Appendices

Results

1. Command line: java Generic 10 8 80 24 48

Results:

Enter the 10 occurrence probabilities assigned to the types, in the ascending order
Probability number 0 : 0.452
Probability number 1 : 0.207
Probability number 2 : 0.096
Probability number 3 : 0.082
Probability number 4 : 0.066
Probability number 5 : 0.04
Probability number 6 : 0.035
Probability number 7 : 0.011
Probability number 8 : 0.008
Probability number 9 : 0.003

List of the Minutia points generated, as the input set:
Minutia 0 Type: 0 Direction: 6 X-value: 62 Y-Value: 22 Weight: 0.34486157
Minutia 1 Type: 0 Direction: 7 X-value: 63 Y-Value: 23 Weight: 0.34486157
Minutia 2 Type: 0 Direction: 0 X-value: 64 Y-Value: 0 Weight: 0.34486157
Minutia 3 Type: 0 Direction: 1 X-value: 65 Y-Value: 1 Weight: 0.34486157
Minutia 4 Type: 0 Direction: 2 X-value: 66 Y-Value: 2 Weight: 0.34486157
Minutia 5 Type: 0 Direction: 3 X-value: 67 Y-Value: 3 Weight: 0.34486157
Minutia 6 Type: 0 Direction: 4 X-value: 68 Y-Value: 4 Weight: 0.34486157
Minutia 7 Type: 0 Direction: 5 X-value: 69 Y-Value: 5 Weight: 0.34486157
Minutia 8 Type: 0 Direction: 6 X-value: 70 Y-Value: 6 Weight: 0.34486157
Minutia 9 Type: 0 Direction: 7 X-value: 71 Y-Value: 7 Weight: 0.34486157
Minutia 10 Type: 0 Direction: 0 X-value: 72 Y-Value: 2 Weight: 0.34486157
Minutia 11 Type: 0 Direction: 3 X-value: 75 Y-Value: 3 Weight: 0.34486157
Minutia 12 Type: 0 Direction: 4 X-value: 76 Y-Value: 4 Weight: 0.34486157
Minutia 13 Type: 0 Direction: 5 X-value: 77 Y-Value: 5 Weight: 0.34486157
Minutia 14 Type: 0 Direction: 6 X-value: 78 Y-Value: 6 Weight: 0.34486157
Minutia 15 Type: 0 Direction: 7 X-value: 79 Y-Value: 7 Weight: 0.34486157
Minutia 16 Type: 0 Direction: 0 X-value: 0 Y-Value: 8 Weight: 0.34486157
Minutia 17 Type: 0 Direction: 1 X-value: 1 Y-Value: 9 Weight: 0.34486157
Minutia 18 Type: 0 Direction: 2 X-value: 34 Y-Value: 18 Weight: 0.34486157
Minutia 19 Type: 0 Direction: 3 X-value: 35 Y-Value: 19 Weight: 0.34486157

