|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **НУЛП, ІКНІ, САП** | | Тема | оцінка | підпис |
| СПКс-11 | 4 | реалізувати генетичний алгоритм пошуку максимального і мінімального значення цільової функції |  |  |
| Якимець А.Р. | |
| № залікової: | |
| Методи нечіткої логіки та еволюційні алгоритми при автоматизованому проектуванні | | Викладач: | |
| Кривий Р.З. | |

**Мета роботи**: реалізувати генетичний алгоритм пошуку максимального і мінімального значення цільової функції згідно варіанту.

**Завдання:** реалізувати генетичний алгоритм пошуку максимального і мінімального значення цільової функції f(x) = a + bx + cx2 + dx3 на інтервалі

x = [-10, 53].

В - 15



**Максимальне і мінімальне значення цільової функції**

Графік функції згідно варіанту показаний на рис.1.

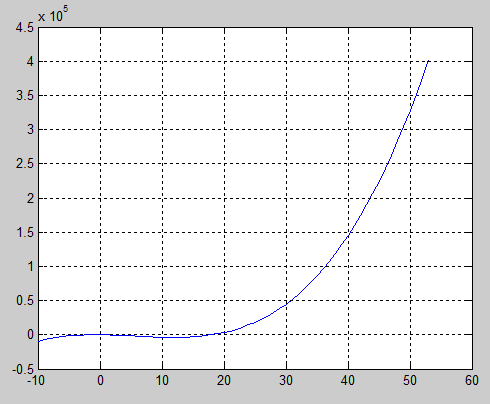
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Рис.1. Графік функції на інтервалі [-10;53]

Для знаходження мінімуму функції було вибрано інтервал [0;53]. Пошук мінімуму цільової функції для перевірки реалізовано у Matlab за допомогою функції fminbnd() і рівний: -3.8509e+003 при x =11.8422.

Для знаходження максимуму функції було вибрано інтервал [-10;10]. Пошук мінімуму цільової функції для перевірки реалізовано у Matlab за допомогою функції fminbnd() змінивши функцію на протилежну і рівний: 72.0430 при x = -0.6755 . Графік функції на інтервалі [-10;10] показаний на рис.2.

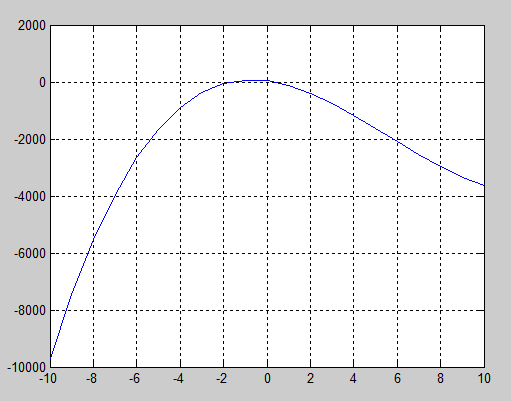


Рис.2. Графік функції на інтервалі[-10;10]

**Результати виконання програми**

Для виконання індивідуального завдання була вибрано використовувати турнірний відбір, рівномірне схрещування і класична мутація обміну.

Результати:

|  |  |  |  |
| --- | --- | --- | --- |
| Кількість поколінь, розмір популяції | 50 | 100 | 250 |
| fmin | -3847.7559 | -3850.8774 | -3850.438 |
| xmin | 12.045266 | 11.852991 | 11.764885 |
| fmax | 71.97658 | 71.59324 | 72.03872 |
| xmax | -0.70525646 | -0.7527714 | -0.68306065 |

Отже похибка при знаходженні мінімуму і максимуму залежать від кількості поколінь і розміру популяції, при їхньому збільшенні похибки прямують до 0.

Результат виконання програми для 10 поколінь з розміром популяції 50 для знаходження мінімуму функції:

