STEVE KRANZ

creative **engineer**
rigorous **scientist**
adept **visualizer**
casual **programmer**
crafty **craftsman**

stevejkranz@gmail.com
(330) 475 - 2458
www.stevecrayons.com
308 N. Orchard St., #3
Urbana, IL 61801

Summary

- Improves quality and efficiency.
- Inventive, ambitious spirit.
- Practical lab experience.
- Utilizes fundamentals to find creative solutions.
- Physically and visually design oriented.
- Works diplomatically on teams.

Skills

3-axis CNC mill, laser cutter, SEM, optical microscopy, SolidWorks, COMSOL, Matlab, optical profilometry, UV photolithography, digital photography and video, Adobe Creative Suite, Java programming

Research

Graduate research assistant
Sept. 2010 - August 2013
Urbana, IL

- Designed and manufactured custom printheads for 3D printing applications.
- Used printheads which reduced the manufacture time of novel, industrial polishing pads by a factor of 60.
- With Prof. Jennifer Lewis and others, filed a US patent for printheads.

Undergrad research assistant
Sept. 2007 - May 2010
Tempe, AZ

- Polished, micrographed analyzed sample of Pb-free solder joints.
- Processed 2D array of X-ray tomography images for 3D reconstruction.
- Work was used in the study of mechanics and failure modes in solder joints.

Education

University of Illinois, Urbana-Champaign
2010 - 2013: M.S. in Materials Science and Engineering, GPA: 3.2/4.0

Arizona State University
2006 - 2010: B.S. in Materials Science and Engineering, GPA: 4.0/4.0

US Patent

"Multinozzle deposition system for direct write applications"
J.A. Lewis, C.J. Hansen, **S. Kranz**, J.J. Vericella, W. Wu, D.B. Kolesky
Pub. No.: US 2014/0314954 A1, Pub. Date: Oct. 23, 2014

Publications

Albert Michelson's Harmonic Analyzer:
A Visual Tour of a Nineteenth Century Machine that Performs Fourier Analysis
W. Hammack, **S. Kranz**, B. Carpenter
Articulate Noise Books (2014)
ISBN: 978-0983966173

"High-throughput printing via microvascular multinozzle arrays"
C.J. Hansen, R. Saksena, D.B. Kolesky, J.J. Vericella, **S.J. Kranz**, G.P Muldowny, K.T. Christensen, J.A. Lewis
Advanced Materials, Vol. 25, 96-102 (2012)

"Three-dimensional (3D) visualization of reflow porosity by X-ray tomography and image-based finite element modeling of deformation in Pb-free solder joints"
M.A. Dudek, L. Hunter, **S. Kranz**, J.J. Williams, S.H. Lau, and N. Chawla.
Materials Characterization, Vol. 61, 433-439 (2010)

Work

Video production assistant
August 2013 - present
Urbana, IL

- Filmed, edited and co-directed educational engineering YouTube videos.
- Published on Prof. Bill Hammack's "EngineerGuy" YouTube channel.
- During tenure, channel increased subscriber base by 40% and earned over 1 million additional views.

Steve Kranz stevejkranz@gmail.com

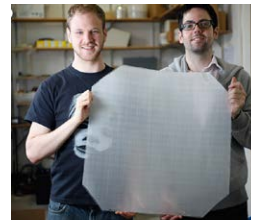
Engineering: 3D printing with multinozzle printheads

Background:

- Goal was to produce novel epoxy polishing pads for electronics applications.
- Pads were produced by 3D printing a visco-elastic wax ink.
- Wax filaments were deposited in a woodpile microstructure.
- Liquid epoxy was flowed through void space of printed structure, then cured.
- Wax filaments were washed out, yielding a solid epoxy structure.
- Epoxy pads were tested by our collaborators at Dow Chemical.

4 layers

The woodpile microstrucure yields a better polishing surface than traditional random structured polishing pads.



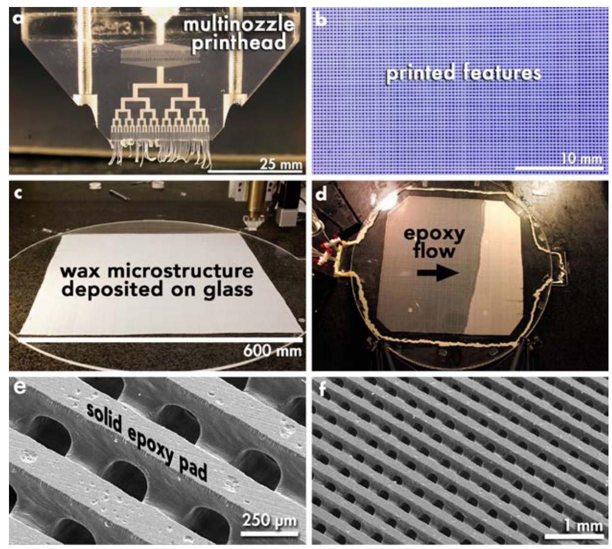
A completed epoxy pad, created with a mulitnozzle printhead.