Minutia 20 Type: 0 Direction: 4 X-value: 36 Y-Value: 20 Weight: 0.34486157
Minutia 21 Type: 0 Direction: 5 X-value: 37 Y-Value: 21 Weight: 0.34486157
Minutia 22 Type: 1 Direction: 6 X-value: 38 Y-Value: 22 Weight: 0.68402964
Minutia 23 Type: 1 Direction: 7 X-value: 39 Y-Value: 23 Weight: 0.68402964
Minutia 24 Type: 1 Direction: 0 X-value: 40 Y-Value: 0 Weight: 0.68402964
Minutia 25 Type: 1 Direction: 1 X-value: 41 Y-Value: 1 Weight: 0.68402964
Minutia 26 Type: 1 Direction: 2 X-value: 42 Y-Value: 2 Weight: 0.68402964
Minutia 27 Type: 1 Direction: 3 X-value: 43 Y-Value: 3 Weight: 0.68402964
Minutia 28 Type: 1 Direction: 4 X-value: 44 Y-Value: 4 Weight: 0.68402964
Minutia 29 Type: 1 Direction: 5 X-value: 45 Y-Value: 5 Weight: 0.68402964
Minutia 30 Type: 1 Direction: 6 X-value: 46 Y-Value: 6 Weight: 0.68402964
Minutia 31 Type: 1 Direction: 7 X-value: 47 Y-Value: 7 Weight: 0.68402964
Minutia 32 Type: 2 Direction: 0 X-value: 48 Y-Value: 8 Weight: 1.0177288
Minutia 33 Type: 2 Direction: 1 X-value: 49 Y-Value: 9 Weight: 1.0177288
Minutia 34 Type: 2 Direction: 2 X-value: 50 Y-Value: 10 Weight: 1.0177288
Minutia 35 Type: 2 Direction: 3 X-value: 51 Y-Value: 11 Weight: 1.0177288
Minutia 36 Type: 2 Direction: 4 X-value: 52 Y-Value: 12 Weight: 1.0177288
Minutia 37 Type: 3 Direction: 5 X-value: 53 Y-Value: 13 Weight: 1.0861862
Minutia 38 Type: 3 Direction: 6 X-value: 54 Y-Value: 14 Weight: 1.0861862
Minutia 39 Type: 3 Direction: 7 X-value: 55 Y-Value: 15 Weight: 1.0861862
Minutia 40 Type: 3 Direction: 0 X-value: 56 Y-Value: 16 Weight: 1.0861862
Minutia 41 Type: 4 Direction: 1 X-value: 57 Y-Value: 17 Weight: 1.180456
Minutia 42 Type: 4 Direction: 2 X-value: 58 Y-Value: 18 Weight: 1.180456
Minutia 43 Type: 4 Direction: 3 X-value: 59 Y-Value: 19 Weight: 1.180456
Minutia 44 Type: 4 Direction: 4 X-value: 60 Y-Value: 20 Weight: 1.180456
Minutia 45 Type: 5 Direction: 5 X-value: 61 Y-Value: 21 Weight: 1.39794
Minutia 46 Type: 5 Direction: 6 X-value: 62 Y-Value: 22 Weight: 1.39794
Minutia 47 Type: 6 Direction: 7 X-value: 63 Y-Value: 23 Weight: 1.4559319

Result: The following subset is the most representative one (G) in the whole input set:
Minutia 0 0 Type: 6 Direction: 7 X-value: 63 Y-Value: 23 Weight: 1.4559319
Minutia 0 1 Type: 0 Direction: 7 X-value: 63 Y-Value: 23 Weight: 0.34486157
Minutia 0 2 Type: 0 Direction: 6 X-value: 62 Y-Value: 22 Weight: 0.34486157
Minutia 0 3 Type: 5 Direction: 6 X-value: 62 Y-Value: 22 Weight: 1.39794
Minutia 0 4 Type: 5 Direction: 5 X-value: 61 Y-Value: 21 Weight: 1.39794
Minutia 0 5 Type: 4 Direction: 4 X-value: 60 Y-Value: 20 Weight: 1.180456
Minutia 0 6 Type: 4 Direction: 3 X-value: 59 Y-Value: 19 Weight: 1.180456
Minutia 0 7 Type: 4 Direction: 2 X-value: 58 Y-Value: 18 Weight: 1.180456

2. Command: java Generic 5 8 80 24 36

Result:

Enter the 5occurrence probabilities assigned to the types, in the ascending order
Probability number 0 :0.2
Probability number 1 :0.2

