Hunting Additional Pixels in Digitally Amplified Art: Looking for Clues in Music, with Inspiration from Mathematics

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Abstract

This paper examines ways that the amplification of visual images can be an integral part of the creative process for digital art, proposing typologies based on parallel examples in music where amplification is also integral to the creation process. The author's own artwork incorporates these visual amplification typologies into the creative process, and this artwork serves as the vehicle for discussion of conceptual issues in this paper. The paper's format first describes each typology with an example from music, next discusses each typology in relation to examples of digital art and then discusses inspirations from mathematics related to each artwork. Visual amplification typologies discussed range from the goal of amplification with few artifacts to the goal of a filtered and processed amplification that totally transforms the original image, becoming something very different from the source image; in each case the goal is to go beyond engineering and to use digital amplification as a philosophical/aesthetic perceptual act.

Introduction

Amplification Focus. Making things larger through "amplification" has been an elusive goal throughout the ages. In visual art, the development of optics allowed the projection of enlarged images [1]. In music, violinmakers used wood to amplify the tiny sound of a vibrating string. In mathematics, trigonometry allowed the measurement of huge distances. However, the realities of the physical world and its distortions placed a practical upper limit on the scalability of these and other processes. In the present, digital amplification techniques for both sound and images represent the latest episode in the dream quest for technically perfect amplification. However, rather than considering technically perfect amplification or the issue of amplification as it relates to the engineering of information for human perception, this paper formulates amplification typologies where the distortions and transformations introduced through amplification become important ingredients in the finished creative work.

Amplification as Artistic Perceptual Act. From one standpoint, visual amplification could be approached as a scientific search for transformations that produce accurate values. However, for a performing musician, this would be similar to searching for a way to computationally reproduce the pitches of a musical composition; it would be a reproduction, but not a performance. From another standpoint, beyond issues of perfect amplification, an amplified version of something tends to produce a different perception from an original, smaller version. For instance, a house cat seated at one's feet elicits different reactions than the reactions elicited by a larger version of cat, such as a tiger. Amplified sound, whether music or not, can produce strong involuntary physical and emotional reactions. Using a different conception of amplification related to duration, an aria takes on a completely different identity when sung at a double tempo. From a musician's or an artist's standpoint, amplification is not just a scientific activity subject to the laws of physics. Amplification is also a philosophical/aesthetic perceptual act.

Amplification and Music. Electronic amplification has become ubiquitous, even in performances of "acoustical" classical music, where "sound enhancement" helps the music fill a large hall. Music has a long history of using aural distortions, introduced during the amplification process, as a vital part of the creative act; a string vibrating on a violin produces a completely different sound from the same string vibrating in a piano, largely due to different types of distortion. Digital synthesizers produce a wide variety of sounds and colors from the same instrument. The use of both digital amplification and distortion in music seems to be accepted and treated as a continuation of musical tradition. Recorded music is still another twist on amplification, where the multiplied copies have developed an identity separate from live performance, and there might be no performance other than the recording itself.

Amplification and Art. In art, unlike in music, discussion of reproduction and digital amplification can elicit heated emotional responses. Some would argue that a reproduction no longer has the authenticity of an original [2]. Perhaps the centuries of controversy and secrecy surrounding lenses [1] (and more recently photography) as aids to accuracy set a precedent for treating digital amplification as a suspect activity. However, borrowing traditions from music can serve as a way to move beyond recurring discussions about art, with the goal of developing a tradition of art in which the original image can be the amplified version.

Mathematics as Inspiration. It has been said that mathematics is a process of simplification, and that science "sets out to break 'nature' down into its component parts... This process is principally one of reduction. The artist, on the other hand, often juxtaposes different features of reality and synthesizes them..." [3]. The digital art examples in this paper owe a great deal of their conception to thinking about mathematics and the way that mathematics addresses issues such as reduction, complexity, interpolation, computation and error. Mathematical ideas have been instrumental in the creation of these artworks and have been used as starting points for synthesis, although as inspiration more than methodology.

