Visualization of Chaos for Finance Majors

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Abstract

Efforts to simulate turbulence in the financial markets include experiments with the logistic equation: x(t)=kappa x(t-1)[1-x(t-1)], with 0 < x(t)<1 and 0 = < kappa < 4. Visual investigation of the logistic equation show the various stability and instability regimes for the various value of the Feigenbaum number kappa. Visualizations for t=20 observations provide clear demonstrations of the stability regimes. We visually investigate these regimes in more detail in the t=101-110 range. For 0 < kappa < 3, the process settles to a unique stable equilibrium. For 3= < kappa < 3.6 the process bifurcates, or, as colored visualization shows but not black-and-white, its pitchfork bifurcation branches "bang-bang" switch between two regimes. For 3.6= < kappa = < 4.0 the process becomes chaotic, i.e., deterministically random. In this regime are windows of stability, e.g., at kappa=3+2sqrt=3.8284. At kappa=4, pure chaos, the process is extremely sensitive to initial values, as visually is clearly demonstrated. We increase the number of observations to t=1000 and compute the homogeneous Hurst exponent of the process at kappa=4: H=0.004, indicating that x(t) is blue noise, i.e., extreme anti-persistent. A histogram shows a highly platykurtic distribution of x(t), with an imploded "mode," with extremely fat tails higher than the "mode," against the reflecting values at x=0 and x=1. Several plots of the state directory of the system in the (x(t),x(t-1))-space trace out the parabolic strange attractor. Although the strange attractor is a well-defined parabole, the points on the attarctor set are deterministically random and unpredictable.

Keywords: Logistic Equation, Visualization, Strange Attractor, Chaos, Hurst Exponent

JEL Classification: C15, C19, C33, C49

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