2-Alex Golodko

Minimization of Test Function

High-dimensional Test Function

Problem is minimize or maximize a n-dimensinal function

$y = f(x_1; x_2; x_3; \cdots ; x_n)$

We may use chromosomes with n genes of real value, such as

(0:32;−0:51; 0:48; · · · ;−0:93)

For example, minimize

$y = x^2_1 + x^2_1 + x^2_1 + \cdots + x^2_{20}$

Rastrigin's Function

Exercise 8 1. Minimize the following y in (i) 20-D, (ii) 3-D and (iii) 2-D cases.

y = nA +Σni=1(x2i− Acos(2_xi))

2. Show the following graphics in each of 3 cases (i), (ii) and (iii).

(1) the graph of _tness vs generation.

(2) Create a population of 20 chromosomes at random, with _tness being y.

Task1

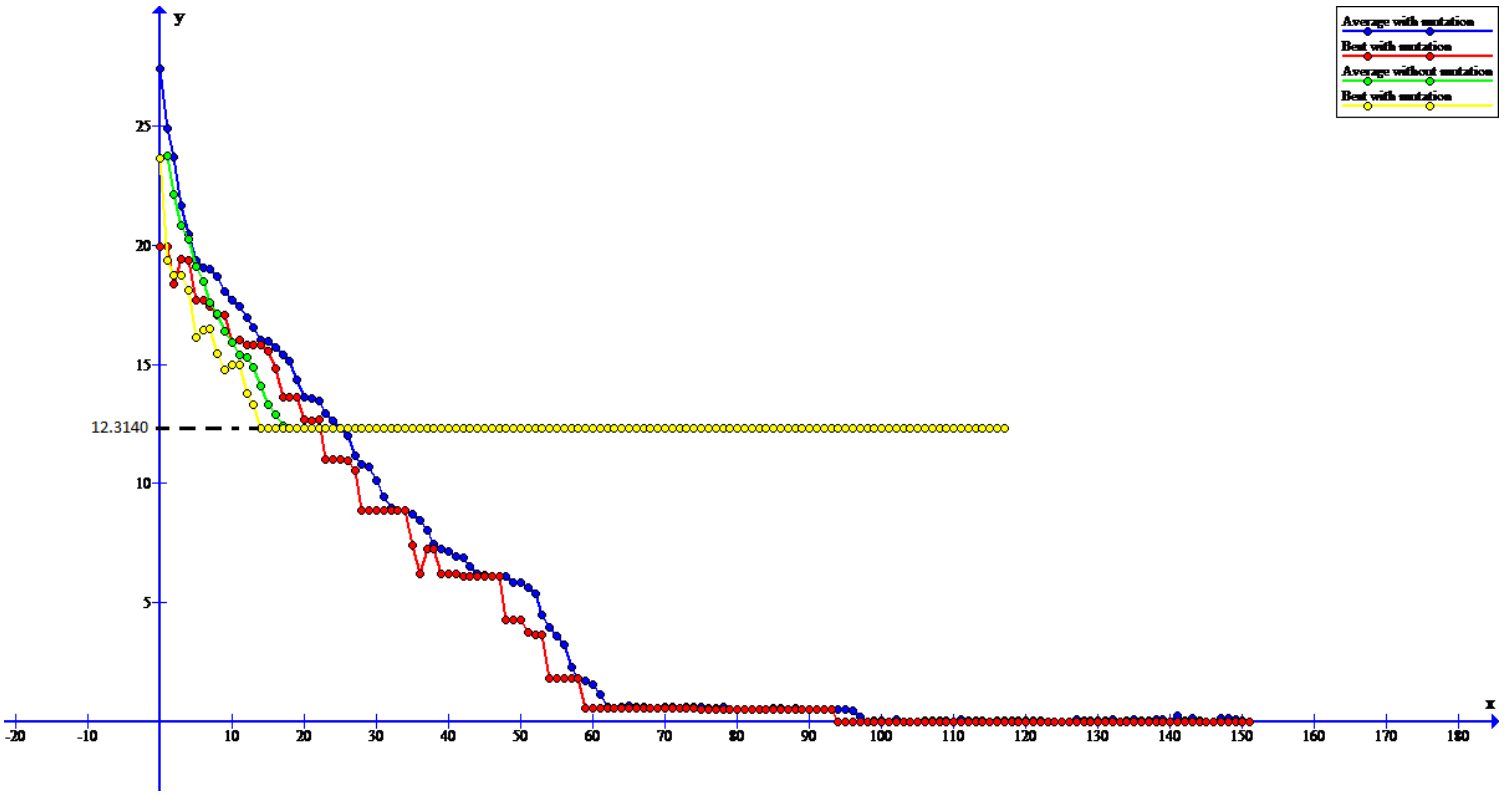
Source code

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace lab3_siit_
{
    class Dot
    {
        public List<double> chromosomes;
        public double fitness;
        public Dot(List<double> chromosomes)
        {
            this.chromosomes = chromosomes;
            fitness = getFitness(chromosomes);
        }
        private double getFitness(List<double> chromosomes)
        {
            double fitness = chromosomes.Count;
            for (int i=0;i<chromosomes.Count;i++)
            {
                double temp = chromosomes[i]* chromosomes[i] - Math.Cos(2 * Math.PI *
chromosomes[i]);
                fitness += temp;
            }
            return fitness;
        }
    }
}


using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace lab3_siit_
{
    class Population
    {
        public List<Dot> dots;
```

```
        public double theBestFitness;
        public double avarageFitness;
        public Population(List<Dot> dogs)
        {
            this.dots = dogs;
            theBestFitness = getTheBestFitness(dogs);
            avarageFitness = getAvarageFitness(dogs);
        }
        public double getTheBestFitness(List<Dot> dogs)
        {
            double bestFitness = 9999;
            for (int i = 0; i < dogs.Count; i++)
                if (bestFitness > dogs[i].fitness)
                    bestFitness = dogs[i].fitness;
            return bestFitness;
        }
        public double getAvarageFitness(List<Dot> dogs)
        {
            double avarageFitness = 0;
            for (int i = 0; i < dogs.Count; i++)
                avarageFitness += dogs[i].fitness;
            avarageFitness /= dogs.Count;
            return avarageFitness;
        }
    }
}
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading;
using System.Threading.Tasks;

namespace lab3_siit_
{
    class GA
    {
        Random random;
