Introduction to Evolutionary Computation

This material is adapted from a presentation constructed by Gerry Dozier at Auburn University

Introduction to Evolutionary Computation

- Evolutionary Computation is the field of study devoted to the design, development, and analysis is problem solvers based on natural selection (simulated evolution).
- Evolution has proven to be a powerful search process.
- Evolutionary Computation has been successfully applied to a wide range of problems including:
  - Aircraft Design,
  - Routing in Communications Networks,
  - Tracking Windshear,
  - Game Playing (Checkers [Fogel])

Introduction to Evolutionary Computation (Applications cont.)

- Robotics,
- Air Traffic Control,
- Design,
- Scheduling,
- Machine Learning,
- Pattern Recognition,
- Job Shop Scheduling,
- VLSI Circuit Layout,
- Evolvable Hardware

Introduction to Evolutionary Computation (cont.)

- An Example Evolutionary Computation

```
Procedure EC{
  t = 0;
  Initialize Pop(t);
  Evaluate Pop(t);
  While (Not Done)
  {
    Parents(t) = Select_Parents(Pop(t));
     Offspring(t) = Procreate(Parents(t));
     Evaluate(Offspring(t));
     Pop(t+1)= Replace(Pop(t),Offspring(t));
     t = t + 1;
  }
```

Introduction to Evolutionary Computation (cont.)

- In an Evolutionary Computation, a population of candidate solutions (CSs) is randomly generated.
- Each of the CSs is evaluated and assigned a fitness based on a user specified evaluation function. The evaluation function is used to determine the 'goodness' of a CS.
- A number of individuals are then selected to be parents based on their fitness. The *Select_Parents* method must be one that balances the urge for selecting the best performing CSs with the need for population diversity.

Introduction to Evolutionary Computation (cont.)

- The selected parents are then allowed to create a set of offspring which are evaluated and assigned a fitness using the same evaluation function defined by the user.
- Finally, a decision must be made as to which individuals of the current population and the offspring population should be allowed to survive.

Introduction to Evolutionary Computation (cont.)

