Assignment 2

COMP9021, Trimester 2, 2019

1. General matter

1.1. **Aims.** The purpose of the assignment is to:

- design and implement an interface based on the desired behaviour of an application program;
- practice the use of Python syntax;
- develop problem solving skills.

1.2. **Submission.** Your program will be stored in a file named `polygons.py`. After you have developed and tested your program, upload it using Ed (unless you worked directly in Ed). Assignments can be submitted more than once; the last version is marked. Your assignment is due by August 11, 11:59pm.

1.3. **Assessment.** The assignment is worth 10 marks. It is going to be tested against a number of input files. For each test, the automarking script will let your program run for 30 seconds.

Late assignments will be penalised: the mark for a late submission will be the minimum of the awarded mark and 10 minus the number of full and partial days that have elapsed from the due date.

1.4. **Reminder on plagiarism policy.** You are permitted, indeed encouraged, to discuss ways to solve the assignment with other people. Such discussions must be in terms of algorithms, not code. But you must implement the solution on your own. Submissions are routinely scanned for similarities that occur when students copy and modify other people's work, or work very closely together on a single implementation. Severe penalties apply.

2. General presentation

You will design and implement a program that will

- extract and analyse the various characteristics of (simple) *polygons*, their contours being coded and stored in a file, and
- - either display those characteristics: perimeter, area, convexity, number of rotations that keep the polygon invariant, and depth (the length of the longest chain of enclosing polygons)
  - or output some Latex code, to be stored in a file, from which a pictorial representation of the polygons can be produced, coloured in a way which is proportional to their area.

Call *encoding* any 2-dimensional grid of size between between 2×2 and 50×50 (both dimensions can be different) all of whose elements are either 0 or 1.

Call *neighbour* of a member m of an encoding any of the at most eight members of the grid whose value is 1 and each of both indexes differs from m's corresponding index by at most 1. Given a particular encoding, we inductively define for all natural numbers d the *set of polygons of depth d* (for this encoding) as follows. Let a natural number d be given, and suppose that for all $d' < d$, the set of polygons of depth d' has been defined. Change in the encoding all 1's that determine those polygons to 0. Then the set of polygons of depth d is defined as the set of polygons which can be obtained from that encoding by connecting 1's with some of their neighbours in such a way that we obtain a **maximal** polygon (that is, a polygon which is not included in any other polygon obtained from that encoding by connecting 1's with some of their neighbours).

3. Examples

3.1. **First example.** The file `polys_1.txt` has the following contents:

```
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11111111111111111111111111111111111111111111111111
```