        List<Population> historyOfPopulation;
        public GA()
        {
            random = new Random();
            List<Dot> dots = new List<Dot>();
            for (int i = 0; i < 20; i++)
            {
                List<double> chromosomes = new List<double>();
                for (int j = 0; j < 20; j++)
                {
                    chromosomes.Add(random.NextDouble() % 2 -1);
                }
                dots.Add(new Dot(chromosomes));
            }
            //Sorting by fitness
            for (int i = 0; i < dots.Count; i++)
            {
                for (int j = dots.Count - 1; j > i; j--)
                {
                    if (dots[j].fitness > dots[j - 1].fitness)
                    {
                        Dot tempDot = dots[j];
                        dots[j] = dots[j - 1];
                        dots[j - 1] = tempDot;
                    }
                }
            }
            Population startPopulation = new Population(dots);
            historyOfPopulation = new List<Population>();
            historyOfPopulation.Add(startPopulation);
            int k = 0;
            while (!isReady(historyOfPopulation))
```

```
            {
                Thread.Sleep(10);
                historyOfPopulation.Add(getNextPupulation(historyOfPopulation[k]));
                k++;
            }
        }
        private Population getNextPupulation(Population parentPopulation)
        {
            List<Dot> childrenPopulationDots = new List<Dot>();

            for (int i = 0; i < 10; i++)
            {
                List<Dot> childrenDots = getChildren(
                    parentPopulation.dots[random.Next() % 10 + 10],
                    parentPopulation.dots[random.Next() % 10 + 10]
                    );
                childrenPopulationDots.AddRange(childrenDots);
            }
            //Sorting by fitness
            for (int i = 0; i < childrenPopulationDots.Count; i++)
            {
                for (int j = childrenPopulationDots.Count - 1; j > i; j--)
                {
                    if (childrenPopulationDots[j].fitness > childrenPopulationDots[j - 1].fitness)
                    {
                        Dot tempDot = childrenPopulationDots[j];
                        childrenPopulationDots[j] = childrenPopulationDots[j - 1];
                        childrenPopulationDots[j - 1] = tempDot;
                    }
                }
            }
            Population childrenPopulation = new Population(childrenPopulationDots);
            return childrenPopulation;
        }

