# 4M17 Exercise III : Optimizing the bird Function

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**Summary:** Summary goes here.

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## 1 Running the Code

The code in this report runs as web app. It can be found in the listings, but is also hosted at `eng-216er.github.io` and can be accessed by launching this URL in a web browser. The code has been tested in the latest versions of the Firefox and Chrome browsers.

## 2 Rationale behind the use of JavaScript

JavaScript is unique in that programs written in it can be embedded in a html document, and executed in a web browser. No other language can be used for client side web programming without either using a browser extension (Java, Flash) or compiling into JavaScript (CoffeeScript).

This provided the motivation for me to implement the optimisation algorithms in JavaScript. In small part, this was because of the possibility of creating a simple html based UI for controlling the optimization parameters and inspecting the results.

Largely however, I was drawn to using JavaScript because being able to solve optimization problems in a browser could potentially be useful within several web programming contexts. For instance, the development of WebGL allows for hardware accelerated graphics problems to be developed for the web. Optimization can be used to solve useful problems in graphics programming. An example is computing the best possible conformal mapping between texture co-ordinates, and coordinates that make up a mesh of a surface. This cam be used to apply a texture to a 3D surface, while minimising the effect of distortion on the surface.

There are currently very few JavaScript optimization libraries. Although the software provided in this report does very little to rectify that, it does provide a starting point for more complex software.

## 3 Genetic Algorithms

A gen

## 4 Tabu Search

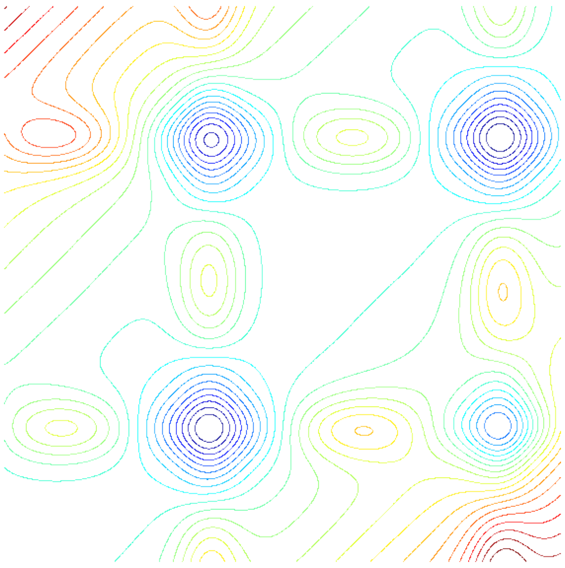
## A Listings

### A.1 PlotImage.m

```
function [  ] = PlotImage(  )
% Plot a contour map of the Bird Function
% This is to be used as the background of the canvas
n = 1000;
range = linspace(-6,6,n);
y = Bird( ones( n,1 ) * range , range' * ones( 1,n )  );

contour( range, range, y, 23);
axis equal
axis off
end
```

