Integration of Real-Time OpenGL Graphics with an Algorithmic Music Composition System
THE GOAL - ALGORITHMIC, REALTIME, FULL-MOTION GRAPHICS & MUSIC

• ALGORITHMIC
connects this aesthetic approach to an existing body of musical composition.

• unifies the musical and visual components of the artwork
  - aesthetic: satisfies first two of Aquinas’ three criteria of Beauty (Unity, Harmony, Clarity.)

• connects with the currently developing “Visual Music” aesthetic.
THE GOAL - REALTIME, ALGORITHMIC, FULL-MOTION GRAPHICS

REALTIME
- emphasizes the performative aspect of this research. The goal is to create a “graphics instrument” which can be performed in realtime just as a traditional musical instrument.

synergistic amplification of creative possibility which occurs with realtime operation that is difficult or impossible to simulate with non-realtime approaches. The classical example of this is in musical instrument performance, where expressive nuance involving the realtime control of loudness and pitch brings a very high aesthetic value to the product.
THE GOAL - REALTIME, ALGORITHMIC, FULL-MOTION GRAPHICS

• **FULL-MOTION**
  - emphasizes the fact that this research is technologically state-of-the-art.
  - implies certain technical standards:

  - minimum 24 frames per second (ideally 30 or 60 fps)
    (Douglas Trumbull says 66 fps hits a resonance in the human nervous system, and 120 fps would be a good standard because 24, 30, 60 could all be derived from it without interpolation.)

  - High Definition resolution of at least 1920w * 1080h
    Theatrical releases are rendered at 2048w, IMAX at 4096w

  - OpenGL is a state-of-the-art graphics environment, highly developed, extremely sophisticated and yet widely available.
OpenGL

• present on virtually every modern personal computer.
• dedicated, specialized highly-parallel hardware to execute it in realtime.
Harmnonia

- Harmnonia (Christos Hatzis)
  - harmonic series expressed simultaneously in visual and audible media.
  - sound generated via a 64-voice additive synthesizer in NI Reaktor
  - visuals generated via openGL 2.1 on a MacPro.
Harmonia

- communicate via MIDI controllers with OpenGL via Transformation Engine (algorithmic composition software)
- each harmonic from 1-64 was independently controlled via MIDI controller 1-64
- additive synth was designed with internal parameter smoothing to make up for MIDI 7-bit resolution.
- worked well for sound

Figure xx: controller data for audio Harmonics 1, 32, 48 and 64 in Harmonia
Harmonia

- **PROBLEM!**
  - MIDI controller resolution is 7 bit (only 128 steps between lowest and highest values)
  - most OpenGL parameters are 32-bit floating point (16,777,216 values between lowest and highest, plus scalable range.)
  - MIDI’s coarse resolution produced unacceptable “stepping” motions and cross-fades. Completely unusable.
Harmonia

• Solution #1

• use MIDI’s high resolution option (14-bit = 16,384 values)

• surprisingly did not substantially reduce the stepping artifacts much

• insufficient resolution esp. where it was needed the most - at the “quiet” or “dim” end of the range, where control values are close to zero

• since each parameter uses TWO controllers, all of MIDI’s controller options were used for simply for the harmonic control. Nothing left for Master Volume, panning, etc.
Solution #2

- Implement a custom controller type within The Transformation Engine which employs 32-bit floating point values.
- Store 32-bit float values within the MIDI track, and outputs them to external software/device via OSC. (UC Berkeley, CNMAT 1997)
- This worked beautifully, allowing complete access to the full-range of OpenGL controls.
Re-Inventing the Wheel

- Direct control adequate for a relatively simple piece (graphically speaking) like Harmonia

- Breaks down when more advanced graphic processing is required.

- Simple example - adding a “glow” to the Harmonia visuals meant I would have to implement my own glow algorithm in OpenGL.

- I needed to find a system that allowed low-level access to OpenGL while also offering high-level processing options.
EARLIER WORK

- **MaxMSP/Jitter**

- **Puredata**
  [http://puredata.info/](http://puredata.info/)

- **Realtime Music Visualization with MIDI and OpenGL**

- **AVSynthesis: Blending Light and Sound with OpenGL and Csound5**

- **Quartz Composer**
Quartz Composer

- Apple Computer 2004-11
- free with OS X Developer Tools
- complete access to the OS graphics libraries, including OpenGL, Core Image, Core Video, Quicktime
- dataflow programming system, (like Max/MSP or PureData)
- Graphics processing modules, ("patches") programmed by connecting input and output ports in data-processing sequence
• with a fast graphics card, OpenGL can calculate a Julia set fractal in less than 1/100 second

• formerly (1980’s) would take overnight on an Atari ST

• possible to consider fractal animation as main Julia set parameters are varied

• rhythmically timed to music

• music freely composed in North Indian Classical style - Bhairava raga (sacred to Shiva) and Jhaptal Tal
• algorithmically controlled music and visual

• Planetary motions from 2000 to 2011 generate musical and visual activity
• Each planet represented musically by a group of orchestral instruments and visually by a particle system.

• TIMEBASE - one minute per year
Anthropos - In Memoriam
Anthropos - In Memoriam

- PLANETARY INTENSITY AFFECTS:
  - pitch width
  - dynamics
  - rhythmic activity
  - harmonicity

- Uses the Transformation Engine compositional renderer
Anthropos - In Memoriam

**ORCHESTRAL CORRESPONDENCES**

- **Moon** - Flutes, Oboes, & Harp
- **Sun** - Strings
- **Mars** - Trumpets, Snare drum, Timpani
- **Mercury** - Clarinets, Bassoons & Xylophone
- **Venus** - Sopranos, Celesta
- **Jupiter** - French Horns
- **Saturn** - Trombones, Tuba, Bass Clarinets, Contrabassoon, Bass Drum & Gong

Tuesday, May 8, 2012
Anthropos - In Memoriam

- VISUAL
  - screen position & size
  - brightness
  - particle activity

Planet Intensity from Transformation Engine (via OSC)
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