Probability number 2 :0.2
Probability number 3 :0.2
Probability number 4 :0.2

List of the Minutia points generated, as the input set:
Minutia 0 Type: 0 Direction: 2 X-value: 2 Y-Value: 18 Weight: 0.69897
Minutia 1 Type: 0 Direction: 3 X-value: 3 Y-Value: 19 Weight: 0.69897
Minutia 2 Type: 0 Direction: 4 X-value: 4 Y-Value: 20 Weight: 0.69897
Minutia 3 Type: 0 Direction: 5 X-value: 5 Y-Value: 21 Weight: 0.69897
Minutia 4 Type: 0 Direction: 4 X-value: 28 Y-Value: 4 Weight: 0.69897
Minutia 5 Type: 0 Direction: 5 X-value: 29 Y-Value: 5 Weight: 0.69897
Minutia 6 Type: 0 Direction: 6 X-value: 30 Y-Value: 6 Weight: 0.69897
Minutia 7 Type: 0 Direction: 7 X-value: 31 Y-Value: 7 Weight: 0.69897
Minutia 8 Type: 1 Direction: 0 X-value: 32 Y-Value: 8 Weight: 0.69897
Minutia 9 Type: 1 Direction: 1 X-value: 33 Y-Value: 9 Weight: 0.69897
Minutia 10 Type: 1 Direction: 2 X-value: 34 Y-Value: 10 Weight: 0.69897
Minutia 11 Type: 1 Direction: 3 X-value: 75 Y-Value: 3 Weight: 0.69897
Minutia 12 Type: 1 Direction: 4 X-value: 76 Y-Value: 4 Weight: 0.69897
Minutia 13 Type: 1 Direction: 5 X-value: 77 Y-Value: 5 Weight: 0.69897
Minutia 14 Type: 1 Direction: 6 X-value: 78 Y-Value: 6 Weight: 0.69897
Minutia 15 Type: 1 Direction: 7 X-value: 79 Y-Value: 7 Weight: 0.69897
Minutia 16 Type: 2 Direction: 0 X-value: 0 Y-Value: 8 Weight: 0.69897
Minutia 17 Type: 2 Direction: 1 X-value: 1 Y-Value: 9 Weight: 0.69897
Minutia 18 Type: 2 Direction: 2 X-value: 2 Y-Value: 10 Weight: 0.69897
Minutia 19 Type: 2 Direction: 3 X-value: 3 Y-Value: 11 Weight: 0.69897
Minutia 20 Type: 2 Direction: 4 X-value: 4 Y-Value: 12 Weight: 0.69897
Minutia 21 Type: 2 Direction: 5 X-value: 5 Y-Value: 13 Weight: 0.69897
Minutia 22 Type: 2 Direction: 6 X-value: 6 Y-Value: 14 Weight: 0.69897
Minutia 23 Type: 2 Direction: 7 X-value: 7 Y-Value: 15 Weight: 0.69897
Minutia 24 Type: 3 Direction: 0 X-value: 8 Y-Value: 16 Weight: 0.69897
Minutia 25 Type: 3 Direction: 1 X-value: 9 Y-Value: 17 Weight: 0.69897
Minutia 26 Type: 3 Direction: 2 X-value: 10 Y-Value: 18 Weight: 0.69897
Minutia 27 Type: 3 Direction: 3 X-value: 11 Y-Value: 19 Weight: 0.69897
Minutia 28 Type: 3 Direction: 4 X-value: 12 Y-Value: 20 Weight: 0.69897
Minutia 29 Type: 3 Direction: 5 X-value: 13 Y-Value: 21 Weight: 0.69897
Minutia 30 Type: 3 Direction: 6 X-value: 14 Y-Value: 22 Weight: 0.69897
Minutia 31 Type: 3 Direction: 7 X-value: 15 Y-Value: 23 Weight: 0.69897
Minutia 32 Type: 4 Direction: 0 X-value: 16 Y-Value: 0 Weight: 0.69897
Minutia 33 Type: 4 Direction: 1 X-value: 17 Y-Value: 1 Weight: 0.69897
Minutia 34 Type: 4 Direction: 2 X-value: 18 Y-Value: 2 Weight: 0.69897
Minutia 35 Type: 4 Direction: 3 X-value: 19 Y-Value: 3 Weight: 0.69897

No exceptional minutia was detected, the whole input set will be used for the matching.

3. Command: java Generic 10 8 80 24 56

Result:

Enter the 10 occurrence probabilities assigned to the types, in the ascending order
Probability number 0 : 0.452
Probability number 1 : 0.207
Probability number 2 : 0.096
Probability number 3 : 0.082
Probability number 4 : 0.066
Probability number 5 : 0.04
Probability number 6 : 0.035
Probability number 7 : 0.011
Probability number 8 : 0.008
Probability number 9 : 0.003