Problem:

- The pad was large (0.36 m^2) while the features were small (200 μm).
- Printing a pad took over 24 hours using a standard single nozzle deposition technique .

Solution:

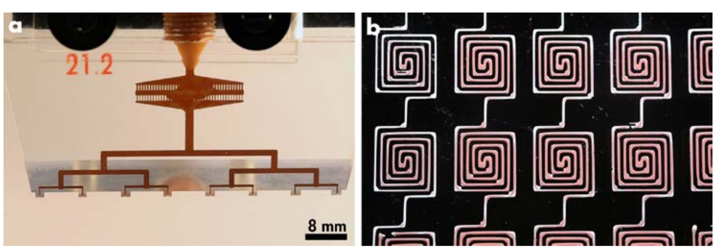
- Built a "multinozzle" printhead to deposit 64 filaments in parallel.
- Printhead is machined from PMMA.
- Contains microchannels that split single input into 64 equal outputs.
- Each output extrudes a square filament 200 μm on a side.
- Variation in flowrate less than 5% across all outputs in a printhead.
- Printheads can withstand >750 psi internal pressure.
- With multinozzle, print time reduced ~60× (24 hours to 25 minutes).
- The process of designing and manufacturing these printheads is described on the followng page.



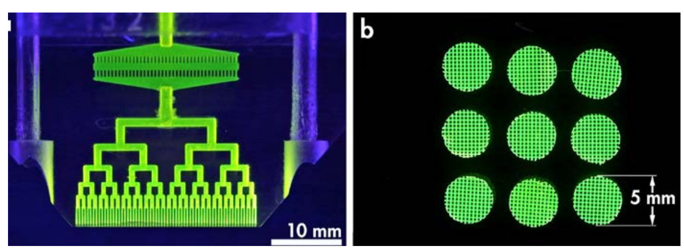
(a) An example of a multinozzle printhead. A single input at top repeatedly forks to 64 outputs at bottom. (b) The deposited woodpile pattern viewed from above. The wax ink flouresces blue under UV. (c) Four layers of wax filaments deposited on a glass plate. (d) The inflow of epoxy from left to right. (e, f) SEM micrographs of a solid epoxy polishing pad.

Further applications:

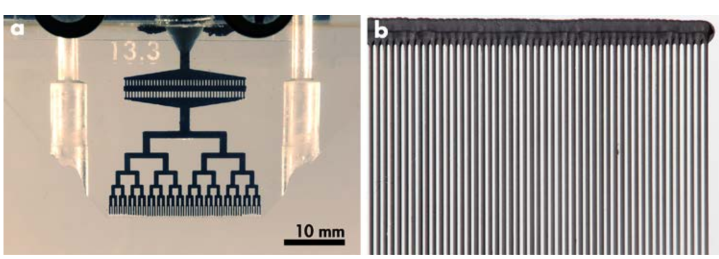
- Upon success of the primary goal of decreasing print time of the pads, further applications of the multinozzle printheads were explored.
- Created multinozzle with 128 outputs and 100 μm feature size.
- Adapted design to print antenna patterns using a conductive silver ink.
- Printed variable gradients (from 13% to 100% fill factor).
- Used poly(hyaluronic) acid ink to print scaffolds for stem cell cultivation.
- Printed ceramic-particle CuO ink to for thermite testing.



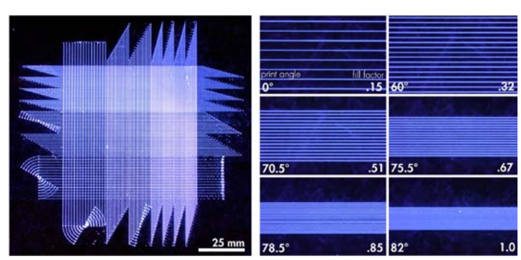
An electrically conductive silver ink patterned in spiral-antenna patterns.



Poly(hyaluronic) hydrogel used to print scaffolds for stem cell cultivation.



Multinozzle used to pattern ceramic CuO ink for thermite studies.



Multinozzle employed to print variable densities depending on orientation of printhead relative to printing direction.

