settings.COURSE_HEADER

Field of study	**Computer Science**	**Degree level and programme type**	**Master's degree full-time programme**
Specialization/ diploma path	**Biometry and Image Processing**	**Study profile**	academic
Course name	**Deep Learning in Biometrics**	**Course code**	**INF2DLB**
		Course type	elective

Forms and number of hours of tuition	L	C	LC	P	SW	FW	S	**Semester**	2
	15				15			**No. of ECTS credits**	**2**
Entry requirements									

Course objectives	To acquaint students with basic machine learning methods. To introduce the subject of inertial measurement units (IMUs) and the information they measure (which are supposed to be a set of studied data). Presentation of the principles of operation, advantages and disadvantages, examples of using elementary algorithms of Machine Learning. In particular, the student will be introduced to algorithms such as DTW (Dynamic Time Warping), SVM (Support Vector Machine), HMM (Hidden Markov Models), as well as selected method of artificial intelligence and basics of Bayesian networks.
Course content	Lecture and specialized lab: 1. quantities measured by selected sensors: accelerometers, gyroscopes, and magnetometers. 2. IMU inertial orientation sensors. 3. Rotation representation methods in three-dimensional space. 4. Feature extraction. 5. machine learning algorithms;. 6. methods: DTW (Dynamic Time Warping), SVM (Support Vector Machine), HMM (Hidden Markov Models). 7. selected artificial intelligence algorithms. 8. Bayesian networks.
Teaching methods	guiding text method, lecture problem, programming, informative lecture,
Assessment method	Lecture - written assessment. Specialist laboratory - reports.

Symbol of learning outcome	**Learning outcomes**	**Reference to the learning outcomes for the field of study**
LO1	knows different methods of representation of rotations in three-dimensional space; is able to perform a transformation of vectors between reference systems	INF2_W01 INF2_W03 INF2_U01
LO2	can extract the necessary features from the processed signals.	INF2_U03 INF2_U04
LO3	is able to implement the selected algorithm in the programming environment	INF2_U03 INF2_U04
LO4	knows the different methods of pattern classification	INF2_W07

Symbol of learning outcome	**Methods of assessing the learning outcomes**	**Type of tuition during which the outcome is assessed**
LO1	Colloquium, written reports	L, SW
LO2	written reports	SW
LO3	written reports	SW
LO4	colloquium	L

Student workload (in hours)		**No. of hours**
Calculation	1 - Participation in the lectures - 15x1h	15
	2 - Participation in specialised workshops - 15x1h	15
	3 - Participation in consultations	5
	4 - Preparation to specialised workshops	5
	5 - Develop lab or lab reports and/or complete homework assignments (homework)	5
	6 - Preparation to the colloquium	5
TOTAL:		**50**

Quantitative indicators	**HOURS**	**No. of ECTS credits**
Student workload – activities that require direct teacher participation	35 (3)+(1)+(2)	1.4
Student workload – practical activities	25 (2)+(4)+(5)	1.0

Basic references	1. F. Dunn, I. Parberry, 3D Math Primer for Graphics and Game Development, Wordware Publishing, 2002. 2. M. Müller, Information Retrieval for Music and Motion, Springer Berlin Heidelberg 2007. 3. S. Taylor, Markov Models: An Introduction to Markov Model, Createspace Independent Publishing Platform, 2017.
Supplementary references	1. A. Alasdair, Basic Sensors in iOS Programming the Accelerometer, Gyroscope, and More, O'Reilly Media, 2011. 2. I.Guyon, S. Gunn, M. Nikravesh, L. A. Zadeh, Feature Extraction: Foundations and Applications, Springer-Verlag, 2006.