List of the Minutia points generated, as the input set:
Minutia 0 Type: 0 Direction: 0 X-value: 72 Y-Value: 8 Weight: 0.34486157
Minutia 1 Type: 0 Direction: 1 X-value: 73 Y-Value: 9 Weight: 0.34486157
Minutia 2 Type: 0 Direction: 2 X-value: 74 Y-Value: 10 Weight: 0.34486157
Minutia 3 Type: 0 Direction: 3 X-value: 75 Y-Value: 11 Weight: 0.34486157
Minutia 4 Type: 0 Direction: 4 X-value: 76 Y-Value: 12 Weight: 0.34486157
Minutia 5 Type: 0 Direction: 5 X-value: 77 Y-Value: 13 Weight: 0.34486157
Minutia 6 Type: 0 Direction: 6 X-value: 29 Y-Value: 21 Weight: 0.34486157
Minutia 7 Type: 0 Direction: 6 X-value: 30 Y-Value: 22 Weight: 0.34486157
Minutia 8 Type: 0 Direction: 7 X-value: 31 Y-Value: 23 Weight: 0.34486157
Minutia 9 Type: 0 Direction: 0 X-value: 32 Y-Value: 0 Weight: 0.34486157
Minutia 10 Type: 0 Direction: 1 X-value: 33 Y-Value: 1 Weight: 0.34486157
Minutia 11 Type: 0 Direction: 6 X-value: 30 Y-Value: 22 Weight: 0.34486157
Minutia 12 Type: 0 Direction: 7 X-value: 31 Y-Value: 23 Weight: 0.34486157
Minutia 13 Type: 0 Direction: 0 X-value: 32 Y-Value: 0 Weight: 0.34486157
Minutia 14 Type: 0 Direction: 1 X-value: 33 Y-Value: 1 Weight: 0.34486157
Minutia 15 Type: 0 Direction: 2 X-value: 34 Y-Value: 2 Weight: 0.34486157
Minutia 16 Type: 0 Direction: 3 X-value: 35 Y-Value: 3 Weight: 0.34486157
Minutia 17 Type: 0 Direction: 4 X-value: 36 Y-Value: 4 Weight: 0.34486157
Minutia 18 Type: 0 Direction: 5 X-value: 37 Y-Value: 5 Weight: 0.34486157
Minutia 19 Type: 0 Direction: 6 X-value: 38 Y-Value: 6 Weight: 0.34486157
Minutia 20 Type: 0 Direction: 7 X-value: 39 Y-Value: 7 Weight: 0.34486157
Minutia 21 Type: 0 Direction: 0 X-value: 40 Y-Value: 8 Weight: 0.34486157
Minutia 22 Type: 0 Direction: 1 X-value: 41 Y-Value: 9 Weight: 0.34486157
Minutia 23 Type: 0 Direction: 2 X-value: 42 Y-Value: 10 Weight: 0.34486157
Minutia 24 Type: 0 Direction: 3 X-value: 43 Y-Value: 11 Weight: 0.34486157
Minutia 25 Type: 0 Direction: 4 X-value: 44 Y-Value: 12 Weight: 0.34486157
Minutia 26 Type: 1 Direction: 5 X-value: 45 Y-Value: 13 Weight: 0.68402964
Minutia 27 Type: 1 Direction: 6 X-value: 46 Y-Value: 14 Weight: 0.68402964
Minutia 28 Type: 1 Direction: 7 X-value: 47 Y-Value: 15 Weight: 0.68402964
Minutia 29 Type: 1 Direction: 0 X-value: 48 Y-Value: 16 Weight: 0.68402964
Minutia 30 Type: 1 Direction: 1 X-value: 49 Y-Value: 17 Weight: 0.68402964