Initial population

0 [30.752493] fitness = 50056.28

1 [35.162846] fitness = 87727.83

2 [51.999397] fitness = 376295.7

3 [39.59706] fitness = 139527.8

4 [14.169377] fitness = -3393.7188

5 [47.062004] fitness = 264065.06

6 [42.57522] fitness = 183200.03

7 [1.73703] fitness = -308.9478

8 [39.360558] fitness = 136378.33

9 [52.36243] fitness = 385584.3

10 [6.3920774] fitness = -2267.4824

11 [39.994976] fitness = 144929.97

12 [51.224243] fitness = 356952.5

13 [37.48338] fitness = 112962.5

14 [17.098413] fitness = -1195.0059

15 [3.7646606] fitness = -1058.5552

16 [43.16871] fitness = 192823.83

17 [4.52999] fitness = -1398.937

18 [29.060057] fitness = 38831.957

19 [25.584885] fitness = 20715.633

20 [36.609356] fitness = 102990.12

21 [48.076317] fitness = 285045.78

22 [41.365097] fitness = 164540.72

23 [32.454426] fitness = 63088.617

24 [47.9143] fitness = 281624.72

25 [14.448065] fitness = -3270.0986

26 [1.8450947] fitness = -341.0966

27 [34.516754] fitness = 81395.086

28 [13.278378] fitness = -3684.126

29 [13.873315] fitness = -3507.5273

30 [41.313927] fitness = 163779.69

31 [49.20695] fitness = 309670.3

32 [21.41858] fitness = 6549.7617

33 [33.422188] fitness = 71324.64

34 [40.59771] fitness = 153362.33

35 [14.634642] fitness = -3178.1348

36 [52.805588] fitness = 397123.6

37 [45.303528] fitness = 230104.0

38 [38.32533] fitness = 123121.78

39 [41.61623] fitness = 168308.22

40 [7.892425] fitness = -2925.6396

41 [30.637905] fitness = 49243.023

42 [48.612617] fitness = 296561.4

43 [15.872672] fitness = -2368.918

44 [34.004715] fitness = 76582.484

45 [0.79439586] fitness = -77.53808

46 [2.0870996] fitness = -416.84705

47 [39.80794] fitness = 142374.56

48 [26.015556] fitness = 22625.559

49 [5.229144] fitness = -1723.1007

New population

0 [14.420231] fitness = -3283.1787

1 [14.391711] fitness = -3296.4111

2 [15.383909] fitness = -2731.0762

3 [15.810425] fitness = -2418.2617

4 [5.842457] fitness = -2011.1614

5 [14.8943615] fitness = -3037.4932

6 [13.278378] fitness = -3684.126

7 [7.811535] fitness = -2892.611

8 [13.779565] fitness = -3539.8994

9 [13.842555] fitness = -3518.3408

10 [11.390446] fitness = -3835.9248

11 [5.3086424] fitness = -1760.3765

12 [14.392397] fitness = -3296.0967

13 [3.2783623] fitness = -854.8771

14 [1.7943043] fitness = -325.8543

15 [14.199087] fitness = -3381.3125

16 [15.044408] fitness = -2949.3994

17 [13.834733] fitness = -3521.0605

18 [15.904626] fitness = -2343.2188

19 [14.464872] fitness = -3262.12

20 [1.0205631] fitness = -124.505974

21 [12.479434] fitness = -3819.3535

22 [15.373306] fitness = -2738.2998

23 [30.62554] fitness = 49155.742

24 [12.779173] fitness = -3781.6602

25 [15.372672] fitness = -2738.7314

26 [13.278378] fitness = -3684.126

27 [14.434888] fitness = -3276.3125

28 [14.278737] fitness = -3347.1455

29 [12.447832] fitness = -3822.4507

30 [14.869392] fitness = -3051.662

31 [6.3920774] fitness = -2267.4824

32 [13.399715] fitness = -3653.579

33 [7.3764334] fitness = -2709.2668

34 [14.665511] fitness = -3162.1934

35 [4.52999] fitness = -1398.937

36 [49.20695] fitness = 309670.3

37 [51.999397] fitness = 376295.7

38 [21.41858] fitness = 6549.7617

39 [35.892426] fitness = 95235.49

40 [34.004715] fitness = 76582.484

41 [13.278378] fitness = -3684.126

42 [39.360558] fitness = 136378.33

43 [32.454426] fitness = 63088.617

44 [48.612617] fitness = 296561.4

45 [13.278378] fitness = -3684.126

46 [14.448065] fitness = -3270.0986

47 [13.278378] fitness = -3684.126

48 [5.229144] fitness = -1723.1007

49 [15.872672] fitness = -2368.918

Best in generation -3835.9248

New population

0 [9.280605] fitness = -3425.2827

1 [12.44808] fitness = -3822.4268

2 [14.46487] fitness = -3262.121

3 [12.3384285] fitness = -3831.9033

4 [12.38666] fitness = -3827.977

5 [13.264212] fitness = -3687.5137

6 [10.906126] fitness = -3788.353

7 [15.44907] fitness = -2686.1006

8 [11.403416] fitness = -3836.7622

9 [13.278866] fitness = -3684.0088

10 [15.387966] fitness = -2728.3066

11 [13.278378] fitness = -3684.126

12 [14.770621] fitness = -3106.3545

13 [13.263256] fitness = -3687.7402

14 [15.389919] fitness = -2726.9717

15 [12.493079] fitness = -3817.9663

16 [11.390446] fitness = -3835.9248

17 [12.321131] fitness = -3833.2192

18 [13.278378] fitness = -3684.126

19 [12.499205] fitness = -3817.333

20 [12.696875] fitness = -3793.5269

21 [11.8904915] fitness = -3850.7104

22 [13.260794] fitness = -3688.3262

23 [15.405315] fitness = -2716.413

24 [12.98229] fitness = -3747.337

25 [12.386664] fitness = -3827.9766

