Facultatea de Matematică și Informatică
Departamentul de Informatică

PROPUNERI TEME DISERTATIE 2024

Bachelor and Master Theses - Erașcu Mădălina madalina.erascu@e-uvt.ro

Specialization: All Bachelor and Master Specializations

Remarks:

1. All theses must be written in English.
2. Usage of Latex (Beamer) is mandatory.
3. If conclusive results are obtained:

a. they will be sent for publication at students' symposia, workshops, conferences

b. teams of students will be encouraged to participate in innovation programs

4. To work with me:

a. you must show and prove outstanding academic record (current GPA greater than 8.50)

b. you must show disponibility in meeting regularly (weekly or bi-weekly) and tackling research problems

c. be open to check the business opportunity of the problem you are working on, so you should show interest in entrepreneurship and innovation

5. I also supervise projects proposed by students, but they should be related to my interests and to the topics proposed:

a. Formal Methods, in particular Static Software Verification;

b. Automated Theorem Proving, in particular First-Order Theorem Proving;

c. Software Engineering

d. Symbolic Computation, in particular Polynomial Algebra;

e. Distributed Computing, in particular Cloud and Big Data Computing.

Remark! Based on previous experience, many students did not show up, without announcing or having childish excuses, at the meetings in which we discuss the progress of their thesis. To avoid any misunderstandings, I state already that at 3 such happenings you will have to find another supervisor.

Topics 1-5 below are aligned with the research project I am leading (SAGE: https://merascu.github.io/links/SAGE.html) so there might be the opportunity for part-time employment or scholarships.

Nr	Topic	Observations
1.	Symmetry Breaking for the Cloud Resource Allocation Problem (1-2 theses)	Suppose you want to buy, at the lowest cost, virtual machines (VM) with certain CPU, memory, storage, from cloud providers which are geographically distributed. This is an NP-hard problem which can be formalized as a constraint satisfaction problem and solved using exact algorithms. The problem exhibits symmetries which makes the search for solution to consider already visited solutions, as well as parts of the search tree which are symmetric to already visited parts. The aim of this project is to implement symmetry breaking methods from the paper [1] in the MANeUveR framework (https://merascu.github.io/links/MANeUveR.html) in order to make the problem above amenable to be solved in practice. **Difficulty**: medium/high **Requirements**: *Programming*: Python; *Mathematics*: Computational logic

2.	Graph Neural Networks for combinatorial optimization problems (1-2 theses)	The project aims to apply Graph Neural Networks for optimization problems coming from cloud resource provisioning (see topic 1 above). *Libraries used*: DGL, PyTorch Geometric. **Difficulty**: high **Requirements**: *Programming*: Python; *Mathematics*: Computational logic; graph theory, machine learning, operational research (optimization).
3.	Training Binarized Neural Networks for Traffic Sign Classification (3 theses)	Traffic signs support road safety and managing the flow of traffic, hence are an integral part of any vision system for autonomous driving. While the use of deep learning is well-known in traffic signs classification due to the high accuracy results obtained using convolutional neural networks (CNNs) (state of the art is 99.46%), little is known about binarized neural networks (BNNs). Compared to CNNs, BNNs reduce the model size and simplify convolution operations and have shown promising results in computationally limited and energy-constrained devices which appear in the context of autonomous driving. This work aims to extend the paper [2] which presents a bottom-up approach for architecting BNNs by studying characteristics of the constituent layers. These constituent layers (binarized convolutional layers, max pooling, batch normalization, fully connected layers) are studied in various combinations and with different values of kernel size, number of filters and of neurons by using the German Traffic Sign Recognition Benchmark (GTSRB) for training. As a result, we propose BNNs architectures which achieve an accuracy of more than 90% for GTSRB (the maximum is 96.45%) and an average greater than 80% (the maximum is 88.99%) considering also the Belgian and Chinese datasets for testing. The number of parameters of these architectures varies from 100k to less than 2M. The accompanying material of this paper is publicly available at https://github.com/apostovan21/BinarizedNeuralNetwork. The (tentative) *tasks* of this project are: 1. exploring the loss and accuracy: what architecture layers and hyperparameters influence the spikes in the output graph? (thesis 1) 2. investigation of BNNs accuracy when there is a large number of non-linear activation functions (e.g. ReLU) but only fully connected layers (thesis 2) 3. deployment of the machine learning models on real devices (thesis 3). **Difficulty**: high **Requirements**: *Programming*: Python; *Mathematics*: Computational Logic, linear algebra and statistics
4.	Verification of Binarized Neural Networks (1-2 theses)	The trained classifiers from point (3) exhibit issues when it comes to robustness to adversarial attacks. This is an issue since these classifiers are used in autonomous cars which are safety-critical systems. To overcome this issue, application of formal verification can be used. More precisely, given a deep neural

