GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Computers Graphics, PG_00047658		
Field of study	Informatics		
Date of commencement of studies	October 2021	Academic year of realisation of subject	2022/2023
Education level	first-cycle studies	Subject group	Obligatory subject group in the field of study
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	2	Language of instruction	Polish
Semester of study	3	ECTS credits	4.0
Learning profile	general academic profile	Assessment form	exam
Conducting unit	Department of Intelligent Interactive Systems -> Faculty of Electronics, Telecommunications and Informatics		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Jacek Lebiedź	
	Teachers	dr inż. Agata Kołakowska dr inż. Maciej Smiatacz dr inż. Jerzy Dembski dr inż. Jacek Lebiedź	

Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	0.0	15.0	0.0	0.0	45
	E-learning hours included: 0.0						

Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
	Number of study hours	45	1.0	54.0	100

Subject objectives	The purpose of education is to acquire the ability to create images using standard graphics APIs (libraries Allegro, GDI, Xlib, OpenGL i DirectX) and to implement transformation of 2D and 3D images.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K6_U07] can apply methods of process and function support, specific to the field of study	Student understands the rendering pipeline and is able to modify its steps.	[SU1] Assessment of task fulfilment [SU4] Assessment of ability to use methods and tools
[K6_U01] can apply mathematical knowledge to formulate and solve complex and non-typical problems related to the field of study and perform tasks, in an innovative way, in not entirely predictable conditions, by:n- appropriate selection of sources and information obtained from them, assessment, critical analysis and synthesis of this information,n- selection and application of appropriate methods and toolsn	Student analyzes the problems and develop appropriate models, data structures and numerical and heuristic algorithms for graphics applications.	[SU1] Assessment of task fulfilment [SU4] Assessment of ability to use methods and tools
[K6_U43] can analyse date and formulate, apply and assess appropriate formal models and algorithms for solving problems in the field of information systems and applications	Student is able to implement basic graphic algorithms.	[SU1] Assessment of task fulfilment [SU4] Assessment of ability to use methods and tools
[K6_W42] Knows and understands, to an advanced extent, architecture, design principles and methods of hardware and software support for local and distributed information systems, including computing systems, databases, computer networks and information applications, as well as the principles of human cooperation with computers and computer-aided teamwork	Student is aware of the hardware support of the rendering pipeline in graphic units and understands what programming of shaders is.	[SW1] Assessment of factual knowledge
[K6_W01] Knows and understands, to an advanced extent, mathematics necessary to formulate and solve simple issues related to the field of study	Student uses mathematical models to define the image.	[SW1] Assessment of factual knowledge

