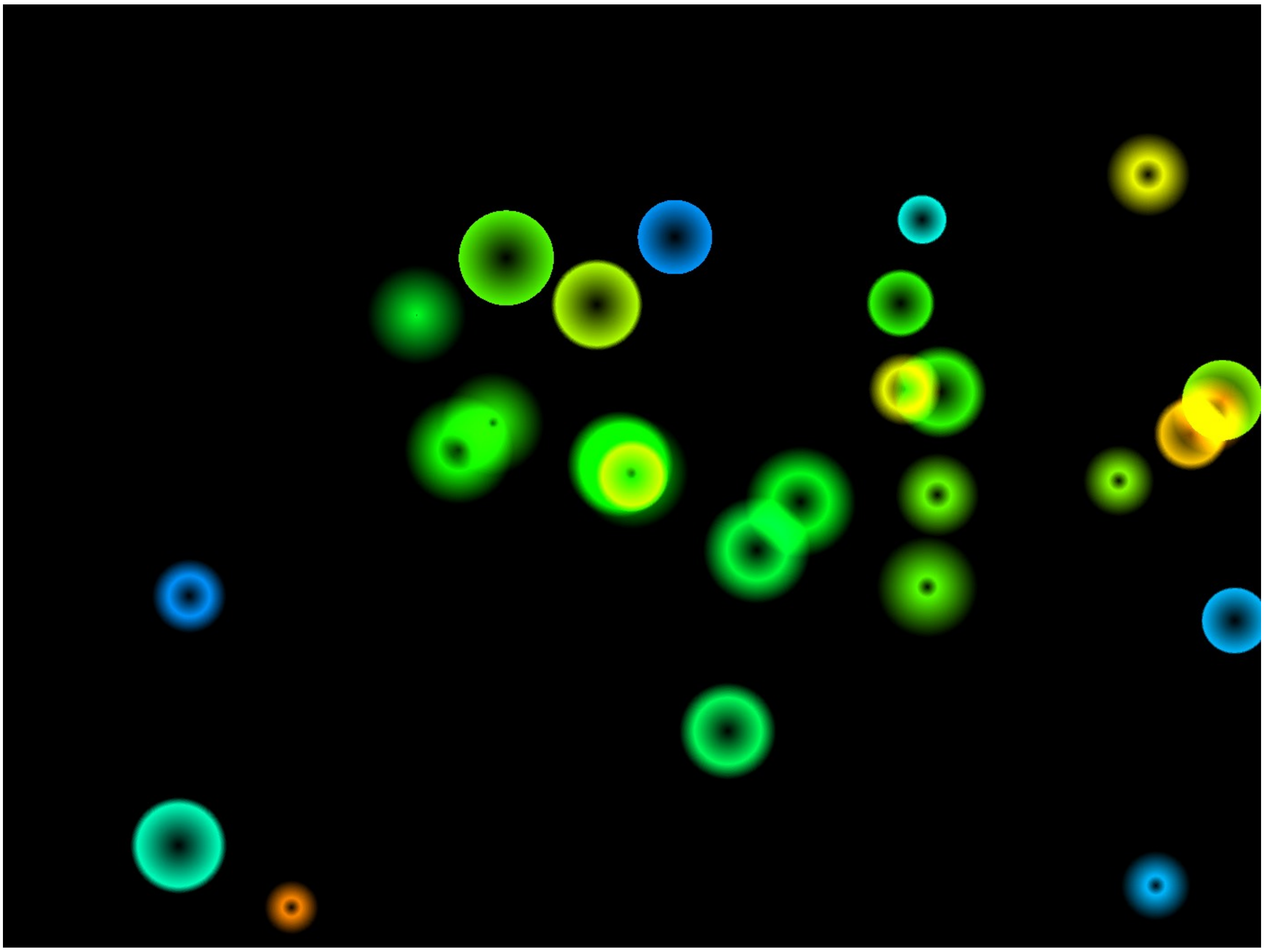
Summary

Dissonant Particles is an abstract animation (duration 7 minutes), generated by a single process which produced both the sound and the video. Psychoacoustic experiments have indicated that when two pure sine tones are played simultaneously, they will sound most dissonant when they are around a semitone apart in pitch. In *Dissonant Particles*, each particle emits a sine tone. The dissonance between particles acts as a repulsive force which pushes them apart, both in position and in pitch. There is also a long-range ("cosmological") attractive force which prevents the particles from flying off to infinity. The resulting interplay of forces allows for interesting behaviour.



A still from *Dissonant Particles*



A second still from *Dissonant Particles*

1. The particles

New particles are born near the centre of the screen, with a slight random offset, at the rate of about one particle per four seconds. The starting frequency for a new particle is 500 Hz, again with a slight random offset. Particles pulsate and slowly evaporate; as a particle evaporates, its rate of pulsation speeds up. The lifetime of a particle (before it evaporates away totally) is about 4 minutes.

A particle is represented on screen by a disc, whose size shrinks as the particle evaporates. The frequency emitted by the particle is represented by colour, with red for low frequencies, green for intermediate frequencies, and blue for high.

