Particle Swarm Optimization

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Optimization

- Maximization
  - Accuracy
  - Profit
- Minimization
  - Error
  - Time
  - Cost

Different Techniques

- Particle Swarm Optimization (PSO)
- Genetic Algorithm (GA)
- Differential Evolution (DE)
- Simulated Annealing (SA)
- ..

Particle Swarm Optimization (PSO)

Particle Swarm Optimization (PSO)

- An optimization technique based on bird flocking behavior.
- *Birds (Particle)* moves around in the search space looking for the *food (best solution)*.
- An individual gains knowledge from other members in the swarm.

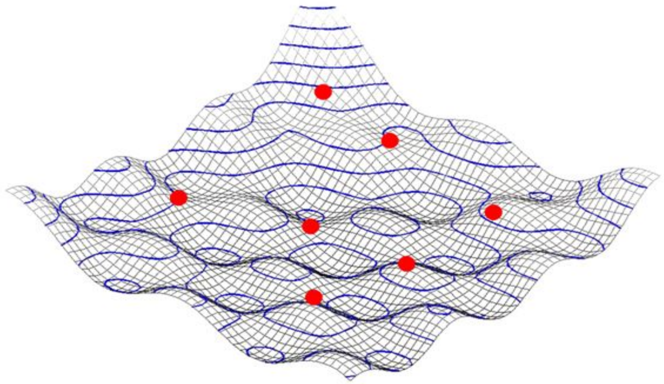

Image courtesy: http://www.turingfinance.com

Animation courtesy: University of Stuttgart

Particle Swarm Optimization (PSO): Basic Idea

1. Evaluate
   - Quantifies the goodness of each particle
2. Compare
   - Obtains the best solution by comparing the particles
3. Imitate
   - Produces new particles based on the best solution

Steps of PSO

Particle *p*: 110100011010011

1. Particles Encoding and Population Initialization
   a. Each particle is a sequence of *binary bits*

2. Fitness values computation
   a. Each particle has real-valued *fitness score* (*objective function score*)

3. Updation of global and best position value
   a. Each particle maintains its *best position* (objective function score) attained so far
   b. A *global best postion* is also maintained across all particles.

4. Updation of velocities
   a. Measures the new velocity according to *global* and *best position* values

5. Sampling new particles
   a. Generate new particle position

6. Repeat steps 2-5 for next iteration until the termination criteria is met.

7. Stop and report fittest particle.

A step-by-step example for Feature Selection using PSO

Feature Selection using PSO

Feature Selection

- Determines the relevant features for the task
    - the most relevant set of features *w.r.t.* some objective function(s)
- Reduces the dimensionality
- Improves predictive accuracy
- Reduces complexity of the training model
    - Space and time both

PSO steps (0 of 5): Prepare feature files

Feature Selection:

Prepare training and testing feature files.

	Features					
	Word	Prev	Next	WordLen	Stop	POS
Sample feature file	The	NULL	food	0	1	DT
	food	The	was	0	0	NN
	was	food	good	0	1	VBD
	good	was	but	0	0	JJ
	but	good	service	0	1	CC
	service	but	was	1	0	NN
	was	service	poor	0	1	VBD
	poor	was	.	0	0	JJ
	.	poor	NULL	0	0	.

PSO steps (1 of 5): Particle encoding and Population Initialization

Feature Selection:

Population size: 5

Particle dimension: 6 (= number of features)

P_1	1	0	1	0	1	1
P_2	0	1	1	0	0	1
P_3	1	0	0	1	1	0
P_4	1	0	1	0	0	1
P_5	1	1	0	1	0	0

Bits are randomly initialized to 0 and 1

PSO steps (2 of 5): Fitness Calculation

Feature Selection:

Train classifier on selected ***features*** and evaluate

P_4	1	0	1	0	0	1	71.24
Features for P_4	The		food			DT	
	food		was			NN	
	was		good			VBD	
	good		but			JJ	
	but		service			CC	71.24
	service		was			NN	
	was		poor			VBD	
	poor		.			JJ	
	.		NULL			.	

PSO steps (3 of 5): Update global and best position value

Calculate *fitness value* for each particle in current iteration

$Iteration_t$	P_1	1	0	1	0	1	69.78
	P_2	1	0	1	1	0	71.24
	P_3	0	1	1	0	0	70.68
	P_4	1	0	0	1	1	70.23
	P_5	1	1	0	1	0	67.94

Update personal best of each particle

$$B(p) = \max\{fitness(p_t), fitness(p_{t-1})\} \quad \forall p \in P$$

Update global best

$$G = \max\{B(p)\} \quad \forall p \in P$$

PSO steps (4 of 5): Update velocity

Velocity controls rate of change of each component of the particle

$$v_d = w * v_d + \mu_1 (b_d - x_d) + \mu_2 (g_d - x_d)$$

where

x_d : current position;

b_d : previous best position;

g_d : global best position;

w : weight (lies between 0 and 1; controls *global* and *local* exploration)

μ_1 and μ_2: cognitive and social scale parameters

PSO steps (5 of 5): Sample new particles

Each position of the particle is updated as follows:

$$x_d = 1 \quad \text{if } r < 1/1+\exp(-v_d)$$

$$= 0 \quad \text{otherwise}$$

where

$$0 \leq r \geq 1$$