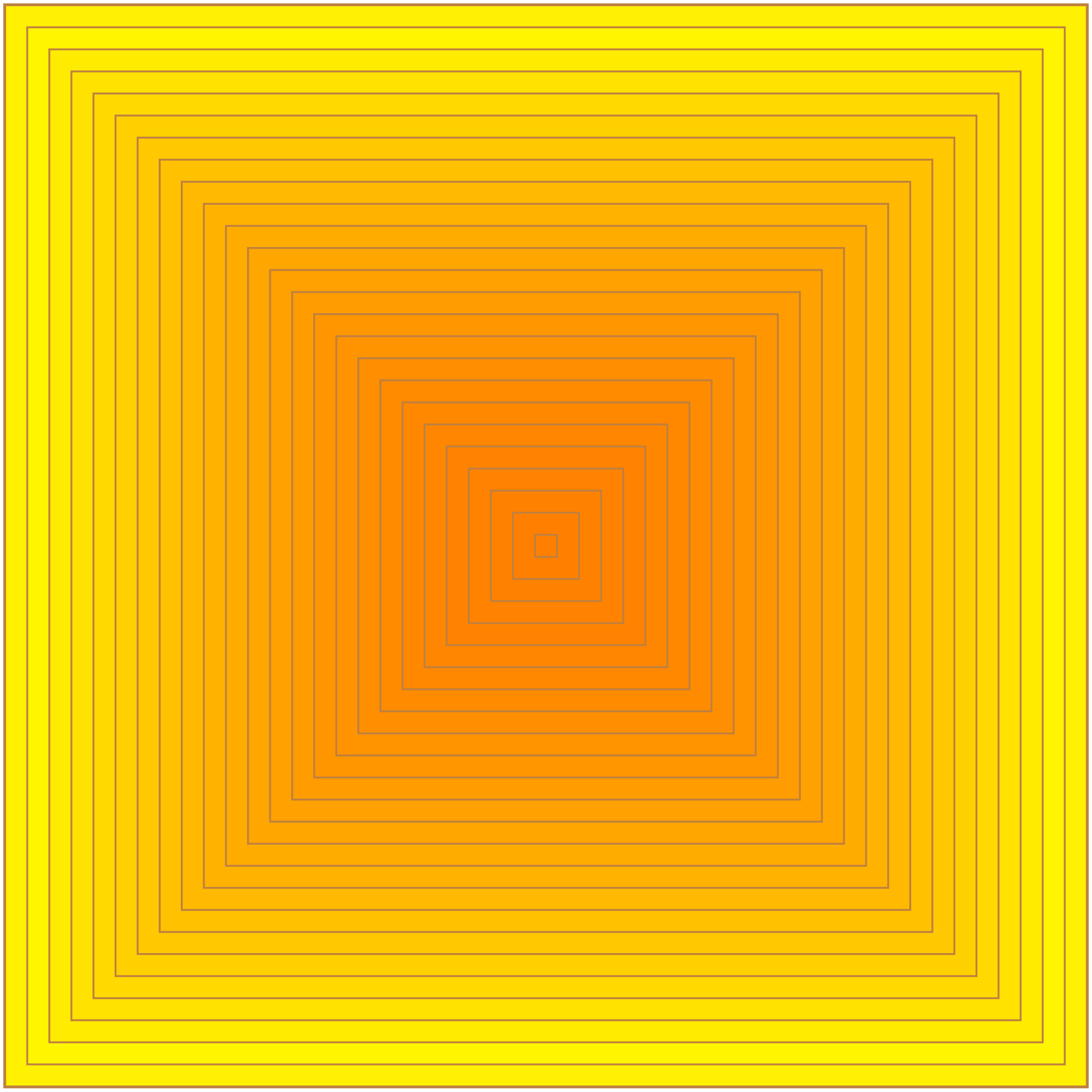
Here is a possible interaction:

```
$ python3
...
>>> from polygons import *
>>> polys = Polygons('polys_1.txt')
>>> polys.analyse()
Polygon 1:
    Perimeter: 78.4
    Area: 384.16
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 0
Polygon 2:
    Perimeter: 75.2
    Area: 353.44
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 1
Polygon 3:
    Perimeter: 72.0
    Area: 324.00
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 2
Polygon 4:
    Perimeter: 68.8
    Area: 295.84
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 3
Polygon 5:
    Perimeter: 65.6
    Area: 268.96
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 4
Polygon 6:
    Perimeter: 62.4
    Area: 243.36
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 5
Polygon 7:
    Perimeter: 59.2
    Area: 219.04
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 6
Polygon 8:
    Perimeter: 56.0
    Area: 196.00
    Convex: yes
    Nb of invariant rotations: 4
```

```
    Depth: 7
Polygon 9:
    Perimeter: 52.8
    Area: 174.24
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 8
Polygon 10:
    Perimeter: 49.6
    Area: 153.76
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 9
Polygon 11:
    Perimeter: 46.4
    Area: 134.56
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 10
Polygon 12:
    Perimeter: 43.2
    Area: 116.64
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 11
Polygon 13:
    Perimeter: 40.0
    Area: 100.00
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 12
Polygon 14:
    Perimeter: 36.8
    Area: 84.64
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 13
Polygon 15:
    Perimeter: 33.6
    Area: 70.56
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 14
Polygon 16:
    Perimeter: 30.4
    Area: 57.76
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 15
Polygon 17:
    Perimeter: 27.2
    Area: 46.24
    Convex: yes
    Nb of invariant rotations: 4
```

```
    Depth: 16
Polygon 18:
    Perimeter: 24.0
    Area: 36.00
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 17
Polygon 19:
    Perimeter: 20.8
    Area: 27.04
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 18
Polygon 20:
    Perimeter: 17.6
    Area: 19.36
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 19
Polygon 21:
    Perimeter: 14.4
    Area: 12.96
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 20
Polygon 22:
    Perimeter: 11.2
    Area: 7.84
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 21
Polygon 23:
    Perimeter: 8.0
    Area: 4.00
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 22
Polygon 24:
    Perimeter: 4.8
    Area: 1.44
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 23
Polygon 25:
    Perimeter: 1.6
    Area: 0.16
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 24
>>> polys.display()
```

The effect of executing polys.display() is to produce a file named polys_1.tex that can be given as argument to pdflatex to produce a file named polys_1.pdf that views as follows.