Minutia 31 Type: 1 Direction: 2 X-value: 50 Y-Value: 18 Weight: 0.68402964
Minutia 32 Type: 1 Direction: 3 X-value: 51 Y-Value: 19 Weight: 0.68402964
Minutia 33 Type: 1 Direction: 4 X-value: 52 Y-Value: 20 Weight: 0.68402964
Minutia 34 Type: 1 Direction: 5 X-value: 53 Y-Value: 21 Weight: 0.68402964
Minutia 35 Type: 1 Direction: 6 X-value: 54 Y-Value: 22 Weight: 0.68402964
Minutia 36 Type: 1 Direction: 7 X-value: 55 Y-Value: 23 Weight: 0.68402964
Minutia 37 Type: 1 Direction: 0 X-value: 56 Y-Value: 0 Weight: 0.68402964
Minutia 38 Type: 2 Direction: 1 X-value: 57 Y-Value: 1 Weight: 1.0177288
Minutia 39 Type: 2 Direction: 2 X-value: 58 Y-Value: 2 Weight: 1.0177288
Minutia 40 Type: 2 Direction: 3 X-value: 59 Y-Value: 3 Weight: 1.0177288
Minutia 41 Type: 2 Direction: 4 X-value: 60 Y-Value: 4 Weight: 1.0177288
Minutia 42 Type: 2 Direction: 5 X-value: 61 Y-Value: 5 Weight: 1.0177288
Minutia 43 Type: 2 Direction: 6 X-value: 62 Y-Value: 6 Weight: 1.0177288
Minutia 44 Type: 3 Direction: 7 X-value: 63 Y-Value: 7 Weight: 1.0861862
Minutia 45 Type: 3 Direction: 0 X-value: 64 Y-Value: 8 Weight: 1.0861862
Minutia 46 Type: 3 Direction: 1 X-value: 65 Y-Value: 9 Weight: 1.0861862
Minutia 47 Type: 3 Direction: 2 X-value: 66 Y-Value: 10 Weight: 1.0861862
Minutia 48 Type: 3 Direction: 3 X-value: 67 Y-Value: 11 Weight: 1.0861862
Minutia 49 Type: 4 Direction: 4 X-value: 68 Y-Value: 12 Weight: 1.180456
Minutia 50 Type: 4 Direction: 5 X-value: 69 Y-Value: 13 Weight: 1.180456
Minutia 51 Type: 4 Direction: 6 X-value: 70 Y-Value: 14 Weight: 1.180456
Minutia 52 Type: 4 Direction: 7 X-value: 71 Y-Value: 15 Weight: 1.180456
Minutia 53 Type: 5 Direction: 0 X-value: 72 Y-Value: 16 Weight: 1.39794
Minutia 54 Type: 5 Direction: 1 X-value: 73 Y-Value: 17 Weight: 1.39794
Minutia 55 Type: 5 Direction: 2 X-value: 74 Y-Value: 18 Weight: 1.39794

List of the potential Gs:
Minutia 0 0 Type: 5 Direction: 0 X-value: 72 Y-Value: 16 Weight: 1.39794
Minutia 0 1 Type: 4 Direction: 7 X-value: 71 Y-Value: 15 Weight: 1.180456
Minutia 0 2 Type: 5 Direction: 1 X-value: 73 Y-Value: 17 Weight: 1.39794
Minutia 0 3 Type: 4 Direction: 6 X-value: 70 Y-Value: 14 Weight: 1.180456
Minutia 0 4 Type: 5 Direction: 2 X-value: 74 Y-Value: 18 Weight: 1.39794
Minutia 0 5 Type: 4 Direction: 5 X-value: 69 Y-Value: 13 Weight: 1.180456
Minutia 0 6 Type: 0 Direction: 4 X-value: 76 Y-Value: 12 Weight: 0.34486157
Minutia 0 7 Type: 4 Direction: 4 X-value: 68 Y-Value: 12 Weight: 1.180456

Minutia 1 0 Type: 5 Direction: 1 X-value: 73 Y-Value: 17 Weight: 1.39794
Minutia 1 1 Type: 5 Direction: 0 X-value: 72 Y-Value: 16 Weight: 1.39794
Minutia 1 2 Type: 5 Direction: 2 X-value: 74 Y-Value: 18 Weight: 1.39794
Minutia 1 3 Type: 4 Direction: 7 X-value: 71 Y-Value: 15 Weight: 1.180456
Minutia 1 4 Type: 4 Direction: 6 X-value: 70 Y-Value: 14 Weight: 1.180456
Minutia 1 5 Type: 0 Direction: 5 X-value: 77 Y-Value: 13 Weight: 0.34486157
Minutia 1 6 Type: 4 Direction: 5 X-value: 69 Y-Value: 13 Weight: 1.180456
Minutia 1 7 Type: 0 Direction: 4 X-value: 76 Y-Value: 12 Weight: 0.34486157