Organisational unit conducting the course	Department of Digital Media and Computer Graphics	**Date of issuing the programme**
Author of the programme		May 22, 2020

L – lecture, C – classes, LC – laboratory classes, P – project, SW – specialization workshop, FW – field work,S – seminar

settings.COURSE_HEADER									
Field of study	**Computer Science**							**Degree level and programme type**	**Master's degree full-time programme**
Specialization/ diploma path	**Biometry and Image Processing**							**Study profile**	academic
Course name	**Game development in VR technology**							**Course code**	**INF2GVR**
								Course type	elective
Forms and number of hours of tuition	L	C	LC	P	SW	FW	S	**Semester**	2
			30					**No. of ECTS credits**	**2**
Entry requirements									

Course objectives	The aim of the course is to introduce the student to the game development engine (Unity) and to familiarize with the basic limitations and principles of programming in virtual reality according to the standards used in industrial projects
Course content	Lab: 1. Introduction to Unity and basic information about the architecture of the graphic user interface of the Unity engine - Overview of MonoBehaviour scripts 2. Code practices - Single initialization point - Building of game objects using components - Layered separation of "business logic" from the game view - Use of design patterns in games - Implementation of dependency injection mechanisms 3. Implementation of a "shoot 'em up" game - Moving objects - Systems of graphical representation of objects - Collision detection systems - "Number of Lives" techniques - Shooting system, destroying objects - System profiling methods 4. Implementation of the game of the "Xortex" type in virtual reality - Interaction with objects - Movement systems - User restriction systems - Sound systems - Ray casting system - Counteracting the "virtual reality disease"
Teaching methods	programming, project method, manufacturing practice,
Assessment method	Lab - project tasks, project defense.

Symbol of learning outcome	**Learning outcomes**	**Reference to the learning outcomes for the field of study**
LO1	knows and applies technologies and tools used in game development	INF2_W05 INF2_W06 INF2_U08
LO2	knows and uses VR technologies to create games	INF2_W03 INF2_W05 INF2_W06 INF2_U04 INF2_U08
LO3	can create games according to the standards of software engineering	INF2_W02 INF2_U03
LO4	uses techniques to counteract the "virtual reality disease"	INF2_K01 INF2_K03 INF2_K05

Symbol of learning outcome	**Methods of assessing the learning outcomes**	**Type of tuition during which the outcome is assessed**
LO1	execution of project tasks, project defense	
LO2	execution of project tasks, project defense	
LO3	execution of project tasks, project defense	
LO4	execution of project tasks, project defense	

Student workload (in hours)		**No. of hours**
Calculation	1 - Participation in classes - 15x2h	30
	2 - Implementation of projects	15
	3 - Participation in consultations	5
TOTAL:		**50**

Quantitative indicators	**HOURS**	**No. of ECTS credits**
Student workload – activities that require direct teacher participation	50 (2)+(1)+(3)	2.0
Student workload – practical activities	50 (2)+(1)+(3)	2.0

Basic references	1. M. McShaffry, D. Graham: Game Coding Complete, 4th edition, Course Technology PTR, 2015. 2. J. Glover, J. Linowes: Complete Virtual Reality and Augmented Reality Development with Unity, Packt Publishing, 2019.	
Supplementary references	1. J. Schell: The Art of Game Design: A Book of Lenses, second Edition, A K Peters/CRC Press, 2014. 2. J. Hocking: Unity in Action Multiplatform game development in C# with Unity, Manning Publications, 2015	
Organisational unit conducting the course	Department of Digital Media and Computer Graphics	**Date of issuing the programme**
Author of the programme		May 22, 2020

L – lecture, C – classes, LC – laboratory classes, P – project, SW – specialization workshop, FW – field work,S – seminar

settings.COURSE_HEADER								
Field of study	**Computer Science**						**Degree level and programme type**	**Master's degree full-time programme**
Specialization/ diploma path	**Biometry and Image Processing**						**Study profile**	academic
Course name	**Sensors**						**Course code**	**INF2SEN**
							Course type	elective
Forms and number of hours of tuition	L	C	LC	P	SW	FW	S	**Semester**	2
	15				15			**No. of ECTS credits**	**2**
Entry requirements								

