MA595 Winter 2012 Mini-Course in Geometry: COMPUTER GRAPHICS & GEOMETRICAL VISUALIZATION

Lawson's Snail. Crossed eye stereo left two, straight stereo right two images.

Professor George Francis
3MWF 141 Altgeld Hall 17jan12-09mar12, 2 credit hours.

We present the geometry of computer graphics, emphasizing real-time interactive computer animation (RTICA) for mathematical visualization, in particular for an immersive virtual environment, the CUBE, CAVE, and CANVAS of the Illinois Simulator Lab (ISL) of the Beckman Institute. Topics include the structure of the OpenGL graphical pipeline, the polyhedral encoding of surfaces as triangular meshes, the geometry of linear and aerial perspective (light and shade), the representation of the 3-D affine group in 4-D homogeneous coordinates, the algebra of 3-D rotations in terms of unit quaternions, projective spaces and their Euclidean, spherical and Minkowski (hyperbolic) metrics. We will explore non-Euclidean splines and morphing techniques, real time interactive texture mapping, and other advanced graphics techniques for innovative mathematical application. The course also includes a survey of classical topics including binocular optics and color theory, Hausdorff dimension and fractals, chaos and strange attractors, Wolfram's cellular automata, Barnsley's iterated function systems, Julia and Mandelbrot sets, discrete and continuous logistic equations, and the Lienard-VanderPol dynamical system.

Prospective students should have a good spatial intuition, some artistic abilities or ambitions, and a solid grounding in linear algebra and vector calculus. Students may participate in a concurrent tutorial, on useful line and surface graphics tools for the classroom and the dissertation, that does not require programming. Students with experience programming in any computer language, such as BASIC, Pascal, C/C++, Java, Python, or Mathematica, may gain 2 additional credits of independent study for a graphics programming project appropriate to the course and tailored to the proficiency of the student. In particular, projects suitable for a virtual environment at ISL are not only supported but strongly encouraged.