Examen final de Sistemes Gràfics Interactius (SGI)

Curs 2011 / 2012, 10 de Juny de 2011

Name :

Remarks:

- Please write your answer within the allocated space
- Justify all answers.

Problem 1. (0.5 point)

Imagine you are given an arbitrary polygonal mesh representing an open surface (that is, a surface with a boundary). A friend of you has developed an application to add the necessary polygons to the mesh (leaving the original polygons untouched) so that the surface becomes closed (i.e. the application adds polygons to fill in the gaps so that each edge in the output is shared by exactly two faces). Does the algorithm above guarantee that the resulting polygonal mesh will always be a **valid manifold** surface? Why?

Problem 2. (0.5 point)

In a polygonal model with R=0, an algorithm finds arbitrary sequences of coplanar edges with the form (v_1,v_2), (v_2,v_3), ..., (v_i, v_{i+1}), ... (v_n,v_1), i.e. each edge in the sequence shares a vertex with the previous edge and a vertex with the next edge. Is each of these sequences of edges guaranteed to bound a face of the polygonal model? That is, is there a face in the model for every possible sequence of connected and coplanar edges? Justify your answer.

Problem 3. (0.5 point)

We want to use the algorithm for creating approximations of a sphere through recursive 1:4 subdivision of octahedron. Write a function that, given the minimum number of desired vertices, returns the number of iterations to be performed (0 iterations means leaving the octahedron as is).

Problem 4. (1 point)

Write a procedure that, given a parameter V, creates the BRep model of a cylinder with **2V vertices**. The cylinder must have unit radius, its major axis aligned with the Z axis, and the taps (top/bottom faces) on the planes Z=0 and Z=1 (each circular face must have V vertices). Use the methods **addVertex** and **addFace** as discussed in class. You are allowed to abuse notation.

Problem 5. (1 point)

Regarding the Boolean intersection of two (partially overlapping) solids A, B, indicate, for each of the following statements, if it is true or false (and **why**):

(a) The resulting solid C **always** includes at least one vertex of A and a vertex of B, regardless of the operation.

(b) The resulting solid C **always** includes **at least a new vertex** not belonging to A or B, regardless of the operation.

Problem 6. (0.5 point)

Given two solids A, B, indicate which vertices will be part of the Boolean **difference A-B**.

Problem 7. (0.5 point)

After computing all vertices of a Boolean operation of two solids A, B, we have found several cycles C_1, ... C_n. Suppose a cycle C_i is enclosed within a cycle C_j. Does this fact guarantee that C_i is the exterior loop of a face? Justify the answer with the help of an example.

Problem 8. (1 point)

In class we proved that, on a **triangle mesh**, the average degree of the vertices is 6. What about the average degree of a vertex in a **quad mesh**?

Problem 9. (1 point)

The CSG representation of a particular solid uses a binary tree with depth D and N nodes. Indicate the **worst case** cost of the point-inside-CSG test, **in terms of the number of nodes N**. Justify the answer!

Problem 10. (0.5 point)

Sort the following operations/interrogations on a solid represented as a CSG model, in order of increasing time complexity (no need to justify):

(a) Boolean operations of two CSG models, (b) compute the volume of the CSG solid, (c) point-inside-CSG test

Problem 11. (0.5 point)

Explain why most stereoscopic devices break the natural relationship between accommodation and convergence.

Problem 12. (1 point)

Explain the main difference between forward kinematics and inverse kinematics.

Problem 13. (1 point)

Explain briefly the three main techniques for compressing the vertex coordinates of a triangle mesh.

Problem 14. (0.5 point)

A particular Bézier segment requires at least 5 points to be specified. Which is the degree of this Bézier curve? (no need to justify)

Laboratory exam

Problem 1. (1 point)

Write a Python function for Blender that, given a Mesh object **with a single shell**, and its genus H, prints "OK" if and only if the mesh satisfies the Euler equation.

```
def EulerCheck(mesh, H):
```

Problem 2. (2 points)

What's the purpose of the following Python code?

```
R = {}
for i,e in enumerate(mesh.edges):
    if e.v1.index in R:
        R[e.v1.index].append(i)
    else:
        R[e.v1.index]=[i]
    if e.v2.index in R:
        R[e.v2.index].append(i)
    else:
        R[e.v2.index]=[i]
```

Problem 3. (1 point)

The MFace class in Blender's API allows the programmer to get the **unit-length normal** of the face and the **area** of the face. Write a Python function that, given a face, prints the area of the screen projection of the face into the X=0, Y=0 and Z=0 planes.

```
def printAreas(face) :
```

Problem 4. (1 point)

Is the output of a Catmull-Clark subdivision step always a quad mesh? Justify the answer with the help of an example.

Problem 5. (1 point)

Explain how "face" vertices are computed in the Catmull-Clark subdivision scheme. Does the computation of "face" vertices require any additional topological relationship beyond those provided by Blender?

Problem 6. (1 point)

Imagine a modified look-up table for the Marching Cubes where the output faces have not been triangulated (of course, some configurations would lead to non-coplanar faces, but let us ignore this issue now). Which will be the degree of each vertex of the resulting mesh?

Problem 7. (2 points)

Explain which is the contents of the different values of the Marching Cubes look-up table. Indicate which interval range do these values belong to.

Problem 8. (1 point)

In the following list of control points, every four points define a cubic Bézier curve:

[4, 0, 1], [-0.5, 0, 1], [-1, 0, 0.5], [-1, 0, 0], [-1, 0, 0], [-2, 1, 0], [-0.5, 0, -1], [0, 0, -1].

Has the resulting curve position continuity?

And tangent continuity?