- Details in full MS thesis: http://stevecrayons.com/msthesis/MS_Thesis_Steve_Kranz_UIUC_2013.pdf

Engineering: manufacturing multinozzle printheads

Background:

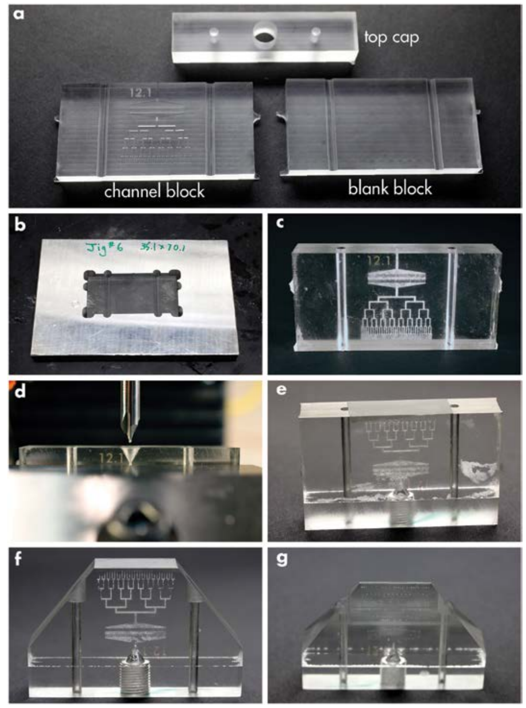
- Made printheads through a series of machining, polishing and welding operations.
- Shaped a block of PMMA to 70 x 35 x 8 mm (±10 μm) using a 3-axis CNC mill.
- Used CNC mill to cut microchannels (200 μm ± 2 μm wide) in face of PMMA block.
- Block with channels mated with two other blocks of PMMA.
- Finishing milling operations cut out package to its final form.

Problem:

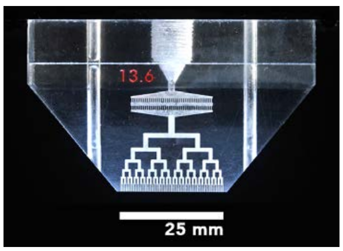
- Early devices suffered from low interfacial strength and low repeatability.
- Early devices were time-consuming and difficult to manufacture.

Solution:

- Developed a work-holding routine to efficiently form the blocks.
- Optimized the G-code program for cutting channels with CNC mill, reducing machining time by 30x (3 hours to 6 minutes).
- Reduced manufacturing defects via robust machining practices.
- Built over 60 total devices with several variations of internal microchannels.



(a) The 3 pieces that compromise the printhead. (b) The channel block is solvent welded to the blank block in a jig (c) The blank and channel block assembly. (d) A conical input reduces pressure drop at internal surface of the device. (e) A fully mated device with top cap welded on. (e,f) Device is formed to a taper to facilitate material deposition and imaging of working device.



Completed multinozzle printhead. This design features a filter that prevents debris from clogging channels.

Made over 60 total multinozzle printheads. Each series increment represents a significant change in manufacture or microchannel design.

Science: 1D & 3D modelling of microfluidic channel networks

Background:

- Microfluidic network must extrude 64 filaments, 200 μm square on a side.
- Network must distribute ink evenly across all outputs.
- Network should minimize hydraulic resistance to increase extrusion rate.

Hypothesis:

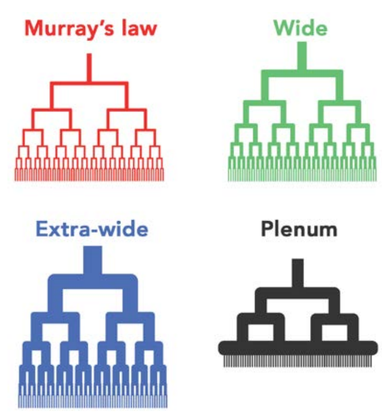
- A network mimicking the structure of organic fluidic networks is an ideal design.
- 3D laminar flow in channels can be modeled using 1D approximations.

Experiment

- Used COMSOL to model 3D Newtoninan and shear-thinning fluid flow in channel networks.
- Wrote MATLAB scripts to implement a custom 1D model of laminar flow in channel networks.
- Performed physical experiments to measure fluid flow for comparison to 1D and 3D models.
- Used 1D model to calculate resistance and tolerance to defects of multiple network designs.

Conclusions

- 1D model validated by 3D model and experiment.
- Very fast 1D model allowed testing of many network variations for design analysis.
- Networks mimicking natural structures (Murray's law) had undesirably high hydraulic resistance.
- A network with wider channels reduced resistance by 5 times, resulting in faster extrusion.
- A "plenum" design reduced resistance by 8 times, but was more prone to uneven flow.