26 [12.479082] fitness = -3819.3896

27 [12.401643] fitness = -3826.6802

28 [12.279173] fitness = -3836.2114

29 [13.259874] fitness = -3688.543

30 [13.835499] fitness = -3520.795

31 [14.462969] fitness = -3263.0273

32 [13.384333] fitness = -3657.6035

33 [13.280785] fitness = -3683.545

34 [9.278378] fitness = -3424.601

35 [53.0] fitness = 402256.0

36 [32.454426] fitness = 63088.617

37 [35.892426] fitness = 95235.49

38 [14.448065] fitness = -3270.0986

39 [14.199087] fitness = -3381.3125

40 [13.418579] fitness = -3648.583

41 [14.8943615] fitness = -3037.4932

42 [40.44783] fitness = 151237.17

43 [53.0] fitness = 402256.0

44 [50.892426] fitness = 348874.22

45 [11.390446] fitness = -3835.9248

46 [11.390446] fitness = -3835.9248

47 [13.278378] fitness = -3684.126

48 [11.390446] fitness = -3835.9248

49 [13.278378] fitness = -3684.126

Best in generation -3850.7104

New population

0 [11.390446] fitness = -3835.9248

1 [13.906118] fitness = -3495.788

2 [12.2810955] fitness = -3836.0806

3 [11.390446] fitness = -3835.9248

4 [11.903416] fitness = -3850.603

5 [11.8904915] fitness = -3850.7104

6 [12.841673] fitness = -3771.8672

7 [9.760365] fitness = -3561.4575

8 [11.403904] fitness = -3836.793

9 [11.390446] fitness = -3835.9248

10 [11.388279] fitness = -3835.7837

11 [11.3904915] fitness = -3835.9282

12 [12.338646] fitness = -3831.8867

13 [13.96471] fitness = -3474.2842

14 [15.281118] fitness = -2799.997

15 [11.405386] fitness = -3836.8877

16 [11.390461] fitness = -3835.9263

17 [12.323044] fitness = -3833.0771

18 [8.39057] fitness = -3120.5657

19 [11.390476] fitness = -3835.9268

20 [8.452946] fitness = -3143.8567

21 [11.388493] fitness = -3835.7964

22 [11.390446] fitness = -3835.9248

23 [11.390446] fitness = -3835.9248

24 [12.451012] fitness = -3822.146

25 [14.417561] fitness = -3284.4258

26 [9.403509] fitness = -3462.2195

27 [11.403629] fitness = -3836.776

28 [12.390448] fitness = -3827.6528

29 [11.390446] fitness = -3835.9248

30 [11.405338] fitness = -3836.8838

31 [11.403873] fitness = -3836.791

32 [10.278667] fitness = -3682.563

33 [11.390495] fitness = -3835.9287

34 [11.889744] fitness = -3850.7148

35 [53.0] fitness = 402256.0

36 [40.386665] fitness = 150375.31

37 [12.3384285] fitness = -3831.9033

38 [11.390446] fitness = -3835.9248

39 [23.0] fitness = 11056.0

40 [8.454426] fitness = -3144.4062

41 [13.263256] fitness = -3687.7402

42 [32.454426] fitness = 63088.617

43 [11.278378] fitness = -3827.7256

44 [12.696875] fitness = -3793.5269

45 [11.390446] fitness = -3835.9248

46 [11.390446] fitness = -3835.9248

47 [11.390446] fitness = -3835.9248

48 [11.390446] fitness = -3835.9248

49 [11.403416] fitness = -3836.7622

Best in generation -3850.7148

New population

0 [11.403629] fitness = -3836.776

1 [11.405369] fitness = -3836.8857

2 [11.890476] fitness = -3850.71

3 [11.905369] fitness = -3850.585

4 [11.403385] fitness = -3836.7603

5 [11.390219] fitness = -3835.9111

6 [11.403904] fitness = -3836.793

7 [11.389759] fitness = -3835.8804

8 [11.887791] fitness = -3850.729

9 [11.890247] fitness = -3850.712

10 [11.890476] fitness = -3850.71

11 [11.405582] fitness = -3836.899

12 [11.388523] fitness = -3835.7993

13 [11.388538] fitness = -3835.7998

14 [11.8904915] fitness = -3850.7104

15 [11.905338] fitness = -3850.5845

16 [11.887791] fitness = -3850.729

17 [11.390446] fitness = -3835.9248

18 [11.390461] fitness = -3835.9263

19 [11.890003] fitness = -3850.7134

20 [11.389713] fitness = -3835.877

21 [11.405827] fitness = -3836.9146

22 [11.903416] fitness = -3850.603

23 [11.405338] fitness = -3836.8838

24 [11.887791] fitness = -3850.729

25 [11.405369] fitness = -3836.8857

26 [11.8904915] fitness = -3850.7104

27 [11.889744] fitness = -3850.7148

28 [11.389759] fitness = -3835.8804

29 [11.405857] fitness = -3836.916

30 [11.903418] fitness = -3850.604

31 [12.265499] fitness = -3837.1255

32 [11.889759] fitness = -3850.7158

33 [11.403904] fitness = -3836.793

34 [11.403416] fitness = -3836.7622

35 [11.390476] fitness = -3835.9268

36 [32.454426] fitness = 63088.617

37 [53.0] fitness = 402256.0

38 [53.0] fitness = 402256.0

39 [53.0] fitness = 402256.0

40 [12.386665] fitness = -3827.9766

41 [11.390446] fitness = -3835.9248

42 [53.0] fitness = 402256.0

43 [8.454426] fitness = -3144.4062

44 [24.841673] fitness = 17627.965

45 [11.889744] fitness = -3850.7148

46 [11.889744] fitness = -3850.7148

47 [11.889744] fitness = -3850.7148

48 [11.889744] fitness = -3850.7148

49 [11.390495] fitness = -3835.9287

Best in generation -3850.729

New population