### A.2 Bird.png



### A.3 index.html

```
<!DOCTYPE html>

<html>
<head>
  <title>Optimization Ex3</title>
  <meta charset="utf-8">
  <script type="text/javascript" src="minmax.js">
</script>
  <script type="text/javascript" src="ex3.js">
</script>
  <script type="text/javascript" src="genetic_algorithm.js">
</script>
  <script type="text/javascript" src="tabu.js">
```

```
</script>
  <style type="text/css">
 body{
     font-family: monospace;
   }
   h1 {
     text-align: center;
     font-size: 16pt;
   }
   .parent {
     max-width: 500px;
     max-height: 500px;
     margin: 1em auto;
     border: 1px solid black;
   }
   .buttons {
     margin: 1em auto;
     text-align: center;
   }
   .animParent{
     margin: 0.5em auto;
     padding: 0;
     height: 4em;
     overflow: hidden;
     text-align: center;
   }
   #loadingAnim{
     margin: 0 auto;
     display: none;
     background-color: black;
     border: 1px solid black;
     -webkit-animation: loader 2s ease infinite;
     animation: loader 2s ease infinite;
   }
   @-webkit-keyframes loader {
     from {
       opacity: 1.0;
       margin-top: 1em;
       width: 0em;
       height: 0em;
       border-bottom-right-radius: 0em;
       border-bottom-left-radius: 0em;
       border-top-right-radius: 0em;
       border-top-left-radius: 0em;
     }
     to {
       opacity: 0;
       margin-top: 0em;
       width: 4em;
       height: 4em;
       border-bottom-right-radius: 2em;
       border-bottom-left-radius: 2em;
       border-top-right-radius: 2em;
       border-top-left-radius: 2em;
     }
   }
   @keyframes loader {
     from {
       opacity: 1.0;
       margin-top: 2em;
       width: 0em;
       height: 0em;
```

```
        border-bottom-right-radius: 0em;
        border-bottom-left-radius: 0em;
        border-top-right-radius: 0em;
        border-top-left-radius: 0em;
      }
      to {
        opacity: 0;
        margin-top: 0em;
        width: 4em;
        height: 4em;
        border-bottom-right-radius: 2em;
        border-bottom-left-radius: 2em;
        border-top-right-radius: 2em;
        border-top-left-radius: 2em;
      }
    }
    #controls {
      text-align: left;
      margin: 0 auto;
      width: 30em;
    }
  </style>
</head>

<body>
  <h1>Bird Function Optimizer</h1>

  <div class="parent">
    <canvas id="c" width="500" height="500"></canvas>
  </div>

  <div class="buttons">
    <button class="algorithm" onclick=
    "genetic_algorithm(␣bird_function␣)">Genetic Algorithm</button>
    <button class="algorithm" onclick=
    "tabu_search(␣bird_function␣)">Tabu Search</button>

    <div class="animParent">
      <div id="loadingAnim">
        &nbsp;
      </div>
    </div>

    <div id="urlsection"></div>

  </div>

  <div id="controls">
    <h3>Settings:</h3>

    <span>Pause Between Iterations</span><br>
    <input type="range" class="range" min="0" max="1000" step="1"
    value="500" id="pause" onchange="updateSlider('pause')">
    <span id="pausespan"></span> ms<br>

    <h3>GA Specific Settings:</h3>

    <span>Population Size</span><br>
    <input type="range" class="range" min="10" max="50" step="5"
    value="25" id="gapopulation" onchange=
    "updateSlider('gapopulation')"> <span id=
    "gapopulationspan"></span><br>

    <span>Parent Count</span><br>
    <input type="range" class="range" min="5" max="25" step="1"
    value="10" id="gaparents" onchange="updateSlider('gaparents')">
    <span id="gaparentsspan"></span><br>

    <span>Selection Strategy</span><br>
    <select id="gastratergy">
      <option value="tournament">
        Tournament Select
      </option>
      <option value="frequency">
        Frequency Dependant Select
      </option>
    </select><br>

    <span>Mutation Rate</span><br>
    <input type="range" class="range" min="0" max="0.5" step="0.02"
    value="0.02" id="gamutate" onchange="updateSlider('gamutate')">
    <span id="gamutatespan"></span><br>

    <h3>Tabu Specific Settings</h3>

    <span>Short Term Memory</span><br>
    <input type="range" class="range" min="1" max="20" step="1"
    value="7" id="tabushort" onchange="updateSlider('tabushort')">
    <span id="tabushortspan"></span><br>

    <span>Medium Term Memory</span><br>
    <input type="range" class="range" min="1" max="20" step="1"
    value="4" id="tabumedium" onchange=
    "updateSlider('tabumedium')"> <span id=
    "tabumediumspan"></span><br>

    <span>Long Term Memory Grid Length</span><br>
    <input type="range" class="range" min="1" max="20" step="1"
    value="3" id="tabulong" onchange="updateSlider('tabulong')">
    <span id="tabulongspan"></span> per side<br>

    <span>Intensification Step</span><br>
    <input type="range" class="range" min="1" max="40" step="1"
    value="10" id="tabuintensify" onchange=
    "updateSlider('tabuintensify')"> <span id=
    "tabuintensifyspan"></span><br>

    <span>Diversification Step</span><br>
    <input type="range" class="range" min="1" max="40" step="1"
    value="15" id="tabudiversify" onchange=
    "updateSlider('tabudiversify')"> <span id=
    "tabudiversifyspan"></span><br>

    <span>Step Size Reduction Step</span><br>
    <input type="range" class="range" min="1" max="40" step="1"
    value="25" id="tabustepreduce" onchange=
    "updateSlider('tabustepreduce')"> <span id=
    "tabustepreducespan"></span><br>

  </div><img id="birdFunctionContour" src="Bird.png" alt=
  "hidden␣image" style="display:␣none">
</body>
</html>
```

