Programming Assignment (optional)

due: Thursday, June 18th, 2020, 23:59

Given a rectangle R and a simple polygon P, our goal is to pack as many congruent copies of P into R such that the copies are pairwise interior disjoint. Each copy is obtained by applying a rigid transformation to P, namely translation and rotation. See the figure below for an illustration (not a very dense packing).

Assume that P is given as a list of vertices $v_1, v_2, \ldots, v_n$ in counterclockwise direction along the boundary of P. A solution is a set of quadruplets $(x_i, y_i, \cos\theta_i, \sin\theta_i)$, where (x_i, y_i) is the location of the vertex v_1 in the ith copy of P, and θ_i is the angle that the ray starting at v_1 and going through v_2 makes with the positive x-axis (for v_1 and v_2 in the ith copy of P). Your solution needs to be absolutely accurate, without rounding errors. To achieve this we only allow *rational rotations*, namely rotations by an angle both whose cosine and sine are rational numbers. Luckily, we can approximate any angle α to any desired level of precision by another angle α' whose cosine and sine are rational. This is one of the services provided by CGAL, which could help you in your project.

This packing problem is in general hard, and we often resort to meta-heuristics (such as simulated annealing) to solve it. See for example the paper "A simulated annealing approach to the nesting problem in the textile manufacturing industry" by Heckmann and Lengauer, Annals of Operations Research, Volume 57(1): 147-173 (1995). The paper solves a more general problem but can give you a good idea how the problem can be attacked.

Your submission should include (i) a description of your algorithm(s) and their implementation, (ii) a discussion of the performance of your solution on a few (say 3–5) different inputs, (iii) an executable of your program, and (iv) documented source code. You may write the program in `C/C++` or `Python`.

You may submit this assignment in pairs—you are encouraged to do that; it will still count, for ecah student, for 15% of the final grade, and only if it improves the final grade. Feel free to discuss the project with your fellow students, but you are not allowed to share code across projects.

Additional information about the project, including the precise input/output format, will be posted on the course's website. Stay tuned.

Packing of copies of a star inside a rectangle.