3.2. **Second example.** The file polys_2.txt has the following contents:

```
00000000000000000000000000000000000000000000000000
01111111111111111111111111111111111111111111111110
00111111111111111111111111111111111111111111111100
00011111111111111111111111111111111111111111111000
01001111111111111111111111111111111111111111110010
01100111111111111111111111111111111111111111100110
01110011111111111111111111111111111111111111001110
01111001111111111111111111111111111111111110011110
01111100111111111111111111111111111111111100111110
01111110011111111111111111111111111111111001111110
01111111001111111111111111111111111111110011111110
01111111100111111111111111111111111111100111111110
01111111110011111111111111111111111111001111111110
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01111100111111111111111111111111111111111100111110
01111001111111111111111111111111111111111110011110
01110011111111111111111111111111111111111111001110
01100111111111111111111111111111111111111111100110
01001111111111111111111111111111111111111111110010
00011111111111111111111111111111111111111111111000
00111111111111111111111111111111111111111111111100
01111111111111111111111111111111111111111111111110
00000000000000000000000000000000000000000000000000
```

Here is a possible interaction:

```
$ python3
...
>>> from polygons import *
>>> polys = Polygons('polys_2.txt')
>>> polys.analyse()
Polygon 1:
    Perimeter: 37.6 + 92*sqrt(.32)
    Area: 176.64
    Convex: no
    Nb of invariant rotations: 2
    Depth: 0
Polygon 2:
    Perimeter: 17.6 + 42*sqrt(.32)
    Area: 73.92
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 1
Polygon 3:
    Perimeter: 16.0 + 38*sqrt(.32)
    Area: 60.80
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 2
Polygon 4:
    Perimeter: 16.0 + 40*sqrt(.32)
    Area: 64.00
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 0
Polygon 5:
    Perimeter: 14.4 + 34*sqrt(.32)
    Area: 48.96
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 3
Polygon 6:
    Perimeter: 16.0 + 40*sqrt(.32)
    Area: 64.00
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 0
Polygon 7:
    Perimeter: 12.8 + 30*sqrt(.32)
    Area: 38.40
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 4
Polygon 8:
    Perimeter: 14.4 + 36*sqrt(.32)
    Area: 51.84
    Convex: yes
    Nb of invariant rotations: 1
```