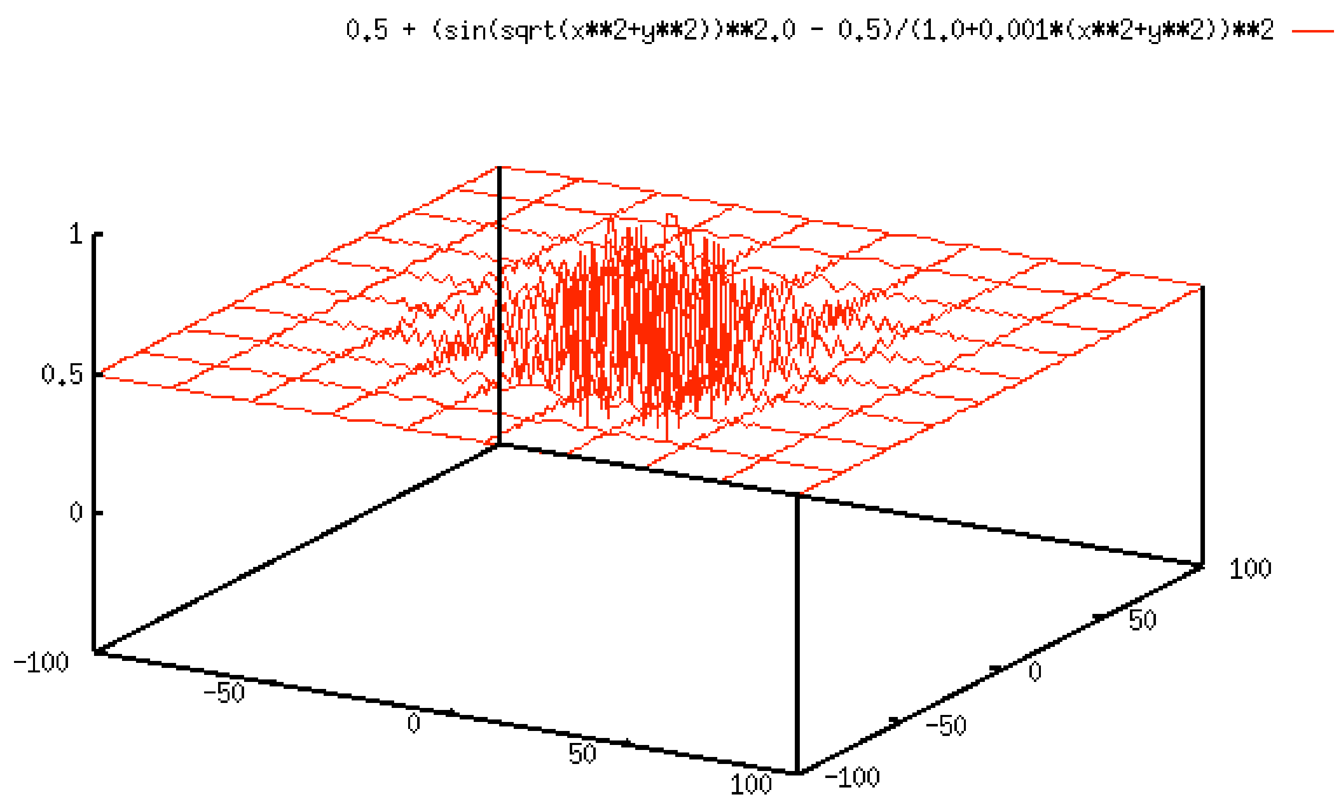
- Once a decision is made the survivors comprise the next generation (Pop(t+1)).
- This process of selecting parents based on their fitness, allowing them to create offspring, and replacing weaker members of the population is repeated for a user specified number of cycles.
- Stopping conditions for evolutionary search could be:
  - The discovery of an optimal or near optimal solution
  - Convergence on a single solution or set of similar solutions,
  - When the EC detects the problem has no feasible solution,
  - After a user-specified threshold has been reached, or
  - After a maximum number of cycles.

Introduction to Evolutionary Computation: A Simple Example

- Let's walk through a simple example!
- Let's say you were asked to solve the following problem:
  - Maximize:
  - $f6(x,y) = 0.5 + (\sin(\mathrm{sqrt}(x^2+y^2))^2 - 0.5)/(1.0 + 0.001(x^2+y^2))^2$
  - Where x and y are take from [-100.0,100.0]
  - You must find a solution that is greater than 0.99754, and
  - you can only evaluate a total of 4000 candidate solutions (CSs)
- This seems like a difficult problem. It would be nice if we could see what it looks like! This may help us determine a good algorithm for solving it.