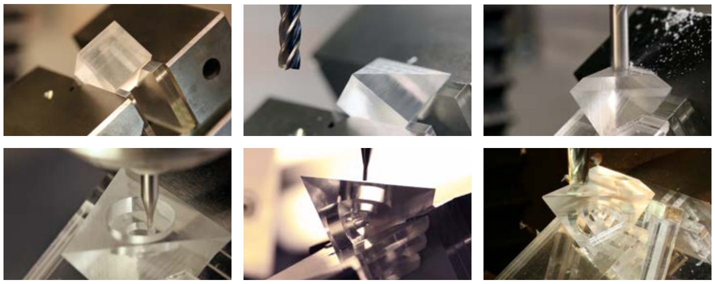


These microfluidic network designs were modeled and tested experimentally. Murray's law is a natural pattern that relates the diameter of a parent channel relative to a child channel. Networks that deviated from Murray's law via wider channels resulted lower hydraulic resistance and yielded faster extrusion rates.

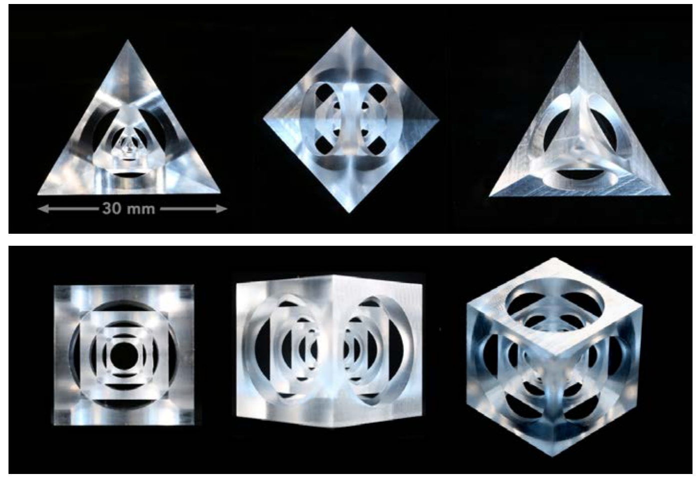
- Details in full MS thesis (.pdf, 40 MB): http://stevecrayons.com/msthesis/MS_Thesis_Steve_Kranz_UIUC_2013.pdf

Craftsmanship: Turner's tetrahedron

- Used a 3-axis CNC mill to machine a complex shape in acrylic.
- Turner's tetrahedron is a novel adaptation of classic "Turner's cube"
- Created by a series of "face-mill" and "pocket" operations.
- Final form is a tetrahedron in a tetrahedron in a tetrahedron.
- Required high precision and innovative work holding.
- Made a step-by-step guide.

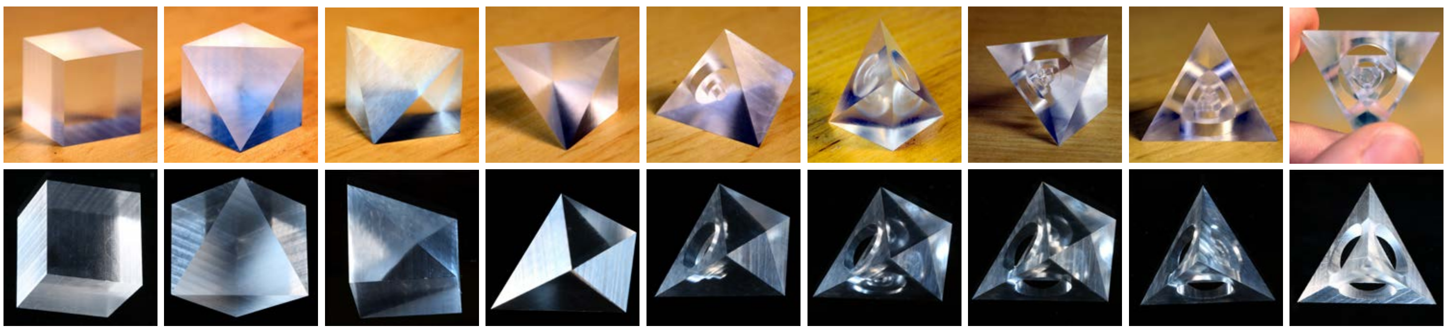


Above, the turner's tetrahedron in various stages of manufacture. The part is held in a sine vise and machined with a 3-axis CNC mill.



Top row: Turner's tetrahedron looking face-on, edge-on, and point-on.
Bottom row: Turner's cube looking face-on, edge-on, and point-on.