## A.4 minmax.js

```
Array.prototype.min = function(comparer) {

    if (this.length === 0) return null;
    if (this.length === 1) return this[0];

    comparer = (comparer || Math.min);

    var v = this[0];
    for (var i = 1; i < this.length; i++) {
        v = comparer(this[i], v);
    }

    return v;
}

Array.prototype.max = function(comparer) {

    if (this.length === 0) return null;
    if (this.length === 1) return this[0];

    comparer = (comparer || Math.max);

    var v = this[0];
    for (var i = 1; i < this.length; i++) {
        v = comparer(this[i], v);
    }

    return v;
}
```

## A.5 ex3.js

```
"use␣strict";

function draw_background( canvas, ctx ){
  var backgroundElem = document.getElementById( "birdFunctionContour" );
  ctx.clearRect ( 0 , 0 , canvas.width, canvas.height );
  ctx.drawImage( backgroundElem, 0, 0, canvas.width, canvas.height );
}

function clear_screen(){
  var canvas = getCanvasAndContext()[0];
  var context = getCanvasAndContext()[1];
  draw_background( canvas, context );
}

var evalCount = 0;
var resetEvalCount = function(){
  evalCount = 0;
};
var getEvalCount = function(){
  return evalCount;
}

function bird_function( x1, x2 ){
  evalCount = evalCount + 1;
  var y = Math.sin(x1) * Math.exp( Math.pow(1 - Math.cos(x2),2 ) ) +
      Math.cos(x2) * Math.exp ( Math.pow(1 - Math.sin(x1), 2) )+
      Math.pow(x1 - x2, 2);
  return y;
}

var getCanvasAndContext;

var drawPoint = function( x1, x2, colour ){

  var canvas = getCanvasAndContext()[0];
  var context = getCanvasAndContext()[1];

  var centerX = canvas.width * ( x1 + 6 )/12;
  var centerY = canvas.height * ( -x2 + 6 ) /12;
  var radius = 2;
  //window.console.log( "X1: " + x1 + " X2: " + x2 );
  context.beginPath();
  context.arc(centerX, centerY, radius, 0, 2 * Math.PI, false);
  context.fillStyle =  colour || 'green';
  context.fill();
  context.lineWidth = 0.5;
  context.strokeStyle = 'black';
  //context.stroke();
}
var connectPoints = function( a1, a2, b1, b2 ){

  var canvas = getCanvasAndContext()[0];
  var context = getCanvasAndContext()[1];

  var aX = canvas.width * ( a1 + 6 )/12;
  var aY = canvas.height * ( -a2 + 6 ) /12;
  var bX = canvas.width * ( b1 + 6 )/12;
  var bY = canvas.height * ( -b2 + 6 ) /12;

  context.beginPath();
  context.moveTo(aX, aY);
  context.lineTo(bX, bY);
  context.stroke();
}

function clearChildren( node ){
  while (node.firstChild) {
    node.removeChild(node.firstChild);
  }
}

function displayCsvStringAsURL( string ){
  var d = document.getElementById("urlsection");
  var a = document.createElement("a");
  a.href = "data:text/csv," + encodeURIComponent( string );
  a.textContent = "data";
  clearChildren( d );
  d.appendChild(a);
}

function logMinimumHistory( minimumHistory ){
  var csvString = "Evaluations, x1, x2, y\n"
  minimumHistory.forEach( function( h ){
    csvString += h.evaluations + ", " + h.x1 + ", " + h.x2 + ", " + h.y + "\n";
  } );
  displayCsvStringAsURL( csvString );
}