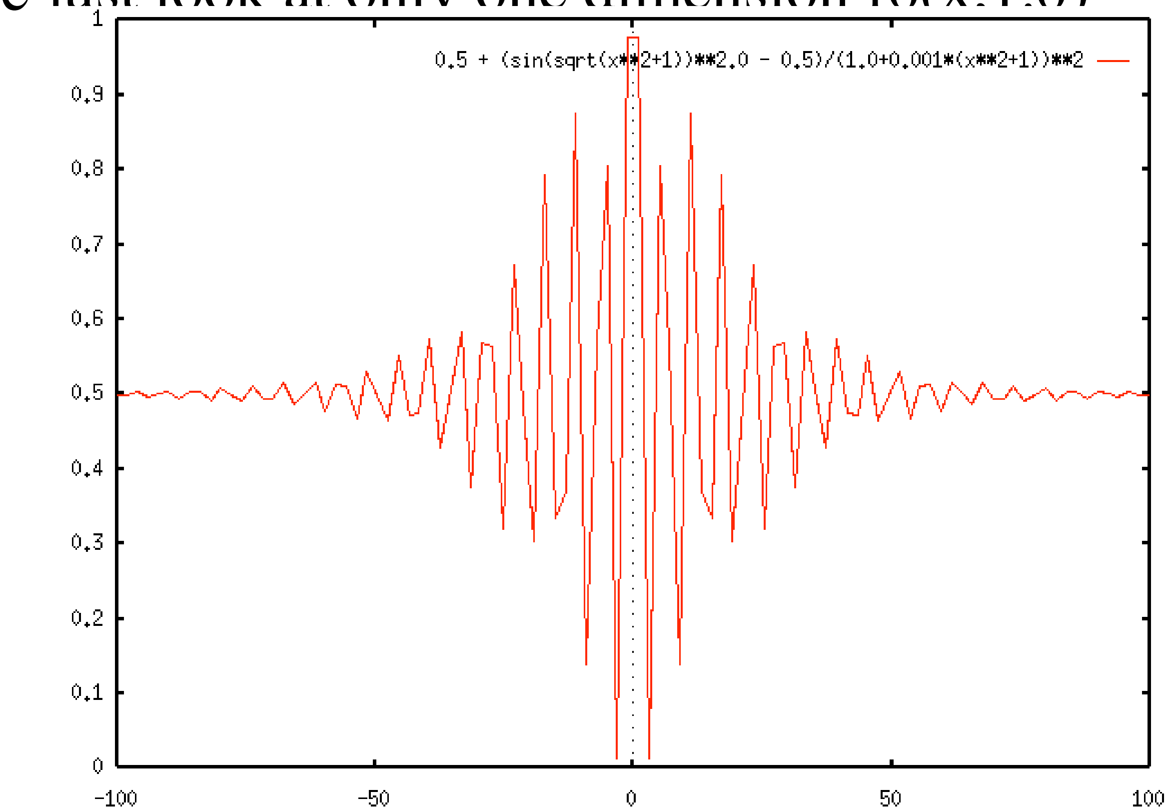
Introduction to Evolutionary Computation: A Simple Example

- A 3D view of f6(x,y)



Introduction to Evolutionary Computation: A Simple Example

- If we just look at only one dimension f6(x,1.0)



Introduction to Evolutionary Computation: A Simple Example

- Let's develop a simple EC for solving this problem
- An individual (chromosome or CS)
  - $<x_i, y_i>$
  - $fit_i = f6(x_i, y_i)$

Introduction to Evolutionary Computation: A Simple Example

```
Procedure simpleEC{
     t = 0;
     Initialize Pop(t); /* of P individuals */
     Evaluate Pop(t);
     while (t <= 4000-P){
        Select_Parent(<x_mom,y_mom>); /* Randomly */
        Select_Parent(<x_dad,y_dad>); /* Randomly */
        Create_Offspring(<x_kid,y_kid>):
           x_kid = rnd(x_mom, x_dad) + N_x(0,□);
           y_kid = rnd(y_mom, y_dad) + N_y(0,□);
        fit_kid = Evaluate(<x_kid,y_kid>);
        Pop(t+1) = Replace(worst,kid);{Pop(t)-{worst}}□{kid}
        t = t + 1;
     }
}
```

Introduction to Evolutionary Computation: Reading List

1. Bäck, T., Hammel, U., and Schwefel, H.-P. (1997). "Evolutionary Computation: Comments on the History and Current State," *IEEE Transactions on Evolutionary Computation*, VOL. 1, NO. 1, April 1997.
2. Spears, W. M., De Jong, K. A., Bäck, T., Fogel, D. B., and de Garis, H. (1993). "An Overview of Evolutionary Computation," *The Proceedings of the European Conference on Machine Learning*, v667, pp. 442-459. (http://www.cs.uwyo.edu/~wspears/papers/ecml93.pdf)
3. De Jong, Kenneth A., and William M. Spears (1993). "On the State of Evolutionary Computation", *The Proceedings of the Int'l Conference on Genetic Algorithms*, pp. 618-623. (http://www.cs.uwyo.edu/~wspears/papers/icga93.pdf)