Minutia 2 0 Type: 5 Direction: 2 X-value: 74 Y-Value: 18 Weight: 1.39794

Minutia 2 1 Type: 5 Direction: 1 X-value: 73 Y-Value: 17 Weight: 1.39794
Minutia 2 2 Type: 5 Direction: 0 X-value: 72 Y-Value: 16 Weight: 1.39794
Minutia 2 3 Type: 4 Direction: 7 X-value: 71 Y-Value: 15 Weight: 1.180456
Minutia 2 4 Type: 4 Direction: 6 X-value: 70 Y-Value: 14 Weight: 1.180456
Minutia 2 5 Type: 0 Direction: 5 X-value: 77 Y-Value: 13 Weight: 0.34486157
Minutia 2 6 Type: 0 Direction: 4 X-value: 76 Y-Value: 12 Weight: 0.34486157
Minutia 2 7 Type: 0 Direction: 3 X-value: 75 Y-Value: 11 Weight: 0.34486157
Minutia 2 8 Type: 4 Direction: 5 X-value: 69 Y-Value: 13 Weight: 1.180456

Result: The following subset is the most representative one (G) in the whole input set:
Minutia 0 Type: 5 Direction: 0 X-value: 72 Y-Value: 16 Weight: 1.39794
Minutia 1 Type: 4 Direction: 7 X-value: 71 Y-Value: 15 Weight: 1.180456
Minutia 2 Type: 5 Direction: 1 X-value: 73 Y-Value: 17 Weight: 1.39794
Minutia 3 Type: 4 Direction: 6 X-value: 70 Y-Value: 14 Weight: 1.180456
Minutia 4 Type: 5 Direction: 2 X-value: 74 Y-Value: 18 Weight: 1.39794
Minutia 5 Type: 4 Direction: 5 X-value: 69 Y-Value: 13 Weight: 1.180456
Minutia 6 Type: 0 Direction: 4 X-value: 76 Y-Value: 12 Weight: 0.34486157
Minutia 7 Type: 4 Direction: 4 X-value: 68 Y-Value: 12 Weight: 1.180456

This small benchmark just shows the output of the algorithm in three different situations:

1st: The probabilities are distinct (the values used are those exposed in the Chpater 4). Only one rarest point is detected, hence the subset G chosen is the one formed with its closest neighbors.

2nd: The probabilities are the same for all the types, thus the whole set needs to be compared in the matching stage, for more reliability.

3rd: The probabilities are the same than the ones of the first test, but here there is more than one rarest point. Therefore, the best subset, is the one with the higher weights' sum.

Generic.java

```
// Main class

import java.io.*;
import java.lang.*;

public class Generic {
	public static void main(String[] argv) throws IOException {
		int t, d, x, y, nb_min;

		// Check number of arguments on the command line
		if (argv.length != 5)
		{	System.out.println("Usage: java Generic Type Direction X-value
Y-value Nb_minutiae");
			System.exit(1);
		}
		// Retrieve the values
		t=Integer.parseInt(argv[0]);
		d=Integer.parseInt(argv[1]);
		x=Integer.parseInt(argv[2]);
		y=Integer.parseInt(argv[3]);
		nb_min=Integer.parseInt(argv[4]);
		if (nb_min<18) {
			System.out.println("The number of minutiae should be greater or
	equal to 18");
			System.exit(1);
		}

		double parray[]=new double[t];
		System.out.println("Enter the " + t + "occurrence probabilities assigned to
the types, in the ascending order");
		for(int j=0; j<t; j++) {
			System.out.println("Probability number " + j + " :");
			BufferedReader stdin = new BufferedReader(new
InputStreamReader(System.in));
			String str;
			str=stdin.readLine();
			parray[j]=Double.valueOf(str).doubleValue();
		}
		float trsum=18*(float)parray[0];
		// Creates the array of minutiae
		Tab T=new Tab(parray, t, d, x, y, nb_min);
		T.DisplayT();
		// Finds the potential Gs, regarding the exception type
```

```
        ExceptionC E=new ExceptionC(T, trsum);
        if(E.nb_ele==T.nb_min) {
            System.out.println("No exceptional minutia was detected, the whole input set will be used for the matching");
        }
        else {
            E.SetG(T);
            if(E.nb_ele>1) {
                System.out.println("List of the potential Gs: ");
                E.DisplayG();
                int card=E.Best_Exist();
                Minutia[] result = E.SelectG(card);
                System.out.println("Result: The following subset is the most representative one (G) in the whole input set: ");
                for(int i=0; i<card; i++) {
                    System.out.println("Minutia " + i + " Type: " + result[i].type + " Direction: " + result[i].direction + " X-value: " + result[i].abc + " Y-Value: " + result[i].ord + " Weight: " + result[i].weight);
                }
            }
            else {
                System.out.println("Result: The following subset is the most representative one (G) in the whole input set: ");
                E.DisplayG();
            }
        }
    }
}
```