```

```
function getItterationPause(){
  return document.getElementById( "pause" ).value;
}


function setRunning(){
  var d = document.getElementById("urlsection");
  clearChildren(d);
  d.textContent = "Running";
  document.getElementById("loadingAnim").style.display = "block";

  var buttons = document.getElementsByClassName( "algorithm" );
  [].forEach.call( buttons, function(b){
    b.disabled = true;
  } );
}

function finishRunning(){
  document.getElementById("loadingAnim").style.display = "";
  var buttons = document.getElementsByClassName( "algorithm" );
  [].forEach.call( buttons, function(b){
    b.disabled = false;
  } );
}

function updateSlider(id){
  var slider = document.getElementById( id );
  var label = document.getElementById( id + "span" );
  label.textContent = slider.value;
}

window.onload = function(){
  var canvas = document.getElementById( "c" );
  var ctx=canvas.getContext("2d");
  draw_background( canvas, ctx );

  var ranges = document.getElementsByClassName( "range" );
  [].forEach.call( ranges, function(r){
    updateSlider( r.id );
  } );

  getCanvasAndContext = function(){
    return [canvas, ctx];
  }
  finishRunning();
}
```

## A.6 tabu.js

```
"use␣strict";

function TabuPoint( f, x1, x2 ){
  this.x1 = x1 || 0;
  this.x2 = x2 || 0;

  this.getValue = function(){
    return [this.x1, this.x2];
  }

  var lastCalled;
  this.getFValue = function(){
    if( lastCalled === undefined || !(this.isEqual( lastCalled )) ){
      this.fValue = f( this.x1, this.x2 );
      lastCalled = this.clone();
    }
    return( this.fValue );
  }
  this.isEqual = function( p ){
    if( p.x1 === this.x1 && p.x2 === this.x2 ){
      return true;
    }
    return false;
  }
  this.clone = function(){
    var o = new TabuPoint( f, this.x1, this.x2 );
    o.lastCalled = this.lastCalled;
    o.fValue = this.fValue;
    return o;
  }
  this.valid = function(){
    if( Math.abs( this.x1 ) <= 6.0 && Math.abs( this.x2 ) < 6.0 ){
      return true;
    }
    return false;
  }
}

function tabuMin( a, b ){
  return a.getFValue() < b.getFValue() ? a : b;
}

function tabuMax( a, b ){
  return a.getFValue() < b.getFValue() ? a : b;
}

function considerForMediumTermMemory( memory, point, size ){
  if( memory.length < size ){
    memory.push( point );
  } else {
    var max = memory.max( tabuMax )
    if( max.getFValue() > point.getFValue() ){
      // add the point
      var rIndex = memory.indexOf( max );
      memory.splice( rIndex, 1, point );
    }
  }
}


function addToMemory( memory, value, memSize ){
  memory.push( value );
  if( memory.length > memSize ){
    memory.splice( 0, memory.length - memSize );
  }
}

function getAveragePoint( memory, f ){
  var x1 = 0, x2 = 0;
  memory.forEach( function(m){
    x1 += m.x1/memory.length;
    x2 += m.x2/memory.length;
  } );
  return new TabuPoint( f, x1, x2 );
```

```
}

function setupLongTermMemory(size){
  var m = Array(size);
  for( var i = 0; i< size; i++ ){
    m[i] = Array( size );
    for( var j = 0; j< size; j++ ){
      m[i][j] = 0;
    }
  }
  return m;
}

function addToLongTermMemory(memory, point){
  var i =  Math.floor( memory.length*( point.x1 + 6 )/12.01 );
  var j =  Math.floor( memory.length*( point.x2 + 6 )/12.01 );
  memory[i][j] +=1;
}

function getDiversePointFromLongTermMemory(memory, f){
  for( var i = 0; i< memory.length; i++ ){
    for( var j = 0; j< memory[i].length; j++ ){
      if( memory[i][j] === 0 ){
        memory[i][j] = 1;
        window.console.log( "i:␣" + i + ",␣j:␣" + j + ",␣m:" + memory[i][j]);
        return new TabuPoint( f,
          12 * ((i+0.5)/memory.length) - 6,
          12 * ((j+0.5)/memory.length) - 6
        );
      }
    }
  }
  return new TabuPoint( f, 0, 0 );
}

function updateTabuMinimumHistory( minimumHist, minimum ){
  var o = {
    evaluations: getEvalCount(),
    x1: minimum.x1,
    x2: minimum.x2,
    y: minimum.getFValue()
  };
  minimumHist.push( o );
}

function getShortSize(){
