Dandelion Algorithm:

An Example of Successful Term Projects

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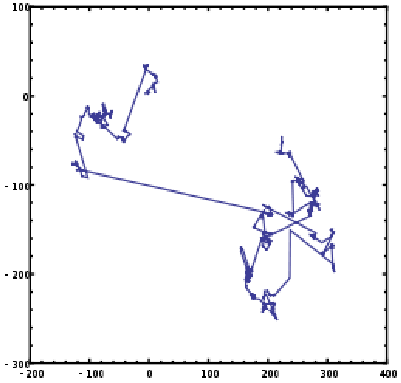
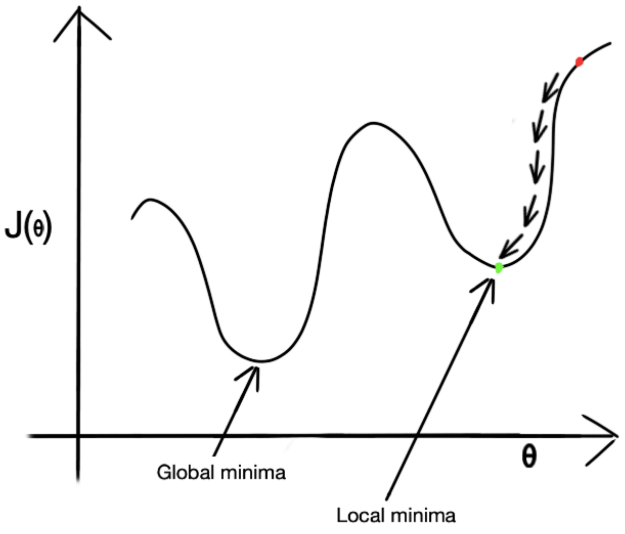
How we started Dandelion Algorithm

- For a term project,
  - We chose “make a new meta-heuristic algorithm” among the subjects
  - There was no specific plan when we started
- Cuckoo search
  - Use Levy filght, heavy-tailed probability distribution
  - Much more random-based algorithm
- I was walking the road beside the dormitory and saw some flowers
  - Seed dispersal is also randomly decided
  - Some places are better than others for flower



Good heuristic optimization method

- Global and local optimal solution
  - Assume we have minimization problem which is not convex
  - If you do not search enough, you might fall into a local minimum



Non-Convex

- Good heuristic optimization method
  - Need a concept that ensures it can find the best solution well locally
  - Need a method that ensures it can search the entire feature space

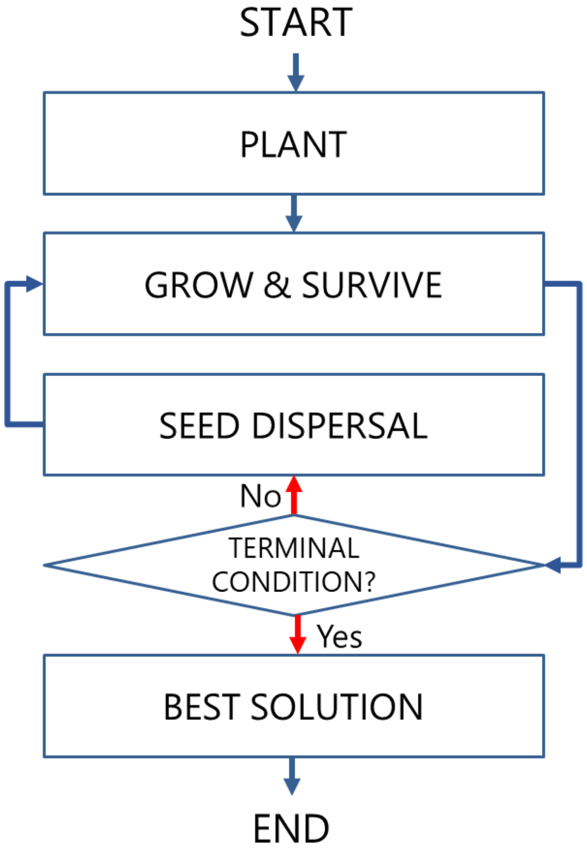
Concept of Dandelion Algorithm

- Population-based optimization
  - Except few flowers, others cannot survive
  - Only the survived flowers can dispersal seeds.
- Better the solution, shorter the flower
  - The shorter the flower, the closer the seeds fly

