**Raport Tema 1**

Sa se determine minimul pentru urmatoarele functii: [De Jong 1](http://www.geatbx.com/docu/fcnindex-01.html#P89_3085), [Schwefel 7](http://www.geatbx.com/docu/fcnindex-01.html" \l "P150_6749), [Rastrigin](http://www.geatbx.com/docu/fcnindex-01.html" \l "P140_6155), [Six-hump camel back](http://www.geatbx.com/docu/fcnindex-01.html#P247_13252) implementand algoritmii Hill Climbing (variantele first improvement si best improvement) si Simulated Annealing.

**De Jong**: f1(x)=sum(x(i)^2), i=1:n, -5.12<=x(i)<=5.12.

C:\Users\luka\Desktop\fcnindex-1.gif

global minimum: f(x)=0, x(i)=0, i=1:n.

**Schwefel:** f7(x)=sum(-x(i)·sin(sqrt(abs(x(i))))), i=1:n; -500<=x(i)<=500.

**C:\Users\luka\Desktop\fcnindex-16.gif**

global minimum: f(x) = -n·418.9829; x(i)=420.9687, i=1:n.

**Rastrigin:** f6(x)=10·n+sum(x(i)^2-10·cos(2·pi·x(i))), i=1:n; -5.12<=x(i)<=5.12.C:\Users\luka\Desktop\fcnindex-13.gif

global minimum: f(x)=0; x(i)=0, i=1:n.

**Six-hump camel back**

fSixh(x1,x2)=(4-2.1·x1^2+x1^4/3)·x1^2+x1·x2+(-4+4·x2^2)·x2^2

-3<=x1<=3, -2<=x2<=2.

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global minimum:

f(x1,x2)=-1.0316; (x1,x2)=(-0.0898,0.7126), (0.0898,-0.7126).

Hill Climbing

Pseudocod:

ITERARE HC **begin**

t := 0

initialize *best*

**repeat**

*local* := FALSE

BEGIN HC select a candidate solution (bitstring) *vc* at random

evaluate *vc*

**repeat**

*vn* := Improve(*Neghborhood(vc)*)

**if** eval(*vn*) is better than eval(*vc*)

**then** *vc* := *vn*

**else** *local* := TRUE

END HC **until** local

*t* := *t* + 1

**if** *vc* is better than *best*

**then** *best* := *vc*

**until** *t* = MAX

**end**

Functia *Improve* cauta in vecinatate prima solutie candidat care e mai buna decat solutia curenta sau cea mai buna solutie (first improvement sau best improvement).

Detalii implementare *Improve*: se va parcurge pe rand fiecare parametru al functiei si se va schimba pe rand, de la stanga la dreapta, cate un singur bit(*Neghborhood)*, la fiecare mutatie fiind evaluat daca este un candidat mai bun decat cel precedent. In functie de metoda aleasa(first sau best), se va opri la primul candidat mai bun gasit, sau se vor itera toate combinatiile si selecta cel mai bun candidat gasit.

Acest pas se va repeat pana cand nu a fost gasit nici-un candidat mai bun printre vecini, aflandu-ne intr-un minim local. Astfel trecem la urmatoarea iteratie, pornind din alt punct random al functiei.

Simulated Annealing

Pseudocod:

**begin**

*t* := 0

initialize the temperature *T*

select a current candidate solution (bitstring) *vc* at random

evaluate *vc*

**repeat**

**repeat**

select at random *vn* - a neighbor of *vc*

**if** eval(*vn*) is better than eval(*vc*)

**then** *vc* := *vn*

**else if** random[0,1) < exp(-|eval(*vn*)-eval(*vc*)|/*T*)

**then** *vc* := *vn*

**until** (termination-condition)

*T* := g(*T*; *t*)

*t* := *t* + 1

**until** (halting-criterion)

**end**

Functia g(T; t) de modificare a "temperaturii" T va asigura o scadere treptata a acesteia cu fiecare iteratie (de exemplu, prin inmultirea cu o valoare subunitara).

*Detalii implementare:* se va folosi un termination-condition = un nr maxim de iteratii generat aleator, si ca halting-criterion temperature va fi comparat cu 10^(-20)

**Reprezentarea solutiilor:**

* siruri binare: spaţiul de căutare se va disctretiza până la o anumită precizie 10-d. Un interval [*a*, *b*] va fi împărţit în N = (b-a)\*10d subintervale egale.
* Pentru a putea reprezenta cele (b-a)\*10d valori, este nevoie de un număr
* n = parte\_intreaga\_superioara(log2(N)) de biţi.
* Lungimea şirului de biţi care reprezintă o soluţie candidat va fi suma lungimilor reprezentărilor pentru fiecare parametru al funcţiei de optimizat. In momentul evaluarii solutiei (apelul functiei de optimizat) este necesara decodificarea fiecarui parametru reprezentat ca sir de biti in numar real, dupa formula: Xreal = a+decimal(xbiti)\*(b-a)/(2n-1)

