Thomas Jansen
University College Cork
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Assignment 7

Topic 'Unimodal Functions'

In the following let $k \in \mathbb{N}$ and $n \in \mathbb{N}$ such that n is a multiple of k. We consider bit strings $x_1, x_2, \dots \in \{0,1\}^n$. We define a sequence S_k^n of such bit strings. We use the usual notation for the concatenation of bit strings: We write b^k for the concatenation of k bs. Thus, e. g., $0^2 1^4 0^3 = 001111000$.

We define S_k^n in the following way. For $n = 0$, we define S_k^n as the empty bit string. For $n > 0$ we assume that the sequence $S_k^{n-k} = x_1, x_2, \dots x_l$ is already defined. (Note that $n - k \geq 0$ since n is a multiple of k.)

$S_k^n = 1^k x_1, 1^k x_2, \dots, 1^k x_l, 1^{k-1} 0 x_l, 1^{k-2} 0^2 x_l 1^{k-3} 0^3 x_l, \dots, 1 0^{k-1} x_l, 0^k x_l, 0^k x_{l-1}, \dots, 0^k x_1$

Problem 1 Write down the sequence P_3^6 explicitly. Prove that the sequence P_k^n contains exactly $k \cdot 2^{n/k} - k + 1$ bit strings.

Problem 2 For the following function consider the sequence $S_k^n = x_1, x_2, \dots, x_l$.

$$f_{S_k^n}(x) = \begin{cases} n + i & \text{if } x = x_i \text{ for some } x_i \text{ in } S_k^n, \\ \textsc{OneMax}(x) & \text{otherwise.} \end{cases}$$

Prove that $f_{S_k^n}$ is unimodal.

Problem 3 <u>**Implementation Task**</u>
Remember the implementation of the random local search and the (1+1) EA from Assignments 4 and 6. Implement $f_{S_k^n}$ as objective function. Compare the (1+1) EA and random local search on $f_{S_3^n}$ for $n \in \{9, 18, 27, 36, 45\}$. In each run, let each algorithm run until it finds the global optimum. Average the number of steps taken over several runs. Can you explain your results?

Assignments are handed out on each Friday during the lecture. Written solutions are due the next Wednesday. Feedback is given and solutions are discussed the Wednesday after that.