Tab.java

```
//Class Tab, array of number of minutiae specified in the command line. This array represents the set of minutia points in the Feature F

import java.lang.*;
public class Tab implements Cloneable {
    public int nb_min;
    public Minutia[] tab;


    //constructor 1: creates the tab from the parameters of the minutiae
    public Tab(double ttyp[], int ty, int dt, int xv, int yv, int nb) {
        int start=0, j=0, sum=0, nt;
        this.nb_min=nb;
        this.tab = new Minutia[nb];
```

```
		big_loop:while(start<nb && j<ty) {
				nt=(int)Math.ceil(nb*ttyp[j]);
				for (int k=start; k<nt+start; k++) {
					if(k>=nb) { break big_loop;}
					this.tab[k]=new Minutia(j,dt,xv,yv);
					this.tab[k].weight=(float)(-
Math.log(ttyp[j]))/Math.log(10d));
			}
				j++;
				start+=nt;
			}

		for(int i=0; i<nb; i++) {
			this.tab[i].direction=(this.tab[i].direction+i)%dt;
			this.tab[i].abc=(this.tab[i].abc+i)%xv;
			this.tab[i].ord=(this.tab[i].ord+i)%yv;
		}
	}

	//constructor 2: creates an empty Tab object
	public Tab(int n) {
		this.nb_min=n;
		this.tab = new Minutia[n];
	}

	//Displays the content of a Tab object
	public void DisplayT() {
		System.out.println("List of the Minutia points generated, as the input
set:");
		for (int i=0; i<this.nb_min; i++)
		{	System.out.println("Minutia " + i + " Type: " + this.tab[i].type + "
Direction: " + this.tab[i].direction + " X-value: " + this.tab[i].abc + " Y-Value: " +
this.tab[i].ord + " Weight: " + this.tab[i].weight);
		}
	}

	// deletes the element locates at ind_from indice
	public void Del_min(int ind_from) {
		for(int i=ind_from; i<this.nb_min-1; i++) {
			this.tab[i]=this.tab[i+1]; }
		this.nb_min--;
	}

	//implements the clone() method
	public Object clone() {
		Tab T2= new Tab(this.nb_min);
```

```
		for(int i=0; i<this.nb_min; i++) {
			T2.tab[i] = this.tab[i];
		}
		return T2;
	}
}
```

Minutia.java

```
//Class Minutia defines a minutia point
import java.lang.*;
import java.util.*;

public class Minutia {
	public int type, direction, abc, ord;
	public float weight;

	public Minutia(int t, int d, int x, int y){
		this.type=t;
		this.direction=this.Counter(d);
		this.abc=this.Counter(x);
		this.ord=this.Counter(y);
	}

	public int Counter(int n) {
		Random r=new Random();
		int valeur=Math.abs(r.nextInt() % n);
		return valeur;
	}
}
```

