Supplementary Materials

1. Symbiotic Organism Search (SOS)

Figure S1 shows a flowchart of the SOS algorithm used in the proposed study. As the initial population (i.e., ecosystem) settles, a set of organisms is randomly generated from the feasible solution domain and is chosen to be in the initial ecosystem. Each organism is treated as a candidate solution (CAS) for the corresponding problem with a certain objective function value (OFV). The search procedure begins when the initial ecosystem is set up. Each organism may be benefitted or harmed from interacting with another organism continuously during the following three states:

(1) Mutualism: The relationship is beneficial for each organism. An example is the interaction between bees and flowers;

(2) Commensalism: The relationship in which one organism benefits from the other without affecting it. An example is the relationship between remora fish and sharks;

(3) Parasitism: A nonmutual relationship in which one species benefits at the expense of the other. An example is the plasmodium parasite, which uses its relationship with Anopheles mosquitoes to transfer between human hosts.

1.1. Mutualism

An organism Xi randomly selects another organism Xj as its mutualism partner from the current ecosystem for interaction between the organisms. The interaction increases the chances of survival in the ecosystem. The new candidate solutions for both organisms based on the mutualistic mechanism between Xi and Xj are respectively denoted as

$$X_{inew} = X_i + RD_M \times (X_{best} - MV \times BF_1) \quad \text{(S1)}$$

and

$$X_{jnew} = X_j + RD_M \times (X_{best} - MV \times BF_2), \quad \text{(S2)}$$

where RD_M is a random number vector varying from 0 to 1; X_{best} is the current best organism with the best OFV in the ecosystem; MV is the vector of mutual connection between both organisms and is defined as $MV = (X_i + X_j)/2$; and BF_1 and BF_2 are the random benefit factors, either 1 or 2. Some mutualism relationships may give a greater beneficial advantage to just one organism than another may. These benefit factors represent the level of benefit to each organism.

1.2. Commensalism

After the procedure of mutualism, the organism X_i randomly chooses a commensalism partner X_j from the current ecosystem for an interaction, during which X_i gains a benefit from X_j, but X_j neither benefits nor suffers from this relationship. The new X_i can be modeled as

$$X_{inew} = X_i + RD_C \times (X_{best} - X_j), \quad \text{(S3)}$$

where RD_C is the vector of random numbers varying from −1 to 1. The organism X_i updates only when its new fitness is better than its pre-interaction fitness.

1.3. Parasitism

After commensalism, a parasitical organism X_P is cloned from a random organism X_i and then self-mutates in random dimensions using a random number with a range between the given lower and upper bounds. The parasite X_P is added into the ecosystem and then attempts to replace the stochastic host organism X_j. Both X_P and X_j are then used to evaluate and compare their fitness values. The organism with the better fitness value is alive in the competition, whereas the worse one is terminated. The mechanisms for updating the best organism are conducted after one generation of organisms has completed its three states. Readers may refer to Cheng and Prayogo (2014) for details on the use of the SOS algorithm.

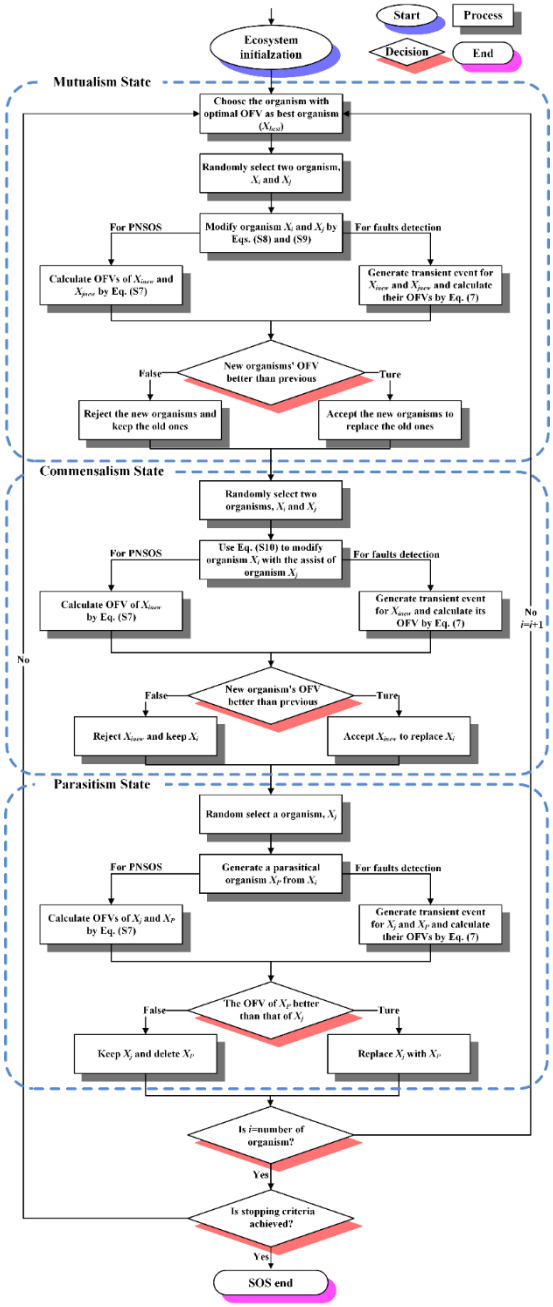

Figure S1. Flowchart of symbiotic organism search (SOS).

Reference

Cheng, M.-Y., and Prayogo, D. (2014). "Symbiotic Organisms Search: A new metaheuristic optimization algorithm." *Comput. Struct.*, 139, 98-112. http://dx.doi.org/10.1016/j.compstruc.2014.03.007.