    (Need a concept that ensures it can find the best solution well locally)
  - The longer the flower, the farther the seeds fly
- The direction and speed of wind is randomly decided
  - With strong wind, seed can go farther

    (Need a method that ensures it can search the entire feature space)

Dandelion Algorithm



Description including example

Initial generation: Plant 20 Seeds randomly

Seed Grow & Becomes Flower: Calculate each seed of objective value
Survive : Only the 4 best elites Flower survive

Each Elite Flowers release 4 Seeds
(To maintain the number of seeds)

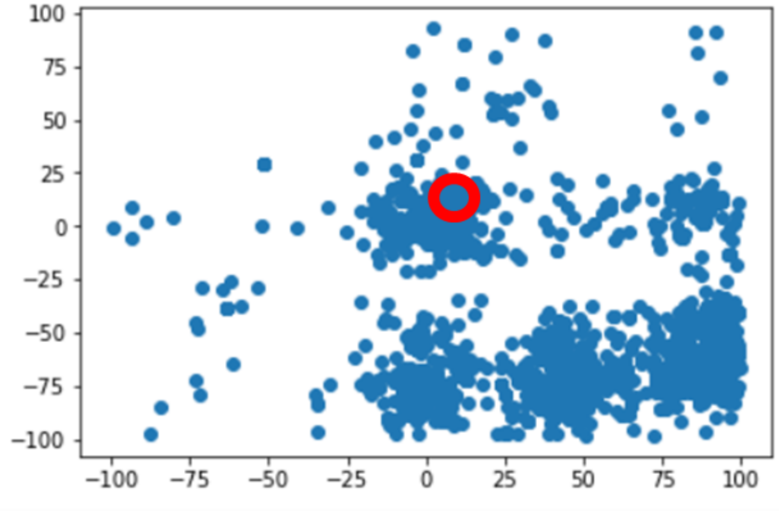
If it satisfies the terminal condition, it stops the iteration

- The number of iteration
- Variation of Function <= 0.00001

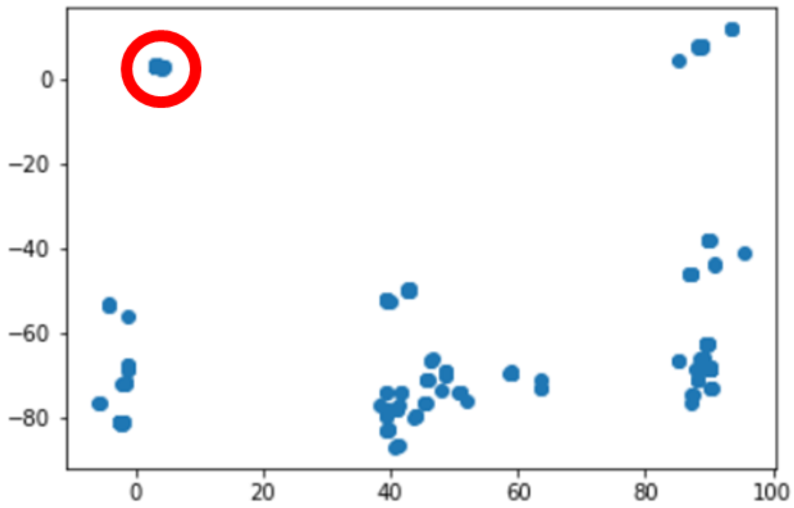
- Treat the flowers differently
  - In GA, all elite solutions are treated equally
  - However, the height of elite flowers are all different

Result

Over all seed



The Best seed



Test Functions	**CS**	**GA**	**PSO**	**SD**
Easom's TF	6751±1902 (100%)	19239±3307 (92%)	17273 ± 2929 (90%)	244±194 (100%)
Griewangk's TF	10912±4050 (100%)	70925±7652 (90%)	55970±4223(92%)	701±111 (100%)