		network (DNN) and a specification, is there a proof that the DNN satisfies the specification for all inputs? Not surprisingly, the main challenge of applying formal methods to the verification of DNNs is scalability. This is because verification is a non-trivial problem: DNNs are large (high number of neurons and layers) and involve activation functions which are non-linear and non-convex. These make the problem NP-complete. This thesis should check which tools from https://github.com/ChristopherBrix/vnncomp2022_results can be used to check the robustness of the classifiers proposed in [2]. **Difficulty**: medium **Requirements**: *Programming*: Python, C/C++; *Mathematics*: Computational Logic
5.	Code refactoring	This thesis aims to refactor the code of the Recommendation Engine which plans component-based applications for deployment in the Cloud. The code has being developed in the research projects MANeUveR (https://merascu.github.io/links/MANeUveR.html) and SAGE (https://merascu.github.io/links/SAGE.html). Repositories: https://github.com/Maneuver-PED and https://github.com/SAGE-Project (under release). **Difficulty**: medium **Requirements**: *Programming*: Python, Design Patterns, strong algorithmic skills
6.	Designing a half-semester course on using Formal Methods for Software Engineering	This thesis is a support for a half-semester course and lab for teaching formal methods in Software Engineering for computer science students (Bachelor level) that Mădălina will be introducing in her classes. Among the topics discussed should be Hoare logic and weakest precondition, verification of Java Programs (tentative topics). The thesis should contain relevant examples and case studies both at theoretical and practical level (usage of tools). During the development, we will look into other curricula, presented here: https://fme-teaching.github.io. **Difficulty**: medium **Requirements**: *Mathematics*: Computational Logic; *Programming*: Java

References

[1] M. Eraşcu, F. Micota, and D. Zaharie, 'Scalable optimal deployment in the cloud of component-based applications using optimization modulo theory, mathematical programming and symmetry breaking', *J. Log. Algebr. Methods Program.*, vol. 121, 2021.

[2] A. Postovan and M. Erascu, 'Architecturing Binarized Neural Networks for Traffic Sign Recognition', 2023.

Dr. Marc Eduard FRÎNCU (marc.frincu@e-uvt.ro)

Nr. crt.	Denumire temă	Descriere temă	Specializare AIDC/BigData /IS/Bioinfo/SC
1	Distributed Ensemble Machine Learning	**Description**: The spread of IoT and mobile devices opens the way for a new kind of ML approach in which the learning is performed distributed among devices. This poses several challenges such as synchronization, data sharing, security, and scalability. In this topic, students will explore one more distributed ensemble ML algorithms and analyze their applicability in such a scenario. **Technologies**: Python, ML libraries. **Positions**: 2 The best **results** will be considered for publication in conferences/journals. The **research** is aligned with the theme of the group I currently lead and there will be the opportunity for future part-time employment in upcoming R&D projects.	AIDC/BigData
2	Securitatea modelelor de învățarare automată	**Descriere**: Modele distribuite de învățare sunt vulnerabile din punct de vedere al partajării datelor (inclusiv din modele) între entități care deși colaborează pentru antrenarea unui meta model nu doresc să divulge informațiile private. În cadrul acestei teme, studenții vor realiza o explorare teoretică (studiu al literaturii) pentru identificarea problemelor și vor propune soluții. Aceste soluții vor fi acompaniate de algoritmi demonstrativi (opțional). **Tehnologii**: ML, Python.	SC/AIDC

		Poziții: 1 **Rezultatele** cele mai bune vor fi considerate spre publicare în conferințe/jurnale. Tematica este aliniată grupului de cercetare pe care îl conduc și poate conduce ulterior la poziții de cercetare part-time plătite în cadrul proiectelor noastre R&D.	
3			

