Institution:        **West University of Timisoara**

Specialization:    **Computer Science  - Artificial Intelligence and Distributed Computing**

**Aim of the course**: Prepare the students to be able to use theoretical and practical tools in order to solve computational problems and design software products.  A particular emphasis is put on Artificial Intelligence and Distributed Computing.

| Artificial Intelligence |
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| Description: |
| *Objectives:*  Combining theoretical and practical aspects in solving search problems; understanding heuristics; knowledge representation and reasoning; logical reasoning, pattern-oriented programming. Application of the studied concepts in problem solving, planning, games, constraint satisfaction problems, classification, expert systems etc.<br>*Content:* C1. Artificial Intelligence: definitions. History. Domains. Applications. C2. Problem representation. Uninformed search algorithms. C2. Problem representation. Uninformed search algorithms. C3.  Blind search and heuristic algorithms. C4.  Search algorithms applied in games. C5. Constraint Propagation. C6. Planning. C7. Knowledge types and representation modes. Logic. Procedural representation. Production rules. C8. Knowledge representation based on inheritance – semantic networks, frames, object oriented representation. C9. Reasoning. Logical reasoning. C10. The architecture of expert systems. Rule based expert systems -  how does the infference engine works. C11. Expert system frameworks (Clips, Jess). Pattern oriented programming. C12. Natural language understanding. C13. Machine learning. C14. Distributed AI. Multi-agent systems. |
| Examination: |
| Final written exam (50%) + continuous assessment of lab activity (20%) + projects (30%) |

| 5 ECTS | 4 hours/week | 1$^{st}$ semester |
|---|---|---|

| Web Technologies |
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| Description: |
| *Objectives* : To understand how client side and server side web applications work.<br>To have basic understanding of various key client and server side web technologies.<br>To understand the complex ecosystem of web applications<br><br>*Content :*<br>C1. Introduction. Internet and HTTP.  C2. HTML 4/5 and CSS 2/3. C3. Web forms.  C4. XML and XHTML. C5. Introduction in client side programming.  C6. State preservation. C7. Synchronous vs. asynchronous execution. C8. Jquery. C9. Introduction to server side programming. C10-11. Rest and SOAP web services. C12. Node.js. C13-14. Cloud computing. |
| Examination: |
| Assessment of student knowledge on web tech basic challenges and existing technologies (multiple choice written exam )(60%) + Lab assignments (oral presentations) (40%) |

| 5 ECTS | 4 hours/week | 1$^{st}$ semester |
|---|---|---|

## Programming Environments (A1)

**Description:**

*Objective:* Learning programming techniques using Python language. Programming in one of the most used development environment for Python, PyCharm. Development of the applications using Pythin standard libraries, but also third-party dedicated frameworks (Django)

*Content: C1.* Introduction to Python programming language. Advantages and disadvantages.C2. Data types: numeric, boolean, string, lists, sets, tuples while and for loops. The name and value binding mechanism. Passing parameters to functions. C3. Dictionary data type. Lists and dictionaries comprehension. Files and methods of files processing. Objects comparison. Significance of True and False in Python programming language. C4. Modules a packages in Python. Organizing programs. C5. OOP in Python. Introduction to classes, attributes and specific methods.Constructors nd inheritance. C6. eval() function in Python and its importance. More about object creation, inheritance, composition, delegation nd other specific elements in OOP. C7. Elements of functional programming using Python. Lambda functions, closures and decorarors. C8. Using standard exceptions in Python. Creating custom exceptions. Processes and threads in Python. Synchronization between threads. Queues. C9. Design patterns based on Python programming language: singleton, proxy, facade, factory, adapter. C10. Data serialization in Python, using pickle, json and databases. C11. Elements of networking programming based on sockets and usage of urllib library. C12. Introduction to Python's Django framework.

**Examination:**

Final written test (40%) + continuous evaluation of lab activity (30%)+projects(30%)

| 4 ECTS | 3 hours/week | 1$^{st}$ semester |
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## Distributed and Concurrent Programming (A1)

**Description:**

*Objectives:* introduction to the mechanism of communication and synchronization between processes and threads and to the distributed communication mechanisms.

