**Silesian University of Technology**

**Hierarchical Control Lab-3**

**Title of the exercise:**

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| --- |
| “Direct Method of Coordination”  **Date of the exercise:**  15.11.2013 |

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**Introduction:**

The aim of this lab is to apply the direct method of coordination to a

complex static system composed of three cross-coupled subsystems.

**main.m (Without coordination method)**

clear;clc;f=myfun;%section number 5

%without any coordination method

format shortG;

lb1 = [0 0 0 0 0 0 0 0 0];ub1 = [45 45 45 25 25 25 25 25 25];

x0 = [25 25 25 10 10 10 10 10 10];

[x\_optnocoord,f\_valnocoord] = fmincon( @f.p, x0, [], [], [], [], lb1, ub1 )

**main.m (With direct method of coordination)**

clear;clc;f=myfun;%section number 5

%without any coordination method

format shortG;

lb1 = [0 0 0 0 0 0 0 0 0];ub1 = [45 45 45 25 25 25 25 25 25];

x0 = [25 25 25 10 10 10 10 10 10];

% % direct method of coordination

% % v12 v23 v31 m11 m12 m21 m22 m31 m32

x1 = fmincon( @f.p1, x0, [], [], [], [], lb1, ub1 );

m11\_opt = x1(4);m12\_opt = x1(5);

x2 = fmincon( @f.p2, x0, [], [], [], [], lb1, ub1 );

m21\_opt = x2(6);m22\_opt = x2(7);

x3 = fmincon( @f.p3, x0, [], [], [], [], lb1, ub1 );

m31\_opt = x3(8);m32\_opt = x3(9);

x0 = [25 25 25 m11\_opt m12\_opt m21\_opt m22\_opt m31\_opt m32\_opt];

lbe = [0 0 0 m11\_opt m12\_opt m21\_opt m22\_opt m31\_opt m32\_opt];

ube = [45 45 45 m11\_opt m12\_opt m21\_opt m22\_opt m31\_opt m32\_opt];

[x\_opt,f\_val] = fmincon( @f.p, x0, [], [], [], [], lbe, ube )

f\_vald=f\_val;x\_optd=x\_opt;

%iteration part

decide = 0;

error = 0.01;

N = 100;

for i=1:1:N

x0 = x\_opt;

[x\_opt, f\_val] = fmincon(@f.p, x0, [], [], [], [], lb1, ub1);

number\_of\_iterations = i;

if((decide-f\_val) < error)

break;

end

decide = f\_val;

end

**myfun.m**

classdef myfun % in myfun.m

methods (Static) % attribute to true

%Without any coordination method

function x = p( vector )

v12 = vector (1);v23 = vector (2);v31 = vector (3);

m11 = vector (4);m12 = vector (5);m21 = vector (6);m22 = vector (7);m31 = vector (8);m32 = vector (9);

a = -(v31 - 2)^2 - 2\*(v12 - 3)^2 - v31\*m12 - (m11 - v12)^2 + m11 + 40;

b = -3\*(v12 - 4)^2 - (v23 - 1)^2 + v23\*m21 - (m22 - v12)^2 - m22 + 20;

c = -2\*(v23 - 5)^2 - 4\*(v31 - 1)^2 - v23\*m31 - (m32 - v31)^2 + m32 + 30;

x=(a+b+c);x=-x;end

%Direct method of coordination

function x = p1( vector )

v12 = vector (1);v31 = vector (3);m11 = vector (4);m12 = vector (5);

x = -(v31 - 2)^2 - 2\*(v12 - 3)^2 - v31\*m12 - (m11 - v12)^2 + m11 + 40;

x=-x;end

function x = p2( vector )

v12 = vector (1);v23 = vector (2);m21 = vector (6);m22 = vector (7);

x = -3\*(v12 - 4)^2 - (v23 - 1)^2 + v23\*m21 - (m22 - v12)^2 - m22 + 20;

x=-x;end

function x = p3( vector )

v23 = vector (2);v31 = vector (3);m31 = vector (8);m32 = vector (9);

x = -2\*(v23 - 5)^2 - 4\*(v31 - 1)^2 - v23\*m31 - (m32 - v31)^2 + m32 + 30;

x=-x;end

end

end

**Task 1:** Write a Matlab script which solves the complex system problem with-

out any coordination method.