1. Florin Fortiș (florin.fortiș@e-uvt.ro)

Nr. crt.	Denumire temă	Descriere temă	Specializare AIDC/BigData /IS/Bioinfo/SC
1	Ingesting VIVO	Dezvoltarea/adaptarea unor mecanisme pentru colectare si import automat a datelor in VIVO, utilizand o abordare bazata pe tehnologii workflow (Camunda, Activiti) Pot fi propuse alte tipuri de teme care vizează sisteme de gestiune a informațiilor bibliografice/științifice.	Toate temele sunt alocabile oricărei specializări Alegerea tehnologiilor se va realiza după ce studenții realizează o analiză inițială a domeniului problemelor/aplicațiilor
2	Wokflow engines & patterns	Realizarea unui studiu comparativ al principalelor solutii de tipul workflow engine (ex. Camunda, Activiti, jBPM, etc.) prin prisma “workflow patterns”. https://github.com/meirwah/awesome-workflow-engines	
3	Limbaje pentru micro-servicii	Realizarea unor studii comparative asupra pricipalelor limbaje/biblioteci pentru micro-servicii (ex. Akka, Vert.x, jolie, etc.), sau abordări care presupun utilizarea unor astfel de tehnologii	
4	Integration patterns/data integration	Realizarea unui studiu legat de Enterprise Integration Patterns și utilizarea acestora. Studiul va acoperi diferite sisteme care facilitează transportul mesajelor (Enterprise Service Bus), cu o atenție deosebită pentru Apache Camel și concepte legate de ‘data integration’. (Enterprise Integration Patterns Designing, Building, and Deploying Messaging Solutions by Gregor Hohpe and Bobby Woolf)	
5	Digital Twins & Digital Threads	Abordările din această categorie de teme vizează diferitele aspecte legate de IoT, WoT și modelarea resurselor asociate. Direcția de studiu se stabilește după o perioadă de documentare, existând posibilități variate de lucru. Resurse de studiu:	

		https://www.w3.org/WoT/ https://ieeexplore.ieee.org/document/9103025 https://www.digitaltwinconsortium.org/glossary/	
6	Teme propuse	Cel mult patru teme la propunerea masteranzilor, cu justificarea încadrării în domeniile temelor anterioare și a nivelului de noutate necesar.	

Teme Lucrări de Disertaţie

Anul universitar 2023-2024

Coordonator: ***lector dr. Mafteiu-Scai Liviu Octavian, liviu.mafteiu@e-uvt.ro***

Nr. crt.	Denumire temă	Descriere temă	Specializare -toate-
1	Rezolvarea paralela a sistemelor de ecuatii liniare folosind metaeuristici	In ultimii ani, pe langa metodele clasice de rezolvare, au fost propuse si validate metode netraditionale, inspirate din inteligenta artificiala (algoritmi genetici, programare genetica, etc). Candidatul trebuie sa propuna si sa implementeze o modalitate de rezolvare a sistemelor de ecuatii (liniare/neliniare) de dimensiuni medii (aprox 1000) folosind o metaeuristica noua sau 3 deja existente	
2	Demonstrarea convergentei algoritmilor evolutivi	Nu exista o demontratie unitara si unanim acceptata decat pentru cateva cazuri particulare Preconditii: cunostinte temeinice de matematica si analiza numerica. Validare experimentala.	
3.	Paralelizarea algoritmilor evolututivi	Stiut fiind ca implementarea seriala a algoritmilor evolutivi nu conduce la solutii eficiente din punct de vedere al timpului de executie, candidatul va trebui sa implementeze variante paralele (MPI, OpenMP) pentru cativa algoritmi evolutivi. Studiu experimental comparativ.	
4	Invatarea automata in educatie	Studiu teoretic, propunere si implementare model (modul de invatare automata intr-un sistem intelligent de instruire (ITS))	

Nume (email) Flavia Micota flavia.micota@e-uvt.ro

Nr. crt.	Denumire temă	Descriere temă	Specializare AIDC/BigData/IS/ Bioinfo/SC
1	Algoritmi de planificare a producției	Realizarea unei aplicații care permite compararea performanțelor a cel puțin doi algoritmi utilizați într-o problemă de planificare a producției într-o fabrică.	AIDC/IS
2	Teme propunere studenti	Maxim 2-3 teme	