  return document.getElementById( "tabushort" ).value;
}
function getMediumSize(){
  return document.getElementById( "tabumedium" ).value;
}
function getLongSize(){
  return document.getElementById( "tabulong" ).value;
}
function getIntensifyStep(){
  return document.getElementById( "tabuintensify" ).value;
}
function getDiversifyStep(){
  return document.getElementById( "tabudiversify" ).value;
}
function getReduceStep(){
  return document.getElementById( "tabustepreduce" ).value;
```

```
}


function tabu_search( f ){

  var shortTerm = [];
  var mediumTerm = [];
  var longTerm = setupLongTermMemory(getLongSize());

  var minimumHist = [];

  var point = new TabuPoint( f, 0, 0 );
  var minimum = point;

  var initialInterval = 1;
  var interval = initialInterval;
  minimum.interval = initialInterval;

  resetEvalCount();
  updateTabuMinimumHistory( minimumHist, minimum );

  setRunning();

  var isInShortTermMem = function( p ){
    var found = false;
    shortTerm.forEach( function( s ){
      if( s.isEqual( p ) ){
        found = true;
      }
    });
    return found;
  };

  var improvementCounter = 0;

  clear_screen();

  var step = function(){
    var nextSteps = [];
    ["x1", "x2"].forEach( function( param ){
      var inc = point.clone();
      var dec = point.clone();
      inc[param] += interval;
      dec[param] -= interval;
      if( !isInShortTermMem( inc ) && inc.valid() ){
        nextSteps.push( inc );
      }
      if( !isInShortTermMem( dec ) && dec.valid() ){
        nextSteps.push( dec );
      }
    } );
    var best = nextSteps.min( tabuMin );
    if( nextSteps.length === 0 ){
      window.console.log( "All␣points␣are␣Tabu" );
      best = point;
    }

    if( best.getFValue() < point.getFValue() ){
      //pattern move
      var change = { x1: best.x1 - point.x1, x2: best.x2 - point.x2 };
      var pattern = point.clone();
      pattern.x1 += 2.0 * change.x1;
      pattern.x2 += 2.0 * change.x2;
      if( pattern.getFValue() < best.getFValue() && pattern.valid() ){
        best = pattern;
      }
    }

    // store old point for Line Drawing purposes
    var oldPoint = point;

    point = best;

    addToMemory( shortTerm, best, getShortSize() );
    considerForMediumTermMemory( mediumTerm, best, getMediumSize() );
    addToLongTermMemory( longTerm, best );

    improvementCounter += 1;
    if( point.getFValue() < minimum.getFValue() ){
      improvementCounter = 0;
      minimum = point;
      minimum.interval = interval;
      updateTabuMinimumHistory( minimumHist, minimum );
    }

    var colour = "green";
    window.console.log
    if( improvementCounter == getIntensifyStep() ){
      //Intensify
      window.console.log( "intensifying" );
      point = getAveragePoint( mediumTerm, f );
      colour = "red";
    } else if( improvementCounter == getDiversifyStep() ) {
      //Diversify
      window.console.log( "diversifying" );
      point = getDiversePointFromLongTermMemory(longTerm, f);
      window.console.log( "␣point:␣" + point.x1 + ",␣" + point.x2 );
      // clear the minimum term memory
      minimumTerm = [];
      //reset the step Size
      interval = initialInterval;
      colour = "cyan";
    } else if( improvementCounter == getReduceStep() ){
      //Step Size Reduction
      window.console.log( "Step␣Size␣Reduce" );
      point = minimum;
      interval = 0.5 * minimum.interval;
      colour = "yellow"
      improvementCounter = 0;
    } else {
      connectPoints( oldPoint.x1, oldPoint.x2, point.x1, point.x2 );
    }
    drawPoint( point.x1, point.x2, colour );

    if( point.getFValue() < minimum.getFValue() ){
      improvementCounter = 0;
      minimum = point;
      minimum.interval = interval;
      updateTabuMinimumHistory( minimumHist, minimum );
    }

    if( getEvalCount() < 1000 - 10 ){
      window.setTimeout( step, getItterationPause() );
    } else {
      logMinimumHistory( minimumHist );
      finishRunning();
    }
  }
  step();
}
```

