**Questions for PA010 / Autumn 2019**

Note: Use pictures, pseudo-code and explanatory text to an adequate extent when formulating the answer.

Answers for questions can be found in given lecture (L\_) on listed slides – all written in red letters.

**Reconstruction and sampling – L2**

• Explain the spatial and temporal alias. In what situations does it arise, what is its cause and effect? List the methods used for antialiasing, including an explanation of the basic principles. 6-17, 48-70

• Explain the concepts of sampling and quantization. What is a reconstruction filter? How does it affect the display of the sampled signal? Draw the reconstruction result with the selected filter in the given sampling example. 3-5, 18-22, 38-45

• What is the spectrum of non-periodic function, how do we obtain the spectrum? How does regular sampling affect the spectrum of the sampled function? What are the conditions that will allow a complete reconstruction of the sampled signal? 23-28

• Properties of the convolution of two functions in the frequency and image domain, convolution theorem, consequences for working with digital images. 29-33

• What is the shape of ideal reconstruction filter in the frequency domain? What is it used for? What convolution filter is his image in the image domain? Draw and explain on the example of regularly sampled signal with limited frequency range. 32-38

• When reconstructing the values of the image function in individual pixels, the solution of the convolutional integral can be approximated numerically from a finite number of samples. Explain the meaning of each member of the formula. 34-38

• Explain the principles and differences of signal processing by pre-filtering, post-filtering, super-sampling, and stochastic sampling. 50-52, 57-70

• What characteristics should a good sampling algorithm have? Explain sampling algorithms, their principles and properties using examples. ???

• Practical antialiasing methods when drawing graphic primitives in a raster. 53-70

• Alpha channel, pixel coverage model, alpha-blending of images and antialiasing. 104-107

• Adaptive refinement sampling. Refinement criteria, result reconstruction. 96-103

**Textures – L5**

• What is texture? Provide some examples of different types of textures. Indicate the possibilities of applying texture in the light model. 2-9

• Explain the sequence of mapping transformations 2D texture to a solid surface. Explain the direct and inverse mapping of 2D textures and the associated problems. 11-17 + 18-24

• Approximation of the texture area mapped to the square area of the pixel. Texture filtering using MIP-MAP, SAT. Principle and use in rendering. 25-43

• Explain the procedure for applying the texture defined by samples (table, photograph) and the related problems (interpolation vs. filtering). 25-31

• Explain the principles of two-part texture mapping. Variants of texture transfer from auxiliary surface to object surface. What is reflex mapping, variants of reflex maps. How would you create a reflection map? 44-54

• What are bump textures, how are applied? Approximation of normals (explain formula). 57-63

• What are 3D textures? The definition, noise-based textures. 68-95

+ light maps, modulation textures 55-56, displacement mapping, complex surfaces 63-67

**Advanced modelling – L4**

• Barr deformations, the result of their application. Give some examples. 3-8

• Free deformation of solids (Sederberg, Parry). Principle and effect of deformation. Explain the formula and calculation. Comment on ensuring continuity in a deformed solid when using multiple deformation tools. 9-23

• EFFD deformation techniques using general point lattices. Principle of calculation. What local coordinates and parameters does it use? 24-36

• Deformation by CC subdivision volumes. Principle of calculation. 42-51

• What is the principle of deCasteljau deformation? What local coordinates and parameters does it use? 53-57 + GOOGLE!

• Implicit surfaces, distant surfaces, smooth blends (blobs), examples. 76-91

+ axial deformations, wires, sweep-based FFD

**Volume data rendering - surface reconstruction – L7**

• Characterize voxel and cellular 3D data. How do you find the value at a general spatial point in volume data? 4, 7-16

• Explain and compare trilinear, tricubic and radial approximation. Which types of spatial data are they used for?

• Explain the display of volume data using opaque or semi-transparent cubes. Indicate the shortcomings and possible remedies. 4, 15-16, ???

