FACULTY OF INFORMATICS AND MANAGEMENT / DEPARTMENT……

SUBJECT CARD

Name in Polish: Zaawansowana grafika komputerowa
Name in English: Advanced Computer Graphics
Main field of study (if applicable): Informatics
Specialization (if applicable): Computer Engineering
Level and form of studies: 2nd level, full-time
Kind of subject: optional
Subject code INZ0145Wl
Group of courses YES

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	60		120		
Form of crediting	Examination /	Examination / crediting with grade*	Crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course	X				
Number of ECTS points	2.0		4.0		
including number of ECTS points for practical (P) classes	0.0				
including number of ECTS points for direct teacher-student contact (BK) classes	1,2		2.4		

*delete as applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

knowledge of methods and techniques of computer graphics in the scope corresponding to the contents of „Introduction to Computer Graphics" lecture
advanced skills in C++ or Java programming language
basic knowledge of linear algebra and 2D and 3D geometry

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SUBJECT OBJECTIVES

C1 Acquainting students with state-of-art methods of photorealistic 3D image synthesis, their properties and limitations with particular attention paid to lighting simulation

C2 Practical training in efficient programming of algorithms specific to lighting simulation, rendering and procedural texturing and modeling

C3 Developing skills related to design, implementation and optimization of specific methods aimed on various visual effects simulation and modeling and scene elements

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEK_W01 Knows properties, scope of application and limitations of basic lighting simulation and photorealistic rendering techniques

PEK_W02 Knows widely used techniques of ray tracing acceleration techniques

PEK_W03 Knows methods of space subdivision and SEADS structures traversal algorithms and is able to explain their role in efficient rendering

PEK_W04 Is able to describe typically used concepts of procedural creation of randomized patterns and related concepts of anti-aliasing

relating to skills:

PEK_U01 Is able to efficiently implement elements of ray tracing, radiosity, photon mapping techniques

PEK_U02 Can derive the formulas of ray object intersection for polygons, quadrics, metaballs

PEK_U03 Is able to design and implement the procedures of domain space traversal based on uniform and non uniform space subdivision and bounding volumes

PEK_U04 Is able to design a procedure for natural pattern rendering like wood, stone, Feather etc. and select appropriate anti-aliasing procedure

PEK_U05 Can modify and extend existing well-structuring code of 3D rendering systems so as to obtain New Visual effects or to improve its efficiency

PEK_U06 Can use the software and hardware available in the laboratory and knows principles of its safe use.

relating to social competences:

PEK_K01 Knows the areas of application of computer graphics and is able to identify new areas of CG usage in specific domains

PROGRAMME CONTENT

Form of classes - lecture		**Number of hours**
Lec 1	Introduction to photorealistic rendering and lighting simulation. Basic optical phenomena reproducer in CG, basic photometry, lighting models, surface properties, basic geometry modeling method	
Lec 2	Basic photorealistic rendering paradigms: ray tracing, radiosity, photon mapping, properties, scope of aplication, limitations	2
Lec 3	Geometry for ray tracing, ray equation, intersections with geometry promitives, finding refleted and refracted rays	2
Lec 4	Implementation elements of ray tracer, overall architecture, advantages and disadvantages of structural and object oriented approaches in case of highly optimized implementation, usefull	2

	geometry classes and methods	
Lec 5	Ray tracing optimization, classification, ray-object intersection tests elimination, space subdivision concepts, bounding volumes, interpolation in image and in object space, reduction of shadow tests	2
Lec 6	Uniform space subdivision and its application to reduce ray-object intersection tests, DDDA traversal, optimizing subdivision density	2
Lec 7	Non-uniform space subdivision, octrees, kd-trees, building SEADS data structures, finding triangles for a voxel, efficient nonuniformly subdivided domain traversal	2
Lec 8	Interpolation in image space, adaptive sampling density selection, interpolation in object space, progressive ray tracing	2
Lec 9	Radiosity and diffused lighting simulation, principles, methods of illumination equation set solving, modified Gauss-Seidel method	2
Lec 10	Photon mapping, photon tracing, methods of photon maps organization, computing illumination from photon maps, optimization by selective tracing of photons	2
Lec 11	Simplified shadow analysis, shadow maps, shadow volumes, reducing shadow tests count with Ward method	2
Lec 12	Texturing in CG, classification of textures, examples of application, mapped textures, methods of 3D->2D mapping, mapped textures anti-aliasing, MIP-mapping, summed area tables	2
Lec 13	Procedural texturing, classification of patterns, examples of regular pattern procedures, randomized patterns, wood pattern textures	2
Lec 14	Cellular textures, application to stone and leather modeling, bump mapping and displacement mapping	2
Lec 15	Volumetric effects modeling, clouds modeling, light dispersion in foggy environment, smog and fire modeling	2
	Total hours	30

Form of classes - class		**Number of hours**
Cl 1		
Cl 2		
Cl 3		
Cl 4		
..		
	Total hours	

Form of classes - laboratory		**Number of hours**
Lab1	Presentation of lab scope, breief review of assignments, presentation of grading principles, presentation of suggested tools, preparation of IDE environment	2
Lab2	Ray tracing - implementation of data loading procedures, primary ray casting	2
Lab3	Implementation of ray triangle intersection tests	2
Lab4	Implementation of Phong lighting model, building ray tree, implementation of secondary rays tracing	2