**Rezultate:**

First Improvement

|  |  |  |  |
| --- | --- | --- | --- |
| **Rastrigin** | Minim | Mediu | Maxim |
| 5 | 2.230727936569167 | 11.187704520622189 | 26.774714088579948 |
| 10 | 13.661929003611846 | 25.8324853902286 | 39.83550137520716 |
| 30 | 49.81671837494798 | 72.6426404174599 | 105.21953246408032 |

|  |  |  |  |
| --- | --- | --- | --- |
| **De Jong** | Minim | Mediu | Maxim |
| 5 | 1.136868326394184e-16 | 1.136868326394184e-16 | 1.136868326394184e-16 |
| 10 | 2.273736652788368e-16 | 2.273736652788368e-16 | 2.273736652788368e-16 |
| 30 | 6.821209958365109e-16 | 6.821209958365109e-16 | 6.821209958365109e-16 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Schwefel** | Minim | Mediu | Maxim |
| 5 | -941.6471943269635 | -592.7618725504008 | -261.4015224911689 |
| 10 | -561.7801042058545 | -227.0592421032984 | -799.2979601517986 |
| 30 | -10274.913595995422 | -9273.159167794805 | -8357.37603222544 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Six-hump CamelBack** | Minim | Mediu | Maxim |
| 2 | -1.031613569652786 | -.9833651012397701 | -.7499999930150807 |
|  |  |  |  |
|  |  |  |  |

Best Improvement

|  |  |  |  |
| --- | --- | --- | --- |
| **Rastrigin** | Minim | Mediu | Maxim |
| 5 | 2.4715368836270173 | 9.766055920047753 | 28.04014613666785 |
| 10 | 9.21056058839524 | 19.073268608314077 | 37.57633035449161 |
| 30 | 39.85158129252136 | 60.00687462020615 | 75.71523847397788 |

|  |  |  |  |
| --- | --- | --- | --- |
| **De Jong** | Minim | Mediu | Maxim |
| 5 | 1.136868326394184e-16 | 1.136868326394184e-16 | 1.136868326394184e-16 |
| 10 | 2.273736652788368e-16 | 2.273736652788368e-16 | 2.273736652788368e-16 |
| 30 | 6.821209958365104e-16 | 6.821209958365104e-16 | 6.821209958365104e-16 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Schwefel** | Minim | Mediu | Maxim |
| 5 | -941.9240468927153 | -557.4416943545975 | -142.3707654582402 |
| 10 | -721.6273253338113 | -3261.369196263472 | -2739.435819153165 |
| 30 | -1243.713607575904 | -0095.001257618773 | -9223.08663465039 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Six-hump CamelBack** | Minim | Mediu | Maxim |
| 2 | -1.0316283974755278 | -0.880292774712619 | 0.6656250393425589 |
|  |  |  |  |
|  |  |  |  |

Simulated Annealing

|  |  |  |  |
| --- | --- | --- | --- |
| **Rastrigin** | Minim | Mediu | Maxim |
| 5 | 2.47153688362701 | 4.030258501466298 | 128.2028492906784 |
| 10 | 3.225686895342932 | 6.691263346693893 | 203.0091220456169 |
| 30 | 49.81671837494798 | 59.78041357829392 | 616.032575018713 |

|  |  |  |  |
| --- | --- | --- | --- |
| **De Jong** | Minim | Mediu | Maxim |
| 5 | 1.136868326394184e-16 | 57.27522066363474 | 0.8142539907332157 |
| 10 | 2.273736652788368e-16 | 1.6525064227011468 | 117.81824879216099 |
| 30 | 6.821209958365104e-16 | 5.1556886852897685 | 294.77909443838905 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Schwefel** | Minim | Mediu | Maxim |
| 5 | -1964.0611345890595 | -1859.071803203648 | -1640.5780457275043 |
| 10 | -3480.0773221065792 | -3472.7039857813747 | -1571.4699873473703 |
| 30 | -10473.258748041022 | -10438.712542185272 | -3283.122019746764 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Six-hump CamelBack** | Minim | Mediu | Maxim |
| 2 | -0.9999867470714369 | -0.8173996981463845 | 37.67574777137537 |
|  |  |  |  |
|  |  |  |  |

**Comparatii:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Rastrigin** | First Improvement | Best Improvement | SA |
| 5 | 2.230727936569167 | 1.136868326394184e-16 | 2.47153688362701 |
| 10 | 13.661929003611846 | 2.273736652788368e-16 | 3.225686895342932 |
| 30 | 49.81671837494798 | 6.821209958365104e-16 | 49.81671837494798 |

|  |  |  |  |
| --- | --- | --- | --- |
| **De Jong** | First Improvement | Best Improvement | SA |
| 5 | 1.136868326394184e-16 | 1.136868326394184e-16 | 1.136868326394184e-16 |
| 10 | 2.273736652788368e-16 | 2.273736652788368e-16 | 2.273736652788368e-16 |
| 30 | 6.821209958365109e-16 | 6.821209958365104e-16 | 6.821209958365104e-16 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Schwefel** | First Improvement | Best Improvement | SA |
| 5 | -941.6471943269635 | -941.9240468927153 | -1964.0611345890595 |
| 10 | -561.7801042058545 | -721.6273253338113 | -3480.0773221065792 |
| 30 | -10274.913595995422 | -10243.713607575904 | -10473.258748041022 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Six-hump CamelBack** | First Improvement | Best Improvement | SA |
| 2 | -1.031613569652786 | -1.0316283974755278 | -0.9999867470714369 |
|  |  |  |  |
|  |  |  |  |

Va fi observata evolutia solutiei candidat dupa fiecare candidat vecin mai bun gasit. Grafice:

 