0 [11.887791] fitness = -3850.729

1 [11.890476] fitness = -3850.71

2 [11.88805] fitness = -3850.7275

3 [11.887791] fitness = -3850.729

4 [11.889759] fitness = -3850.7158

5 [11.888294] fitness = -3850.7256

6 [11.887791] fitness = -3850.729

7 [11.887791] fitness = -3850.729

8 [11.887791] fitness = -3850.729

9 [11.889744] fitness = -3850.7148

10 [11.887791] fitness = -3850.729

11 [11.905369] fitness = -3850.585

12 [11.890232] fitness = -3850.7114

13 [11.889744] fitness = -3850.7148

14 [11.888538] fitness = -3850.7236

15 [11.887791] fitness = -3850.729

16 [11.887791] fitness = -3850.729

17 [11.887791] fitness = -3850.729

18 [11.887791] fitness = -3850.729

19 [11.889744] fitness = -3850.7148

20 [11.890003] fitness = -3850.7134

21 [11.887791] fitness = -3850.729

22 [11.889759] fitness = -3850.7158

23 [11.889744] fitness = -3850.7148

24 [11.887791] fitness = -3850.729

25 [11.889744] fitness = -3850.7148

26 [11.890247] fitness = -3850.712

27 [11.888279] fitness = -3850.726

28 [11.887791] fitness = -3850.729

29 [11.887791] fitness = -3850.729

30 [11.889744] fitness = -3850.7148

31 [11.887791] fitness = -3850.729

32 [11.889759] fitness = -3850.7158

33 [11.887791] fitness = -3850.729

34 [11.887791] fitness = -3850.729

35 [12.265499] fitness = -3837.1255

36 [11.405582] fitness = -3836.899

37 [53.0] fitness = 402256.0

38 [41.903416] fitness = 172683.4

39 [25.389713] fitness = 19879.516

40 [11.405582] fitness = -3836.899

41 [42.405827] fitness = 180510.81

42 [13.403904] fitness = -3652.4756

43 [53.0] fitness = 402256.0

44 [53.0] fitness = 402256.0

45 [11.887791] fitness = -3850.729

46 [11.889744] fitness = -3850.7148

47 [11.887791] fitness = -3850.729

48 [11.890003] fitness = -3850.7134

49 [11.8904915] fitness = -3850.7104

Best in generation -3850.729

New population

0 [11.887791] fitness = -3850.729

1 [11.887791] fitness = -3850.729

2 [11.887791] fitness = -3850.729

3 [11.887791] fitness = -3850.729

4 [11.887791] fitness = -3850.729

5 [11.887791] fitness = -3850.729

6 [11.887791] fitness = -3850.729

7 [11.887791] fitness = -3850.729

8 [11.887791] fitness = -3850.729

9 [11.887791] fitness = -3850.729

10 [11.887791] fitness = -3850.729

11 [11.887791] fitness = -3850.729

12 [11.887791] fitness = -3850.729

13 [11.887791] fitness = -3850.729

14 [11.887791] fitness = -3850.729

15 [11.887791] fitness = -3850.729

16 [11.887791] fitness = -3850.729

17 [11.887791] fitness = -3850.729

18 [11.887791] fitness = -3850.729

19 [11.887791] fitness = -3850.729

20 [11.887791] fitness = -3850.729

21 [11.887791] fitness = -3850.729

22 [11.887791] fitness = -3850.729

23 [11.887791] fitness = -3850.729

24 [11.887791] fitness = -3850.729

25 [11.887791] fitness = -3850.729

26 [11.887791] fitness = -3850.729

27 [11.887791] fitness = -3850.729

28 [11.887791] fitness = -3850.729

29 [11.887791] fitness = -3850.729

30 [11.887791] fitness = -3850.729

31 [11.887791] fitness = -3850.729

32 [11.887791] fitness = -3850.729

33 [11.887791] fitness = -3850.729

34 [11.887791] fitness = -3850.729

35 [14.890003] fitness = -3039.9766

36 [11.887791] fitness = -3850.729

37 [19.88779] fitness = 3094.0625

38 [11.889744] fitness = -3850.7148

39 [11.889759] fitness = -3850.7158

40 [53.0] fitness = 402256.0

41 [11.887791] fitness = -3850.729

42 [53.0] fitness = 402256.0

43 [53.0] fitness = 402256.0

44 [11.890232] fitness = -3850.7114

45 [11.887791] fitness = -3850.729

46 [11.887791] fitness = -3850.729

47 [11.887791] fitness = -3850.729

48 [11.887791] fitness = -3850.729

49 [11.887791] fitness = -3850.729

Best in generation -3850.729

New population

0 [11.887791] fitness = -3850.729

1 [11.887791] fitness = -3850.729

2 [11.887791] fitness = -3850.729

3 [11.887791] fitness = -3850.729

4 [11.887791] fitness = -3850.729

5 [11.887791] fitness = -3850.729

6 [11.887791] fitness = -3850.729

7 [11.887791] fitness = -3850.729

8 [11.887791] fitness = -3850.729

9 [11.887791] fitness = -3850.729

10 [11.887791] fitness = -3850.729

11 [11.887791] fitness = -3850.729

12 [11.887791] fitness = -3850.729

13 [11.887791] fitness = -3850.729

14 [11.887791] fitness = -3850.729

15 [11.887791] fitness = -3850.729

16 [11.887791] fitness = -3850.729

17 [11.887791] fitness = -3850.729

18 [11.887791] fitness = -3850.729

19 [11.887791] fitness = -3850.729

20 [11.887791] fitness = -3850.729

21 [11.887791] fitness = -3850.729

22 [11.887791] fitness = -3850.729

23 [11.887791] fitness = -3850.729

24 [11.887791] fitness = -3850.729

25 [11.887791] fitness = -3850.729

26 [11.887791] fitness = -3850.729