Cristina Mindruta (cristina.mindruta@e-uvt.ro)

Nr. crt.	Denumire temă	Descriere temă	Specializare IACD, AIDC, IS, BigData, BioInf, SC
1	Suport cloud pentru arhitecturi de aplicații bazate pe evenimente	Se vor analiza serviciile cloud oferite de diverși furnizori pentru rularea aplicațiilor construite în arhitecturi bazate pe evenimente.	IS
2	Performanța în arhitecturile cu microservicii	Se va analiza atributul de calitate performanță pentru diferite arhitecturi cu microservicii și se vor căuta soluții de îmbunătățire a acestuia.	IS
3	Modificabilitatea în arhitecturile cu microservicii	Se va analiza atributul de calitate modificabilitate pentru diferite arhitecturi cu microservicii și se vor căuta soluții de îmbunătățire a acestuia.	IS
4	Securitatea în arhitecturile cu microservicii	Se va analiza atributul de calitate securitate pentru diferite arhitecturi cu microservicii și se vor căuta soluții de îmbunătățire a acestuia.	IS
5	Toleranța la defecte în arhitecturile cu microservicii	Se va analiza atributul de calitate toleranță la defecte pentru diferite arhitecturi cu microservicii și se vor căuta soluții de îmbunătățire a acestuia.	IS
6	Temă stabilită în colaborare cu studenta/studentul		IS

Onchis Darian (darian.onchis@e-uvt.ro)

Nr. crt.	Denumire temă	Descriere temă	Specializare IACD, AIDC, IS, BigData, BioInf, SC
1.	Dezvoltare de modele de învățare automată neuro-simbolice	Se vor dezvolta noi metode de inteligență artificială care combină rețele neuronale, care extrag structuri statistice din fișiere de date brute cu reprezentări simbolice ale problemelor și cu folosirea logicii. Mai multe informații: https://arxiv.org/abs/2305.03063	AIDC, BigData
2.	Încorporarea de tehnici de inteligentă artificială în dezvoltarea unui campus virtual	În cadrul proiectului UNITA, în care UVT este partner, se dorește dezvoltarea unui campus virtual. Pentru această platformă, se vor dezvolta tehnici de AI cum are fi translation chatbots, automated academic path selection, etc.	IACD, AIDC, IS, BigData, SC
3.	Dezvoltare de metode de învățarea automată incrementală	Se dorește dezvoltarea unor metode de învățare automată incrementală pentru task-uri de Computer Vision în care să fie atenuat fenomenul de uitare catastrofală. Colaborare cu CEA Paris.	Toate
4.	Algoritmi XAI de inteligență artificială explicabilă	Utilizarea pe seturi de date și îmbunătățirea algoritmilor LIME, SHAP, Anchors, DeepLift, DeepTaylor, GradCAM etc. Vezi website-ul xaion.uvt.ro pentru exemple de competiții de inteligență artificială explicabilă.	Toate
5.	Machine Learning with Docker and Kubernetes	Scopul nostru va fi să folosim Kubernetes pentru a încarca datele de antrenament stocate în GitHub, a antrena un model de învățare automată, a serializa modelul și a-l stoca în afara clusterului. Pentru a stoca datele în afara cluster-ului nostru, am putea folosi diferite	IACD, AIDC, IS, BigData, SC

		locații, cum ar fi un cloud public, un cloud privat sau local. Tehnologii: Kubernetes, Docker, Python și Scikit-Learn	

1. **PETCU Dana (Dana.Petcu@e-uvt.ro)**

Nr. crt.	Denumire temă	Descriere temă	Specializare AIDC/BigData /IS/Bioinfo/SC
1	Cognitive Cloud Continuum Applications	• Cognitive cloud continuum – investigation of approaches and current applications • Design and implementation of a novel proof-of-concept application that uses Cloud, IoT and adaptation	AIDC
2	Engineering the Cloud Continuum	• Cloud continuum – investigation of engineering requirements • Design and implementation of a novel proof-of-concept application that uses DevOps in Cloud Continuum	IS
3	Monitoring of streaming applications	• Investigate the approaches of monitoring applications • Investigate the available streaming applications and their internal or external monitoring features • Design and implement a novel streaming application with monitoring features with low intrusion overhead	BigData