        Boolean isReady(List<Population> historyOfPopulation)
        {
            if (historyOfPopulation.Count < 100)
                return false;
            else
            {
                for (int i = historyOfPopulation.Count - 100; i < historyOfPopulation.Count; i++)
                {
                    if (historyOfPopulation[historyOfPopulation.Count - 100].avarageFitness !=
historyOfPopulation[i].avarageFitness)
                        return false;
                }
                return true;
            }
        }
        private List<Dot> getChildren(Dot father, Dot mother)
        {
            List<Dot> childrenDots = new List<Dot>();
            int pointCross = random.Next()%20;
            List<double> firstChromosomes = new List<double>();
            List<double> secondChromosomes = new List<double>();
            for (int j = 0; j < 20; j++)
            {
                if(j<pointCross)
                {
                    firstChromosomes.Add(father.chromosomes[j]);
                    secondChromosomes.Add(mother.chromosomes[j]);
                }
                else
                {
                    firstChromosomes.Add(mother.chromosomes[j]);
                    secondChromosomes.Add(father.chromosomes[j]);
                }
            }
```

```
            childrenDots.Add(new Dot(firstChromosomes));
            childrenDots.Add(new Dot(secondChromosomes));

            //Mutation
            for (int j = 0; j < childrenDots.Count; j++)
            {
                int prob = random.Next(0, 20);
                if (prob == 7)
                {
                    int number = random.Next(20);
                    childrenDots[j].chromosomes[number] = random.NextDouble() % 2 - 1;
                }
            }
            return childrenDots;
        }
    }
}
```



Best fitness with mutation equal 0;

Best fitness without mutation equal 12,314;

Task2

Rastrigin's Function

Exercise 8 1. Minimize the following y in (i) 20-D, (ii) 3-D and (iii) 2-D cases.

y = nA +Σni=1(x2i− Acos(2_xi))

Where A and n equal 1;

2. Show the following graphics in each of 3 cases (i), (ii) and (iii).

(1) the graph of _tness vs generation.

(2) Create a population of 20 chromosomes at random, with _tness being y.

Source code

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
```

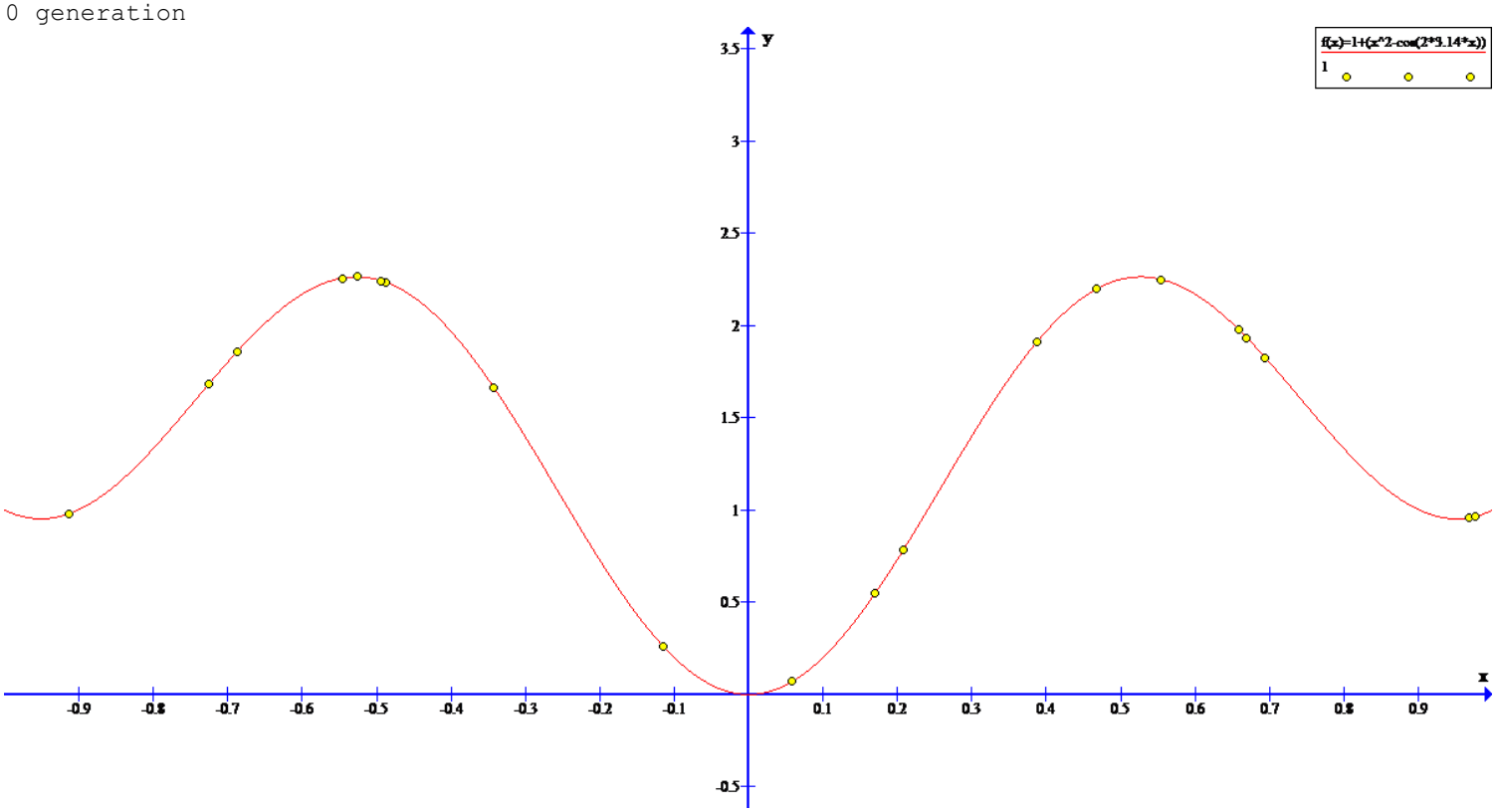
```
namespace lab3_siit_
    class Dot
    {
        public List<double> chromosomes;
        public double fitness;
        public Dot(List<double> chromosomes)
        {
            this.chromosomes = chromosomes;
            fitness = getFitness(chromosomes);
        }
        private double getFitness(List<double> chromosomes)
        {
            double fitness = chromosomes.Count;
            double x=0;
            for (int i = 1; i < chromosomes.Count; i++)
                if (chromosomes[i] == 1)
                    x += Math.Pow(2, i - 1);
            x /= 1023;
            if (chromosomes[0] == 0)
                x *= -1;
            return 1 + (x * x - Math.Cos(Math.PI * 2 * x));
        }
    }
}
```