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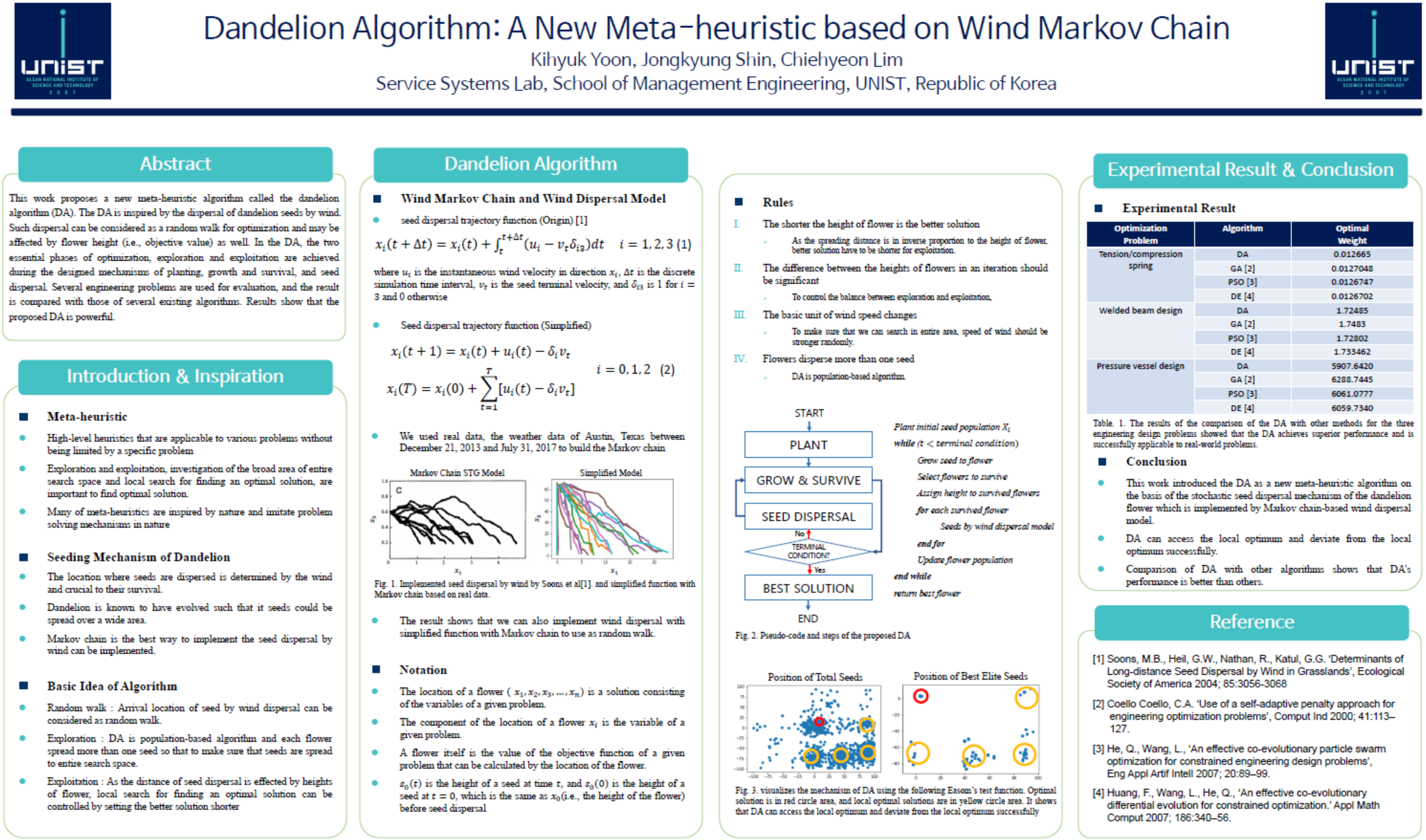

Dandelion Algorithm: A New Meta-heuristic based on Wind Markov Chain

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Abstract

This work proposes a new meta-heuristic algorithm called the dandelion algorithm (DA). The DA is inspired by the dispersal of dandelion seeds by wind. Such dispersal can be considered as a random walk for optimization and may be affected by flower height (i.e., objective value) as well. In the DA, the two essential phases of optimization, exploration and exploitation are achieved during the designed mechanisms of planting, growth and survival, and seed dispersal. Several engineering problems are used for evaluation, and the result is compared with those of several existing algorithms. Results show that the proposed DA is powerful.