Typology Format. The typologies discussed below derive from common practices and perceptual acts in contemporary music performance. The paper's format first describes each typology with an example from music, next discusses each typology in relation to examples of digital art and then discusses inspirations from mathematics related to the artwork. It is hoped that the typologies illustrate ways that visual images, like musical performances, can take on new lives through the controlled use of interpolation when hunting for the additional pixels needed for digital amplification.

Typology 1: Sweet Acoustic Sound / Volume Enhancement

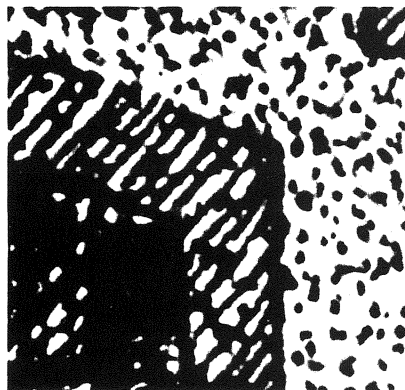**Figure 1:** Ink on Bristol, 4.5"x10" original amplified to 9"x20"

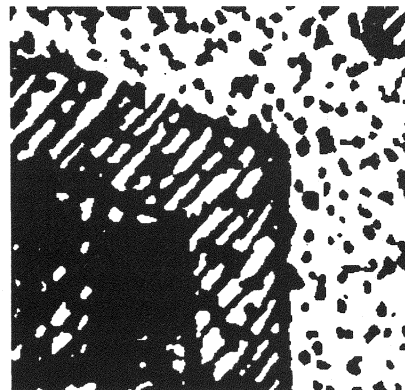**Figure 2:** Detail, of window at lower left of Figure 1, filtered for natural feel.

Figure 3: Detail, of Figure 2, filtered to black & white.

Music. Even when the goal is to faithfully reproduce the sound of an acoustic instrument, as in a flamenco guitar performance, the act of amplification changes the scale of the music and its relationship to the listener. In order to keep the sound sweet, the sound is enhanced through noise filtering and tonal adjustments. As the sound becomes more amplified, a larger audience can hear it. However, when listened to at positions too close to a speaker the sound loses its natural feel. Typology 1 is most effective when the nuances of the acoustic sound mix with the amplified sound.

Art. The drawing is of a village in France, visited while on a European trip (Figure 1). The original drawing, executed in ink on Bristol board, has a loose ink style. While the scale of the original image is appropriate for viewing by a single person at arm's length, the drawing was to be included in a gallery show and would work better in a large space with a larger audience if it were amplified. A straightforward digital enlargement fails to satisfy perceptually. To maintain a natural feeling, the density of the ink at the centers of the lines must be increased on the enlargements (Figure 2), and background noise not evident on the original needs to be filtered out. While filtering the drawing all the way to black and white (Figure 3) adds "punch," allowing amplification to higher levels for viewing at greater distances, the crisp edges of the dots begin to look square, and the image is not acceptable as it no longer has the softness of an ink drawing at close range. An ink drawing such as this seems to lose its sweet sound when amplified more than 200%.

Mathematical Inspiration. When working on the amplified image in Figure 2, it was difficult to avoid thinking of linear equations; every dot on the original would be multiplied by the same scale factor, resulting in an exact copy of the original. However, a "linearly" amplified version was not perceptually acceptable. Even thinking about exponential amplification, as with sound, did not work. What did prove to be helpful was to approach the amplification as a process of setting different ranges of density for different areas. The white background was reduced to a plus or minus range of zero, while a set of tone gradients kept values for different parts of the ink dots within a range that looked acceptable.