## A.7 genetic_algorithm.js

```
"use␣strict";

function GAPoint(){
  var precision = 16;
  this.x1 = Array(precision);
  this.x2 = Array(precision);

  var getSinglePoint = function( xval ){
    var val = -6;
    for( var i = 0; i< precision; i++ ){
      if( xval[i] ){
        val += 6.0 * Math.pow(0.5, i);
      }
    }
    return val;
  }

  this.getValue = function(){
    return [ getSinglePoint( this.x1 ), getSinglePoint( this.x2 ) ];
  }
  this.getFunctionValue = function( f ){
    if( this.fvalue === undefined ){
      var x = this.getValue();
      this.fvalue = f( x[0], x[1] );
    }
    return this.fvalue;

  }
}

function getRandomGAPoint(){
  var point = new GAPoint();
   var randomizeBool = function(){
    var a;
    if(Math.random()<.5){
      a = true;
    } else {
      a = false;
    }
    return a;
  };
  for( var i = 0; i< point.x1.length; i++ ){
    point.x1[i] = randomizeBool();
    point.x2[i] = randomizeBool();
  }
  return point;
}

function getSeveralRandomGAPoints( N ){
  var points = Array(N);
  for( var i = 0; i< N; i++ ){
    points[i] = getRandomGAPoint();
  }
  return points;
}

function drawGAPoints( points, colour ){

  points.forEach( function(p) {
    var x = p.getValue();
    drawPoint( x[0], x[1], colour );
  } );

}


function swapPoints( points, i, j ){
  var tmp = points[i];
  points[i] = points[j];
  points[j] = tmp;
}

function getRandomInt(min, max) {
    return Math.floor(Math.random() * (max - min + 1)) + min;
}

function fisherYatesShuffle( list ){
  for( var i = 0; i< list.length; i++ ){
    var j = getRandomInt( i, list.length -1 );
    swapPoints( list, i,  j);
  }
}


function split(a, n) {
  var len = a.length;
  var out = [];
  var i = 0;
  while (i < len) {
    var size = Math.ceil((len - i) / n--);
    out.push(a.slice(i, i += size));
  }
  return out;
}

function tournamentSelect( points, f, groups ){

  var size = points.length / groups;
  fisherYatesShuffle( points );
  var splitGroups = split( points, groups );
  var comparer = function( a, b ){
    return a.getFunctionValue(f) < b.getFunctionValue(f) ? a : b;
  }

  var selected = [];

  splitGroups.forEach( function(g){
    selected.push( g.min(comparer) );
  } );
  return selected;
}

function fitnessProportionateSelect( points, f, N ){
  var sum = 0;
  //the function has range that's roughly -100 to 100
  // it goes a little lower than this, but we can still use 100 - function as a
  // fitness score
  points.forEach( function(p){
    sum += 100 - p.getFunctionValue(f);
  } );
  var selected = [];
  for( var i = 0; i < N; i++ ){
    var r = Math.random();
    var j = 0;
    while( r > 0 && j < points.length ){
      r -= (100-points[j].getFunctionValue(f))/sum;
      j++;
    }
    if( points[j-1] === undefined ) alert("scary");
    selected.push( points[j-1] );
  }
  return selected;
}

function doSingleValCrossover( p1, p2, c1, c2, val ){
  var crossoverPoint1 = getRandomInt( 1,
    Math.floor( ( p1[val].length -1) * 0.75 ) );
  var crossoverPoint2 = getRandomInt( crossoverPoint1,  p1[val].length );
  for( var i = 0; i < p1.x1.length; i++ ){
    if( i < crossoverPoint1 || i > crossoverPoint2 ){
      c1[val][i] = p1[val][i];