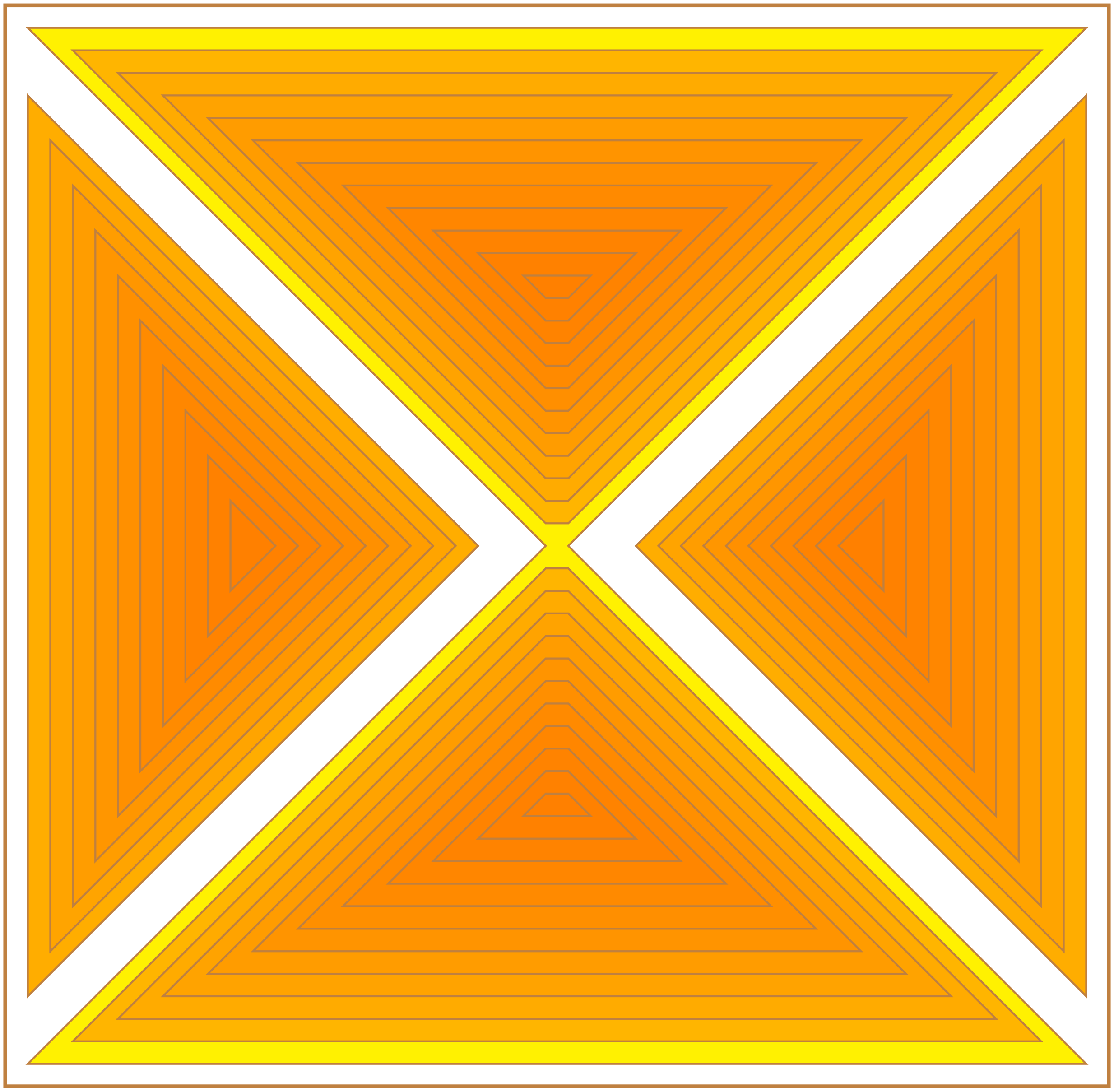
```
    Depth: 1
Polygon 9:
    Perimeter: 11.2 + 26*sqrt(.32)
    Area: 29.12
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 5
Polygon 10:
    Perimeter: 14.4 + 36*sqrt(.32)
    Area: 51.84
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 1
Polygon 11:
    Perimeter: 9.6 + 22*sqrt(.32)
    Area: 21.12
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 6
Polygon 12:
    Perimeter: 12.8 + 32*sqrt(.32)
    Area: 40.96
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 2
Polygon 13:
    Perimeter: 8.0 + 18*sqrt(.32)
    Area: 14.40
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 7
Polygon 14:
    Perimeter: 12.8 + 32*sqrt(.32)
    Area: 40.96
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 2
Polygon 15:
    Perimeter: 6.4 + 14*sqrt(.32)
    Area: 8.96
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 8
Polygon 16:
    Perimeter: 11.2 + 28*sqrt(.32)
    Area: 31.36
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 3
Polygon 17:
    Perimeter: 4.8 + 10*sqrt(.32)
    Area: 4.80
    Convex: yes
    Nb of invariant rotations: 1
```

```
    Depth: 9
Polygon 18:
    Perimeter: 11.2 + 28*sqrt(.32)
    Area: 31.36
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 3
Polygon 19:
    Perimeter: 3.2 + 6*sqrt(.32)
    Area: 1.92
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 10
Polygon 20:
    Perimeter: 9.6 + 24*sqrt(.32)
    Area: 23.04
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 4
Polygon 21:
    Perimeter: 1.6 + 2*sqrt(.32)
    Area: 0.32
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 11
Polygon 22:
    Perimeter: 9.6 + 24*sqrt(.32)
    Area: 23.04
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 4
Polygon 23:
    Perimeter: 8.0 + 20*sqrt(.32)
    Area: 16.00
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 5
Polygon 24:
    Perimeter: 8.0 + 20*sqrt(.32)
    Area: 16.00
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 5
Polygon 25:
    Perimeter: 6.4 + 16*sqrt(.32)
    Area: 10.24
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 6
Polygon 26:
    Perimeter: 6.4 + 16*sqrt(.32)
    Area: 10.24
    Convex: yes
    Nb of invariant rotations: 1
```

```
    Depth: 6
Polygon 27:
    Perimeter: 4.8 + 12*sqrt(.32)
    Area: 5.76
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 7
Polygon 28:
    Perimeter: 4.8 + 12*sqrt(.32)
    Area: 5.76
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 7
Polygon 29:
    Perimeter: 3.2 + 8*sqrt(.32)
    Area: 2.56
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 8
Polygon 30:
    Perimeter: 3.2 + 8*sqrt(.32)
    Area: 2.56
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 8
Polygon 31:
    Perimeter: 1.6 + 4*sqrt(.32)
    Area: 0.64
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 9
Polygon 32:
    Perimeter: 1.6 + 4*sqrt(.32)
    Area: 0.64
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 9
Polygon 33:
    Perimeter: 17.6 + 42*sqrt(.32)
    Area: 73.92
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 1
Polygon 34:
    Perimeter: 16.0 + 38*sqrt(.32)
    Area: 60.80
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 2
Polygon 35:
    Perimeter: 14.4 + 34*sqrt(.32)
    Area: 48.96
    Convex: yes
    Nb of invariant rotations: 1
```

```
    Depth: 3
Polygon 36:
    Perimeter: 12.8 + 30*sqrt(.32)
    Area: 38.40
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 4
Polygon 37:
    Perimeter: 11.2 + 26*sqrt(.32)
    Area: 29.12
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 5
Polygon 38:
    Perimeter: 9.6 + 22*sqrt(.32)
    Area: 21.12
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 6
Polygon 39:
    Perimeter: 8.0 + 18*sqrt(.32)
    Area: 14.40
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 7
Polygon 40:
    Perimeter: 6.4 + 14*sqrt(.32)
    Area: 8.96
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 8
Polygon 41:
    Perimeter: 4.8 + 10*sqrt(.32)
    Area: 4.80
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 9
Polygon 42:
    Perimeter: 3.2 + 6*sqrt(.32)
    Area: 1.92
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 10
Polygon 43:
    Perimeter: 1.6 + 2*sqrt(.32)
    Area: 0.32
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 11
>>> polys.display()
```