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace lab3_siit_
{
    class Population
    {
        public List<Dot> dots;
        public double theBestFitness;
        public double avarageFitness;
        public Population(List<Dot> dogs)
        {
            this.dots = dogs;
            theBestFitness = getTheBestFitness(dogs);
            avarageFitness = getAvarageFitness(dogs);
        }
        public double getTheBestFitness(List<Dot> dogs)
        {
            double bestFitness = 9999;
            for (int i = 0; i < dogs.Count; i++)
                if (bestFitness > dogs[i].fitness)
                    bestFitness = dogs[i].fitness;
            return bestFitness;
        }
        public double getAvarageFitness(List<Dot> dogs)
        {
            double avarageFitness = 0;
            for (int i = 0; i < dogs.Count; i++)
                avarageFitness += dogs[i].fitness;
            avarageFitness /= dogs.Count;
            return avarageFitness;
        }
    }
}
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading;
using System.Threading.Tasks;
```

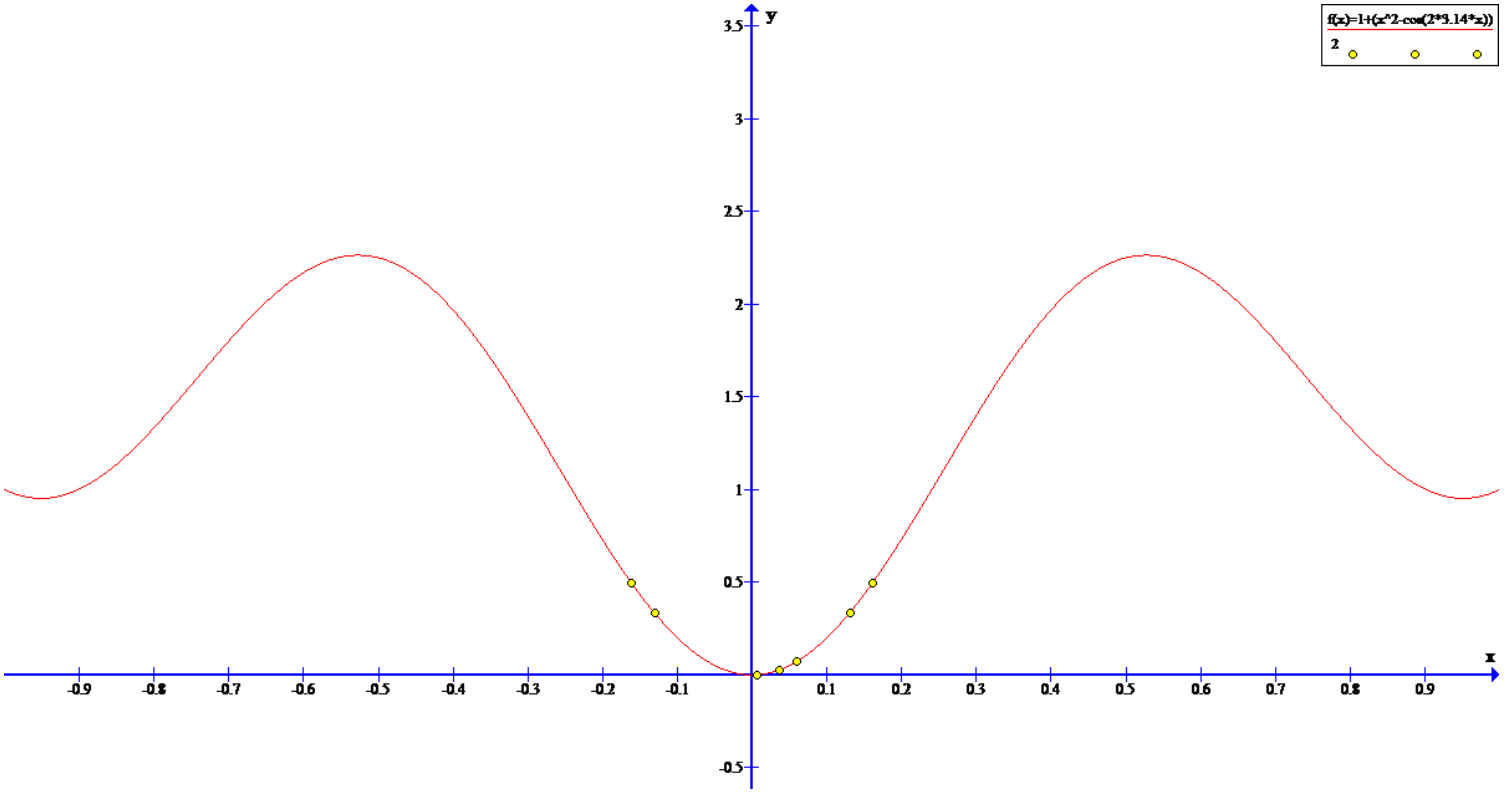
```
namespace lab3_siit_
{
    class GA
    {
        Random random;
        List<Population> historyOfPopulation;
        public GA()
        {
            random = new Random();
            List<Dot> dots = new List<Dot>();
            for (int i = 0; i < 20; i++)
            {
                List<double> chromosomes = new List<double>();
                for (int j = 0; j < 11; j++)
                {
                    chromosomes.Add(random.Next() % 2);
                }
                dots.Add(new Dot(chromosomes));
            }
            //Sorting by fitness
            for (int i = 0; i < dots.Count; i++)
            {
                for (int j = dots.Count - 1; j > i; j--)
                {
                    if (dots[j].fitness > dots[j - 1].fitness)
                    {
                        Dot tempDot = dots[j];
                        dots[j] = dots[j - 1];
                        dots[j - 1] = tempDot;
                    }
                }
            }
            Population startPopulation = new Population(dots);
            historyOfPopulation = new List<Population>();
            historyOfPopulation.Add(startPopulation);
            int k = 0;
            while (!isReady(historyOfPopulation))
            {
                Thread.Sleep(10);
                historyOfPopulation.Add(getNextPupulation(historyOfPopulation[k]));
                k++;
            }
        }
        private Population getNextPupulation(Population parentPopulation)
        {
            List<Dot> childrenPopulationDots = new List<Dot>();

