Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Кафедра програмного забезпечення комп'ютерних систем

Multimedia Systems Software. Part 2. XR Applications

Syllabus

Requisites of the Course	
Cycle of Higher Education	***First (Bachelor)***
Field of Study	*12 Information technologies*
Speciality	*121 Software Engineering*
Education Program	*Software Engineering of Multimedia and Information Retrieval Systems*
Type of Course	*Normative*
Mode of Studies	*full-time*
Year of studies, semester	*4 year, 7 semester*
ECTS workload	*36 hours for lectures, 18 hours for practicals, 51 hours for self-study*
Testing and assessment	*Credit, modular test, calendar control*
Course Schedule	*According to http://roz.kpi.ua/*
Language of Instruction	*English*
Course Instructors	*Senior lecturer, Shkurat Oksana, PhD, shkurat@pzks.fpm.kpi.ua*
Access to the course	*Google classroom.*

Outline of the Course

1. Course description, goals, objectives, and learning outcomes

Study of the discipline "Multimedia Systems Software. Part 2. XR Applications" allows students to form the competencies necessary for solving practical tasks of professional activity related to the development of virtual and augmented reality applications, as well as to use of virtual and augmented reality elements in software.

The purpose *of studying the discipline "Multimedia Systems Software. Part 2. XR Applications" is the formation of students' ability to independently develop software that implements technologies of augmented and virtual reality, as well as to use third-party software for the development of multimedia components and scenes of augmented and virtual reality.*

The subject *of the discipline "Multimedia Systems Software. Part 2. XR Applications" are technologies for developing virtual and augmented reality scenes.*

Study of the discipline "Multimedia Systems Software. Part 2. XR Applications" forms the ***professional competences (PC)*** *necessary for solving practical tasks of professional activity related to the development, improvement and support of elements of virtual and augmented reality in software for various purposes:*

PC19 *Ability to develop software for multimedia and mulsemedia systems.*
PC20 *Ability to apply the acquired fundamental mathematical knowledge to develop calculation methods in the multimedia and information retrieval systems creation.*

Study of the discipline "Multimedia Systems Software. Part 2. XR Applications" forms students ***program learning outcomes (PLO)*** *according to the educational program:*
PLO05 *To know and apply relevant mathematical concepts, domain methods, system and object-oriented analysis and mathematical modeling for software development.*
PLO12 *To apply effective approaches to software design in practice.*
PLO25 *To know and to be able to use fundamental mathematical tools in the algorithms construction and modern software development.*
PLO26 *To be able to develop and use methods and algorithms for the mathematical problems approximate solution during the multimedia and information retrieval systems design.*
PLO28 *To know the mathematical and algorithmic basics of computer graphics and to be able to apply them to develop multimedia software.*
PLO29 *To know the principles of using the latest multimedia technologies, mulsemedia and immersive technologies.*
PLO31 *To be able to identify, analyze and document software requirements for multimedia and information retrieval systems.*
PLO42 *To know the basic presentation models of textual and multimedia information and methods of its pre-processing for use in the design of information retrieval systems.*
PLO43 *To know and be able to use in practice the existing software resources and libraries for processing of textual information and multimedia data in information retrieval systems.*

2. Prerequisites and post-requisites of the course (the place of the course in the scheme of studies in accordance with curriculum)

Successful study of the discipline "Multimedia Systems Software. Part 2. XR Applications" precedes the study of the disciplines " Multimedia Systems Software. Part 1. Computer Graphics" of the curriculum for training bachelors in the specialty 121 Software engineering.

Received during the assimilation of the discipline "Multimedia Systems Software. Part 2. XR Applications" theoretical knowledge and practical skills ensure the successful implementation of course and diploma projects in the specialty 121 Software Engineering. Also, the acquired knowledge and skills are a prerequisite for successfully mastering the discipline "Multimedia Interfaces and 3D visualization" of the Master's training plan in the specialty 121 Software Engineering.