The effect of executing `polys.display()` is to produce a file named `polys_2.tex` that can be given as argument to `pdflatex` to produce a file named `polys_2.pdf` that views as follows.



3.3. **Third example.** The file `polys_3.txt` has the following contents:

```
0 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 0
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0 0 1 0 0 1 0 0 0 0 1 0 0 1 1 0 1 0 0 0 0 0 0 1 0 1 1 0 0 1 0 0 0 0 1 0 0 1 0 0
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0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 1 0 1 0 0 0 0 1 0 1 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0
1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 0 0 1 0 0 1 0 0 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1
1 1 0 1 0 1 0 1 0 0 1 0 0 0 1 1 0 1 0 0 0 0 1 0 1 1 0 0 0 1 0 0 1 0 1 0 1 0 1 1
1 1 1 0 1 0 1 0 1 0 1 0 0 0 1 1 0 0 1 0 0 1 0 0 1 1 0 0 0 1 0 1 0 1 0 1 0 1 1 1
1 1 0 0 1 1 1 0 1 0 1 0 0 0 1 1 0 1 0 0 0 0 1 0 1 1 0 0 0 1 0 1 0 1 1 1 0 0 1 1
1 1 0 0 1 0 1 0 1 0 1 0 0 0 1 1 0 0 1 0 0 1 0 0 1 1 0 0 0 1 0 1 0 1 0 1 0 0 1 1
1 1 0 0 1 0 1 0 1 0 1 0 0 0 1 1 0 1 0 0 0 0 1 0 1 1 0 0 0 1 0 1 0 1 0 1 0 0 1 1
1 1 0 0 1 0 1 0 1 0 1 0 0 0 1 1 0 0 1 0 0 1 0 0 1 1 0 0 0 1 0 1 0 1 0 1 0 0 1 1
1 1 1 0 1 1 1 0 1 0 1 0 0 0 1 1 0 1 0 0 0 0 1 0 1 1 0 0 0 1 0 1 0 1 1 1 0 1 1 1
1 1 0 1 0 1 0 1 0 0 1 0 0 0 1 1 0 0 1 0 0 1 0 0 1 1 0 0 0 1 0 0 1 0 1 0 1 0 1 1
1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 0 1 0 0 0 0 1 0 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1
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0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 1 0 0 0 0 0 0 0 0 1 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 1 0 0 1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 0 1 0 0 0 0 0 0 1 0 0 0
0 0 1 0 1 0 0 0 0 0 1 0 0 0 1 0 1 1 1 1 1 1 1 1 0 1 0 0 0 1 0 0 0 0 0 1 0 1 0 0
0 0 1 0 0 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 0 1 0 0 1 0 0
0 0 1 0 0 1 0 0 0 0 1 0 0 1 1 0 1 0 0 0 0 0 0 1 0 1 1 0 0 1 0 0 0 0 1 0 0 1 0 0
0 1 0 0 0 1 0 0 0 0 1 0 0 1 1 0 0 1 0 0 0 0 1 0 0 1 1 0 0 1 0 0 0 0 1 0 0 0 1 0
0 1 0 0 1 0 0 0 0 0 1 0 0 1 1 0 0 0 1 0 0 1 0 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 1 0
1 0 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 1
0 1 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 0
```
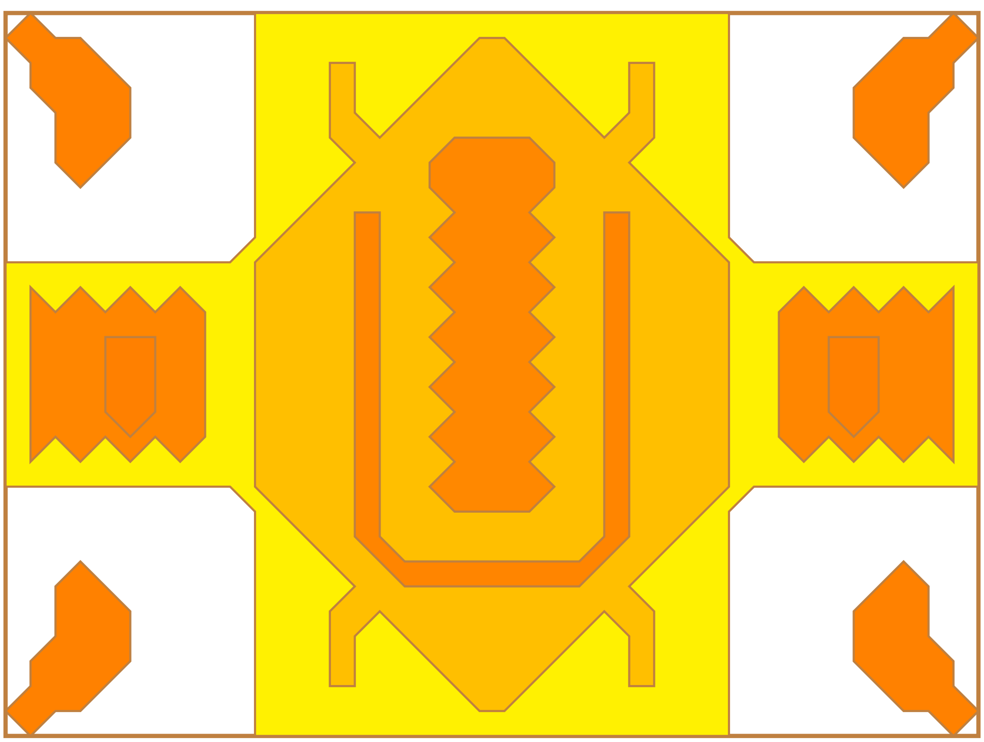