*Content:* Tools for Unix programming; Processes (creation, fork mechanism, program loading); Signals (signal generation and interception, blocking and unblocking UNIX signals; signal treatment); Threads (creation, inter-thread relation, termination and synchronization); Communication between threads (mutual exclusion, semaphores, condition variables, critical sections); File operation; Network communication (sockets, client server applications); Case studies (a server application, a client application)

**Examination:**

Written test (40%) + lab activity (40%) + project (20%)

| 4 ECTS | 3 hours/week | 1$^{st}$ semester |
|--------|--------------|-------------------|

## Design Patterns (A2)

**Description:**

*Objective:* Designing an application using certain design patterns. Identification in existing applications of the possibility to use design patterns Acquiring knowledge in order to use design patterns in object-oriented application development

*Content:* C1. Design Patterns. Introductions. C2. Fundamental patterns. C3. Creational patterns.C 4. Structural patterns. C5. Structural- behavioral patterns. C6. Behavioral patterns. C7. Behavioral.

| Partitioning patterns. C8. GUI patterns. C9. Refactoring. C10. Antipatterns. C11-12. Tiered Applications. J2EE – design patterns. C13. A study case |||
|---|---|---|
| **Examination:** |||
| Final written test (50%) + lab and course activity (25%) + pattern presentation (10%) + project presentation(15%) |||
| 4 ECTS | 3 hours/week | 1st semester |

## Information Theory (A2)

**Description:**

*Objective:* Provides abilities to compute the important formulas and to apply the data compresion algorithms. Understanding several definitions of information.

*Content:* C**1. Fundamental quantities of information theory.** Entropy, Joint Entropy and Conditional Entropy. Relative Entropy and Mutual Information. C**2. Entropy Rates of a Stochastic Process**. Markov Chains. Entropy Rate. C**3. Second Law of Thermodynamics. C4. Data Compression**. Kraft Inequality,Optimal Codes. Huffman Codes. C**5. Data Compression**. Optimality of Huffman Codes. Shannon–Fano–Elias Coding. C**6. Source Coding Theorem**. Entropy and compression. C**7. Channel capacity**. Noiseless Binary Channel. Noisy Channel Coding Theorem. C**8-9. Channel Capacity**. Zero-Error Codes. Hamming Codes. Source–Channel Separation Theorem. C**10. Network Information Theory**. Broadcast and Multiple-Access Channels Correlated source coding and the Slepian-Wolf Theorem. **C11-12. Kolmogorov Complexity.** Kolmogorov Complexity: Definitions and Examples. Kolmogorov Complexity and Entropy. Kolmogorov Complexity of Integers. Kolmogorov Complexity and Universal Probability. C**13. Rate-Distortion Theory**. Ultimate limits of compression, communication and signal processing. Measure matching. Blahut-Arimoto Algorithm.

| **Examination:** |||
|---|---|---|
| Final written test (20%) + Continous theoretical examination (30%) + Final laboratory examination (20%) +projects (30%) |||
| 4 ECTS | 3 hours/week | 1st semester |

## Diploma Stage I

**Description:**

*Objective:* preparing the diploma stage

*Content:* the supervisor follows the activity of the student by weekly discussions concerning the status of the diploma work

| **Examination:** |||
|---|---|---|
| The student activity is continuously evaluated by the supervisor (there is only a "passed/ not passed" evaluation not a grade) |||
| 3 ECTS | 2 hours/week | 1st semester |

## Graphics and User Interfaces

**Description:**

*Objectives:* understanding how the GPU and the rendering pipeline are working; knowledge of at least one graphics library; understanding that a graphics application is not just about programming but that it requires knowledge from multiple previously studied disciplines

*Content:* C1. Introduction. Short history of computer graphics. Lecture sylabus. C2. Graphics devices for user interfacing. Rendering pipeline. Logical devices. C3. Digital images. Image processing. Operations with images. C4. Recap on vectors and matrices. Reference systems. Affine transformations. C5. Drawing graphics primitives. C6. Object modeling. Solid and procedural modeling. C7. Projection types.C8. Clipping algorithms for points, lines and polygons. C9. Visibility algorithms. C10-11. Direct and global illumination, Ray tracing. C12. Transparency and reflection. C13. Textures. C14. Reality through physics and artificial intelligence.

**Examination:**

Final written exam (30%) + project evaluation (20%) + oral assignment evaluation (50%).

| 5 ECTS | 4 hours/week | 2$^{nd}$ semester |
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## Numerical Methods

**Description:**

*Objective:* (1) to describe numerical methods for solving systems of equations; (2) to present numerical methods for the interpolation of functions; (3) to describe numerical differentiation and integration; (4) to present numerical methods for solving differential equations.