Below, each step in manufacture. Top row the part sits on a wood table, in bottom row part sits above a piece of glass, camera shooting from below.

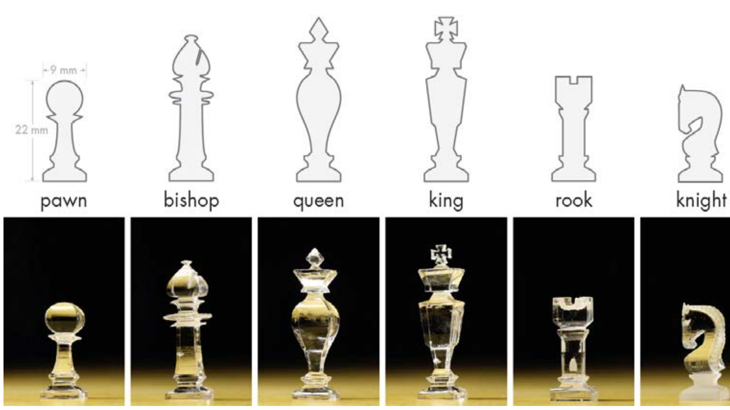


step 0	1	2	3	4	5	6	7	8
cube	cut first face	second face	third face	first pockets	second pockets	third pockets	fourth face	fourth pockets

- Step-wise guide to making Turner's tetrahedron (.pdf, 4 MB): http://stevecrayons.com/pdf/Turner's_Tetrahedron.pdf

Craftsmanship: Miniature chess pieces

- Used a CO_2 laser cutter to create miniature chess pieces.
- Used 3/8" thick acrylic sheet.
- Drew profiles of the pieces in Adobe Illustrator.
- Made a step-by-step guide.



- Guide to making chess pices (.pdf, 4 MB): http://stevecrayons.com/chess/Laser_Cutter_Chess_Pieces.pdf

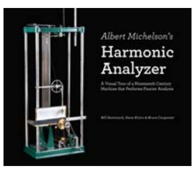
Visualization: Albert Michelson's harmonic analyzer

Videos

- Filmed video series for YouTube (23 min total).
- 300,000+ views for series.
- Edited videos using Adobe PremierePro.
- Helped restore a 19th century calculating machine.
- Machine uses gears and levers to add sine waves.
- Input values by adjusting the position of bars.
- Turn hand crank to drive machine.
- Output is a curve plotted on paper.
- Machine performs Fourier synthesis and analysis.
- https://www.youtube.com/watch?v=8KmVDxkia_w

Book

- Co-wrote a 130-page companion book to the video series.
- Responsible for the 150 photographs of the machine.
- Laid out the book using Adobe InDesign.



Albert Michelson's Harmonic Analyzer:
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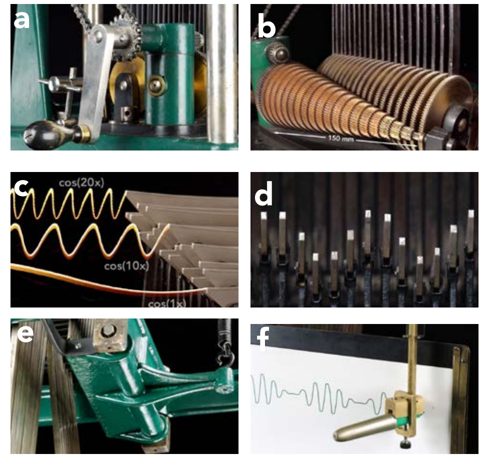
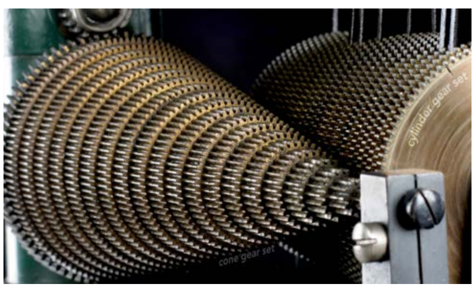
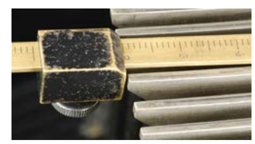


(a) The crank that drives the machine. (b) A conical set of gears drives a second set of gears at various rates. (c) In turn, levers rock up and down at various frequencies. (d) Inputs, corresponding to the amplitudes of of sine waves, are set by positioning a set of bars. (e) Apparatus at top of the machine sums the frequencies × amplitudes. (f) A pen plots the result of the summation on paper.