3. Content of the course

Discipline "Multimedia Systems Software. Part 2. XR Applications" involves studying the following topics:

Topic 1. Introduction to virtual and augmented reality technologies

Topic 2. Immersive technologies: software and hardware components

Topic 3. Image recognition as a component of positional tracking technologies of augmented reality

Topic 4. Development of constituent elements of augmented and virtual reality scenes

Modular test

Credit

4. Coursebooks and teaching resources

Main literature:

1. Multimedia Systems Software. Part 2. XR Applications. Educational and methodological complex on Coogle Class. Access to registered students.

2. Understanding Augmented Reality / Alan B. Craig. – Elsevier Inc., 2013. – 297 p.

Additional literature:

3. PlugXR Platform. URL: https://www.plugxr.com/

4. Blender. URL: https://www.blender.org/
5.Unity. URL: https://docs.unity3d.com/Manual/

Educational content

5. Methodology

№	Type of a class	Description of a class
	Topic 1. Introduction to virtual and augmented reality technologies	
1	*Lecture 1. Fundamentals of augmented reality technologies*	*Augmented reality technologies (Augmented Reality, AR). Scheme of operating augmented reality. Types of augmented reality. The devices implemented augmented reality. Fields of applying the augmented reality technologies. Functional capabilities of modern augmented reality applications.* *Materials for self-studying: 6 № 1.*
2	*Lecture 2. Fundamentals of virtual reality technologies*	*Virtual reality technologies (Virtual Reality, VR). Types of virtual reality. Devices of immersion in virtual reality. Fields of applying the virtual reality technologies. Functional capabilities of modern virtual reality applications.* *Materials for self-studying: 6 № 2.*
3	*Computer class 1. Creation of the visual elements of augmented reality (part 1)*	*Task: Using the Blender graphic editor, build a "complex" 3D object.* *Materials for self-studying: 6 № 3.*
	Topic 2. Immersive technologies: software and hardware components	
4	*Lecture 3. Hardware of the immersive environment*	*Virtual object visualization devices: VR helmets, augmented reality glasses. Devices for interacting with virtual objects: head, eye, body movement tracking systems, gloves.* *Methods of positioning augmented reality objects. Built-in mobile positioning sensors. Positional tracking: a visual positioning system.* *Materials for self-studying: 6 № 4.*
5	*Lecture 4. Software tools for creating an immersive environment (part 1)*	*Cloud platforms for AR solutions PlugXR and Blippbuilder. SparkAR platform. EV Studio platform. ARKit, ARCore and ARFoundation platforms for Android and iOS operating systems.* *Materials for self-studying: 6 № 5.*
6	*Computer class 1. Creation of visual elements of augmented reality (part 2)*	*Task: Using the Blender graphic editor, build a "complex" 3D object.* *Materials for self-studying: 6 № 6.*
7	*Lecture 5. Software tools for creating an immersive environment (part 2)*	*SDK (Software Development Kit) for augmented and virtual reality solutions: Vuforia, Steam VR. Platforms for the development of augmented and virtual reality: Unity, Anreal Engine.* *Materials for self-studying: 6 № 7.*