Subiecte de disertație 2023-2024

Specializarea: Informatică

Coordonator: Conf. dr. ing. Ciprian Pungilă (ciprian.pungila@e-uvt.ro)

Nr	Tema	Detalii	Specializare
1	Review/study of pattern-matching algorithms on heterogeneous CPU/GPU systems	Analiza și implementarea a cel puțin 5 algoritmi diferiți pentru regăsirea de șabloane (texte) pe CPU și GPU (CUDA sau OpenCL). Realizarea unui profil de performanță a algoritmilor testați. Evidențierea domeniilor de interes pentru acest tip de algoritmi. Analiza posibilității implementării algoritmilor în arhitecturi eterogene CPU/GPU. Opțional: propunerea unui algoritm propriu pentru pattern-matching, și compararea acestuia (ca nivel de performanță) cu cele existente. Cunoștințe necesare: structuri de date avansate, algoritmică, calcul paralel.	Securitate cibernetică, Big data, IS
2	Review/study of static and/or dynamic data analysis methods for threat detection/mitigation in intrusion detection systems.	Analiza metodelor recente de analiză statică și/sau dinamică, folosite în mod activ în detecția programelor malițioase (e.g. trojans, viruses, etc.) sau în sistemele de detecție a intrușilor (e.g. firewalls, packet sniffers, etc.). Evidențierea metodelor de detecție și contextul aplicării acestora în sistemele de detecție a intrușilor. Analiza performanțelor metodelor selectate și compararea acestora sub formă de studiu bibliografic. Opțional: Propunerea unei metode proprii de analiză statică și/sau dinamică pentru sistemele de detecție a intrușilor. Cunoștințe necesare: structuri de date avansate, algoritmică, calcul paralel.	Securitate cibernetică, Big data, IS
3	Review/study of static and dynamic data analysis in digital forensics.	Analiza metodelor de analiză statică și/sau dinamică de date pentru investigații digitale. Compararea performanțelor acestora sub formă de studiu bibliografic (cu implementarea cel puțin a unui algoritm din cele studiate). Studiul fezabilității aplicării metodelor în diverse contexte: reconstrucția imaginilor, recuperarea datelor, reconstrucția formatelor video, etc. Opțional: propunerea și implementarea unui algoritm propriu pentru analiză statică și/sau dinamică de date în contextul ales (cu compararea performanțelor sale cu cele existente).	Securitate cibernetică, Big data, IS

		Cunoștințe necesare: structuri de date avansate, algoritmică, calcul paralel.	
4	Review/study of static analysis applied to biometric forensics. Case-study: DNA analysis through pattern-matching techniques.	Analiza metodelor de analiză statică pentru investigații biometrice. Compararea performanțelor acestora în diverse contexte și sub diverse abordări (e.g. folosind expresii regulare simple, complexe sau ambele), sub formă de studiu bibliografic (cu implementarea cel puțin a unui algoritm din cele studiate). Opțional: propunerea, formalizarea și implementarea unui algoritm propriu de analiză statică, cu sau fără suport pentru expresii regulate. Cunoștințe necesare: structuri de date avansate, algoritmică, elemente de bază de bioinformatică.	Securitate cibernetică, Big data, Bioinformatică, IS
5	Review/Proposal of techniques for a) ensuring blockchain-based smart-contract execution safety (Proof of Execution), b) malicious behavior detection in blockchain-based smart-contracts, c) detection of blockchain-driven financial fraud (money laundering, Ponzi scheme, wash trading, market manipulation, etc.), d) static analysis of blockchain-driven smart-contracts for tracking design faults, bugs, etc.	Două abordări posibile: 1) o lucrare de sinteză a abordărilor existente în literatura de specialitate, sau 2) o propunere/abordare nouă, proprie masterandului, pentru (se alege un singur topic): a) Proof of Execution: garanția execuției cu succes a unui contract inteligent în tehnologia blockchain b) detecția comportamentului malițios în contractele inteligente din tehnologia blockchain c) detecția fraudelor financiare în tehnologia blockchain (spălarea de bani, scheme Ponzi, wash trading, manipularea pieței, etc.) d) analiza statică a contractelor din tehnologia blockchain pentru identificarea problemelor de design, a bug-urilor, etc. Cunoștințe necesare: structuri de date avansate, algoritmică, elemente fundamentale de baze de date.	Securitate cibernetică, Big data, Bioinformatică, IS