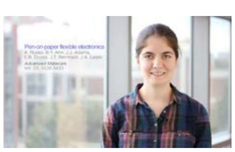


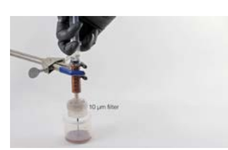
- PDF of book (45 MB): http://www.engineerguy.com/fourier/pdfs/albert-michelsons-harmonic-analyzer.pdf

Visualization: Electrically conductive silver ink pen

Video

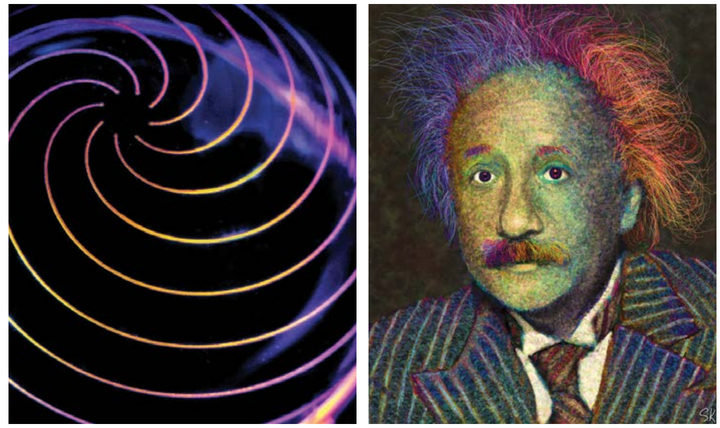
- Directed, filmed and edited video (3.5 min).
- 150,000+ views on YouTube.
- Video introduces a pen that writes conductive silver traces.
- Includes stepwise guide to manufacturing the silver ink.
- Product is educational aid for teaching circuit basics.
- "Circuit Scribe" was successfully funded on Kickstarter.
- Product now commerically available.
- Research and development by A. Russo, J. A. Lewis, et al.
- https://www.youtube.com/watch?v=dfNByi-rrO4