Here is a possible interaction:

```
$ python3
...
>>> from polygons import *
>>> polys = Polygons('polys_3.txt')
>>> polys.analyse()
Polygon 1:
    Perimeter: 2.4 + 9*sqrt(.32)
    Area: 2.80
    Convex: no
    Nb of invariant rotations: 1
    Depth: 0
Polygon 2:
    Perimeter: 51.2 + 4*sqrt(.32)
    Area: 117.28
    Convex: no
    Nb of invariant rotations: 2
    Depth: 0
Polygon 3:
    Perimeter: 2.4 + 9*sqrt(.32)
    Area: 2.80
    Convex: no
    Nb of invariant rotations: 1
    Depth: 0
Polygon 4:
    Perimeter: 17.6 + 40*sqrt(.32)
    Area: 59.04
    Convex: no
    Nb of invariant rotations: 2
    Depth: 1
Polygon 5:
    Perimeter: 3.2 + 28*sqrt(.32)
    Area: 9.76
    Convex: no
    Nb of invariant rotations: 1
    Depth: 2
Polygon 6:
    Perimeter: 27.2 + 6*sqrt(.32)
    Area: 5.76
    Convex: no
    Nb of invariant rotations: 1
    Depth: 2
Polygon 7:
    Perimeter: 4.8 + 14*sqrt(.32)
    Area: 6.72
    Convex: no
    Nb of invariant rotations: 1
    Depth: 1
Polygon 8:
    Perimeter: 4.8 + 14*sqrt(.32)
    Area: 6.72
    Convex: no
    Nb of invariant rotations: 1
```

```
    Depth: 1
Polygon 9:
    Perimeter: 3.2 + 2*sqrt(.32)
    Area: 1.12
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 2
Polygon 10:
    Perimeter: 3.2 + 2*sqrt(.32)
    Area: 1.12
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 2
Polygon 11:
    Perimeter: 2.4 + 9*sqrt(.32)
    Area: 2.80
    Convex: no
    Nb of invariant rotations: 1
    Depth: 0
Polygon 12:
    Perimeter: 2.4 + 9*sqrt(.32)
    Area: 2.80
    Convex: no
    Nb of invariant rotations: 1
    Depth: 0
>>> polys.display()
```

The effect of executing `polys.display()` is to produce a file named `polys_3.tex` that can be given as argument to `pdflatex` to produce a file named `polys_3.pdf` that views as follows.



