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
    - A real firefly version of “*Maneater*” or “*Fireflyeater*”
    - Could this be the basis of another metaheuristc?

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 fun landscape
  - Maximization = brightness proportional to value of cost function
  - Brightness function similar to fitness function

Light Intensity & Attractiveness

- Brightness at location ***x*** can be $I(\boldsymbol{x}) \propto f(\boldsymbol{x})$
- 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 $I = I_0 e^{-\gamma r^\wedge 2}$, 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

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Begin
    1) Objective function: f(x),   x = (x_1, x_2, ..., x_d);
    2) Generate an initial population of fireflies x_i  (i = 1, 2, ..., n);.
    3) Formulate light intensity I so that it is associated with f(x)
       (for example, for maximization problems, I ∝ f(x) or simply I = f(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(-γ 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
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Questions?