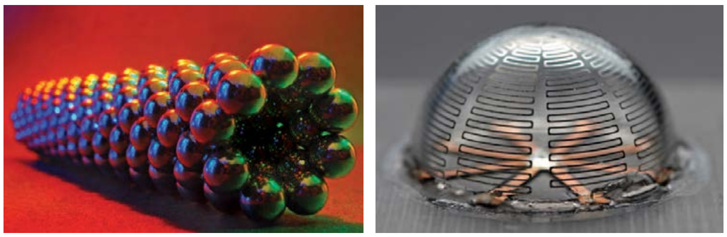


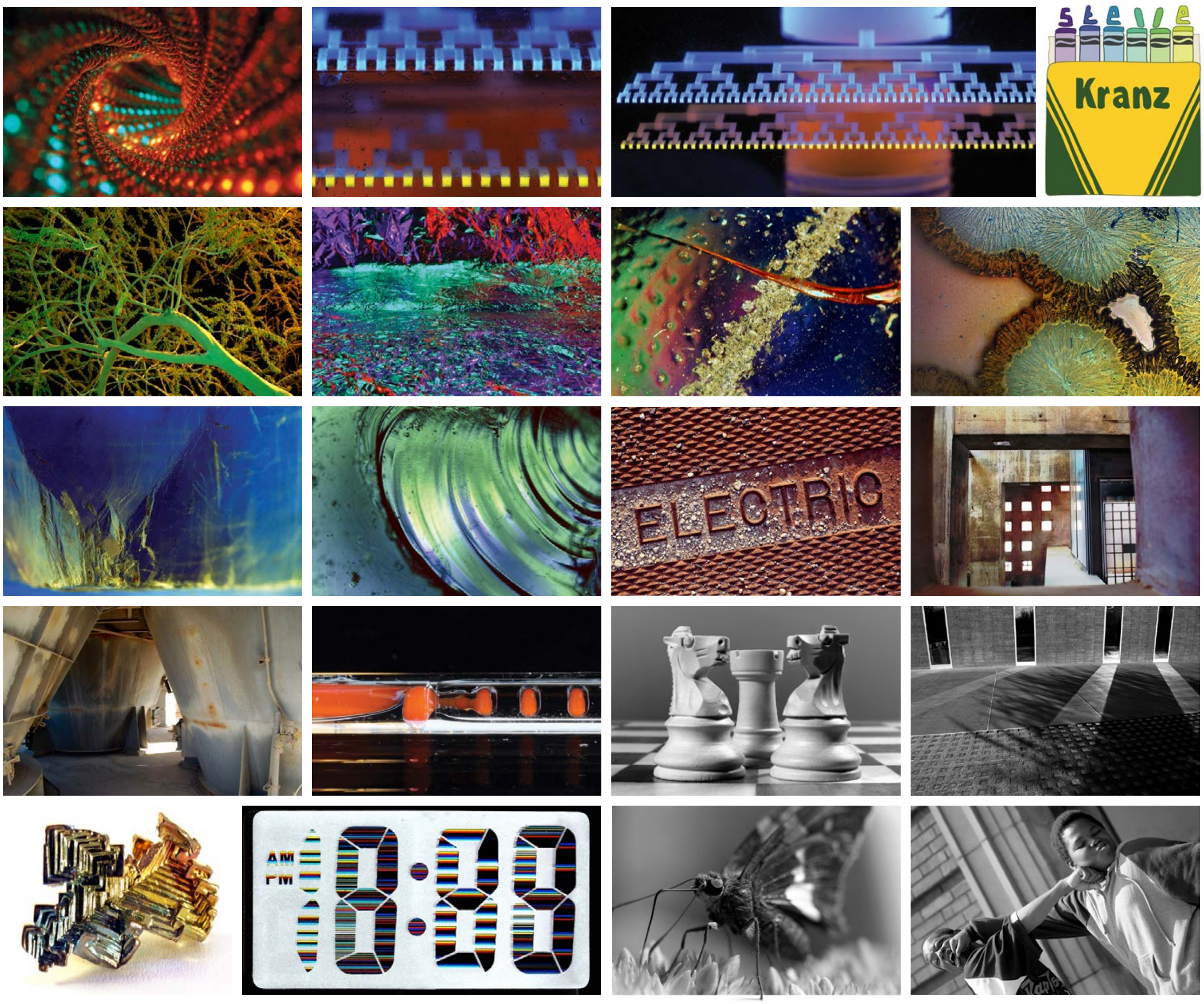


Visualization: Photography & Illustration

- 10+ years photography experience.
- Taken 25,000+ photos.
- Extensive practice in macro photography.
- Specialize in lighting still life subjects.
- Experience in 2D and 3D illustration.
- Proficient in Adobe Photoshop and Illustrator.



