P2.

Real world problems are often represented as “multimodal” which means multiple local optima are exited, like this function.

An example of real world problems is safe landing sites selection in lunar mission. In this case, we have to find many landing sites (at the red point) which are located in flat area and here, we can easily communicate for sending moon data to the earth (shown in the right figure). Finding one best landing site is important, but the best landing site is not always the best because it might be changed.

So, we would like to know some landing sites as possible as we can.

P3

For searching multiple optima is so-called Niching methods in the research field “evolutionary computation”.

In a couple of decades, many niching methods have been developed in the past.

Basically, niching methods are designed evolutionary algorithms combined with niching scheme. As major niching methods, crowding DE is proposed by Thomsen to replace high-quality solution with similar solution candidates, and DE with Speciation is proposed by Li to keep solutions away from the nearest neighbor solutions.

However, these methods are not enough to find multiple local optima solutions are fallen into global optima or high-fitness local optima. These mechanisms are just considered the solution movement between nearest neighbor solution. They need to consider the global search.

P4

We focused on Bat algorithm, this is one of the evolutionary algorithms. BA is superior for switching exploitation and exploration search here.

As bat approach a food/prey, the loudness decreases and the pulse emission rate increases, to control the search performance.

The BA mechanism consists of 3 search steps.

P5,6

According to the slide

P7

Another local search in step3, if pulse rate r is less than random value, solution candidates are generated as this equation.

P8

In step4, solution candidates are randomly generated in the search space.

P9

Then here, if the loudness value is larger than random value and the fitness value of candidates are better than the current solution, the new one is overwritten as the current solution. Moreover, the loudness value goes down and the pulse emission rate rises up in contrast.

P11

This is the novelty search. When some solutions are crowded in the dense area, the sparseness function rho can keep solution x away from the nearest neighbor solutions mu i. But this function calculates norm vector, so we represented it to vector equation as below. Moreover, we changed this equation independent of parameter k. when solutions already distributed, the vector is calculated almost 0.

P12

In this step from conventional BA to NSBA, we changed global best solution to local best solution.

P14

This mechanism can locate solutions to multiple local optima.

P15

To measure the number of global and local optima by NSBA compared with BA, we employed 2 multimodal functions for minimization. These figures show the 2-dimensional fitness landscape and the contour plot. The global and local optima located in the blue area in both functions. F1 has 1/16, and F2 has 1/120.

P16-20

According to slide