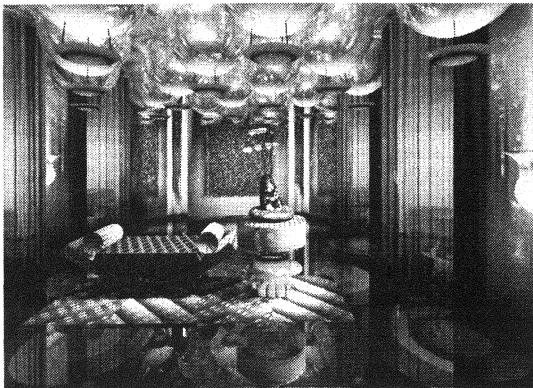## Typology 2: Total Digital Synthesis / Maximum Volume, Tone and Clarity

Figure 4: Digital ray tracing, 50"x36"

Figure 5: Detail of sofa corner

Music. Some types of audio synthesizers start with mathematical values, reducing all parameters of sound to equations. In theory, an unlimited number of sounds can be created and, since they are mathematically based, the sounds should be able to be amplified indefinitely with no signal loss. A skillful "sound designer" can emulate the sound of an acoustic instrument, without distortions and noise. This type of perfect sound is able to fill a room or a stadium with a shimmering wall of music. However, the "realism" is sometimes most effective when heard from the next room. In addition, at higher amplification levels the sound may seem to be too perfect, and to begs for some signal degradation.

Art. The design of this art interior is an update of the painter Whistler's 19th Century design for a wealthy client (Figures 4, 6). The original design caused scandals and lawsuits, and the original space has even been restored and transported to the United States from Whistler's native England. The update assumes that Whistler's ghost would receive the commission from the ghost of Walt Disney and that Sigmund Freud's ghost would get involved as a technical advisor. The result is a sensuous riot of form and color, with an overdose of latent symbolism.

The images are digital raytracings of digital vector models with procedural materials and textures. This means all characteristics of the virtual space exist as mathematical equations in a database, as do physical material characteristics like lighting, reflective qualities and color. The mathematical data is processed using mathematical equations that simulate real-world behaviors, resulting in what appears to be a virtually real image. Massive amplification is possible, since all the underlying equations (for both geometry and materials) can be scaled to any amount while rendering an image, without losing any precision.

With this particular art project, the visual conflict between geometric elements such as the cylindrical pillows and what appears to be fabric covering the pillows is an important element; the geometry gives one message, while the colors, patterns and materials give a conflicting message. A future goal is to fabricate the furniture pieces literally from the images, with sharp edges and hard surfaces (Figure 5). This questions the concept of visual realism, and links the visual to perceptions about what things would feel like to the touch.
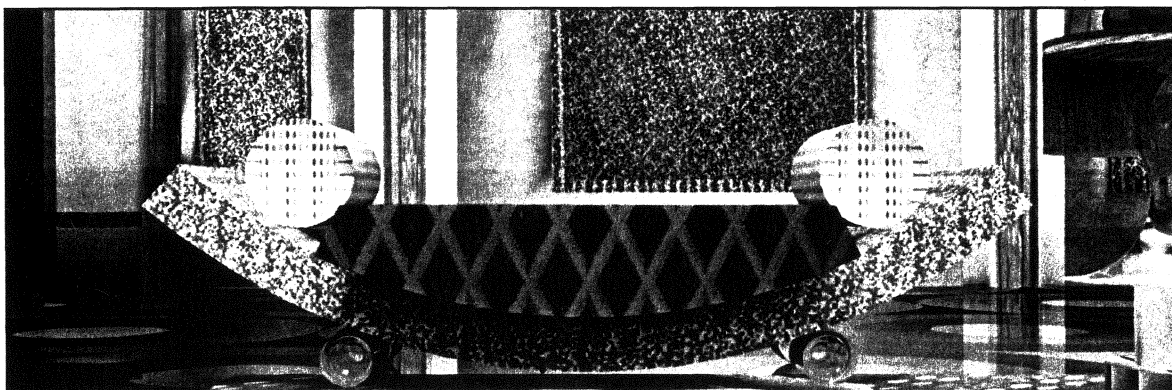

Figure 6: Digital ray tracing, 110"x36".