27 [11.887791] fitness = -3850.729

28 [11.887791] fitness = -3850.729

29 [11.887791] fitness = -3850.729

30 [11.887791] fitness = -3850.729

31 [11.887791] fitness = -3850.729

32 [11.887791] fitness = -3850.729

33 [11.887791] fitness = -3850.729

34 [11.887791] fitness = -3850.729

35 [53.0] fitness = 402256.0

36 [14.887791] fitness = -3041.2344

37 [41.88779] fitness = 172443.53

38 [41.88779] fitness = 172443.53

39 [45.0] fitness = 224544.0

40 [11.887791] fitness = -3850.729

41 [11.887791] fitness = -3850.729

42 [53.0] fitness = 402256.0

43 [53.0] fitness = 402256.0

44 [53.0] fitness = 402256.0

45 [11.887791] fitness = -3850.729

46 [11.887791] fitness = -3850.729

47 [11.887791] fitness = -3850.729

48 [11.887791] fitness = -3850.729

49 [11.887791] fitness = -3850.729

Best in generation -3850.729

New population

0 [11.887791] fitness = -3850.729

1 [11.887791] fitness = -3850.729

2 [11.887791] fitness = -3850.729

3 [11.887791] fitness = -3850.729

4 [11.887791] fitness = -3850.729

5 [11.887791] fitness = -3850.729

6 [11.887791] fitness = -3850.729

7 [11.887791] fitness = -3850.729

8 [11.887791] fitness = -3850.729

9 [11.887791] fitness = -3850.729

10 [11.887791] fitness = -3850.729

11 [11.887791] fitness = -3850.729

12 [11.887791] fitness = -3850.729

13 [11.887791] fitness = -3850.729

14 [11.887791] fitness = -3850.729

15 [11.887791] fitness = -3850.729

16 [11.887791] fitness = -3850.729

17 [11.887791] fitness = -3850.729

18 [11.887791] fitness = -3850.729

19 [11.887791] fitness = -3850.729

20 [11.887791] fitness = -3850.729

21 [11.887791] fitness = -3850.729

22 [11.887791] fitness = -3850.729

23 [11.887791] fitness = -3850.729

24 [11.887791] fitness = -3850.729

25 [11.887791] fitness = -3850.729

26 [11.887791] fitness = -3850.729

27 [11.887791] fitness = -3850.729

28 [11.887791] fitness = -3850.729

29 [11.887791] fitness = -3850.729

30 [11.887791] fitness = -3850.729

31 [11.887791] fitness = -3850.729

32 [11.887791] fitness = -3850.729

33 [11.887791] fitness = -3850.729

34 [11.887791] fitness = -3850.729

35 [53.0] fitness = 402256.0

36 [11.887791] fitness = -3850.729

37 [53.0] fitness = 402256.0

38 [11.887791] fitness = -3850.729

39 [53.0] fitness = 402256.0

40 [13.887791] fitness = -3502.373

41 [35.88779] fitness = 95186.57

42 [53.0] fitness = 402256.0

43 [25.88779] fitness = 22049.555

44 [11.887791] fitness = -3850.729

45 [11.887791] fitness = -3850.729

46 [11.887791] fitness = -3850.729

47 [11.887791] fitness = -3850.729

48 [11.887791] fitness = -3850.729

49 [11.887791] fitness = -3850.729

Best in generation -3850.729

New population

0 [11.887791] fitness = -3850.729

1 [11.887791] fitness = -3850.729

2 [11.887791] fitness = -3850.729

3 [11.887791] fitness = -3850.729

4 [11.887791] fitness = -3850.729

5 [11.887791] fitness = -3850.729

6 [11.887791] fitness = -3850.729

7 [11.887791] fitness = -3850.729

8 [11.887791] fitness = -3850.729

9 [11.887791] fitness = -3850.729

10 [11.887791] fitness = -3850.729

11 [11.887791] fitness = -3850.729

12 [11.887791] fitness = -3850.729

13 [11.887791] fitness = -3850.729

14 [11.887791] fitness = -3850.729

15 [11.887791] fitness = -3850.729

16 [11.887791] fitness = -3850.729

17 [11.887791] fitness = -3850.729

18 [11.887791] fitness = -3850.729

19 [11.887791] fitness = -3850.729

20 [11.887791] fitness = -3850.729

21 [11.887791] fitness = -3850.729

22 [11.887791] fitness = -3850.729

23 [11.887791] fitness = -3850.729

24 [11.887791] fitness = -3850.729

25 [11.887791] fitness = -3850.729

26 [11.887791] fitness = -3850.729

27 [11.887791] fitness = -3850.729

28 [11.887791] fitness = -3850.729

29 [11.887791] fitness = -3850.729

30 [11.887791] fitness = -3850.729

31 [11.887791] fitness = -3850.729

32 [11.887791] fitness = -3850.729

33 [11.887791] fitness = -3850.729

34 [11.887791] fitness = -3850.729

35 [11.887791] fitness = -3850.729

36 [11.887791] fitness = -3850.729

37 [13.887791] fitness = -3502.373

38 [14.887791] fitness = -3041.2344

39 [11.887791] fitness = -3850.729

40 [25.88779] fitness = 22049.555

41 [11.887791] fitness = -3850.729

42 [11.887791] fitness = -3850.729

43 [11.887791] fitness = -3850.729

44 [11.887791] fitness = -3850.729

45 [11.887791] fitness = -3850.729

46 [11.887791] fitness = -3850.729

47 [11.887791] fitness = -3850.729

48 [11.887791] fitness = -3850.729

49 [11.887791] fitness = -3850.729

Best in generation -3850.729

Result:

[11.887791] fitness = -3850.729

Результат виконання програми для десяти поколінь з розміром популяції 50 для знаходження максимуму функції:

Initial population

0 [-2.205124] fitness = -117.99069

1 [-5.8874702] fitness = -2534.4707

2 [5.2923] fitness = -1752.7102

3 [-0.5197725] fitness = 70.23552

4 [3.3890734] fitness = -900.19574

5 [7.065256] fitness = -2573.0308

6 [0.39784908] fitness = -9.54664

7 [-2.9828253] fitness = -376.92004

8 [5.20487] fitness = -1711.729

9 [-9.84541] fitness = -9327.638

10 [3.9204464] fitness = -1126.1188

11 [2.125268] fitness = -429.2516

12 [-2.3772883] fitness = -165.1718

13 [0.03494358] fitness = 35.563778

14 [1.2644463] fitness = -181.42154

15 [3.8911877] fitness = -1113.3528

16 [7.6763115] fitness = -2836.6216

17 [-7.023828] fitness = -3978.1597

18 [-5.968654] fitness = -2625.4023

19 [7.0055504] fitness = -2546.475

20 [-5.1263785] fitness = -1768.4915

21 [-7.5493994] fitness = -4775.882

22 [9.567501] fitness = -3509.3398

23 [-0.6986542] fitness = 72.00281

24 [-2.794013] fitness = -303.05676

25 [8.079668] fitness = -3000.6812

26 [-1.0987768] fitness = 58.286507

27 [-7.9919505] fitness = -5514.9727

28 [6.7624874] fitness = -2437.164

29 [-3.7262535] fitness = -740.52795

30 [-0.5728493] fitness = 71.25512

31 [1.7147398] fitness = -302.44968

32 [-1.2885513] fitness = 42.898643

33 [-0.3247652] fitness = 62.97379

34 [-2.0792723] fitness = -87.01376

35 [2.4199924] fitness = -529.0062

36 [-8.151011] fitness = -5796.095

37 [2.3054228] fitness = -489.41083

38 [6.582344] fitness = -2355.0515

39 [-2.4828587] fitness = -196.8961

40 [-4.8787823] fitness = -1551.9147

41 [-3.2198644] fitness = -480.0454

42 [-4.2235937] fitness = -1052.1052

43 [-5.5632915] fitness = -2189.3286

44 [-2.0094347] fitness = -71.083725

45 [7.320364] fitness = -2685.006

46 [-1.7853594] fitness = -25.931938

47 [2.3227043] fitness = -495.3181

48 [1.5383549] fitness = -252.67767

49 [2.3272219] fitness = -496.86615

New population

0 [-0.5197725] fitness = 70.23552

1 [-0.6986542] fitness = 72.00281

2 [-2.205124] fitness = -117.99069

3 [-1.2885513] fitness = 42.898643

4 [-1.2885513] fitness = 42.898643

5 [-0.5197725] fitness = 70.23552

6 [-2.0094347] fitness = -71.083725

7 [-0.5197725] fitness = 70.23552

8 [-0.5197725] fitness = 70.23552

9 [-1.0987768] fitness = 58.286507

10 [-0.6986542] fitness = 72.00281

11 [-1.0987768] fitness = 58.286507

12 [0.03494358] fitness = 35.563778

13 [-2.794013] fitness = -303.05676

14 [-0.5728493] fitness = 71.25512

15 [-1.0987768] fitness = 58.286507

16 [-1.7853594] fitness = -25.931938

17 [-0.3247652] fitness = 62.97379

18 [-0.5197725] fitness = 70.23552

19 [0.39784908] fitness = -9.54664

20 [-1.2885513] fitness = 42.898643

21 [0.03494358] fitness = 35.563778

22 [-0.5197725] fitness = 70.23552

23 [1.5383549] fitness = -252.67767

24 [-0.5197725] fitness = 70.23552

25 [-0.3247652] fitness = 62.97379

26 [0.39784908] fitness = -9.54664

27 [-0.5197725] fitness = 70.23552

28 [0.03494358] fitness = 35.563778

29 [-1.7853594] fitness = -25.931938

30 [-0.5728493] fitness = 71.25512

31 [-1.0987768] fitness = 58.286507

32 [-1.2885513] fitness = 42.898643

33 [-0.5197725] fitness = 70.23552

34 [-0.6986542] fitness = 72.00281

35 [-7.8825893] fitness = -5326.4766

36 [-2.0029044] fitness = -69.639755

37 [-2.111415] fitness = -94.64642

38 [9.36319] fitness = -3450.2532

39 [7.2663517] fitness = -2661.5112

40 [-5.928665] fitness = -2580.3843

41 [-3.1723857] fitness = -458.44897

42 [-3.6060214] fitness = -673.61115

43 [5.0430384] fitness = -1636.0686

44 [-9.0384865] fitness = -7520.3887

45 [-0.6986542] fitness = 72.00281

46 [-0.3247652] fitness = 62.97379

47 [-2.205124] fitness = -117.99069

48 [-1.2885513] fitness = 42.898643

49 [-0.5728493] fitness = 71.25512

Best in generation 72.00281

New population

0 [-0.5197725] fitness = 70.23552

1 [-0.5728493] fitness = 71.25512

2 [-0.5728493] fitness = 71.25512

3 [-0.6986542] fitness = 72.00281

4 [-0.6986542] fitness = 72.00281

5 [-0.5197725] fitness = 70.23552

6 [-0.6986542] fitness = 72.00281

7 [-0.5197725] fitness = 70.23552

8 [-0.6986542] fitness = 72.00281

9 [-0.5197725] fitness = 70.23552

10 [-0.6986542] fitness = 72.00281

11 [-0.5197725] fitness = 70.23552

12 [-0.5197725] fitness = 70.23552

13 [-0.6986542] fitness = 72.00281

14 [-0.5197725] fitness = 70.23552

15 [-0.5728493] fitness = 71.25512

16 [-0.6986542] fitness = 72.00281

17 [-0.5197725] fitness = 70.23552

18 [-0.5728493] fitness = 71.25512

19 [-0.5197725] fitness = 70.23552

20 [-0.5728493] fitness = 71.25512

21 [-0.6986542] fitness = 72.00281

22 [-0.6986542] fitness = 72.00281

23 [-0.6986542] fitness = 72.00281

24 [-0.5728493] fitness = 71.25512

25 [-0.5728493] fitness = 71.25512

26 [-0.6986542] fitness = 72.00281

27 [-0.6986542] fitness = 72.00281

28 [-0.6986542] fitness = 72.00281

29 [-0.5728493] fitness = 71.25512

30 [-0.6986542] fitness = 72.00281

31 [-0.6986542] fitness = 72.00281

32 [-0.6986542] fitness = 72.00281

33 [-0.6986542] fitness = 72.00281

34 [-0.6986542] fitness = 72.00281

35 [-2.880558] fitness = -336.01364

36 [-9.429987] fitness = -8367.906

37 [-0.9485254] fitness = 66.364944

38 [1.3835611] fitness = -211.48215

39 [-4.4728518] fitness = -1229.9778

40 [0.6987715] fitness = -59.43214

41 [-0.42131424] fitness = 67.25414

42 [-9.661739] fitness = -8895.533

43 [-3.6886702] fitness = -719.2654

44 [-5.523444] fitness = -2148.861

45 [-0.5728493] fitness = 71.25512

46 [-0.5197725] fitness = 70.23552

47 [-0.5197725] fitness = 70.23552

48 [-0.6986542] fitness = 72.00281

49 [-0.6986542] fitness = 72.00281

Best in generation 72.00281

New population

0 [-0.6986542] fitness = 72.00281

1 [-0.5728493] fitness = 71.25512

2 [-0.6986542] fitness = 72.00281

3 [-0.6986542] fitness = 72.00281

4 [-0.6986542] fitness = 72.00281

5 [-0.6986542] fitness = 72.00281

6 [-0.6986542] fitness = 72.00281

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33 [-0.6986542] fitness = 72.00281