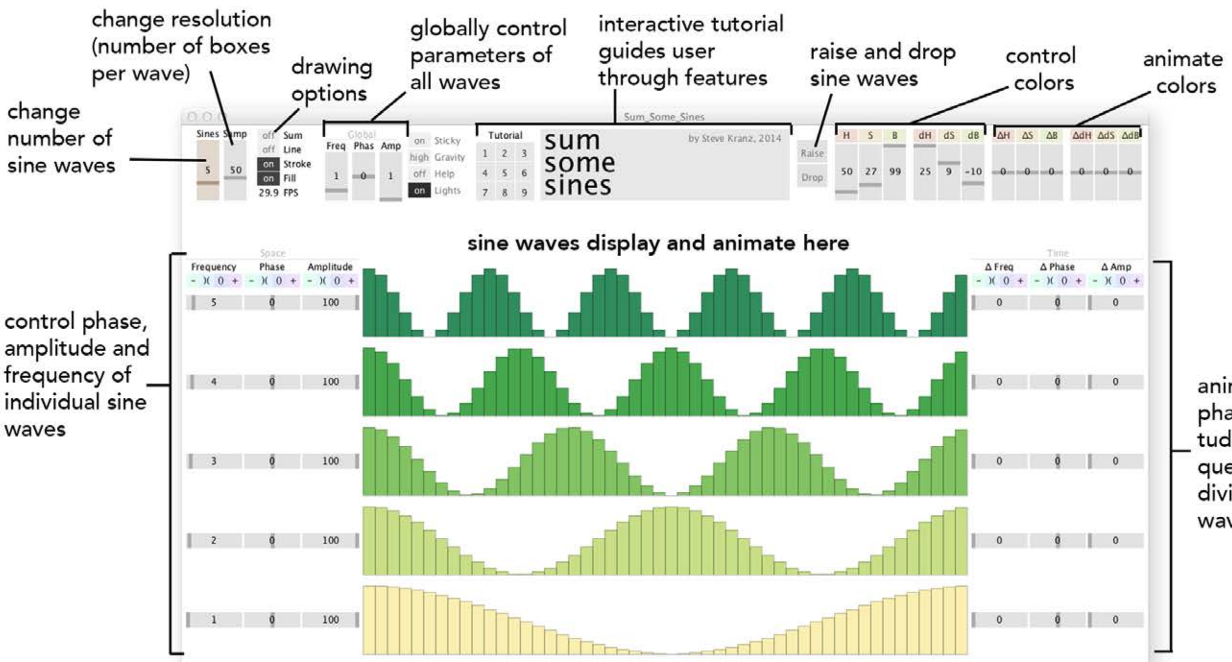


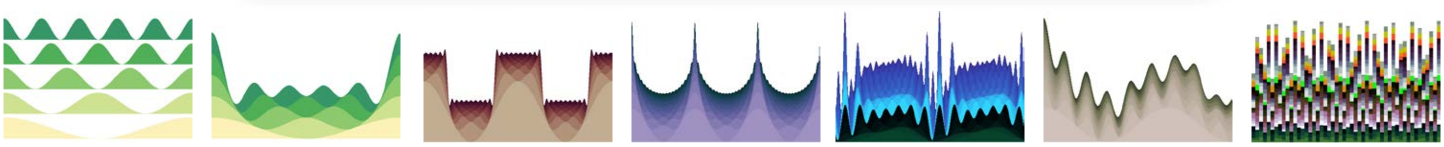


- Portfolio, 2013 - 2011 (.pdf, 14 MB): http://stevecrayons.com/pdf/Portfolio_2013_Steve_Kranz.pdf
- Portfolio, 2010 - earlier (.pdf, 10MB): http://stevecrayons.com/pdf/Portfolio_2010_Steve_Kranz.pdf

Programming: Sum some sines

- Programmed in Java using Processing (100+ hours).
- Exported as Java applet and online JavaScript app.
- Program visualizes the addition of sinusoids.
- Each sinusoid is a series of boxes with varying height.
- Boxes of one sinusoid drop and stack onto others.
- 300+ total buttons, sliders and controls.
- Can control amplitude, phase and frequency of up to 40 sine waves.
- Amplitude, phase and frequency can vary in time.
- Many complex shapes like a square wave or a sinc can be made.
- Colors of sinusoids can be controlled and animated.

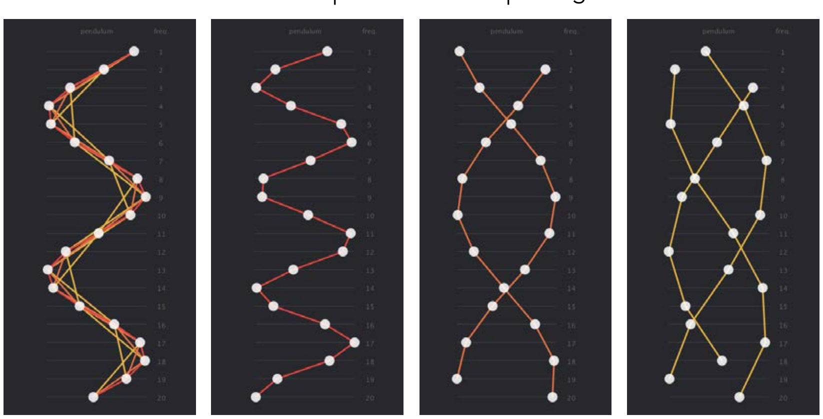


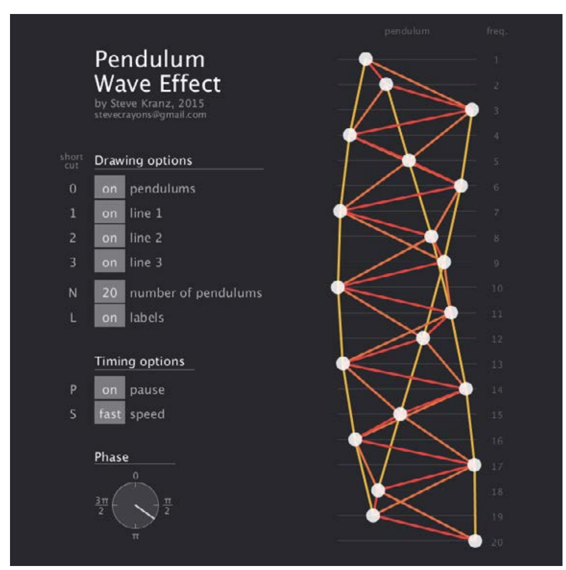


- JavaScript applet (runs slow) : http://stevecrayons.com/sines
- Java download (fast): http://stevecrayons.com/sinesDL

Programming: Pendulum wave effect

- Programmed in Java using Processing (10 hours).
- Program simulates an array of oscillating pendulum bobs.
- Top bob oscillates left and right at a fundamental frequency.
- Other bobs oscillate at the harmonics of the first bob.
- The bobs' collective motion produces a 3D spinning illusion.





- JavaScript applet: http://stevecrayons.com/pendulum