Mathematical Inspiration. The basic amplification process in this typology is purely mathematical in terms of computation, involving vector scaling of geometry and scaling of procedural materials. However, perceptual geometry and color perception become increasingly important as the image is amplified to larger-than-life size. Proportions between mathematical values must constantly be adjusted in response to the viewer's perceptions, and have here also been adjusted visually in raster format after amplification. Things that are not important at small scales, such as the reflections on the ceiling, become increasingly important at large scales, just as rounding and truncation errors do in computation [7].

Typology 3: Blues Dobro and Harmonica / Controlled Live Sound

Music. The Dobro is a purely acoustic variant of the guitar, but can physically replicate some of the distorted qualities of an amplified electric guitar. The instrument has a metal resonator that works a bit like a kazoo. Likewise, the blues harmonica is a standard harmonica, overblown to the point of distortion. Capturing these instruments' "live" sound on a recording or in a performance requires careful filtering and processing to avoid cleaning up the sound and losing the distinctively distorted flavor of the original instruments. Conversely, too much additional distortion can create a muddled aural stew with no flavor.

Figure 7: Original ink sketch on yellow tracing paper, 5.5"x10.5"

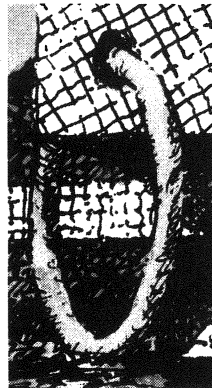**Figure 8:** Mixed media ink/watercolor/digital, 18"x36",

Figure 9a: Proposed pierced "earring," 92' tall.

Figure 9b: Proposed fiber-optic "Mohawk," 60' tall.

Art. The building pictured with proposed art installation (Figures 7 & 8) is Cleveland's Rock and Roll Hall of Fame, designed by I. M. Pei. The building itself seems like a small model that was amplified to huge proportions without addressing perceptual issues at human scale. Among other things, the author's proposed art installation comments on the building's lack of subtlety by adding additional amplified elements. These elements consist of an oversized earring and a fiber optic mohawk (Figures 9a & 9b), over one hundred times larger than life, giving the building a human persona. The drawing in Figure 8 began life as a digital model, which was then used as the basis for the textured ink sketch in Figure 7. The ink sketch was scanned, amplified to twice its original size and then printed on watercolor paper,. The print was next painted over with watercolor and scanned again. This image was processed further, with digital color enhancing the watercolor, and finally printed about 3.5 times larger than the original sketch. Throughout the different steps, care had to be taken not to lose the rawness of the original sketch, and at the same time to not add so much noise or distortion that the clarity of the image was lost.
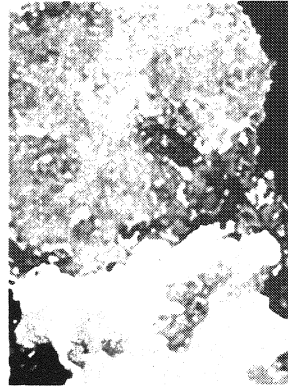
Mathematical Inspiration. Working on this image felt like working on solving a complicated equation, where a substitution might at first seem to be correct, but then turn out to cause unfortunate results, such as a zero in the denominator. It was helpful to think about hue, saturation, density, brightness, transparency or other characteristics as variables, and then to solve for each one separately. Then, returning to the original image, the individual results could be plugged back into the larger process and the whole equation could be solved at once. Just as in solving an equation, intuition, experience and experiment often proved to be more useful than using logic to balance the different steps in the amplification process.

Typology 4: Sampling Synthesizer (Musique Concrete) / Maximum Tone and Volume

Music. The sounds in a sampling synthesizer start with a sample (or digital recording) of a note from an actual instrument. In theory, a high quality sample should be indistinguishable from the original instrument, as the sample contains all the overtones of the original sound. In practice, adjustments to the sound must be made from note to note. More interestingly, however, samples can be further modified as they are amplified, becoming hyper-sounds that resemble the original instrument sounds, but possessing over-saturated color and tonal detail. Another related musical technique is musique concrete, in which recorded instruments and sounds are electronically manipulated to create new musical compositions.