3.4. **Fourth example.** The file `polys_4.txt` has the following contents:

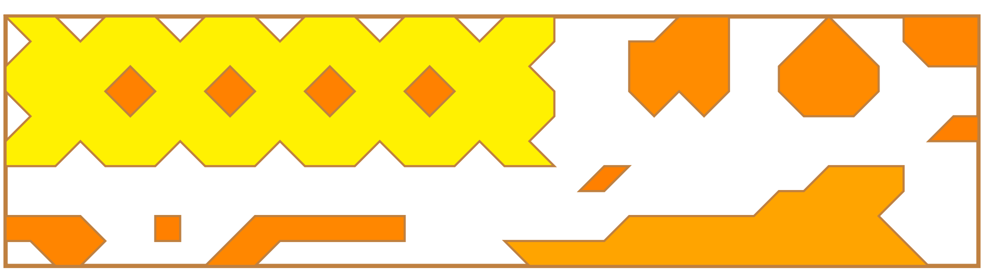
```
1    1  101     11 0  1 1             1 0 1      1 1011 10        1 1 1 0 000       1 1 1 0      00  1 001  11 1

01  0100010001000100010010                        110010010101001

100 0010 0             0 1            00 0 1 0 00         100         01000             100 0 1 01 0001011         1

100010101010101010100010010101010100010000
01000100010001000100001000101000111000 11

100      1 0 0 0            10  0 0 1     00 0 1     00       01   010   000      0000    0 0 0 0      00 01     11

11101            1101110     1                 1           1               0111011101100000001111000
000000000000000000000011000000110001000                                            0

1                                  1110011001111111000000000111111000      010000

110 01      0 1 1 0                                                   10111111000111110000000000001000

001  1000011      10          000000000                 1111111111111111                            00
```

Here is a possible interaction:

```
$ python3
...
>>> from polygons import *
>>> polys = Polygons('polys_4.txt')
>>> polys.analyse()
Polygon 1:
    Perimeter: 11.2 + 28*sqrt(.32)
    Area: 18.88
    Convex: no
    Nb of invariant rotations: 2
    Depth: 0
Polygon 2:
    Perimeter: 3.2 + 5*sqrt(.32)
    Area: 2.00
    Convex: no
    Nb of invariant rotations: 1
    Depth: 0
Polygon 3:
    Perimeter: 1.6 + 6*sqrt(.32)
    Area: 1.76
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 0
Polygon 4:
    Perimeter: 3.2 + 1*sqrt(.32)
    Area: 0.88
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 0
Polygon 5:
    Perimeter: 4*sqrt(.32)
    Area: 0.32
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 1
Polygon 6:
    Perimeter: 4*sqrt(.32)
    Area: 0.32
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 1
Polygon 7:
    Perimeter: 4*sqrt(.32)
    Area: 0.32
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 1
Polygon 8:
    Perimeter: 4*sqrt(.32)
    Area: 0.32
    Convex: yes
    Nb of invariant rotations: 4
```

```
    Depth: 1
Polygon 9:
    Perimeter: 1.6 + 1*sqrt(.32)
    Area: 0.24
    Convex: yes
    Nb of invariant rotations: 1
    Depth: 0
Polygon 10:
    Perimeter: 0.8 + 2*sqrt(.32)
    Area: 0.16
    Convex: yes
    Nb of invariant rotations: 2
    Depth: 0
Polygon 11:
    Perimeter: 12.0 + 7*sqrt(.32)
    Area: 5.68
    Convex: no
    Nb of invariant rotations: 1
    Depth: 0
Polygon 12:
    Perimeter: 2.4 + 3*sqrt(.32)
    Area: 0.88
    Convex: no
    Nb of invariant rotations: 1
    Depth: 0
Polygon 13:
    Perimeter: 1.6
    Area: 0.16
    Convex: yes
    Nb of invariant rotations: 4
    Depth: 0
Polygon 14:
    Perimeter: 5.6 + 3*sqrt(.32)
    Area: 1.36
    Convex: no
    Nb of invariant rotations: 1
    Depth: 0
>>> polys.display()
```

The effect of executing `polys.display()` is to produce a file named `polys_4.tex` that can be given as argument to `pdflatex` to produce a file named `polys_4.pdf` that views as follows.