Introduction & Inspiration

Meta-heuristic

- High-level heuristics that are applicable to various problems without being limited by a specific problem
- Exploration and exploitation, investigation of the broad area of entire search space and local search for finding an optimal solution, are important to find optimal solution.
- Many of meta-heuristics are inspired by nature and imitate problem solving mechanisms in nature

Seeding Mechanism of Dandelion

- The location where seeds are dispersed is determined by the wind and crucial to their survival.
- Dandelion is known to have evolved such that it seeds could be spread over a wide area.
- Markov chain is the best way to implement the seed dispersal by wind can be implemented.

Basic Idea of Algorithm

- Random walk : Arrival location of seed by wind dispersal can be considered as random walk.
- Exploration : DA is population-based algorithm and each flower spread more than one seed so that to make sure that seeds are spread to entire search space.
- Exploitation : As the distance of seed dispersal is effected by heights of flower, local search for finding an optimal solution can be controlled by setting the better solution shorter

Dandelion Algorithm

Wind Markov Chain and Wind Dispersal Model

- seed dispersal trajectory function (Origin) [1]

$$x_i(t+\Delta t) = x_i(t) + \int_t^{t+\Delta t} (u_i - v_t\delta_{i3})dt \quad i = 1, 2, 3 \ (1)$$

where u_i is the instantaneous wind velocity in direction x_i, Δt is the discrete simulation time interval, v_t is the seed terminal velocity, and δ_{i3} is 1 for i = 3 and 0 otherwise

- Seed dispersal trajectory function (Simplified)

$$x_i(t+1) = x_i(t) + u_i(t) - \delta_i v_t$$
$$x_i(T) = x_i(0) + \sum_{t=1}^{T} [u_i(t) - \delta_i v_t] \qquad i = 0, 1, 2 \quad (2)$$

- We used real data, the weather data of Austin, Texas between December 21, 2013 and July 31, 2017 to build the Markov chain

Markov Chain STG Model

Simplified Model

Fig. 1. Implemented seed dispersal by wind by Soons et al[1]. and simplified function with Markov chain based on real data.

- The result shows that we can also implement wind dispersal with simplified function with Markov chain to use as random walk.

Notation

- The location of a flower ($x_1, x_2, x_3, \dots, x_n$) is a solution consisting of the variables of a given problem.
- The component of the location of a flower x_i is the variable of a given problem.
- A flower itself is the value of the objective function of a given problem that can be calculated by the location of the flower.
- $s_0(t)$ is the height of a seed at time t, and $s_0(0)$ is the height of a seed at $t = 0$, which is the same as x_0(i.e., the height of the flower) before seed dispersal

Rules

I. The shorter the height of flower is the better solution
   - As the spreading distance is in inverse proportion to the height of flower, better solution have to be shorter for exploitation.

II. The difference between the heights of flowers in an iteration should be significant
   - To control the balance between exploration and exploitation,

III. The basic unit of wind speed changes
   - To make sure that we can search in entire area, speed of wind should be stronger randomly.

IV. Flowers disperse more than one seed
   - DA is population-based algorithm

START
PLANT
GROW & SURVIVE
SEED DISPERSAL
No
TERMINAL CONDITION?
Yes
BEST SOLUTION
END

```
Plant initial seed population $X_i$
while ($t <$ terminal condition)
    Grow seed to flower
    Select flowers to survive
    Assign height to survived flowers
    for each survived flower
        Seeds by wind dispersal model
    end for
    Update flower population
end while
return best flower
```

Fig. 2. Pseudo-code and steps of the proposed DA

Position of Total Seeds

Position of Best Elite Seeds

Fig. 3. visualizes the mechanism of DA using the following Easom's test function. Optimal solution is in red circle area, and local optimal solutions are in yellow circle area. It shows that DA can access the local optimum and deviate from the local optimum successfully

Experimental Result & Conclusion

Experimental Result

Optimization Problem	Algorithm	Optimal Weight
Tension/compression spring	DA	0.012665
	GA [2]	0.0127048
	PSO [3]	0.0126747
	DE [4]	0.0126702
Welded beam design	DA	1.72485
	GA [2]	1.7483
	PSO [3]	1.72802
	DE [4]	1.733462
Pressure vessel design	DA	5907.6420
	GA [2]	6288.7445
	PSO [3]	6061.0777
	DE [4]	6059.7340

Table. 1. The results of the comparison of the DA with other methods for the three engineering design problems showed that the DA achieves superior performance and is successfully applicable to real-world problems.

