

# ME/IE/CS 558

## Assignment 5

*Due May 9, 2016*

**For all assignments:** *Unless specifically indicated, you are free to use any publicly available sources: papers, books, programs, online material, etc. – as long as you clearly indicate and attribute the origin of the information.*

The goal of this assignment is to gain experience with implicit representation of a shape  $S$  by an inequality  $f(x, y) \geq 0$ . More specifically, given an expression  $f(x, y)$  and a size parameter  $h$ , your program needs to construct a piecewise linear approximation (a connected sequence of line segments) of the boundary  $\partial S$  defined by  $f(x, y) = 0$ , such that the length of every segment is  $\leq h$ ; and produce the answers to the following four information about the shape:

1. the number of connected components of  $S$ ;
2. determine if  $S$  is simply connected;
3. determine if  $S$  has non-empty interior;
4. max distance from your approximation to the actual boundary  $\partial S$

For **extra credit**, determine one or more of the following properties:

- Is  $S$  closed regular set?
- Does  $S$  have any sharp corners?
- What is the smallest feature of  $S$  that is possibly missed by your construction?
- Is  $f(x, y)$  the distance function for set  $f(x, y) = 0$ ?

### Analysis (50 points)

1. Describe the algorithm to construct a piecewise linear approximation of set  $f(x, y) = 0$ . The algorithm could be designed by you or by somebody else, but you must fully account for your sources and have clear understanding of how it works.
2. Describe how the answers to the four required questions are computed.
3. Describe the assumptions used by the algorithm: what are the assumed or required properties of function  $f$ ? What will happen if  $f$  does not have these properties?
4. What are the limitations of the algorithm: are there functions for which it will not work? are there features of shape  $S$  or portions of boundary that may be missed?
5. Explain your approach to answering any extra credit questions.

### Implementation & Testing (50 points)

1. Implement the program to produce a graphic output showing the computed piecewise linear approximation of  $f \geq 0$ , including its interior. Your program should also output the answer to the four required questions.
2. The input to the program is string specifying the function as a Python expression, such as `"5*x**3 - 17.3 * y**2 + sin(x*y)"`, etc. and a real number specifying the value of the size parameter  $h$ . The expressions may be evaluated in Python using `eval()` function.
3. Test your program on variety of functions. Wolfram is a good source for variety of such functions <http://mathworld.wolfram.com>

### Deliverables

Please use the course website to submit a single zip named `FirstName.LastName_HW5.zip` The zip archive should contain: (1) the analysis portion of the assignment, (2) the documented python source file, and (3) a PDF readme file specifying the instructions for running the code. It should also include at least 1 sample run with input and output, and specify any specific dependencies or requirements of your code.