Figures 10a & 10b: "My UP Kitchen Window," each 30"x 40"   **Figures 11a & 11b:** Enlarged areas of 10a, showing intensified texture and saturated color

Art. The images, inspired by Georgia O'Keeffe, began as 16,000 dpi scans of a window frame from a farmhouse in Michigan's Upper Peninsula. The prints are amplified about 75 times greater than the original object. The images were processed in PhotoShop, narrowing down the palette, shaping the tonal curves, and generally treating the images as if they were a painting, including the use of color in place of black for dark tonal areas. The images blur the lines between painting, photography and drawing.

In this typology, the original image is sampled at such a high rate that it could be highly amplified without geometric distortion. Just as with rich audio samples, however, these image samples have been augmented with over-saturated color and tonal detail during the amplification process.

Mathematical Inspiration. An inspiration for this work was the idea of fitting data to a straight line [4]. Unlike the other typologies, the initial scan had a huge dataset that had not been filtered by the eye. Part of the amplification process was discarding color data that fell too far from a visual curve. Additionally, creating the images was a bit like some mathematical problems, where the attraction is more emotional than intellectual; the process involves striving to describe the world in a new way.

Typology 5: Raw Electric Guitar / Saturated Power Chords

Music. The musical parallel for this typology is the amplified electric guitar. The barely audible fundamental pitch, as well as the overtones created by the vibrating string, serves as the raw material for rich sonorities that can fill a large hall. Filters and effects pedals chop, stretch and focus the sound, until the sound becomes a soaring rich chorus of color. The amplifier and speakers provide even more color as the sound echoes out over a packed stadium [5].

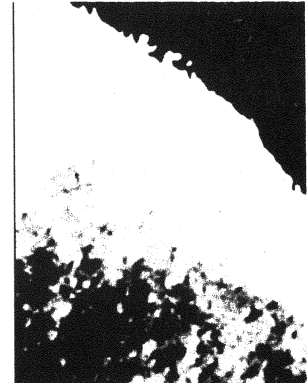**Figure 12:** Amplified charcoal and conte drawing, 90" x 36".   **Figure 13:** Full size detail

Art. The piece is one in a series of large-scale portrait/life drawings in digital print media. Thematically, the drawings focus on people reflecting, resting and pursuing contemplative activities. A charcoal and conte life drawing on paper serves as the raw material. The monochrome hand drawing, after conversion to digital format, becomes amplified and filtered to create a soaring rich chorus of color; color is added to what originally had no color, and patterns emerged from the amplified hand-drawn tone. The edges have the feel of a colored ink drawing, responding to the visual overtones of the original. The figure and background began to merge. Different areas received selective editing until the colors, textures and forms related to each other. The result is a tonally rich piece, with the background melting into the figure, and the figure reflecting the background.

Mathematical Inspiration. The different color areas, as well as the edges of the body, detailed in Figure 13, were inspired in part by a composite Fourier analysis graph of all of the overtones for the pitched tone of an acoustical brass instrument. When Figure 12 is seen in color at full scale, what looks like an irregular line at the edge of the body is actually a set of several different colored lines, with each line representing a different visual "overtone" of the body. It seems appropriate, when amplifying the human figure, that the perceptual geometry of the image reflects the harmonics of nature.

Typology 6: Total Digital Synthesis with Audio Distortion

Music. A digital synthesizer used for creating music starts with simple square waveforms that graph as steps. These original square-edged electronic pulses are then smoothed through filtering, and can produce a pure sound such as that of the flute. Additional texture can be added during amplification, letting the sound attain the richness of an opera singer's voice in a concert hall. The vivid final result is based on a cold, hard beginning, as square waveforms sound more like noise than music.
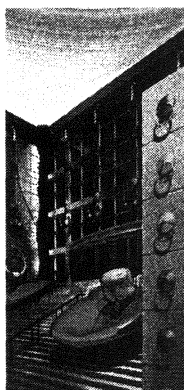