*Content:* C1. *Systems of Linear Equations I.* Gaussian Elimination and Pivoting. LU Factorization. C2. *Systems of Linear Equations II.* Tridiagonal Systems. Cholesky Factorization. C3. *Systems of Linear Equations III.* Householder Factorization . The Jacobi Method. C4 *Systems of Linear Equations IV.* The Gauss-Seidel Method. Successive Over-relaxation (SOR) Method. C5 *Numerical Solutions of Equations and Systems of Nonlinear Equations* . Fixed-Point Iterative Method. The Newton Method. Quasi-non-expansion Operators. C6-8 *Interpolation, Polynomials Approximation, Spline Functions.* The Newton Divided Difference Formulas. The Lagrange Interpolating Polynomial. Piecewise Polynomial Approximations: Spline Functions. The Spline Polynomial Interpolation. Bernstein Polynomial. C9 *Numerical Differentiation.* Derivatives' Approximation by Finite Differences. Derivatives' Approximation Using Derivatives of the Interpolating Polynomials. C10. *Numerical Integration* The Newton-Cotes Formula, the Trapezoidal Rule, the Simpson formula. Gaussian Integration Formulas. C11-14 *Differential Equations, Initial-Value Problems.* Finite Difference Method for a Numerical Solution of Initial-Value Problems (IVP). The Taylor Method for a Numerical Solution of IVP. The Runge-Kutta Method of the Second Order for a Numerical Solution of IVP. The Runge-Kutta Method of the Third Order and Fourth Order for Numerical Solution of IVP. The Multi-step Method for Numerical Solution of IVP: Adams-Bashforth, Adams-Moulton. The Predictor-corrector Method. The Finite Differences Method for a Numerical Solution of a Limit Linear Problem. The Collocation Method and the Least Squares Method.

**Examination:**

Final written exam (50%) + lab projects (50%)

| 5 ECTS | 4 hours/week | 2$^{nd}$ semester |
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## Security and Criptography (B1)

Description:

*Objective:*

Getting to know and use cryptographic and security concepts – hash functions, key exchange protocols, encryption and decryption algorithms, digital signatures, public key certificates and infrastructure, data protection principles, secure communication, internet threats prevention. It leads to: (1) Good understanding of the mathematical foundations of cryptography; (2) Knowing the main encryption and decryption algorithms and the key exchange protocols (3) Understanding the nature of security threats; (4) Ability to implement secure communication (5) Ability to recognize and prevent threats.

*Content:* C1. Cryptography and cryptanalysis; C2. Classical cryptography, Diffie-Hellman algorithm; C3. Hash functions - MD5, SHA-1; C4. DES, AES, specifications and algorithms; C5. Elements of number theory, the RSA algorithm; C6. DSS, specification and implementation; C7. The SSL protocol, Secure Shell; C8. Data security, Network security ; C9.Traffic analyzers, passwords; C10. Torrents, the hide and seek game; C11. Viruses, examples, protection; C12. Trojans, examples, protection; C13. Software exploits, Internet specific threats.  C14. Security Proxies.

Examination:  final written exam (50%) and 2 lab projects (50%)

| 5 ECTS | 3 hours/week | 2nd semester |
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## Cloud Computing and Internet of Things  (B1)

Description:

*Objective:* Provides knowledge on design and implementation of algorithms and data structures for IoT.  (lectures delivered in collaboration with Nokia Romania)

*Content:* C1-2. Nokia approach for Cloud computing applications. C3. 4G to 5G. C4. Nokia approach for Internet of Things. C5. HTML, CSS technologies. C6. JavaScript , NodeJS. C7. Database basics. C8. AJAX principles, client-server RESTfull applications. C9. C++. C10. C++ 11. C11. Boost libraries.  C12. Memory management.