Course objectives	The main goal of the course is to familiarize students with the basics of data acquisition systems and basic forms of communication with sensors. In addition, students will become familiar with the main communication protocols and modern ways to program simple circuits. The lectures will include a presentation of the main pillars of measurement methods. The goal of this course is to provide students with a broad perspective on a variety of sensors, as well as to familiarize them with how to select sensors and implement simple programs based on the operation of sensors in real-world conditions. An additional aim of the course is to present the students with the ways to test the quality of prepared solutions, as well as to use artificial intelligence and machine learning techniques in the process of analyzing data collected from sensors.
Course content	Lecture: 1. measurement methods and signals. 2. Criteria for the selection of measuring equipment. Classification of sensors. 3. Methods of artificial intelligence and machine learning in systems using sensors. 4. principles of sensor operation. 5. ADC and DAC processing; Beacons. 6. communication protocols with sensors. 7. biometric sensors. Python language libraries for programming biometric sensors. Specialized lab: 1. familiarization and analysis of the capabilities of diverse devices: Raspberry Pi, Arduino and Nano Pi. 2. Discussing and testing Python and C libraries used in sensor programming. Implementation of programs using sensors: temperature, accelerometers, gyroscopes, distance and motion. 3. To acquaint students with artificial intelligence and machine learning methods used in sensor-based systems. 4. develop biometric solution using embedded system and appropriate biometric sensors.
Teaching methods	simulation, programming, lecture problem, lecture, informative lecture,
Assessment method	Lecture - colloquium. Specialist laboratory - assessment of project reports.

Symbol of learning outcome	**Learning outcomes**	**Reference to the learning outcomes for the field of study**
LO1	independently designs and implements systems using sensors and embedded systems	INF2_W02 INF2_U13 INF2_K04
LO2	independently analyses and then selects communication protocols between sensors and the embedded system. He/she can justify his/her choice and implement a given protocol taking into account relevant security procedures.	INF2_W05 INF2_U06 INF2_K04
LO3	can independently implement artificial intelligence and machine learning algorithms within the framework of data collected using sensors	INF2_W07 INF2_U02 INF2_U03 INF2_K01
LO4	knows the methodology of testing solutions based on embedded systems and sensors; is able to prepare testing strategies for the developed solutions	INF2_W02 INF2_W03 INF2_U05 INF2_U06 INF2_K04

Symbol of learning outcome	**Methods of assessing the learning outcomes**	**Type of tuition during which the outcome is assessed**
LO1	colloquium, evaluation of project reports	L, SW
LO2	evaluation of project reports	SW
LO3	evaluation of project reports	SW
LO4	colloquium, evaluation of project reports	L, SW

Student workload (in hours)		**No. of hours**
Calculation	1 - Participation in the lectures - 15x1h	15
	2 - Participation in specialised workshops - 15x1h	15
	3 - Develop lab or lab reports and/or complete homework assignments (homework)	5
	4 - Participation in consultations	5
	5 - Completion of project assignments (including preparation of presentations and preparation for implementation)	5
	6 - Preparation to colloquium	5
TOTAL:		**50**

Quantitative indicators	**HOURS**	**No. of ECTS credits**
Student workload – activities that require direct teacher participation	35 (1)+(2)+(4)	1.4
Student workload – practical activities	25 (2)+(3)+(5)	1.0

Basic references	1. S. Tumanski, Principles of electrical measurement, CRC Taylor&Francis, 2006.	
Supplementary references	1. R. Dorf, Sensors, nanoscience, biomedical engineering and instruments, CRC/Taylor & Francis, 2006. 2. S. Le, T. Worch - "Analyzing sensory data with R", CRC/Taylor & Francis, Boca Raton, 2015.	
Organisational unit conducting the course	Department of Digital Media and Computer Graphics	**Date of issuing the programme**
Author of the programme		May 22, 2020

L – lecture, C – classes, LC – laboratory classes, P – project, SW – specialization workshop, FW – field work,S – seminar

settings.COURSE_HEADER									
Field of study	**Computer Science**							**Degree level and programme type**	**Master's degree full-time programme**
Specialization/ diploma path	**Biometry and Image Processing**							**Study profile**	academic
Course name	**Graphics Accelerators Programming**							**Course code**	**INF2PAG**
								Course type	elective
Forms and number of hours of tuition	L	C	LC	P	SW	FW	S	**Semester**	2
	15				15			**No. of ECTS credits**	**2**
Entry requirements									