34 [-0.6986542] fitness = 72.00281

35 [-3.8975582] fitness = -841.45935

36 [-1.6033182] fitness = 4.200239

37 [-1.8384113] fitness = -35.809708

38 [-4.328972] fitness = -1125.4983

39 [-4.235134] fitness = -1060.0149

40 [-6.918783] fitness = -3828.8538

41 [2.115734] fitness = -426.14172

42 [-9.503571] fitness = -8533.322

43 [0.96517754] fitness = -112.47556

44 [8.184834] fitness = -3041.9177

45 [-0.6986542] fitness = 72.00281

46 [-0.6986542] fitness = 72.00281

47 [-0.6986542] fitness = 72.00281

48 [-0.5728493] fitness = 71.25512

49 [-0.6986542] fitness = 72.00281

Best in generation 72.00281

New population

0 [-0.6986542] fitness = 72.00281

1 [-0.6986542] fitness = 72.00281

2 [-0.6986542] fitness = 72.00281

3 [-0.6986542] fitness = 72.00281

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32 [-0.6986542] fitness = 72.00281

33 [-0.6986542] fitness = 72.00281

34 [-0.6986542] fitness = 72.00281

35 [-6.165963] fitness = -2854.045

36 [-6.3127065] fitness = -3031.1997

37 [0.06594181] fitness = 32.3794

38 [-1.0773487] fitness = 59.658066

39 [5.2359953] fitness = -1726.311

40 [2.1010208] fitness = -421.3573

41 [6.0495453] fitness = -2108.1743

42 [-9.1304455] fitness = -7714.574

43 [5.4003143] fitness = -1803.4114

44 [-7.5247726] fitness = -4736.586

45 [-0.6986542] fitness = 72.00281

46 [-0.6986542] fitness = 72.00281

47 [-0.6986542] fitness = 72.00281

48 [-0.6986542] fitness = 72.00281

49 [-0.6986542] fitness = 72.00281

Best in generation 72.00281

New population

0 [-0.6986542] fitness = 72.00281

1 [-0.6986542] fitness = 72.00281

2 [-0.6986542] fitness = 72.00281

3 [-0.6986542] fitness = 72.00281

4 [-0.6986542] fitness = 72.00281

5 [-0.6986542] fitness = 72.00281

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31 [-0.6986542] fitness = 72.00281

32 [-0.6986542] fitness = 72.00281

33 [-0.6986542] fitness = 72.00281

34 [-0.6986542] fitness = 72.00281

35 [-1.4877224] fitness = 20.357841

36 [0.7715874] fitness = -73.12319

37 [-1.986476] fitness = -66.04135

38 [-2.7950373] fitness = -303.438

39 [4.6617393] fitness = -1459.3264

40 [9.656319] fitness = -3533.7937

41 [4.5796185] fitness = -1421.6365

42 [1.2227688] fitness = -171.2488

43 [-9.678463] fitness = -8934.364

44 [-5.600481] fitness = -2227.4797

45 [-0.6986542] fitness = 72.00281

46 [-0.6986542] fitness = 72.00281

47 [-0.6986542] fitness = 72.00281

48 [-0.6986542] fitness = 72.00281

49 [-0.6986542] fitness = 72.00281

Best in generation 72.00281

New population

0 [-0.6986542] fitness = 72.00281

1 [-0.6986542] fitness = 72.00281

2 [-0.6986542] fitness = 72.00281

3 [-0.6986542] fitness = 72.00281

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30 [-0.6986542] fitness = 72.00281

31 [-0.6986542] fitness = 72.00281

32 [-0.6986542] fitness = 72.00281

33 [-0.6986542] fitness = 72.00281

34 [-0.6986542] fitness = 72.00281

35 [8.935589] fitness = -3314.5752

36 [-0.6411085] fitness = 71.95404

37 [-2.0102081] fitness = -71.25528

38 [8.286415] fitness = -3081.0933

39 [2.0314589] fitness = -398.98343

40 [8.58987] fitness = -3194.0364

41 [6.701887] fitness = -2409.6367

42 [-1.5483036] fitness = 12.175143

43 [6.9168243] fitness = -2506.7883

44 [-3.4261703] fitness = -579.4511

45 [-0.6986542] fitness = 72.00281

46 [-0.6986542] fitness = 72.00281

47 [-0.6986542] fitness = 72.00281

48 [-0.6986542] fitness = 72.00281

49 [-0.6986542] fitness = 72.00281

Best in generation 72.00281

New population

0 [-0.6986542] fitness = 72.00281

1 [-0.6986542] fitness = 72.00281

2 [-0.6986542] fitness = 72.00281

3 [-0.6986542] fitness = 72.00281

4 [-0.6986542] fitness = 72.00281

5 [-0.6986542] fitness = 72.00281

6 [-0.6986542] fitness = 72.00281

7 [-0.6986542] fitness = 72.00281

8 [-0.6986542] fitness = 72.00281

9 [-0.6986542] fitness = 72.00281

10 [-0.6986542] fitness = 72.00281

11 [-0.6986542] fitness = 72.00281

12 [-0.6986542] fitness = 72.00281

13 [-0.6986542] fitness = 72.00281

14 [-0.6986542] fitness = 72.00281

15 [-0.6986542] fitness = 72.00281

16 [-0.6986542] fitness = 72.00281

17 [-0.6986542] fitness = 72.00281

18 [-0.6986542] fitness = 72.00281

19 [-0.6986542] fitness = 72.00281

20 [-0.6986542] fitness = 72.00281

21 [-0.6986542] fitness = 72.00281

22 [-0.6986542] fitness = 72.00281

23 [-0.6986542] fitness = 72.00281

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34 [-0.6986542] fitness = 72.00281

