Questionnaire CGII SS2020

Stand 06.07.2020

Implicit Surfaces

Basics

1. Define the term implicit surface and explain the idea with a sketch!
2. What is a regular implicit function and what does the implicit function theorem say about them?
3. How can one compute the surface normal of an implicit surface?
4. Explain the advantage of an analytic computation of the gradient of an implicit function!
5. Compare levelset surfaces with implicit surfaces!
6. How can CSG-operations be expressed in the formalism of implicit functions?

Primitives

7. Name examples of implicit surface primitives!
8. Given an image of a superquadric estimate the exponents p_1 and p_2 of the used Minkowski norms!
9. Name same example shapes that can be represented by a quadratic implicit surface and precisely specify implicit functions for sphere and cylinder!
10. Explain the principle of meta balls!

Tesselation

11. Explain the Marching Cubes algorithm!
12. What problems arise at sharp creases when using Marching Cubes?
13. How can one circumvent the problems at sharp creases with the Dual Contouring approach? Sketch the Dual Contouring algorithm!

Manipulation

14. Compare Space Warping and Function Value Mapping for the manipulation of implicit surfaces!
15. Explain how to transform an implicit surface with an affine transformation! How can one compute the transformed gradient?
16. Given an image of a space warped implicit surface, argue whether it was generated via a Tapper, Twist or Bend transformation!

Blending

17. Explain modified union and intersection operations that smoothly blend between implicit surfaces!
18. How can one define the extent of the smoothing area?

19. What problems arise in areas where the implicit surfaces coincide? How can one avoid these problems?

Skeleton Based Implicit Surfaces

20. What is a convolution surface and how is it defined?
21. Compare distance surfaces and convolution surfaces!
22. How can one evaluate a convolution surface defined over a set of primitives?
23. Which filter kernels do you know and over which can these be integrated analytically?
24. Do bulding artefacts also arise for convolution surfaces and if so, how can they be cured?

3D Scanning

Overview of 3D Acquisition Techniques

1. Name some techniques to acquire the shape of 3D objects!
2. Explain the idea of a structured light scanner!

2D Projective Geometry and Homographies

3. What is a homography?
4. How many feature correspondences are needed to estimate a homography?
5. Under which conditions can two images be brought into correspondence with a homography?

Geometric Camera Model

6. What are the intrinsic and extrinsic camera parameters in the pinhole camera model?
7. How many degrees of freedom do we have for the intrinsic and extrinsic parameters?
8. Why is the pinhole model for practicle applications not sufficient and how can it be extended?

Camera Calibration

9. Explain the procedure for camera calibration according to Zhang!
10. How many shots of the calibration plate are needed at least? Why?
11. Why are the parameters of the camera model estimated in two steps?

Projector Model and Calibration

12. What is the typical procedure to calibrate a camera?
13. Explain a method to calibrate a camera-projector setup!

Triangulation

14. Explain the term Triangulation in the domain of structured light scanning!
15. What difficulty does one face with a non-linear camera-projector model for triangulation when working with strip patterns? How can the problem be circumvented?

Acquisition Setups

16. Explain advantages of a 2-camera structured light scanning setup!
17. Discuss the scanning of dynamic 3D scenes with structured light approaches!

Structured Light Approaches

18. Explain and compare Line-Shift, Intensity Coding, Gray-Code and phase shift based structured light scanning!
19. Why is the Gray-Code better suited for structured light 3D scanning?
20. How can one use de Bruijn Sequences to build a Single-Shot 3D Scanner?
21. Explain the basic idea for the separation of direct from indirect illumination! How can one make decoding of bit codes more robust with direct-indirect light separation?

3D Scan Processing

Neighbor Graph

1. Explain what the Riemannian-Graph is and how it can be used to filter outliers!
2. Describe a method to estimate the local sampling density of a point cloud!