Course objectives	The aim of the course is to expose students to advanced hardware acceleration techniques based on graphics processor usnits (GPUs), and multimedia extensions SIMD (MMX / SSE), and multi-core general purpose units (CPUs). In particular, the student will be exposed to the following technologies: OpenMP, Intel threading building blocks (TBB), GLSL shader language and dedicated GPGPU computing environments: Cuda, OpenCL.
Course content	Lecture and laboratories: 1. Computing in graphics and multimedia, code vectorization, parallel computing. 2. Multimedia extensions (MMX / SSE) for general purpose processors, an introduction to the 64bit architecture. 3. The use of assembler inlines and built-in functions (intrinsics), code optimization. 4. Programming based on multi-core processors - OpenMP, TBB technologies. 5. Architecture of graphics processor units (GPUs), unification of the compute units. 6. Shaders, GLSL (OpenGL Shading Language) technology. 7. Implementation of the advanced graphics effects using GLSL. 8. Introduction to general GPU computing: GLSL / Vulkan computing shaders and the Cuda and OpenCL technologies.
Teaching methods	lecture problem, programming, informative lecture, subject exercises,
Assessment method	Lectures: passing test Laboratories: realization of the project tasks, project defense

Symbol of learning outcome	**Learning outcomes**	**Reference to the learning outcomes for the field of study**
LO1	has knowledge of current trends and tools in the hardware acceleration techniques using GPUs and multi-core general purpose units	INF2_W03 INF2_W06
LO2	has extended knowledge in the field of computer graphics	INF2_W03 INF2_W06
LO3	is able to use learned technologies for image processing	INF2_U03 INF2_U04
LO4	has a basic knowledge of the current trends in GPU-based computing; is able to define the directions of further learning and self-education.	INF2_W06 INF2_U14

Symbol of learning outcome	**Methods of assessing the learning outcomes**	**Type of tuition during which the outcome is assessed**
LO1	passing test	
LO2	passing test	
LO3	realization of the project tasks, project defense	
LO4	realization of the project tasks, project defense	

Student workload (in hours)		**No. of hours**
Calculation	1 - participation in lectures - 15x1h	15
	2 - participation in laboratories - 15x1h	15
	3 - consultations - 5	5
	4 - homeworks - 10	10
	5 - preparation for passing test - 5	5
TOTAL:		**50**

Quantitative indicators	**HOURS**	**No. of ECTS credits**
Student workload – activities that require direct teacher participation	35 (3)+(1)+(2)	1.4
Student workload – practical activities	25 (4)+(2)	1.0

Basic references	1. K. Sobiesiak, P. Sydow: Zaawansowane programowanie w GLSL, PWN, 2015. 2. J. Kessenich (ed.): The OpenGL Shading Language v 4.2, The Khronos Group, 2011 (dok. On-line). 3. A. Munshi (ed.): The OpenCL Specification, Version: 1.2, Khronos OpenCL Working Group, 2011 (dok. On-line).
Supplementary references	1. NVIDIA CUDA C Programming Guide, Version 4.2 (dok. on-line). 2. Y. Magda: Visual C++ .NET Optimization with Assembly Code, A-LIST Publishing, 2004. 3. Wen-mei W. Hwu (ed.): GPU Computing Gems Emerald Edition, Morgan Kaufmann, 2011. 4. D.B. Kirk,Wen-mei W. Hwu: Programming Massively Parallel Processors: A Hands-on Approach, Morgan Kaufmann, 2011. 5. OpenMP Application Program Interface, OpenMP Architecture Review Board, 2011 (dok. On-line). 6. Intel(R) Threading Building Blocks Reference Manual, Intel Corp., 2012 (dok. on-line).