35 [9.082779] fitness = -3363.034

36 [-3.227538] fitness = -483.58057

37 [-4.2704153] fitness = -1084.3909

38 [6.6053333] fitness = -2365.5767

39 [-8.878111] fitness = -7188.8193

40 [8.263594] fitness = -3072.3494

41 [-5.6800747] fitness = -2310.3813

42 [0.9491997] fitness = -109.06799

43 [6.7589607] fitness = -2435.565

44 [8.789753] fitness = -3264.8435

45 [-0.6986542] fitness = 72.00281

46 [-0.6986542] fitness = 72.00281

47 [-0.6986542] fitness = 72.00281

48 [-0.6986542] fitness = 72.00281

49 [-0.6986542] fitness = 72.00281

Best in generation 72.00281

New population

0 [-0.6986542] fitness = 72.00281

1 [-0.6986542] fitness = 72.00281

2 [-0.6986542] fitness = 72.00281

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33 [-0.6986542] fitness = 72.00281

34 [-0.6986542] fitness = 72.00281

35 [-0.11062622] fitness = 48.794743

36 [-2.6585555] fitness = -254.49094

37 [-5.461091] fitness = -2086.3865

38 [-7.4714317] fitness = -4652.126

39 [4.4192715] fitness = -1348.5245

40 [6.7490997] fitness = -2431.0916

41 [9.897545] fitness = -3596.2688

42 [3.7245197] fitness = -1041.3141

43 [-3.7440777] fitness = -750.72217

44 [-9.705715] fitness = -8997.86

45 [-0.6986542] fitness = 72.00281

46 [-0.6986542] fitness = 72.00281

47 [-0.6986542] fitness = 72.00281

48 [-0.6986542] fitness = 72.00281

49 [-0.6986542] fitness = 72.00281

Best in generation 72.00281

New population

0 [-0.6986542] fitness = 72.00281

1 [-0.6986542] fitness = 72.00281

2 [-0.6986542] fitness = 72.00281

3 [-0.6986542] fitness = 72.00281

4 [-0.6986542] fitness = 72.00281

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32 [-0.6986542] fitness = 72.00281

33 [-0.6986542] fitness = 72.00281

34 [-0.6986542] fitness = 72.00281

35 [1.9099026] fitness = -360.8812

36 [0.55415726] fitness = -34.09344

37 [6.3744793] fitness = -2259.345

38 [7.1691856] fitness = -2618.951

39 [5.7133045] fitness = -1950.5099

40 [-0.8658781] fitness = 69.29464

41 [9.735868] fitness = -3555.0413

42 [7.557701] fitness = -2786.7534

43 [-5.2345657] fitness = -1868.0498

44 [-0.33917522] fitness = 63.69708

45 [-0.6986542] fitness = 72.00281

46 [-0.6986542] fitness = 72.00281

47 [-0.6986542] fitness = 72.00281

48 [-0.6986542] fitness = 72.00281

49 [-0.6986542] fitness = 72.00281

Best in generation 72.00281

Results:

[-0.6986542] fitness = 72.00281

Код програми

**public** GAPopulation generate(GAPopulation p, **int** xrate, **int** mrate,

**float**[] min\_range, **float**[] max\_range) {

//creating new population with p, xrate - % of population is mating

// mrate - % of population mutated, rest - recreation

**if** (xrate < 0 || xrate > 100 || mrate < 0 || mrate > 100

|| xrate + mrate > 100)

System.***err***.println("error: xrate and/or mrate set incorrectly");

GAIndividual[] newg = **new** GAIndividual[p.pop\_size];

**int** newg\_index = 0;

**int** xn = xrate \* p.pop\_size / 100;

//xn: amount of sons to mate

**int** mn = mrate \* p.pop\_size / 100;

// mn: amount of sons to mutate

**for** (**int** i = 0; i < xn; i++) {

// select to parents for cross-over:

**int** p1 = p.tr\_select();

**int** p2 = p.tr\_select();

//System.out.println(p1+ " "+ p2);

newg[newg\_index++] = GAIndividual.*xover1p*(p.ind[p1], p.ind[p2]);

}

// mutation

**for** (**int** i = 0; i < mn; i++)

newg[newg\_index++] = p.ind[p.tr\_select()].mutate(min\_range,

max\_range);

// recreation:

**for** (**int** i = newg\_index; i < p.pop\_size; i++)

newg[i] = p.ind[p.tr\_select()];

//for (int i = 0; i < p.pop\_size; i++) {

// System.out.println(i + " " + p.ind[i]);}

**return** **new** GAPopulation(newg);

}

**public** **int** tr\_select() {

//tournament selection of size pop\_size/10

**int** s\_index = *randg*.nextInt(pop\_size);

**float** s\_fitness = ind[s\_index].fitness;

**int** tr\_size = Math.*min*(10, pop\_size);

**for** (**int** i = 1; i < tr\_size; i++) {

**int** tmp = *randg*.nextInt(pop\_size);

**if** (ind[tmp].fitness > s\_fitness) {//< for min//>for max

s\_index = tmp;

s\_fitness = ind[tmp].fitness;

}

}

**return** s\_index;

}

**private** **void** evaluate() {

//evaluation

**int** best = 0;

// index of best individual

**float** best\_fitness = ind[0].fitness;

**float** sum = ind[0].fitness;

**for** (**int** i = 1; i < pop\_size; i++) {

sum += ind[i].fitness;

**if** (ind[i].fitness > best\_fitness) {//< for min//>for max

best = i;

best\_fitness = ind[i].fitness;

}

}

best\_index = best;

}

**Висновки:** виконавши лабораторну роботу я вивчив еволюційні оператори схрещування та мутації в генетичних алгоритмах. Реалізував за допомогою програмної мови Java програмне забезпечення для пошуку оптимумів функції в якому використав турнірний відбір, одно-точковий кросинговер і точкову мутацію. В результаті виконання програми похибка знаходження оптимуму є невеликою, і прямує до 0 при збільшенні кількості популяції і кількості поколінь.