2. The forces

The repulsive force between two particles is derived from the formula for the dissonance of two sine waves given by W. Sethares (1993, 2005). The formula used in (Sethares 2005) for the dissonance of two sine tones of frequencies f_1 and f_2 Hz, with $f_1 \leq f_2$, is equivalent to the following.

Set $q = \frac{f_2 - f_1}{0.0207 f_1 + 18.96}$. The dissonance is $e^{-0.8424q} - e^{-1.38q}$.

The repulsive force is this dissonance quantity, divided by the distance between the two particles, and multiplied by the mass of the each particle and by their "states of pulsation" (ranging from 0.0 for "contracted" to 1.0 for "expanded"). This repulsion pushes the particles apart in both space and frequency.

The long-range attractive force is simply a weak attraction between each pair of particles. It is independent of distance, but is affected by mass and state of pulsation in the same way as the repulsive force. This attraction pulls particles together both in space and in frequency.

Note that in particular a particle "feels" the forces acting on it according to its state of pulsation.

3. The camera

The display of the particles uses a mixture of two-dimensional and three-dimensional calculations. The particles are simulated in the computer in three-dimensional space. The camera is attached to the first particle (which is like all the others except that it has a longer lifetime). At each instant, a line is drawn from the camera to the origin (centre of the space), the plane through the origin orthogonal to this line is constructed, and then the position of every particle is projected orthogonally onto this plane. The image is a portion of this projection, whose size depends on the distance of the camera particle from the origin.

The projection is oriented in such a way that the projected direction of movement of the camera points to the top of the screen. If the camera particle changes direction fairly abruptly, the image will swing round quite rapidly. Since the camera particle, like the other particles, "feels" the forces acting on it in proportion to its state of pulsation, the viewpoint can change in a series of jerks.

4. The sound

Each particle emits a sine wave. The volume of the sine wave emitted by the particle pulsates in the same way as the visual pulsation.

The sound is 5.1 surround. For the sound, the projection was considered in two zones, an inner zone consisting of what is visible on the screen and an outer zone with three times the width and height of the inner zone. A particle on the inner zone is heard in one or two of the three front speakers (left, centre and right), according to its horizontal position on the screen. As the particle moves into the outer zone some of the sound moves into the two surround speakers, in a somewhat complicated way; even a particle which moves vertically up and off the top of the screen will contribute some sound to the surround speakers.

For particles in the outer zone a delay is added according to how far off-screen the particle is, and so a Doppler effect is produced. Some reverberation is also added. As a particle moves to the edge of the outer zone, its sound is attenuated to silence.

5. Comments

This piece was an experiment in setting up a single process to produce both sound and image. The process was intended to be quite simple. Its elements are:

(1) The autonomous behaviour of each particles: particles are born, pulsate and evaporate.

(2) The interactions between particles: the particles push each other around according to the two forces (attractive and repulsive) described above.

I was pleased to find that I could work with forces as described above; I had originally thought I might need to add some viscosity or other mechanism to make the particles behave tractably. The only concession of this sort I made is that if two particles are very close together the force between them is temporarily turned off, to avoid dividing by a near-zero quantity. Since I am not trying to imitate any sort of realistic physics, I didn't feel bad about this.

2D or 3D?

Originally this piece was entirely in 2D. However, there was then no natural way of assigning the camera movement. I decided that the camera movement should arise from the process; this led to the idea of attaching the camera to a particle, which in turn meant that the particles had to be simulated in 3D. However, I liked the effect, which I had obtained with the 2D system, of particles merging with one another. Hence the system of projecting down to a continuously varying plane.

The pulsation of the particles is achieved as follows. The particle is drawn as a series of concentric circles of the same hue but varying brightness. If the radius ranges from 0 to 1, the brightest circle is drawn at the radius corresponding to the state of pulsation, and the colour fades towards black both further in and further out. This produced the rather odd effect of particles going in and out of focus as they pulsated. I liked the result, and kept it.

How autonomous is autonomous?

There is an aesthetic question which I have not resolved concerning this piece. The particles are born with small random offsets in both position and frequency, and these random offsets determine the behaviour of the system. In particular, it is possible for the camera particle to be flung rapidly into the distance; the animation would presumably then just show some diminishing specks. Before rendering anything, I created a skeleton version of the program (with no sound or image output) which just indicated the distance of the camera particle from the origin. I ran this skeleton program 400 times with different random number seeds, and chose a seed which gave what appeared to be an interesting movement of the camera particle. I then used this seed to render the piece, with no further manipulation on my part.

This exemplifies what appears to be a perennial dilemma concerning algorithmic or generative art. On the one hand I want the process to function autonomously, and one of the motivations for this is to let the process lead me into areas I would not otherwise discover. On the other hand I am creating an artwork, presumably for humans, so it should be interesting to humans, and a bunch of rapidly disappearing specks is not going to be very interesting.

Perhaps the solution, in the case of *Dissonant Particles*, is to render out all 400 versions and display them simultaneously on 400 screens?

References

Sethares, W. (1993) "Local consonance and the relationship between timbre and scale", *Journal of the Acoustical Society of America*, Vol 94, Issue 3 (September 1993), pp. 1218-1228.

Sethares, W. (2005) "Some useful computer programs", http://eceserv0.ece.wisc.edu/~sethares/comprog.html (last modified 8 Jan 2005; last viewed 5 Nov 2005).

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