Topic 3. Image recognition as a component of positional tracking technologies of augmented reality		
8	*Lecture 6. Image recognition algorithms in marker augmented reality (part 1)*	*Image recognition technologies. Levels of image processing. Feature space and image feature vector. Binarization of images.* *Materials for self-studying: 6 № 8.*
9	*Computer class 2. Building animated augmented reality for MobileAR solutions (part 1)*	*The task: to develop several scenes of augmented reality using an animated 3D object created in the Blender editor and the tools of the PlugXR platform.* *Materials for self-studying: 6 № 9.*
10	*Lecture 7. Image recognition algorithms in marker augmented reality (part 2)*	*Recognition of augmented reality markers. Morphological analysis of images. Operations of erosion, dilatation. Morphological gradient.* *Materials for self-studying: 6 № 10.*
11	*Lecture 8. Image recognition technologies for positioning augmented and virtual reality objects (part 1)*	*Image feature extraction algorithms. Images of images. Compare and contrast image control points. Technologies for recognizing vertical, horizontal, homogeneous surfaces.* *Materials for self-studying: 6 № 11.*
12	*Комп'ютерний практикум 2. Побудова анімованої доповненої реальності для MobileAR рішень (частина 2)*	*The task: to create an augmented reality book from several designed scenes using the tools of the PlugXR platform.* *Materials for self-studying: 6 № 12.*
13	*Lecture 9. Image recognition technologies for positioning augmented and virtual reality objects (part 2)*	*Pattern recognition methods and tasks. OpenCV library. Graphic libraries. Computer vision libraries and algorithms. Neural network recognition technologies.* *Materials for self-studying: 6 № 13.*
Topic 4. Development of elements for augmented and virtual reality scenes		
14	*Lecture 10. Technologies for creating visual elements of augmented and virtual reality (part 1)*	*Formation of 2D graphics. Adobe Illustrator, CorelDraw, Inkscape, Adobe Photoshop editors. Formats of graphic files. Concept of index image for data compression. Bit depth.* *Materials for self-studying: 6 № 14.*
15	*Computer class 3. Building an augmented reality scene on the Unity platform (part 1)*	*Task: create multimedia elements of a 3D scene on the Unity platform.* *Materials for self-studying: 6 № 15.*
16	*Lecture 11. Technologies for creating visual elements of augmented and virtual reality (part 2)*	*Image depth and volume of 2D objects. The concept of perspective. Illusion of movement in 2D. Global lighting. Types of light sources. Models of diffusely reflected light. Specular models Flood and directional light. Ray tracing.* *Materials for self-studying: 6 № 16.*
17	*Lecture 12. Technologies for creating visual elements of*	*3D scene. Ways to create 3D objects. File formats that store 3D objects. Methods of estimating the depth of a 3D scene. The shadows. Editors OGRE, Maya, 3ds Max, Blender, Cinema*

	augmented and virtual reality (part 3)	*4D, Lightwave 3D, Anim8or, Art of Illusion, Adobe Photoshop Extended.* *Materials for self-studying: 6 № 17.*
18	*Computer class 3. Building an augmented reality scene on the Unity platform (part 2)*	*Task: to create an augmented reality scene on the Unity platform using SDKs for augmented reality (Vuforia, ARKit, ARCore, ARFoundation).* *Materials for self-studying: 6 № 18.*
19	*Lecture 13. Technologies for creating audio elements of augmented and virtual reality*	*Physiology of hearing. Physics of sound waves. Psychoacoustic model. Disguise. Perception of surround sound. Sounds that do not exist in nature.* *Materials for self-studying: 6 № 19.*
20	*Lecture 14. Software tools for converting audio elements of augmented and virtual reality*	*Creation of audio data. Audio data processing. Editors: Audacity, Wavosaur, WavePad, OcenAudio.* *Materials for self-studying: 6 № 20.*
21	*Computer class 4. Building a virtual reality scene on the Unity platform (part 1)*	*Task: Create a virtual reality scene on the Unity platform using the SDK for virtual reality (Steam VR, XP Management).* *Materials for self-studying: 6 № 21.*
22	*Lecture 15. Video creation technologies for augmented and virtual reality*	*Motion perception. Inertia of vision. The after-good-bye effect. Laws of subjective perception of brightness. Shooting plans. Alternation of plans. Cartoon. Phases and physical laws of movement of bodies.* *Principles of animation.* *Materials for self-studying: 6 № 22.*
23	*Lecture 16. Video processing software tools for augmented and virtual reality*	*Create video data. Video data processing. Editors: Sony Vegas Pro, Movavi, Avidemux, Lightworks, Jahshaka, Adobe Premiere Pro.* *Materials for self-studying: 6 № 23.*
24	*Computer class 4. Building a virtual reality scene on the Unity platform (part 2)*	*The task: to implement interaction with the elements of the virtual reality scene on the Unity platform, using the SDK (Steam VR, XP Management).* *Materials for self-studying: 6 № 24.*
25	*Lecture 17. Tools for developing augmented and virtual reality applications and their integration*	*The main stages of development of augmented and virtual reality. The concept of a game engine. Unity 3D. Interface, programming language; Preparation for the development of augmented and virtual reality on Unity. The process of game development on the Unity 3D engine.* *Materials for self-studying: 6 № 25.*
Modular test		

6. Self-study

The discipline "Multimedia Systems Software. Part 2. XR Applications" is based on self-study for a classes on theoretical and practical topics.