Conclusion

- This work introduced the DA as a new meta-heuristic algorithm on the basis of the stochastic seed dispersal mechanism of the dandelion flower which is implemented by Markov chain-based wind dispersal model.
- DA can access the local optimum and deviate from the local optimum successfully.
- Comparison of DA with other algorithms shows that DA's performance is better than others.

Reference

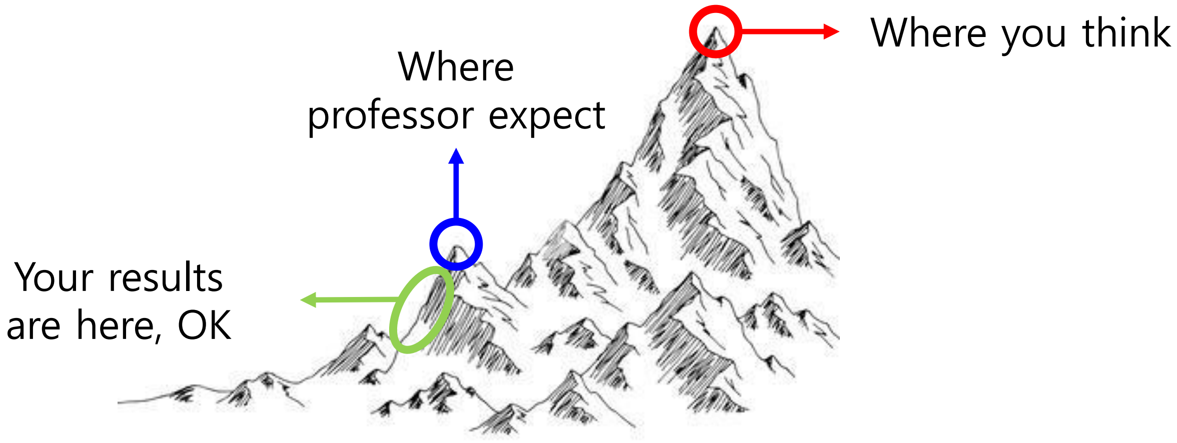
[1] Soons, M.B., Heil, G.W., Nathan, R., Katul, G.G. 'Determinants of Long-distance Seed Dispersal by Wind in Grasslands', Ecological Society of America 2004; 85:3056-3068

[2] Coello Coello, C.A. 'Use of a self-adaptive penalty approach for engineering optimization problems', Comput Ind 2000; 41:113–127.

[3] He, Q., Wang, L., 'An effective co-evolutionary particle swarm optimization for constrained engineering design problems', Eng Appl Artif Intell 2007; 20:89–99.

[4] Huang, F., Wang, L., He, Q., 'An effective co-evolutionary differential evolution for constrained optimization.' Appl Math Comput 2007; 186:340–56.

Professor wants something special



- As you Know, he wants something special
  - It seems too hard, but it is not that hard
  - Your result should not be perfect, analysis about the result is important
  - Start with specifying your problem definition

Term project example

- From kaggle, there is a dataset named “Amazon Movie Ratings”
  - In the dataset, 207 movies are rated by 4848 users.
  - You can just build a recommendation system with existing method
- Everything starts with specifying the problem to solve
  - I found that there are a lot of movies with only one rating
  - It would be hard to recommend such movies to other people
  - For such recommendation, I will add some logics to cluster the movies
  - I can build the logic by my own, or use some cluster methods
  - After applying my logic, I will analysis the result and suggest the future works

Well-done projects

- Simple data engineering with packages is no more special
  - Everyone can do prediction, regression, or clustering with python packages
  - Without deeper consideration about a problem, there is nothing special

- Well-done term projects can be helpful for your career
  - Your GPA is not all for your career, companies or labs want you to prove your skills
  - The well-done term projects can be one way to prove it