      c2[val][i] = p2[val][i];
    } else {
      c2[val][i] = p1[val][i];
      c1[val][i] = p2[val][i];
    }
  }
}

function crossTwoPoints( p1, p2 ){
  var c1 = new GAPoint();
  var c2 = new GAPoint();
  doSingleValCrossover( p1, p2, c1, c2, "x1" );
  doSingleValCrossover( p1, p2, c1, c2, "x2" );
  return [c1, c2];
}


function breedPoints( selectedPoints, nextGenSize ){
  var newPoints = [];
  for( var i = 0; i < nextGenSize/2; i += 1){
    // pair each point in turn with a random point, and breed them
    newPoints = newPoints.concat(
      crossTwoPoints(
        selectedPoints[i%selectedPoints.length],
        selectedPoints[getRandomInt(0, selectedPoints.length-1)]
      )
    );
  }
  return newPoints;
}


function mutatePoint( point, value ){
  var bit = getRandomInt( 0, point[value].length -1 );
  if( point[value][bit]  ){
    point[value][bit] = false;
  } else {
    point[value][bit] = true;
  }
}

function getMutationRate(){
  return document.getElementById( "gamutate" ).value;
}

function mutatePoints(points){

  var mutationProbability = getMutationRate();

  points.forEach( function(p){
    if( Math.random() < mutationProbability ){
      var value = "x1";
      if(Math.random() < 0.5 ){
        value = "x2";
      }
      mutatePoint( p, value );
    }
  } );
}

function updateGAMinimumHistory( points, f, minimumHistory ){
  var comparer = function( a, b ){
    return a.getFunctionValue(f) < b.getFunctionValue(f) ? a : b;
  }

  var min = points.min(comparer)
  var x = min.getValue();
  var y = min.getFunctionValue( f );

  if( minimumHistory.length === 0 ||
    minimumHistory[minimumHistory.length-1].y > y ){
    var o = {};
    o.x1 = x[0];
    o.x2 = x[1];
    o.y = y;
    o.evaluations = getEvalCount();
    minimumHistory.push( o );
  }
}


function getGAPopulation(){
  return document.getElementById( "gapopulation" ).value;
}

function getGAParentsCount(){
  return document.getElementById( "gaparents" ).value;
}

function getGAParents(points, f){
  var stratergy = document.getElementById( "gastratergy" ).value;
  if( stratergy === "tournament" ){
    return  tournamentSelect( points, f, getGAParentsCount() );
  } else if( stratergy === "frequency" ){
    return fitnessProportionateSelect( points, f, getGAParentsCount() );
  }
}
```

```

function GAItteration( points, f, minimumHistory ){
  clear_screen();

  drawGAPoints( points, "green" );

  var reproducing = getGAParents(points,  f );

  drawGAPoints( reproducing, "red" );

  var nextGen = breedPoints(reproducing, points.length);

  updateGAMinimumHistory( points, f, minimumHistory);

  var last = minimumHistory[minimumHistory.length-1];

  drawPoint( last.x1, last.x2, "blue" );

  mutatePoints( nextGen );

  if( getEvalCount() < 1000 - nextGen.length){
    window.setTimeout( function(){
      GAItteration( nextGen, f, minimumHistory );
    }, getItterationPause() );
  } else {
    logMinimumHistory( minimumHistory );
    finishRunning();
  }
}

function genetic_algorithm( f ){
  resetEvalCount();
  var nPoints = getGAPopulation();
  var points = getSeveralRandomGAPoints(nPoints);
  setRunning();
  GAItteration(points, f, []);
}
```