No	Topic for self-studying	Hours	Literature
1	Preparation to the lecture 1	1	1; 2;
2	Preparation to the lecture 2	1	1; 2;
3	Preparation to the computer class 1 (part 1)	4	3; 4; 5
4	Preparation to the lecture 3	1	1; 2;
5	Preparation to the lecture 4	1	1; 2;
6	Preparation to the computer class 1 (part 2)	4	3; 4; 5
7	Preparation to the lecture 5	1	1; 2;
8	Preparation to the lecture 6	1	1; 2;
9	Preparation to the computer class 2 (part 1)	4	3; 4; 5
10	Preparation to the lecture 7	1	1; 2;
11	Preparation to the lecture 8	1	1; 2;
12	Preparation to the computer class 2 (part 2)	4	3; 4; 5
13	Preparation to the lecture 9	1	1; 2;
14	Preparation to the lecture 10	1	1; 2;
15	Preparation to the computer class 3 (part 1)	4	3; 4; 5
16	Preparation to the lecture 11	1	1; 2;
17	Preparation to the lecture 12	1	1; 2;
18	Preparation to the computer class 3 (part 2)	4	3; 4; 5
19	Preparation to the lecture 13	1	1; 2;
20	Preparation to the lecture 14	1	1; 2;
21	Preparation to the computer class 4 (part 1)	4	3; 4; 5
22	Preparation to the lecture 15	1	1; 2;
23	Preparation to the lecture 16	1	1; 2;
24	Preparation to the computer class 4 (part 2)	4	3; 4; 5
25	Preparation to the lecture 17	1	1; 2
26	Preparation to the modular test	7	1; 2
27	Preparation to the credit	10	1; 2

Policy and Control

7. Course policy

Students are required to be on time to attend all the lessons according to the timetable, and adhere to the code of ethical conduct. To successfully complete the course students need to study coursebook materials and use learning resources available in print, in digital form, and online. Regular attendance at the lessons, self-study and continuous revisions are essential for completion of the course.

According to the Code of Honour of the university (https://kpi.ua/code) students are expected to be self-disciplined, well-behaved, considerate, honest and responsible.

During the course, writing an essay/ a conference abstract, presenting at a conference, taking part in a language contest/ university project will bring rewarding points added to the student's performance score.

8. Monitoring and grading policy

During the semester, students perform 4 computer clases. The maximum number of points for computer clases №1-2: 10 points; for computer clases №3-4: 15 points.

Points for computer clases № 1-2 are calculated for:
- quality of the computer clases: 0-4 points;
- answer during the defense of the computer clases: 0-2 points;
- execution of a report from a computer clases: 0-2 points;
- timely presentation of computer clases for defense: 0-2 points.

Performance evaluation criteria:
4 points – the computer clase is done qualitatively, in full;
3 points – the computer clase is done qualitatively, in full, but has flaws;
2 points – the computer clase is completed in full, but contains minor errors;
1 points – the computer clase is completed in full, or contains significant errors;
0 points – the computer clase is not fully completed.

Answer evaluation criteria:
2 points – the answer is complete, well-argued;
1 point – in general, the answer is correct, but has flaws or minor errors;
0 points – there is no answer or there are significant errors in the answer.

Report evaluation criteria:
2 points – the report is completed in full;
0-1 point – the report is missing or there are significant deficiencies in the report.

Criteria for evaluating the timeliness of computer class submission for defense:
2 бали – the computer class is submitted for defense no later than the specified deadline;
0 балів – the computer class is submitted for defense later than the specified deadline.

Points for computer clases № 3-4 are calculated for:
- quality of the computer clases: 0-9 points;
- answer during the defense of the computer clases: 0-2 points;
- execution of a report from a computer clases: 0-2 points;
- timely presentation of computer clases for defense: 0-2 points.

Performance evaluation criteria:
8-9 points – the computer clase is done qualitatively, in full;
6-7 points – the computer clase is done qualitatively, in full, but has flaws;
5 points – the computer clase is completed in full, but contains minor errors;
4 points – the computer clase is completed in full, or contains significant errors;
0-3 points – the computer clase is not fully completed.