            for (int i = 0; i < 10; i++)
            {
                List<Dot> childrenDots = getChildren(
                    parentPopulation.dots[random.Next() % 10 + 10],
                    parentPopulation.dots[random.Next() % 10 + 10]
                    );
                childrenPopulationDots.AddRange(childrenDots);
            }
            //Sorting by fitness
            for (int i = 0; i < childrenPopulationDots.Count; i++)
            {
                for (int j = childrenPopulationDots.Count - 1; j > i; j--)
                {
                    if (childrenPopulationDots[j].fitness > childrenPopulationDots[j - 1].fitness)
                    {
                        Dot tempDot = childrenPopulationDots[j];
                        childrenPopulationDots[j] = childrenPopulationDots[j - 1];
                        childrenPopulationDots[j - 1] = tempDot;
                    }
                }
            }
            Population childrenPopulation = new Population(childrenPopulationDots);
            return childrenPopulation;
```

```
        }

        Boolean isReady(List<Population> historyOfPopulation)
        {
            if (historyOfPopulation.Count < 100)
                return false;
            else
            {
                for (int i = historyOfPopulation.Count - 100; i < historyOfPopulation.Count; i++)
                {
                    if (historyOfPopulation[historyOfPopulation.Count - 100].avarageFitness !=
historyOfPopulation[i].avarageFitness)
                        return false;
                }
                return true;
            }
        }
        private List<Dot> getChildren(Dot father, Dot mother)
        {
            List<Dot> childrenDots = new List<Dot>();
            int pointCross = random.Next()%20;
            List<double> firstChromosomes = new List<double>();
            List<double> secondChromosomes = new List<double>();
            for (int j = 0; j < 11; j++)
            {
                if(j<pointCross)
                {
                    firstChromosomes.Add(father.chromosomes[j]);
                    secondChromosomes.Add(mother.chromosomes[j]);
                }
                else
                {
                    firstChromosomes.Add(mother.chromosomes[j]);
                    secondChromosomes.Add(father.chromosomes[j]);
                }
            }

            //Mutation
            for (int j = 0; j < childrenDots.Count; j++)
            {
                int prob = random.Next(0, 20);
                if (prob == 7)
                {
                    int number = random.Next(20);
                    childrenDots[j].chromosomes[number] = random.NextDouble() % 2 - 1;
                }
            }