• What are the main steps of an isosurface reconstruction algorithm? (Ekoule et al.). What is the input and output of the algorithm? Solution of 1:1 concave connections. Branching 1: M (principle). 17-32

• What is the principle of the “marching cubes” algorithm (Lorensen)? What is the input and output of the algorithm? How are the coordinates of triangle vertices and normal vectors calculated? Deficiencies. For the given situation (8 evaluated vertices and threshold value), draw the appropriate configuration of triangles. 33-49

• Simplification of triangular mesh. Decimation criteria, preservation of shape important features of simplified surface. Principle of algorithm with QEM (quadratic error metric). L6 55-59; 50-57

• Progressive meshes. Principle and use for geomorphs. 58-64

**Raster images – L11**

• Image warping using a triangular mesh. Principle of calculation. 22-26

• Image warping using a spline network. Principle of calculation. 27-32

• Image warping using feature pairs. Principle of calculation. 33-44+45-

• Compositing images for metamorphosis, interpolation and warps. 2-3, 16-21, 45-56, 69 + L12 20 + L13 2-4

+ warping 2-3, 16-44; rotations 5-15; morphing 45-56, 69

**Hierarchical representations – L8**

• Space hierarchies vs. bounding volume hierarchies - comparison, advantages, disadvantages. 16-21

• Convex bounding volumes and bounding volume hierarchies (sphere, AABB, k-DOP, OBB). Construction of BVH, general principles (top-down, bottom-up, heuristics). 28-70, collision detection using BVH (SAT, ...) 71-94

+ Space partitioning 21-27

**Surface models – L6**

Surface representation 4-5 + 25-38, operations 19-24 + 39-68, data structures 70-107, manifolds 31-33, Euler-Poincare formula 10-18

**Visibility and occlusion – L10**

• Types of visibility (point, region), potentially visible sets (PVS). 2-5

• Culling techniques. Overview, usage, comparison. 6-79

• Portal culling, principle and characteristics of the method, overestimated portals. 20-35

• Occlusion maps, HOM, culling with occlusion maps. 45-79

**Computational geometry – L3**

• Bentley-Ottman algorithm for intersection of line segments, principle, complexity. 6-21

• Convex hull. Definition, construction algorithms, complexity. 22-39

• Triangulation. Naive algorithm. 40-49

• BSP trees. Types, construction, usage. 50-78

**Image composition – L13**

• Intensity keying (luma), colour keying (blue-screen), differential keying. What is the input and output of individual methods, pros, cons? 14-53

• Natural matting. Basic procedure, input data. Construction and usage of matting mask. 34-53

**Shadows – L14**

• Lighting and shadows, limitations to simplify calculations in practice. 4-16

• Shadows by ray tracing, principle, method, illustrate by image. Usage of Zbuffer. 9-10

• Planar shadows, method, additive and subtractive strategies. Using depth bias. 13-14, 25

• Shadow volumes, method, problems, solution. Simplification for convex silhouettes. 16, 46-56

• Projective texture shadows, principle and properties. 15,

• Shadow maps, method, subtractive and additive strategies. 16, 18-45

+ Soft shadows 57-74, ambient occlusion 75-

**Subdivision surfaces – L9**

• Subdivision schemes for curve construction. Chaikin, Bezier subdivision. 2-9, 20, 23, 46-47

• Regular B-spline subdivision, generalization to CC subdivision scheme. 21-38, 48-68, 75-82

• Primal and dual subdivision schemes, interpolation and approximation. Types of rules, types of vertices. 10-20, 39-45, 69-75 (76-82 CC, 83-93 loop, 94-99 butterfly, 100-105 Doo-Sabin, 106 midedge, 107-109 Kobbelt), 110-113

**Point-set registration – L12**

• Rigid registration calculation 3, 8-11, 52, ICP, image registration 19-26, point-based IR 27-43, intensity-based IR 44-51

• ICP algorithm 12-18