



Optimization through Fireflies

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Biologically-Inspired Intelligent Systems

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The Firefly Algorithm (FA)



- Based on flashing behavior of tropical fireflies (>2K species)
 - Rhythm of flash, rate of flashing, & amount of time between flashes create signal system for sex
 - Females respond to male's unique pattern of flashing (in same species)
 - Some fireflies can synchronize flashes → emergent biological self-organized behavior
- Light intensity at distance r (from light source) follows inverse-square law
 - Intensity I decreases as distance r increases, $I \propto \frac{1}{r^2}$
 - Air absorbs light (makes it weaker w/ increasing distance)
 - Above 2 factors make fireflies visible at bounded distance (~100 meters) and flashing light can be tied to an objective function to be optimized

Side Note

- Some outsider (Photuris) females could “eavesdrop” and trick a male to coming to hear so she can *eat* him
 - This is a real firefly version of “*Maneater*” or “*Fireflyeater*”
 - Could this be the basis of yet another metaheuristic?



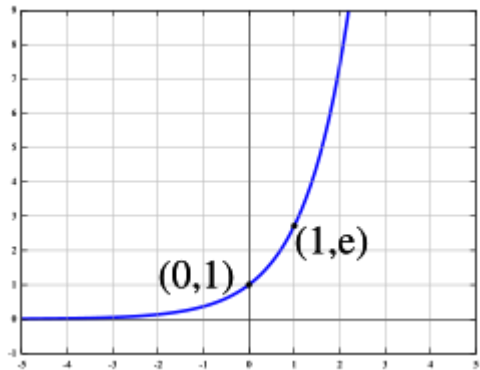
Firefly Simplified Principles

- All fireflies are unisex – one will be attracted to other regardless of sex
- Attractiveness is proportional to fly's brightness
 - For any 2 flashers, less brighter one will move to brighter one (attractiveness decreases w/ distance)
 - If no one is brighter, then move is random
- Brightness is determined by objective function landscape $f(\mathbf{x})$
 - Maximization = brightness proportional to value of cost function
 - Brightness function similar to fitness function

Light Intensity & Attractiveness

- Brightness at location \mathbf{x} can be $I(\mathbf{x}) \propto f(\mathbf{x})$
- Attractiveness β between agent i and j is relative to “eyes of beholder”
- Intensity varies $I(r) = \frac{I_s}{r^2}$, where I_s is intensity at source
 - For medium w/ fixed light absorption γ , light intensity varies w/ distance r
 - Approximate inverse-square law & absorption via $I = I_0 e^{-\gamma r^2}$, where I_0 is original light intensity at $r = 0$ (Gaussian form)
- Attractiveness proportional to light intensity as seen by adjacent fireflies, thus $\beta = \beta_0 e^{-\gamma r^2}$ w/ β_0 is attractiveness at $r = 0$
 - Fast approximation: $\beta = \frac{\beta_0}{1 + \gamma r^2}$

FA Movement/Mechanics



Begin

- 1) Objective function: $f(\mathbf{x})$, $\mathbf{x} = (x_1, x_2, \dots, x_d)$;
- 2) Generate an initial population of fireflies \mathbf{x}_i ($i = 1, 2, \dots, n$);
- 3) Formulate light intensity I so that it is associated with $f(\mathbf{x})$
(for example, for maximization problems, $I \propto f(\mathbf{x})$ or simply $I = f(\mathbf{x})$);
- 4) Define absorption coefficient γ

while (t < MaxGeneration)

for i = 1 : n (all n fireflies)

for j = 1 : i (n fireflies)

if ($I_j > I_i$),

 Vary attractiveness with distance r via $\exp(-\gamma r)$;

 move firefly i towards j ;

 Evaluate new solutions and update light intensity;

end if

end for j

end for i

 Rank fireflies and find the current best;

end while

end

Binary PSO (BPSO) and FA (BFA)

- Many problems are combinatorial & take on discrete values (i.e., binary)
 - Need “discretized PSO/FA” (w/ stochastic velocity)
- Alterations to PSO mechanics



Questions?

