Takeaway exam - GPR

Master in Innovation and Research in Informatics January 18, 2020

Exercise 1 [1 point]

We have seen two techniques for fitting a plane to a point set: unconstrained least squares and PCA. Both work by minimizing an error function. Explain the difference between the error functions of both methods and the consequences this has on the result.

Exercise 2 [1 point]

In the version of MLS (Moving Least Squares) we saw in the theory sessions the implicit function $f: \Re^3 \rightarrow \Re$ is computed from all points in the input cloud. This implies that the cost of computing the value of f at any point increases with the size of the input, complicating the reconstruction of very large point clouds. How would you improve the performance if the weight functions are Gaussian? Describe in detail how you would modify the basic algorithm to improve performance, and how much improvement you would expect.

Exercise 3 [1 point]

In ICP (Iterative Closest Point), once we have determined the correspondence between points, it is necessary to find the rigid transformation (rotation and translation) that brings the two clouds closer. The performance of this step depends on the size of the point clouds. One way to improve performance is to choose subsets of both clouds to compute the rigid transformation. What criteria do you think may be important to apply when choosing this subset? Explain why.

Exercise 4 [2 points]

Assuming that we are using uniform Laplacian weights, show that the iterative formulation of the Laplacian update vectors and the matrix formulation (in the product form of the weak Laplacian matrix and the mass matrix) are equivalent.

Exercise 5 - Parameterization [1 point]

A certain parameterization maps a triangle of the mesh with vertices (x,y,z) (5,0,3), (6, 0, 3), (5, 1, 3) to a triangle on the parameter domain with vertices (u,v) (0,0), (1,-1), (0.5, 2).

(a) Describe a simple local coordinate frame for the mesh triangle (use the first vertex as the origin).
(b) Find the 2x2 transformation matrix A that maps the mesh triangle (with vertices on your local basis) to the parameterization domain triangle.
(c) Compute the singular values of A. Give a geometric interpretation of these values.
(d) Matrix A maps unit circles into ellipses. Can you draw/write the main axes of such ellipse?

Exercise 6 – Parameterization [1 point]

Complete the following table, with at least two new rows, following the example:

Parameterization property	**Sample application**
Minimize angle distortion	Remeshing with isotropic elements
…	…

Exercise 7 – Parameterization [1 point]

The planar parameterization of complex surfaces requires introducing seams/cuts on the mesh. Provide a comprehensive list of problems caused by such cuts, with one example of application where such problems are relevant.

Exercise 8 - Repairing [1 point]

Nooruding and Turk's 2003 method for classifying points as inside/outside is quite heuristic.

(a) For the parity-count method, draw a 2D example of a mesh and a point that you expect to be classified as inside but the method classifies as outside (using n=5 rays).
(b) For the parity-count method, draw a 2D example of a mesh and a point that you expect to be classified as outside but the method classifies as inside (using n=5 rays).

Exercise 9 - Repairing [1 point]

Give your own example of a failure case for Borodin et al. 2002 method for Gap Closing. Describe the type of artifact, draw an example, and explain why the method won't be able to fix it.