Examination:

Final written test (40%)  +  a final project(60%)

| 5 ECTS | 3 hours/week | 2nd semester |
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## Intelligent Systems (B2)

Description:

*Objectives:* Learning to think differently that classical programming by applying the Expert Systems (ES) and Multi Agent Systems (MAS) approches to programming. The sttudents will get the ability to model various problems using notions of ES and MAS theory, and also to solve them efficiently

*Content:* C1. Intelligent Systems: definition, history, applicability. C2. Expert Systems. Languages and tools. Production Rules Systems. Artificial Neural Networks. C3. Knowledge representation. Production rules. Sementic networks. Frames. First order predicate logic. C4. Inference. And/Or trees. Resolution. Forward and backward chaining. C5. Uncertainty reasoning. Probability theory elements. Markov chains. Inference networks. C6. Inexact reasoning. Principles of building an Expert System. C7. CLIPS system. Facts. Rules. Pattern matching. C8. CLIPS programming. C9. The RETE algorithm. Decision trees. Backward chaining in CLIPS. C10. Multi Agent Systems. FIPA specifications. JADE environment. C11. Programming using JADE: ontologies, behaviours, interaction protocols. C12. Embedded JADE. Mobile agents. Agents on mobile devices. C13. JADE and Web services integration. ASCML – Agent-Society Configuration Manager and Launcher. C14. Natural world inspired algorithms. The ant colony model.

Examination:

Written exam (50%) and lab projects (50%)

| 5 ECTS | 3 hours/week | 2nd semester |
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## Network Administration (B2)

Description:

*Objectives:* It provides knowledge and skills on how to configure and manage a mixed network containing Linux/UNIX machines and Windows machines; the accent is on configuring Linux machines. The students will get the ability to debug and repair various situations that appear in the network administration tasks

*Content:* C1. Introduction. The network administrator's tasks. C2. User and group account creation. C3. Managing the File Sytem through rights and permissions. C4. Configuring the system services. Run levels. C5. Network card configuration. Routing tables. C6. Printers and mail configuration. C7. Configuring NFS and NIS. C8. File sharing: Samba configuration, the user and share security levels. C9. Samba configuration 2: the security levels server and domain. Configuring a PDC using Samba, LDAP and Kerberos. C10. LDAP configuration. C11. SSH and DNS configuration. C12. Firewall configuration. C13. C client-server applications. C14. Java client-server applications.

Examination: written exam (50%) and 2 practical tests (50%)

| 5 ECTS | 3 hours/week | 2nd semester |
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| Management Information Systems (B3) | | |
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| Description: | | |
| *Objectives:* Providing knowledge on SAP, information management, distributed and local storage architectures and devices.<br>*Content:* C1. Information Management, Business Information management, Information storage management – basic concepts. C2. Information overload. Business Intellignece. Information quality. Information life cycle. C3. Management Information Software. ERP, SAP, DBMS, CRM, SCM. C4. Management Information Technology. C5. Management Information Strategy. C6. Knowledge management strategy. C7. Information system strategy. C8. Components of a storage device. C9. RAID system. C10. Intelligent system storage. C11. DAS architecture. C12. SAN arcitecture. C13. NAS and CAS architecture. C14. Virtualization storage. Backup and data recovery. Backup NAS architecture | | |
| Examination: | | |
| Written exam (30%) and individual project (70%) | | |
| 5 ECTS | 3 hours/week | 2$^{nd}$ semester |

| Formal Methods in Software Development (B3) | | |
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| Description: | | |
| *Objectives:* Presentation and understanding of (1) the importance of logical theories in the verification of programs, (2) static analysis of programs, (3) particularities of Java programs verification. Understanding and usage propositional and predicate logic, loop invariants, termination terms, program specification, with emphasis on Java programs.<br>*Content:* C1 - C3 Introduction. Importance of program verification. Propositional logic. First-order predicate logic. Basic proof techniques. C4 - C6. Specification and verification of sequential programs. Hoare method. Generation of the verification conditions and their proof. Termination. C7 - C8. Specification and verification of Java programs. C9 - C13. Presentation of different actual research in formal methods and closely related to the topics in C1-C8. Suggestions of topics are: model checking, SAT and SMT solving, quantifier elimination for different logical theories. | | |
| Examination: | | |
| Written exam (50%) and homework (50%) | | |
| 5 ECTS | 3 hours/week | 2$^{nd}$ semester |

| Diploma Stage | | |
| --- | --- | --- |
| Description: | | |
| *Objective:* preparing the diploma stage<br>*Content:* the supervisor follows the activity of the student by weekly discussions concerning the status of the diploma work | | |
| Examination: | | |
| Continuous evaluation during the semester and a final oral presentation with a jury | | |
| 5 ECTS | 3 hours/week | 2$^{nd}$ semester |

**Note:** One of the subjects marked with the same label (A1, A2, B1, B2, B3) should be selected.

**Range of the marks**

10:     excellent

 9:     very good

7-8:    good

5-6:    sufficient

0 – 4: not passed