Organisational unit conducting the course	Department of Digital Media and Computer Graphics	**Date of issuing the programme**
		May 22, 2020

Author of the programme		

L – lecture, C – classes, LC – laboratory classes, P – project, SW – specialization workshop, FW – field work,S – seminar

settings.COURSE_HEADER								
Field of study	**Computer Science**						**Degree level and programme type**	**Master's degree full-time programme**
Specialization/ diploma path	**Biometry and Image Processing**						**Study profile**	academic
Course name	**Informatics in Robotics**						**Course code**	**INF2IWR**
							Course type	elective
Forms and number of hours of tuition	L	C	LC	P	SW	FW	S	**Semester**	2
	15				15			**No. of ECTS credits**	**2**
Entry requirements								

Course objectives	Lectures: To familiarize students with the basics of robotics. Developing a broad perspective on problems related to the work of robots in real conditions. Practical classes: Implementation of navigation algorithms on real mobile constructions based on Mindstorms NXT educational robots. Designing the behavior of mobile systems.
Course content	Lectures: Basics of robotics: simple and inverse kinematics. Sensors and motors in robotics. PID control. Navigation algorithms. Programming mobile robots to perform navigation tasks: avoiding obstacles, location, mapping, SLAM. Intelligent Robots. Practical classes: Not eXactly C (NXC). Testing various sensors and engines. Conditions, loops, threads in parallel. Mindstorms NXT programming. Real robot control - avoiding obstacles. Covering the distance with many obstacles of unknown dimensions. Graphic information recognition. Implementation of space orientation algorithms.
Teaching methods	lecture problem, programming, informative lecture,
Assessment method	Lecture - tests. Practical classes - work during the classes, reports from the classes.

Symbol of learning outcome	**Learning outcomes**	**Reference to the learning outcomes for the field of study**
LO1	understands the tasks of kinematics in robotics and can solve simple kinematics tasks	INF2_W05
LO2	understands and implements mobile navigation algorithms	INF2_W03 INF2_U04
LO3	designs and implements two robot communications	INF2_U04 INF2_K01
LO4	tests the accuracy and effectiveness of mobile systems in various conditions.	INF2_U11 INF2_K01

Symbol of learning outcome	**Methods of assessing the learning outcomes**	**Type of tuition during which the outcome is assessed**
LO1	test	L
LO2	test, reports	L, Pc
LO3	reports	Pc
LO4	reports	Pc

Student workload (in hours)		**No. of hours**
Calculation	1 - Participation in lectures - 15x1h	15
	2 - Participation in practical classes - 15x1h	15
	3 - Preparation to the lecture	5
	4 - Implementation of project tasks (including preparation of presentations)	10
	5 - Participation in teachers hours	5
TOTAL:		**50**

Quantitative indicators	**HOURS**	**No. of ECTS credits**
Student workload – activities that require direct teacher participation	35 (1)+(2)+(5)	1.4
Student workload – practical activities	25 (2)+(4)	1.0

Basic references	1. W. Kaczmarek, J. Panasiuk, S. Borys, Środowiska programowania robotów, PWN, 2017. 2. B. Siemiątkowska, A. Borkowski, R. Chojecki i in., Reprezentacja otoczenia robota mobilnego, Akademicka Oficyna Wydawnicza EXIT, 2011. 3. R. Murphy, Introduction to AI robotics, The MIT Press Cambridge, 2000.
Supplementary references	1. T. Zielińska, Maszyny kroczące: podstawy, projektowanie, sterowanie i wzorce biologiczne, PWN, 2013. 2. K. Kozłowski, P. Dutkiewicz, W. Wróblewski, Modelowanie i sterowanie robotów, PWN, 2003. 3. S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, 2nd edition, Prentice Hall, 2002. 4. G. Dudek, M. Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, 2000. 5. J. J. Graig, Wprowadzenie do Robotyki, WNT, 1995.

Organisational unit conducting the course	Department of Digital Media and Computer Graphics	**Date of issuing the programme**	
Author of the programme		May 22, 2020	

L – lecture, C – classes, LC – laboratory classes, P – project, SW – specialization workshop, FW – field work,S – seminar