Answer evaluation criteria:
2 points – the answer is complete, well-argued;
1 point – in general, the answer is correct, but has flaws or minor errors;
0 points – there is no answer or there are significant errors in the answer.

Report evaluation criteria:
2 points – the report is completed in full;

0-1 point – the report is missing or there are significant deficiencies in the report.

Criteria for evaluating the timeliness of computer class submission for defense:
2 бали – the computer class is submitted for defense no later than the specified deadline;
0 балів – the computer class is submitted for defense later than the specified deadline.

The maximum number of points for performing and defending computer classes:

10 points × 2 + 15 points × 2 = 50 балів.

*The assignment for **the modular test** consists of 3 questions - 2 theoretical and 1 practical. The answer to each theoretical question is worth 15 points, and the answer to a practical question is worth 20 points.*

Evaluation criteria for each theoretical test question:
14-15 points – the answer is correct, complete, well-argued;
11-13 points – the answer is correct, detailed, but not very well argued;
8-10 points – in general, the answer is correct, but has flaws;
5-7 points – there are minor errors in the answer;
1-4 points – there are significant errors in the answer;
0 point – no answer or the answer is incorrect.

Evaluation criteria for the practical test question:
18-20 points – the answer is correct, the calculations are completed in full;
14-17 points – the answer is correct, but not very well supported by calculations;
9-13 points – in general, the answer is correct, but has flaws;
5-8 points – there are minor errors in the answer;
1-4 points – there are significant errors in the answer;
0 point – no answer or the answer is incorrect.

The maximum number of points for a modular test:

15 points × 2 theoretical test question + 20 points × 1 practical test question = 50 points.

The rating scale for the discipline is equal to:
R = 50 points + 50 points = 100 points.

Calendar attestation of students (8 and 14 weeks of semesters) for the discipline is carried out according to the value of the current rating of the student at the time of attestation. If the value of this rating is not less than 50% of the maximum possible at the time of certification, the student is considered satisfactorily certified. Otherwise, in the attestation statement is set "unsatisfactory".

A necessary condition for obtaining a test by a student is the performance modular control work and defense of all laboratory works with a sum of at least 60%. Students who do not have academic debt can also increase their grades by taking a final test.

The final performance score or the results of the Final/ Pass Test are adopted by university grading system as follows:

Score	*Grade*
100-95	*Excellent*
94-85	*Very good*
84-75	*Good*
74-65	*Satisfactory*
64-60	*Sufficient*
Below 60	*Fail*
Course requirements are not met	*Not Graded*

9. Additional information about the course

Topics for the calendar control in the Attachment 1.

Syllabus of the course

Is designed by teacher PhD, Senior lecturer, Shkurat Oksana;

Adopted by Computer Systems Software Department (protocol № 12 from 26.04.23)

Approved by the Faculty Board of Methodology (protocol № 10 from 26.05.23)

Attachment 1. Topics for the calendar control

1. Definition of augmented reality. Types of augmented reality. Components of augmented reality.
2. Hardware and software technologies of augmented reality.
3. Definition of virtual reality. Components of virtual reality.
4. Hardware and software technologies of virtual reality.
5. Information technology of image recognition for positioning objects of augmented and virtual reality.
6. Image recognition software tools for positioning augmented and virtual reality objects.
7. Technologies for creating and processing visual 2D elements of augmented and virtual reality.
8. Software tools for converting visual 2D elements of augmented and virtual reality.
9. Technologies for creating and processing visual 3D elements of augmented and virtual reality.
10. Software tools for converting visual 3D elements of augmented and virtual reality.
11. Software tools for animating visual 3D elements of augmented and virtual reality.
12. Technologies for creating and processing audio elements of augmented and virtual reality.
13. Software tools for converting audio elements of augmented and virtual reality.
14. Technologies for creating and processing video elements of augmented and virtual reality.
15. Software tools for converting video elements of augmented and virtual reality.
16. Tools for developing augmented and virtual reality applications and their integration
17. The main stages of development of augmented and virtual reality. The concept of a game engine. Unity 3D.