4. Detailed description

4.1. **Input.** The input is expected to consist of y_{dim} lines of x_{dim} 0's and 1's, where x_{dim} and y_{dim} are at least equal to 2 and at most equal to 50, with possibly lines consisting of spaces only that will be ignored and with possibly spaces anywhere on the lines with digits. If n is the x^{th} digit of the y^{th} line with digits, with $0 \leq x < x_{dim}$ and $0 \leq y < y_{dim}$, then n is to be associated with a point situated $x \times 0.4$ cm to the right and $y \times 0.4$ cm below an origin.

4.2. **Output.** Consider executing from the Python prompt the statement `from polygons import *` followed by the statement `polys = Polygons(some_filename)`. In case `some_filename` does not exist in the working directory, then Python will raise a `FileNotFoundError` exception, that does not need to be caught. Assume that `some_filename` does exist (in the working directory). If the input is incorrect in that it does not contain only 0's and 1'a besides spaces, or in that it contains either too few or too many lines of digits, or in that some line of digits contains too many or too few digits, or in that two of its lines of digits do not contain the same number of digits, then the effect of executing `polys = Polygons(some_filename)` should be to generate a `PolygonsError` exception that reads

```
Traceback (most recent call last):
...
polygons.PolygonsError: Incorrect input.
```

If the previous conditions hold but it is not possible to use all 1's in the input and make them the contours of polygons of depth d, for any natural number d, as defined in the general presentation, then the effect of executing `polys = Polygons(some_filename)` should be to generate a `PolygonsError` exception that reads

```
Traceback (most recent call last):
...
polygons.PolygonsError: Cannot get polygons as expected.
```

If the input is correct and it is possible to use all 1's in the input and make them the contours of polygons of depth d, for any natural number d, as defined in the general presentation, then executing the statement `polys = Polygons(some_filename)` followed by `polys.analyse()` should have the effect of outputting a first line that reads

```
Polygon N:
```

with `N` an appropriate integer at least equal to 1 to refer to the `N`'th polygon listed in the order of polygons with highest point from smallest value of y to largest value of y, and for a given value of y, from smallest value of x to largest value of x, a second line that reads one of

```
    Perimeter: a + b*sqrt(.32)
    Perimeter: a
    Perimeter: b*sqrt(.32)
```

with `a` an appropriate strictly positive floating point number with 1 digit after the decimal point and `b` an appropriate strictly positive integer, a third line that reads

```
    Area: a
```

with `a` an appropriate floating point number with 2 digits after the decimal point, a fourth line that reads one of

```
    Convex: yes
    Convex: no
```

a fifth line that reads

```
    Nb of invariant rotations: N
```

with `N` an appropriate integer at least equal to 1, and a sixth line that reads

```
Depth: N
```

with `N` an appropriate positive integer (possibly 0).

Pay attention to the expected format, including spaces.

If the input is correct and it is possible to use all 1's in the input and make them the contours of polygons of depth d, for any natural number d, as defined in the general presentation, then executing the statement `polys = Polygons(some_filename)` followed by `polys.display()` should have the effect of producing a file named `some_filename.tex` that can be given as argument to `pdflatex` to generate a file named `some_filename.pdf`. The provided examples will show you what `some_filename.tex` should contain.

- Polygons are drawn from lowest to highest depth, and for a given depth, the same ordering as previously described is used.
- The point that determines the polygon index is used as a starting point in drawing the line segments that make up the polygon, in a clockwise manner.
- A polygons's colour is determined by its area. The largest polygons are yellow. The smallest polygons are orange. Polygons in-between mix orange and yellow in proportion of their area. For instance, a polygon whose size is 25% the difference of the size between the largest and the smallest polygon will receive 25% of orange (and 75% of yellow). That proportion is computed as an integer. When the value is not an integer, it is rounded to the closest integer, with values of the form $z.5$ rounded up to $z + 1$.

Pay attention to the expected format, including spaces and blank lines. Lines that start with `%` are comments. The output of your program redirected to a file will be compared with the expected output saved in a file (of a different name of course) using the `diff` command. For your program to pass the associated test, `diff` should silently exit, which requires that the contents of both files be absolutely identical, character for character, including spaces and blank lines. Check your program on the provided examples using the associated .tex files, renaming them as they have the names of the files expected to be generated by your program.