            childrenDots.Add(new Dot(firstChromosomes));
            childrenDots.Add(new Dot(secondChromosomes));
            return childrenDots;
        }
    }
}
```

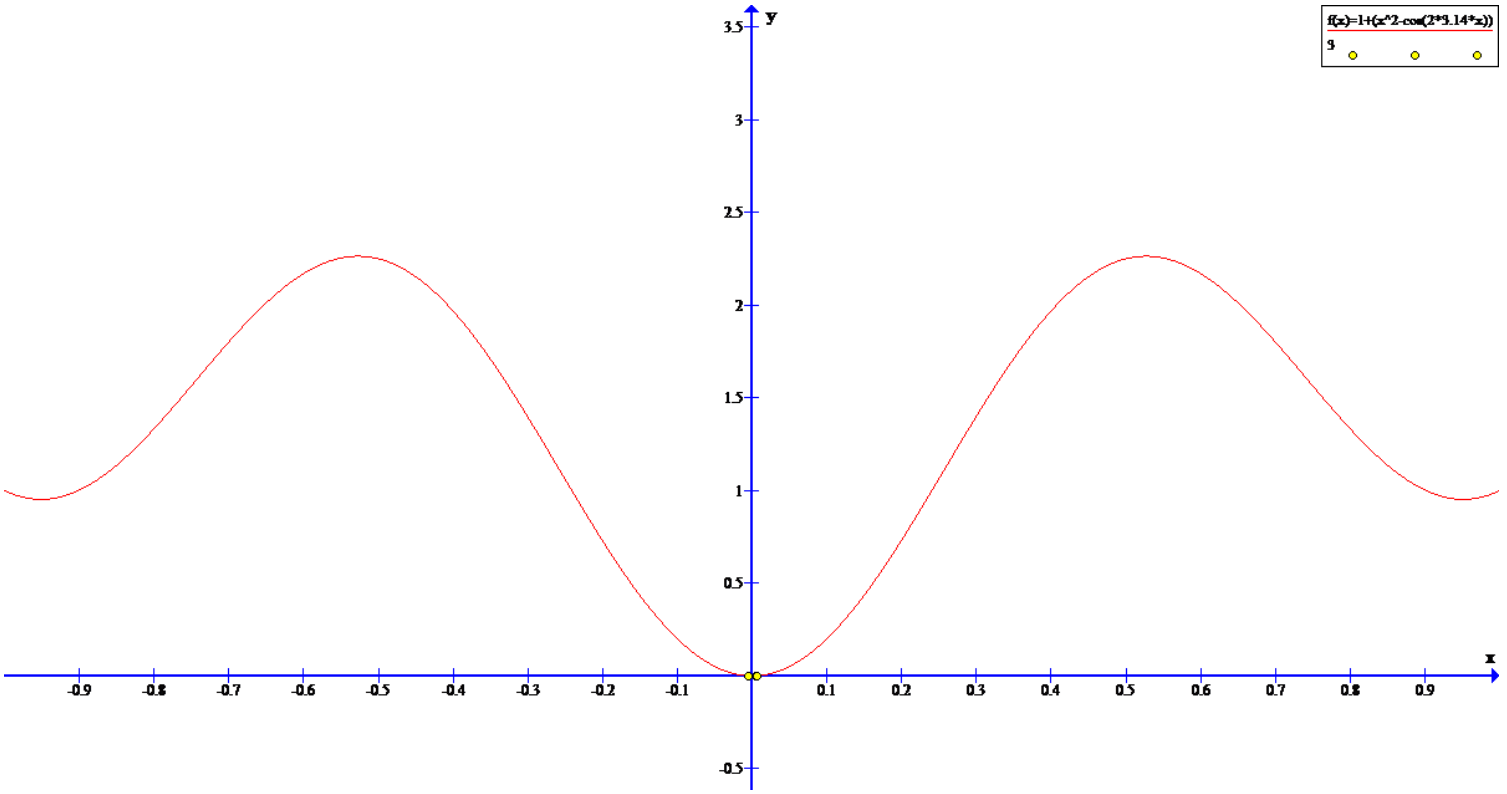
0 generation



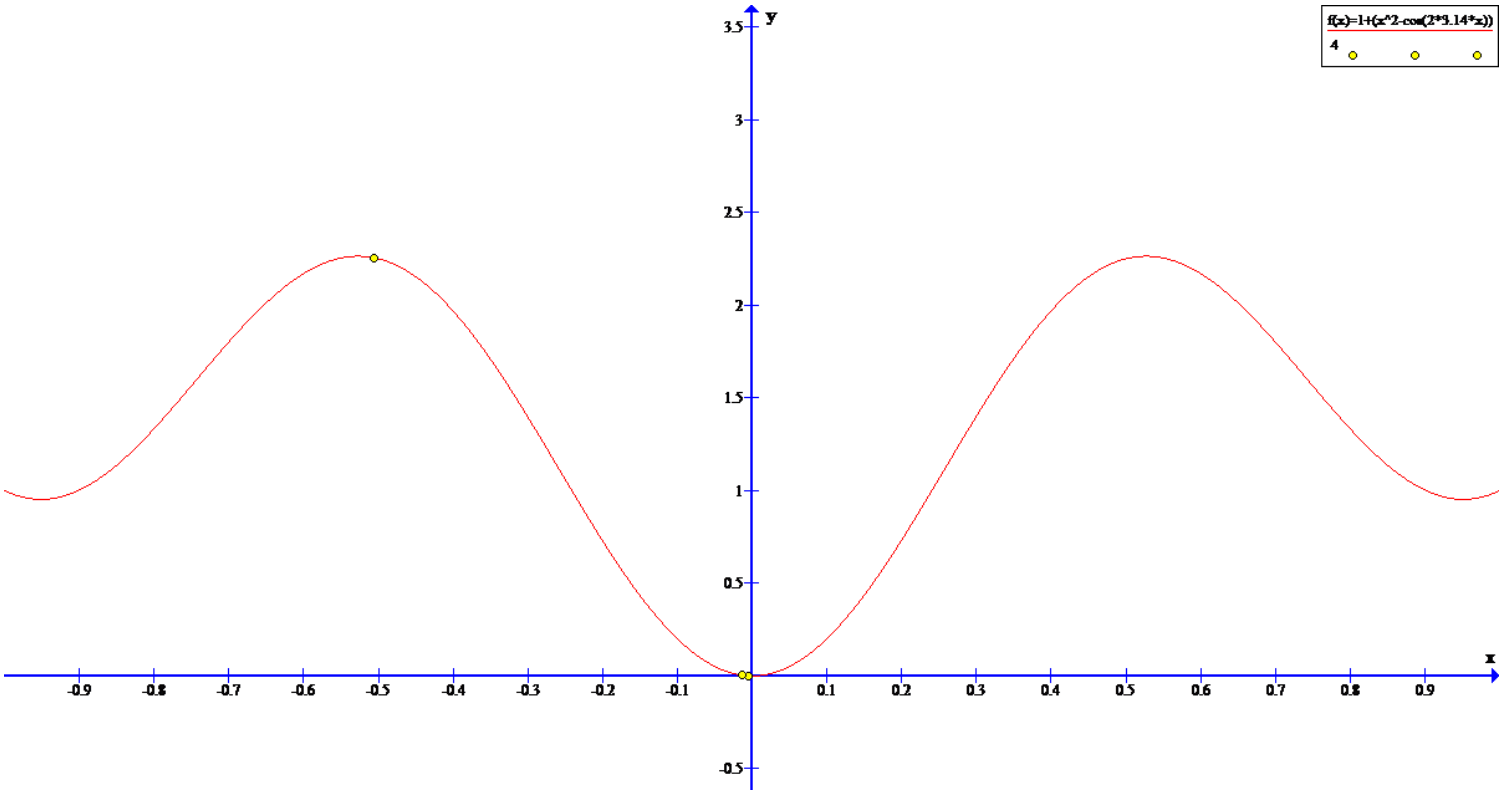
5 generation



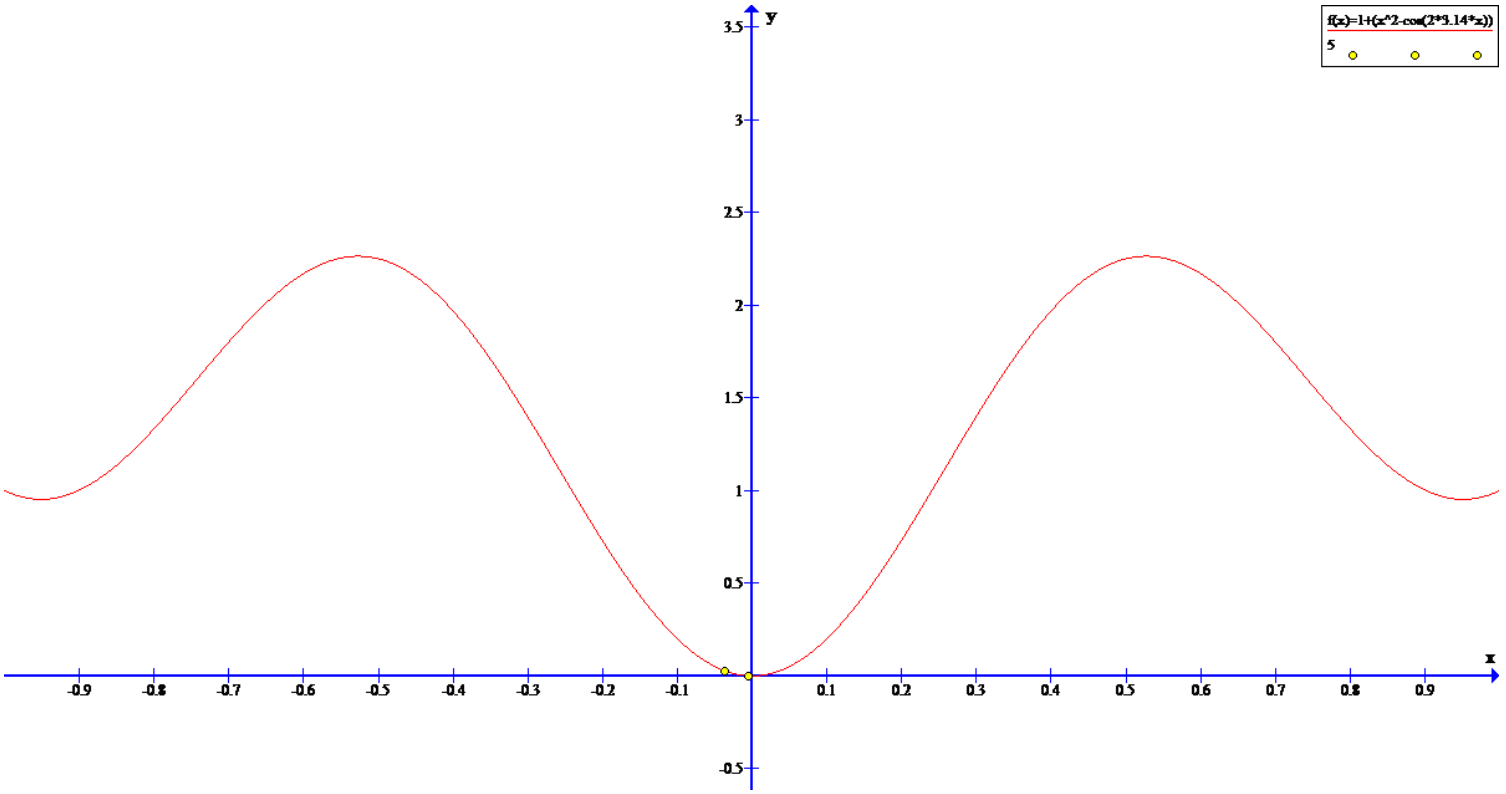
10 generation



15generation



20 generation


f(x)=1+(x^2-cos(2*3.14*x))
5
y
x
3.5
3
2.5
2
1.5
1
0.5
-0.5
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9