Lab5	Building SEADS structure for uniform subdivision, implemantation of selected strategies of subdivision density level selection	2
Lab6	Implementation of ray-triangle intersection reduction by using uniform space subdivision, evaluation of gains	2
Lab7	Optimization of RT efficiency, evaluation of image quality, efficiency test using scenes of various complexity	2
Lab8	Implementation of other selected effect built into ray tracing renderer - part 1	2
Lab9	Implementation of other selected effect built into ray tracing renderer - part 1	2
Lab10	Optimization and tests of implemented RT extension, evaluation of efficiency and image quality, presentation of achieved effects	2
Lab11	Implementation of selected procedural texture, explanation of the proposed concept	2
Lab12	Extension of inpud data format for specification of the texturing procedure parameters, implementation of necessary extensions in data loading methods	2
Lab13	Implementation of procedural texturing methods for selected pattern	2
Lab14	Implementation of procedural texture antialiasing	2
Lab15	Preparation of final documentation of created software, documenting tests carried out, evaluation of the documentation quality, final evaluation of student's works, grading	2
	Total hours	30

Form of classes - project		**Number of hours**
Proj1		
Proj2		
Proj3		
Proj4		
…		
	Total hours	

Form of classes - seminar		**Number of hours**
Sem1		
Sem2		
Sem3		
…		
	Total hours	

TEACHING TOOLS USED

N1. Lecture supported by multimedia presentations (slideshow) and on-line presentation of rendering and modeling software

N2. Compilers and IDEs for used programming languages (C++, Java) - MSVC, Netbeans, Eclipse

N3. Free software for 3D scene modeling and rendering
N4. e-learning system used for publishing of documents and data related to the course

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation(F – forming (during semester), P – concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1 - evaluation of basic ray tracer (Lab2 - Lab7)	PEK_W02 PEK_W03 PEK_U02 PEK_U03 PEK_U04 PEK_U05	Evaluation of visual effect, efficiency, flexibility (parameterization), code quality
F2 - evaluation of the extension related to selected additional visual effect (Lab8 - Lab10)	PEK_W01 PEK_U01 PEK_U05	Evaluation of visual effect, efficiency, flexibility (parameterization), relevance of used techniques and concepts
F2 - evaluation of the extension related to selected procedural texture pattern (Lab11-lab14)	PEK_W04 PEK_U04 PEK_U05 PEK_K01	Evaluation of visual effect, efficiency, flexibility (parameterization), relevance of used techniques and concepts
F4 - evaluation of the final documentation and presentation of achieved results (Lab15)	PEK_W01 PEK_W04 PEK_K01	Evaluation of relevance of used test data, completeness of the documentation, clarity of final presentation

C - the final grade given based on the written exam grade (GE) and the average of four forming grades (F1, F2, F3, F4) given based on the evaluation of three stages of renderer construction implemented in the lab:

$$C = 0.5*GE + 0.5*0.25*(F1+F2+F3+F4)$$

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Shirley P., Morley K.R., Realistic Ray Tracing, Second Edition, A.K.Peters, 2003
[2] Foley J.D. et al. Computer Graphics, Principles and Practice, Third Edition, Addition-Wesley, 2013
[3] Ebert D.s. et al., Texturing and Modeling. A Procedural Approach, Morgan-Kaufman, 2002

SECONDARY LITERATURE:

[1] Akenine-Moller T., Haines E., Hofman N., Real-Time Rendering, Third Edition, A.K.Peters 2008
[2] Shirley P., Fundamentals in Computer Graphics, A.K.Peters 2005

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

Jerzy Sas, jerzy.sas@pwr.wroc.pl, Inst. of Informatics

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT

Advanced Computer Graphics

AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY

Informatics

AND SPECIALIZATION **Computer Engineering**

Subject educational effect	Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**	Subject objectives***	Programme content***	Teaching tool number***
PEK_W01 (knowledge)	K2INF_W06_ S2CE_W03	C1	Lec1. Lec2, Lec9-Lec10 Lec15 Lab1	N1, N3, N4
PEK_W02	K2INF_W06_ S2CE_W03	C1, C3	Lec5-Lec8	N1, N3, N4
PEK_W03	K2INF_W06_ S2CE_W03	C1, C2	Lec6-Lec7	N1, N3, N4
PEK_W04	K2INF_W06_ S2CE_W03	C3, C2	Lec12-Lec14	N1, N3, N4
PEK_U01 (skills)	K2INF_U08_S2CE_U02	C2	Lec3, Lec4 Lab2-Lab6	N2, N3
PEK_U02	K2INF_U08_S2CE_U07	C2	Lec3, Lab3	N2, N3
PEK_U03	K2INF_U08_S2CE_U07	C1, C2	Lec5-Lec8 Lab5-Lab6	N2, N3
PEK_U04	K2INF_U08_S2CE_U07	C1, C2	Lec12-Lec13 Lab11-Lab14	N2, N3
PEK_U05	K2INF_U08_S2CE_U08	C2	Lab8-Lab10	N2, N3
PEK_U06	K2INF_U09	C2	Lab-1	N2,N4
PEK_K01 (competences)		C1, C3	Lab7. Lab10,Lab15	N3

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above