* the values of the coordination variables
* the values of the decision variables
* the value of the performance index

with this initial values x0 = [25 25 25 10 10 10 10 10 10];

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | v12 | v23 | v31 | m11 | m12 | m21 | m22 | m31 | m32 | F\_val |
| x0 | 25 | 25 | 25 | 10 | 10 | 10 | 10 | 10 | 10 | -223 |
| x\_opt | 3,59 | 7,83 | 1,29 | 4,09 | 0 | 25 | 3,09 | 0 | 1,80 |

**Performance index**

f\_valnocoord =

-223.08

**Task 2:** Write a Matlab script which solves the complex system problem us-ing the direct method of coordination. The optimization should be repeated until the diﬀerence between two subsequent values of performance index is small enough. The script should provide the following information:

• the values of the coordination variables v12, v23 and v31

• the values of the decision variables m11, m12, m21, m22, m31 and m32

• the value of the performance index

• the number of performed iterations

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | v12 | v23 | v31 | m11 | m12 | m21 | m22 | m31 | m32 | F\_val |
| x0 | 25 | 25 | 25 | 10 | 10 | 10 | 10 | 10 | 10 | -222,8831 |
| x\_opt | 3,58 | 7,83 | 1,27 | 3,75 | 0 | 25 | 3,33 | 0 | 1,62 |

**After iteration:**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | v12 | v23 | v31 | m11 | m12 | m21 | m22 | m31 | m32 | F\_val | Iter |
| x0 | 25 | 25 | 25 | 10 | 10 | 10 | 10 | 10 | 10 | -223,0833 | 2 |
| x\_opt | 3,60 | 7,83 | 1,29 | 4,10 | 0 | 25 | 3,10 | 0 | 1,79 |

**Task 3:** Check the inﬂuence of the initial variables values on the results of both

scripts and the number of performed iterations in the second script.

**3a- Without coordination method**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | v12 | v23 | v31 | m11 | m12 | m21 | m22 | m31 | m32 | F\_val |
| x0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | -223,0833 |
| x\_optnocoord | 3,59 | 7,83 | 1,30 | 4,10 | 0 | 25 | 3,09 | 0 | 1,79 |
| x0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | -223,0833 |
| x\_optnocoord | 3,59 | 7,83 | 1,29 | 4,10 | 0 | 25 | 3,09 | 0 | 1,80 |
| x0 | 45 | 45 | 45 | 25 | 25 | 25 | 25 | 25 | 25 | -223,0833 |
| x\_optnocoord | 3,59 | 7,83 | 1,30 | 4,10 | 0 | 25 | 3,09 | 0 | 1,79 |
| x0 | 25 | 25 | 25 | 10 | 10 | 10 | 10 | 10 | 10 | -223,0833 |
| x\_optnocoord | 3,59 | 7,83 | 1,30 | 4,10 | 0 | 25 | 3,09 | 0 | 1,79 |

**3b-With the direct method of coordination after iteration “2”**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | v12 | v23 | v31 | m11 | m12 | m21 | m22 | m31 | m32 | F\_val |
| x0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | -223,0833 |
| x\_opt | 3,60 | 7,83 | 1,29 | 4,10 | 0 | 25 | 3,10 | 0 | 1,79 |
| x0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | -223,0833 |
| x\_opt | 3,59 | 7,83 | 1,29 | 4,10 | 0 | 25 | 3,10 | 0 | 1,80 |
| x0 | 45 | 45 | 45 | 25 | 25 | 25 | 25 | 25 | 25 | -223,0833 |
| x\_opt | 3,59 | 7,83 | 1,29 | 4,10 | 0 | 25 | 3,10 | 0 | 1,80 |
| x0 | 25 | 25 | 25 | 10 | 10 | 10 | 10 | 10 | 10 | -223,0833 |
| x\_opt | 3,59 | 7,83 | 1,29 | 4,10 | 0 | 25 | 3,10 | 0 | 1,80 |

**Conclusions:**

We can easily see that

* at **3a- Without coordination method** the initial variables’s values dont effect performance index.
* At **3b-With direct method of coordination** the initial variables’s values dont effect performance index