ExceptionC.java

```
//Class ExceptionC for minutiae's types. Procedure: locates the rarest points and puts them in the 1st column of a 2-dimensional array then for each point in this array, selects its closest neighbors and put them in the same row until the sum of the weights reaches the threshold sum. The max number of neighbors is 17.

import java.lang.*;

public class ExceptionC {
	public Minutia[][] array;
	public int nb_ele;
```

```
	public int ind=0;
	float trsum;

	//constructor: creates an array containing the rarest minutiae of F (Tab)
	public ExceptionC(Tab T, float tsum) {
		int cpt=0, j=0;
		float w=0.0f;

		this.trsum=tsum;
		//find the rarest type (maximum weight)
		for(int i=0; i<T.nb_min; i++) {
			if(T.tab[i].weight>w) {
				w=T.tab[i].weight;
			}
		}
		//Mark the minutiae that have this rarest weight
		int[] temp=new int[T.nb_min];
		for(int i=0; i<T.nb_min; i++) {
			if(T.tab[i].weight==w) {
				cpt++;
				temp[j]=i;
				j++;
			}
		}
		//insert these minutiae in the array
		this.nb_ele=cpt;
		this.array = new Minutia[nb_ele][18];
		for (int i=0; i<cpt; i++) {
			this.array[i][0] = T.tab[temp[i]];
	  }
	}
	public void DisplayPG() {
		System.out.println("List of the rarest minutiae: ");
		for (int i=0; i<this.nb_ele; i++) {
			System.out.println("Minutia " + i + " Type: " + this.array[i][0].type
+ " Direction: " + this.array[i][0].direction + " X-value: " + this.array[i][0].abc + " Y-
Value: " + this.array[i][0].ord + " Weight: " + this.array[i][0].weight);
		}
	}

	public void DisplayG() {
		int j=0;
		for (int i=0; i<this.nb_ele; i++) {
			while(this.array[i][j]!=null) {
				System.out.println("Minutia " + i + " " + j + " Type: " +
this.array[i][j].type + " Direction: " + this.array[i][j].direction + " X-value: " +
```

```
this.array[i][j].abc + " Y-Value: " + this.array[i][j].ord + " Weight: " + this.array[i][j].weight);
					j++;
				}
				j=0;
			}
		}

		//compares 2 minutiae and determines if they're identical
		public boolean same_minutia(Minutia M1, Minutia M2) {
			if(M1.type==M2.type && M1.direction==M2.direction && M1.abc==M2.abc && M1.ord==M2.ord)
				return true;
			else
				return false;
		}

		//computes the Euclidean distance between 2 points
		public double distance(int xa, int xb, int ya, int yb) {
			double xdif=Math.pow(((double)xa - (double)xb), 2);
			double ydif=Math.pow(((double)ya - (double)yb), 2);
			return Math.sqrt(xdif + ydif);
		}

		//For each rare minutia, its neighbors are added, until reaching the threshold sum. Each row will correspond to a G
		public void SetG(Tab T) {
			int flag=0, j=0;
			double dist=Double.MAX_VALUE;
			float cursum;
			Tab I;
			for(int i=0; i<this.nb_ele; i++) {
				cursum=this.array[i][0].weight;
				I=(Tab)T.clone(); //reinitialization of I
				while(j<17 && cursum<this.trsum) {
					for(int k=0; k<I.nb_min; k++) {
						double d=this.distance(this.array[i][0].abc, I.tab[k].abc, this.array[i][0].ord, I.tab[k].ord);
						if(dist > d && same_minutia(this.array[i][0],I.tab[k])==false) {
							dist=d;
							flag=k;
						}
					}
					this.array[i][j+1]=I.tab[flag];
					cursum+=this.array[i][j+1].weight;
```

```
                        I.Del_min(flag);
                        dist=Double.MAX_VALUE;
                        j++;
                    }
                    j=0;
                }
            }

            //checks if there is a G with a minimum number of minutia points( < 17) and the
max weights' sum
            public int Best_Exist() {
                int nbpts=0, j, min=17, flag=0;
                float msumw=Float.MIN_VALUE, csumw;

                for(int i=0; i<this.nb_ele; i++) {
                    j=0;
                    csumw=0.0f;
                    while(this.array[i][j]!=null) {
                        csumw+=this.array[i][j].weight;
                        j++;
                    }
                    nbpts=j;
                    if((nbpts<min) || (nbpts==min && csumw>msumw)) {
                        min=nbpts;
                        flag=i;
                        msumw=csumw;
                    }
                }
                this.ind=flag;
                return min;
            }

            //selects the best G in the array of potential Gs
            public Minutia[] SelectG(int card) {
                Minutia[] result = new Minutia[card];
                for(int j=0; j<card; j++) {
                    result[j] = this.array[this.ind][j];
                }
                return result;
            }
}
```