Subject contents	1. Rules of credit for a course, bibliography 2. Concept of computer graphics, image processing and pattern recognition 3. Applications of computer graphics, image processing and pattern recognition 4. Basic techniques in computer graphics – image generating with use of standard graphical API 5. Implementation of basic transformations (scaling, rotation, translation) by mechanism of standard graphical API 6. Graphical environments: MS Windows, X Window; graphics systems: standard API, DirectX, OpenGL; graphics engines 7. Vectors, vector operations: addition and multiplication by scalar, linear (vector) space and its properties, subspaces 8. Linear dependence and independence of vectors, base and dimension of linear space, vector coordinates in base of linear space 9. Transformation from base to base, isomorphisms of linear spaces 10. Visual perception, human eye, receptors: rods and cones 11. Color – trichromacy theory, metamerism 12. Theoretical and technical color models 13. CIE XYZ color model 14. CIE LUV, CIE LAB, TekHVC color models 15. RGB color model 16. CMY, CMYK color models 17. HSV, HLS color models 18. YUV, YIQ, YCbCr color models 19. Cartesian plane and space, points and vectors, coordinates systems, transformations of coordinates systems 20. Euclidean plane and space, scalar product, canonical base, orthogonal and orthonormal base, vector product 21. Topological space, open and closed sets, boundary and interior of set, dense in itself sets, coherent sets, homeomorphisms 22. Raster graphics – concept, forms of images and representation methods 23. Vector graphics – concept, forms of images and representation methods 24. Comparison of raster and vector graphics, vector graphics emulation for raster graphics devices 25. Hardware of raster graphics: graphics cards – construction, history of development 26. Hardware of raster graphics: monitors, projectors, scanners, digital cameras – technologies 27. Hardware of vector graphics: plotters, digitizers – technologies 28. Digital geometry – concept of pixel, pixel neighborhood 29. Image digitization – sampling, condition of compatibility of region with sampling grid 30. Image digitization – quantization, dithering, error diffusion 31. Lines in Euclidean geometry, history of concept of curve, straight lines, segments of straight lines, conics on plane and in space 32. Methods of curve representation: common equation, confounded equation, parametric equation 33. Equations of straight line, circle, conics 34. Bézier curves – definition and features 35. B-splines – definition and features 36. De Casteljau's algorithm for point of Bézier curve and de Boor-Cox algorithm for point of B-splines 37. Line in discrete geometry, discrete segment, properties 38. Scan-conversion algorithms for straight line segments: numerical, conditional (Bresenham's algorithm, midpoint algorithm), structural 39. Bresenham's algorithm, midpoint algorithm, multistep Gill algorithm – implementation 40. Aliasing and antialiasing – scan-conversion algorithms for antialiased straight line segments: Gupta-Sproull algorithm, Wu's algorithm 41. Scan-conversion algorithms for circular arcs and other conics: numerical, conditional (Bresenham's algorithm, midpoint algorithm) 42. Scan-conversion algorithms for Bézier curves and B-splines: parametric (iterative and recursive), midpoint 43. Location of point and segment in respect of straight line and polygon on plane and in respect of plane and polyhedron in space 44. Distance of point from straight line and plane in space, distance between two slanting straight lines in space 45. Angle of depression of two straight lines, straight line and plane, two planes in space, segment shading by point and segment 46. Clipping lines – Cohen-Sutherland line-clipping algorithm 47. Cyrus-Beck parametric line-clipping algorithm 48. Clipping polygons – Sutherland-Hodgman polygon-clipping algorithm 49. Typography, fonts, parameters of fonts 50. Types of typefaces: serif and sans-serif, monospaced and proportional; Times Roman, Helvetica, Courier 51. Font formats: Type 1, TrueType, OpenType, other formats 52. Ligatures – definition, examples, kerning, tracking 53. Units of measure in typography, Didot's and Pica systems: typographic point, cicéro, pica 54. Desktop publishing, basic concepts, typesetting mistakes: orphans and widows 55. Linear transformation and its properties. Kernel and image of linear transformation, composing of linear transformation 56. Matrix representation of linear transformation, examples of linear transformations: translation, scaling, rotation, axis symmetry 57. Projection to plane: orthogonal projection, perspective projection as an example of linear transformation 58. 3D graphics – principles, rendering pipeline 59. Geometric solid modeling: boundary representation, spatial-partitioning representation (concept of voxel), constructive solid geometry 60. Surface modeling, tessellation, Bézier and B-splines surfaces 61. Visible-surface determination: image-precision algorithms (z-buffer) and object-precision algorithms, generation of shadows 62. Texturing: concept of texel, texture mapping, bump mapping 63. Illumination modeling – Phong illumination model 64. Gouraud shading – color interpolation 65. Phong shading – normal-vector interpolation 66. Global illumination methods: ray tracing, radiosity 67. Matrices, matric operations: addition, multiplication by scalar, product, unit matrix, diagonal matrix, triangular matrix 68. Matrix determinant, matrix order 69. Transpose of a matrix, symmetric matrix, inverse of a matrix and invertible matrix 70. Image processing – contour tracing: all contours tracing algorithm, single contour tracing algorithm 71. Image processing – contour filling: contour filling by parity check, contour filling by connectivity 72. Image processing – thinning: concept of skeleton, basic thinning algorithm, classical thinning algorithm 73. Image processing – filtering: linear and non-linear filters, low-pass and high-pass filters 74. Image processing – examples and properties of low-pass and high-pass filters 75. Image processing – median filter as an example of non-linear filter, Laplacian filter – edges detection 76. Image processing – morphological operations: erosion, dilation, opening, closing 77. Image transformations: geometrical, in color space, histogram 78. Implementation of simple procedures for transformation of 2D images 79. Characteristic polynomial of square matrix, matrix trace 80. Eigenvalues and eigenvectors of matrix and linear operator, Invariant subspace, Cayley-Hamilton theorem 81. Metric space, metric, complete space, Banach theorem 82. Data compression: lossless and lossy compression, parameters of compression 83. Lossless image compression: Huffman coding, arithmetic coding 84. Lossless image compression: dictionary coding (LZ77, LZ78, LZW) 85. Lossless image compression: run length encoding (RLE) 86. Lossy image compression - idea, simple methods: BTC, DPCM 87. Lossy image compression: wavelet compression (JPEG2000) 88. Lossy image compression: discrete cosine transform compression (JPEG) 89. Lossy image compression: fractal compression, fractals – concept, examples, applications, drawing methods, collage theorem 90. Video compression, coding of image sequences, motion-compensation, MPEG standard
Prerequisites and co-requisites	No requirements
Assessment methods and criteria	

Subject passing criteria	Passing threshold	Percentage of the final grade
Midterm colloquium	53.0%	50.0%
Practical exercise	60.0%	50.0%

Recommended reading	Basic literature	1. Angel E.: Interactive Computer Graphics. A Top-Down Approach Using OpenGL (3rd Edition). Addison Wesley 2003. 2. Foley J. D., van Dam A., Feiner S. K., Hughes J. F.: Computer Graphics: Principles and Practice, (2nd Edition). Addison-Wesley, Reading 1990. 3. Hill F. S. jr., Kelley S. M.: Computer Graphics using OpenGL (3rd Edition). Pearson Education 2007. 4. Pharr M., Humphreys G.: Physically Based Rendering. From Theory to Implementation (2nd Edition). Morgan Kaufmann 2010. 5. Schneider Ph. J., Eberly D. H.: Geometric Tools for Computer Graphics. Morgan Kaufmann 2003.
	Supplementary literature	1. Shreiner D., Sellers G., Kessenich J., Licea-Kane B.: OpenGL Programming Guide. The Official Guide to Learning OpenGL, Version 4.3 (8th Edition). Addison-Wesley 2013. 2. Varcholik P.: Real-Time 3D Rendering with DirectX and HLSL: A Practical Guide to Graphics Programming (Game Design). Addison-Wesley 2014.
	eResources addresses	Adresy na platformie eNauczanie:
Example issues/ example questions/ tasks being completed	Application for drawing of given solid using a particular graphics API.	
Work placement	Not applicable	