



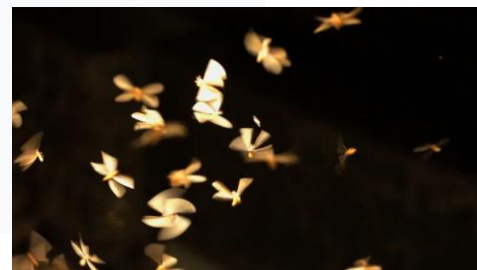
Some Fireflies and Extensions of Metaheuristics to the Discrete

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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
```



Connection to Other Algorithms

- Can recover differential evolution
- Can recover accelerated PSO
- Can recover simulated annealing

Forces of Attraction

- Attraction promotes exploitation
 - Enables quick convergence as swarm evolves, possibly to point where attractor states move toward true global optimality
 - Allows agents to interact w/ each other → forcing term to guide convergence of population

- Exploration/diversity is driven by randomness / diffusion
 - Diffusion process viewed as steps of a Brownian motion $B(t)$, a centered Gaussian distribution w/ time-dependent variance → so if t is sufficiently large, can cover whole search domain

Multimodality & Modifications

- Other forces (distance measures) could be used
 - Charged System Search – based on Coulomb's Law
 - Gravitational Search – based on Newton's law of gravitation
- Local attraction is stronger than global – FA automatically subdivides into subgroups (groups per mode)

Many Variants

- Discrete Firefly Algorithm (DFA) – can deal with NP-hard scheduling problems, TSP, etc. (outperforms ACO)
 - A version for image segmentation outperforms (recursive) Otsu's method
- Chaotic Firefly Algorithm (CFA) – create/use chaotic maps/theory to improve diversity/exploration
- Lagrangian Firefly Algorithm (LFA) – can solve constrained optimization problems
- Multiobjective Firefly Algorithms
- ...and many more

A Sidestep to Discrete Forms

Discrete Metaheuristics

- Discrete (binary) PSO
- Discrete FA (very hard to get right!)

Questions?

