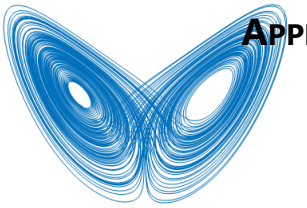

Application of Swarm Intelligence to Bifurcation Analysis

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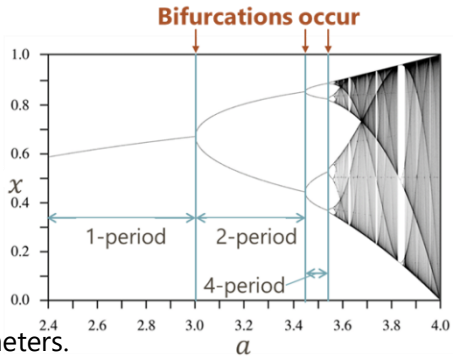
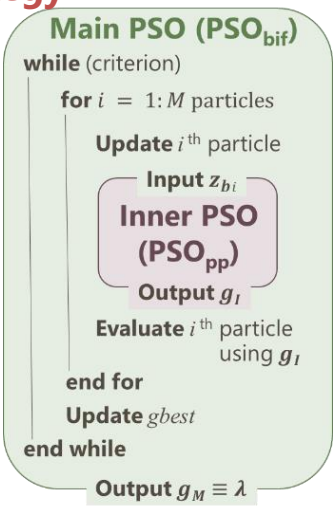
Background



- **Dynamical systems**
  - Complex real-world dynamics can be modeled as dynamical systems.
  - Analyzing dynamical systems is important to solve a variety of problems in the real world.
- **Bifurcation**
  - Dynamical systems mostly contain one or more parameters.
  - Bifurcation occurs when a small change, applied to the parameter values of a system, causes a sudden qualitative change in the periodic solutions' behavior.
  - Bifurcation analysis, which investigates how bifurcation depend on the system parameters, is one of the most important nonlinear analysis techniques for understanding phenomena of systems.
- **Bifurcation Parameter Detection Methods**
  - Brute-force method requires larger amount of calculations.
  - The classic methods based on Newton method require the derivative of the objective functions and appropriate initial conditions.

Proposal of Bifurcation Parameter Detection Strategy Based on Particle Swarm Optimization



- **Particle Swarm Optimization (PSO)**
  - is one of the simplest population-based optimization techniques.
  - avoids the derivative of the objective function.
- **Bifurcation Parameter Detection Strategy by using the Nested-Layer PSO (NLPSO)**
  - is a **non-Newton method** and is performed by two nested PSOs.
  - requires **no strict settings of initial values** or **cumbersome manual calculations**.
  - can accurately and directly find the bifurcation parameters set.
  - can obtain a bifurcation diagram of **both unstable and stable periodic points.**
  - is applicable to detection of
    - local bifurcations including **period-doubling, saddle-node and Neimark-Sacker bifurcations**.
    - **border-collision bifurcations** in piecewise smooth maps.