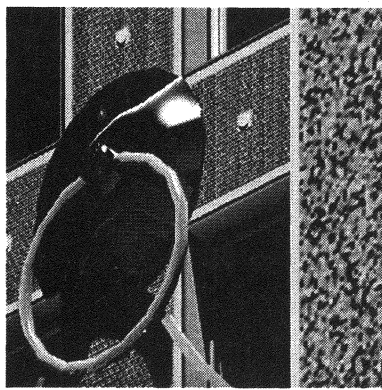**Figure 14:** Digital ray tracing with texture, 36"x75"

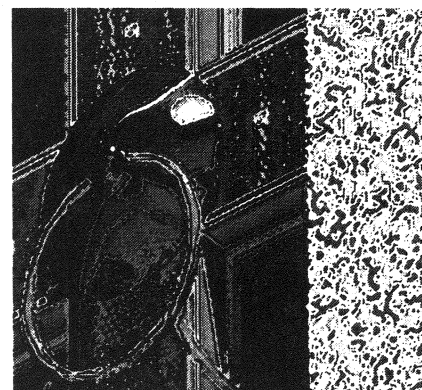**Figure 15:** Detail of amplified body part and jewelry, before texture

Figure 16: Detail of amplified body part and jewelry, after texture

Art. The design is an unsolicited proposal for a site-specific artwork at Chicago's Museum of Contemporary Art. The installation treats the building as someone who needs a makeover, and uses amplified prosthetic body parts, piercings, jewelry and hair to "beautify" the subject. The installation serves as a way to promote discussion about how to modify Modern buildings so that they begin to relate to the human body. Interestingly, the body modifications on the building are also a form of amplification, enhancing the building's physique, as a plastic surgeon would amplify the human form.

In this project, a relatively flat and smooth original digital image (detailed in Figure 15) is treated like the simple waveform that is the building block for a digital synthesizer's sounds. As the image is processed, it acquires a richness of color and texture that can be amplified until the image fills a room, approaching the scale of the viewer (Figure 16). Figure 14 may appear to be related to Figure 15, but is

actually related to Figure 16; the image reads one way from a distance, and continues to reveal more texture as a viewer gets closer.

Mathematical Inspiration. Both the installation artwork and the images describing it are based on a process of fractalization. The existing building is an example of one that lacks a cascading level of interest, especially at close range, where it has a low fractal dimension [6]. The installation increases that fractal dimension. For the images in this typology, the mathematical error for geometry has been kept low, by setting high standards for the computation of geometry (Figure 15). However, the amount of tonal and textural error has been intensified as a way to achieve the desired visual outcome. This is partly inspired by the way a programmer works with predictable and definable error and instability in floating point computations [7]. Another interesting observation is the similarity between edges in Figure 16 and detailed aerial maps of California's coastline, or photos of the edge of the sun, with their fractal edges.

Conclusion

Digitally amplified art presents the opportunity to create artworks that physically relate to human scale and experience, with a physical presence that hand-held images do not have. Typologies from music offer guidance on ways to benefit from the aesthetic and production dilemmas presented by the possibility of high levels of both precision and discontinuity in digital images. These typologies suggest that distortion is a natural part of amplification and, in fact, that controlled distortion may be a human desire.

Image Sources

All images above are original copyrighted works created by Mark Nelson, 2003-2004.

References

[1] David Hockney, *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters*. New York: Viking Studio, 2001.

[2] Rainer Rochlitz, *The Disenchantment of Art: The Philosophy of Walter Benjamin*. New York: The Guilford Press, 1996

[3] Leonard Shlain, *Art and Physics: Parallel Visions in Space, Time and Light*. New York: Quill William Morrow, 1991. p. 16

[4] William H. Press et al, *Numerical Recipes in C: The Art of Scientific Computing*. Cambridge, Massachusetts: Cambridge University Press, 2002. pp 661-666.

[5] The Jimi Hendrix Experience, *Live at Winterland*. Salem, Massachusetts: Rykodisc, 1987.

[6] Carl Bovill, *Fractal Geometry in Art and Design*. Boston, Massachusetts: Burkhauser, 1996.

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