Estimation of Local Quantities

3. Explain how to fit a least squares plane to a set of points! (also repeat details on that from CG1)
4. Is the least squares normal unique?
5. Motivate problems of the least squares fit in the vicinity of outliers, C0 and C1 discontinuities!
6. How to extend the weighted least squares normal fit to avoid smoothing out of normals in the vicinity of sharp corners and creases?
7. How to compute a Minimum / Maximum Spanning Tree efficiently?
8. Explain how to compute a consistent orientation of surface normals with the help of a Minimum Spanning Tree and explain variants of defining the edge costs?

Registration

9. Explain the IPC-algorithm!
10. What is normal-space sampling and how can it help to improve the ICP-algorithm?
11. What possibilities do you know to define the distance measure used for the objective function of the registration optimization problem?
12. What variants do you know to extract corresponding point pairs for the ICP-alpgorithm?

Surface Reconstruction

13. Explain and compare the surface reconstruction techniques silhouette-, space- and volume carving!
14. Given images of reconstructions, find out, which result was produced by silhouette-, space- or volume carving!
15. Explain how to use implicit functions for surface reconstruction! Why are constraints at the sample points not sufficient?

Rotations and Articulated Objects

Rotations

1. Explain 3 representations for rotations and discuss their suitability for interpolation between rotations!
2. Discuss uniqueness of the different representations for rotations!
3. What is a quaternion and how can it be used to rotate a vector around an axis?
4. Which additional transformation can expressed by a not normalized quaternion?

Kinematic Chains

5. Given an image of a robot arm, explain the terms basis, node, joint and end effector!
6. Given images of joint types, classify joint type and enumerate degrees of freedom!

Kinematic Trees

7. What is the difference between a kinematic chain and a kinematic tree?
8. Discuss the difference between representing joint transformation as a sequence of rotation and translation compared to a sequence of translation and rotation!
9. Explain linearization of a kinematic tree for the efficient computation of world to joint transformations!

Denavit-Hartenberg Convention

10. How many parameters are used in the Denavit-Hartenberg Convention to represent bone transformations in a kinematic chain?
11. Which joint types can be represented directly in the Denavit-Hartenberg Convention?
12. How can other joint types be emulated in the Denavit-Hartenberg Convention?
13. How can one compute the angles in the Denavite-Hartenberg Convention such that a full revolution of 360 degrees can be supported?

Skinning

Overview

1. Explain the representation used for mesh skinning and explain advantages!
2. How is a skinned mesh transformed into a specific pose with linear blend skinning?
3. What are typical artefacts of linear blend skinning?

Interpolation of Transformations

4. Why can some artefacts be avoided when interpolating transformations instead of transformed intermediate points?
5. Describe spherical blend skinning and explain why the choice of the origin of rotation is important!
6. How can we incorporate an optimized origin of rotation in spherical blend skinning?

7. What is a good origin for spherical blend skinning of articulated objects with revolute joints?
8. Explain log matrix blending and discuss its drawbacks with respect to interpolation of rigid body transformations!
9. Explain the screw representation of a rigid body transformation! With which parameters can it be parameterized?
10. How can one encode a screw motion with dual quaternions?
11. How do you represent a position vector and how can you transform it with a dual quaternion?
12. Discuss advantages and disadvantages of dual quaternion blending for skinning of rigged meshs!

Transformation of Normals

13. Why can the blended transformation not directly be used to transform mesh normals?
14. How is the principle idea to transform normals correctly?

Sceleton Extraction

1. Explain the term medial axis and be able to draw it into a 2D shape!
2. Why is the medial axis not suitable as a curve skeleton of a 2D or a 3D shape?
3. Name important properties of a curve skeleton!
4. Explain some techniques to compute a curve skeleton!
5. Explain the competing front approach of Sharf et al. and name some advantages!

Rigging

Automatic Rigging

1. Explain the term rigging in the domain of character animation!
2. What are input and output to the Pinoccio automated rigging approach!
3. Give an overview of how the Skeleton is positioned inside the input polygonal mesh!
4. Name some terms of the energy function used to optimize the skeleton and explain how the authors adapted the energy function to a set of good and bad rigging examples!

RigMesh

5. Explain the idea of the RigMesh-Approach

Rigging from Animations

6. Give some sources for mesh animations!
7. How can one approximate a mesh animation with a skinned mesh representation?
8. Explain the principle steps of the “Skinning Mesh Animations” (SMA) approach!
9. What are the feature vectors used for clustering the mesh triangles into bone-clusters?
10. How are the vertex weights computed in the SMA approach?
11. Where is room for improvement in the SMA approach that was used in „Fast&efficient skinning of animated meshes“?

Subdivision Curves

Introduction

1. Explain some properties that subdivision curves and surfaces should fulfill!
2. Explain the corner cutting scheme! What does the limit curve correspond to?
3. Explain the terms stationary!
4. What is necessary to specify a linear stationary curve subdivision scheme completely? What is necessary for a subdivision surface scheme?
5. Explain the terms mask and stencil and motivate what they represent!

Curves

6. How are the masks for B-spline subdivision curves of increasing degree constructed? How can one extract the stencils?
7. Explain the idea behind the interpolating 4-Point-Scheme!

Subdivision Surfaces

1. Explain the term ordinary and extraordinary vertex!
2. Why is continuity analysis only necessary for isolated extraordinary vertices?
3. Compare face split and vertex split subdivision schemes!
4. Cathegorize one out of {Loop, Butterfly, Catmull Clark, Kobbelt, Doo Sabin} according tot he different discussed dimensions!
5. Explain the stencils for the the Loop-Scheme including the boundary case!
6. What happens in the standard Loop scheme at high valence boundary vertices and how can this problem be cured?
7. For what do we need stencils for limit positions and tangents?
8. Explain the regular interior case of the Butterfly-Scheme!
9. For which irregular cases exist special rules?
10. What stencil types are necessary for the Catmull Clark Scheme?
11. What are the boundary rules and which curve type does the limit boundary curve correspond to?
12. Which curve scheme is the basis for the Kobbelt-Scheme?
13. Does the tensor product construction depend on the order of evaluation in the regular case?
14. What is more efficient: the iterative evaluation of the tensor product rule or the use of a 4x4 weight mask?
15. Name a vertex split scheme and explain how the new vertex locations are computed including the boundary case! What curve type does the limit curve correspond to?
16. Given images with control mesh and limit surfaces argue which surface was generated with which subdivision scheme!
17. How can one exploit the limit position to use an approximating scheme for interpolation? Which property oft he subdivision scheme is lost through this construction?

Inverse Kinematics

1. Explain the terms generalized coordinates, degrees of freedom, dependent variable!
2. Which problems make the solution of the inverse kinematics problem difficult?
3. Explain one of the discussed approaches to formulate IK as an energy minimization problem!
4. Explain how to generalize the IK problem of a kinematic chain to a skeleton with more than one end effector and no fixed base!
5. Explain the cyclic coordinate descent (CCD) approach for the optimization of a target location only!
6. In which degenerate constellations can CCD get stuck? How can one circumvent this problem?
7. Explain the weighted non-linear least squares approach to the inverse kinematics problem! (formulas are provided in oral exam)
8. What is the Jacobian and how can it be computed for a kinematic chain?
9. What is a descent direction and how can it be used together with line-searching in energy minimization?
10. Explain how to compute the steepest descent and the Newton directions respectively!
11. What is the advantage of the Newton direction?
12. What is the difference between Newton and Gauss-Newton direction?
13. Give an example for a case where the Newton / Gauss-Newton directions cannot be computed!
14. Explain the general idea of the Levenberg-Marquardt approach for the minimization of non-linear least squares problems!
15. How can one deal with the bounds on joint parameters imposed by the physical limitations of real joints during IK solving?