1. Sancira Monica (monica.tirea@e-uvt.ro)

Nr. crt.	Denumire temă	Descriere team	Specializare IACD, AIDC, IS, BigData, BioInf, SC
1.	Aplicatii ale sistemelor inteligente – Analiza evolutiei pietelor de capital/ Analiza evolutiei Bitcoin Intelligent Systems based on Stock Market Analysis/ Bitcoin Analysis	Lucrarea trebuie sa cuprinda: • Studiul teoretic al modelelor si metodelor aferente analizei tehnice si seriilor de timp, retele neuronale • Descriere aplicatie. Teste. Comparatii Deprinderi: Inteligenta artificiala, Algoritmi	IACD, AIDC, IS, BigData, SC
2.	Sistem de analiza a datelor non-structurate de tip text Text Mining ans Statistical Analysis for Non-Structured Text Data • Mining the Social Web News Articles	Lucrarea trebuie sa cuprinda: • Studiul teoretic al modelelor si metodelor aferente analizei textului • Descriere aplicatie. Teste. Comparatii Deprinderi: Programare, Algoritmi de prelucrare a textului, Algoritmi de analiza a datelor	IACD, AIDC, IS, BigData

3.	Sistem de analiza a riscului aplicat asupra unei investitii pe piata de capital Financial Risk Management System	Lucrarea trebuie sa cuprinda: • Studiul teoretic al modelelor si metodelor aferente analizei riscului • Descriere aplicatie. Teste. Comparatii Deprinderi: Programare, Algoritmi de analiza a riscului, Algoritmi de analiza a optimizarii unui portofoliu de investitii, Inteliganta artificiala, Probabilitati si statistica	IACD, AIDC, IS, BigData
4.	Sistem de recomandare pentru: • Turism • Transport • Optimizare portofoliu de actiuni/bitcoin Recommendation System for: • Tourism • Transport Portfolio optimization	Lucrarea trebuie sa cuprinda: • Studiul teoretic al modelelor si metodelor aferente analizei tehnice si seriilor de timp • Descriere aplicatie. Teste. Comparatii Deprinderi: Programare, Metode de recomandare, Algoritmi de determinare a drumului cel mai scurt, Algoritmi de analiza a optimizarii unui portofoliu de investitii, Inteliganta artificiala, Probabilitati si statistica	IACD, AIDC, IS, BigData
5.	Alte subiecte pot fi acceptate la propunerea studentului Other topics could be accepted based on student's proposal		IACD, AIDC, IS, BigData, BioInf, SC

Spătaru Adrian (adrian.spataru@e-uvt.ro)

Nr. crt.	Denumire temă	Descriere temă	Specializare IACD, AIDC, IS, BigData, BioInf, SC
1.	Componente pentru un Cloud descentralizat	*Scop:* Crearea unor componente ale unui sistem distribuit, descentralizat, care monitorizează și aplică politici pentru servicii Cloud care rulează pe calculatoare personale participante în rețea. *Implementare:* algoritmi distribuiți, blockchain, criptografie, trusted execution environments *Obs:* Temă de cercetare, max 3 studenți	AIDC, IACD, SC
2.	Aplicații Big Data	*Scop:* Crearea de aplicații care agregă date din mai multe surse (structurate și nestructurare) și extrag informații de o calitate superioară prin comparație cu informațiile extrase fără agregare. *Implementare:* Tehnologii BigData (Hadoop, Spark) *Obs:* Propunerile de aplicație sunt făcute de studenți. Max 3 studenți	AIDC, IACD, Big Data

1. **Zaharie Daniela – daniela.zaharie@e-uvt.ro**

Nr. crt.	Denumire temă	Descriere temă	Specializare AIDC, IS, BigData, BioInfo, SC
1	Ensembles of Deep Neural Networks for Image Semantic Segmentation / Ansamble de rețele neuronale cu structură adâncă pentru segmentare semantică a imaginilor	*Context:* Ensembles of machine learning models are collections of several models trained such that they allow the increase of the generalization ability of the aggregated model. Currently there are different ensembling strategies (bagging, boosting, stacking) which can be combined with different data mining models, including deep neural networks. They are state-of-the-art methods, but their performance is influenced by the characteristics of the component models and of the aggregation strategy. On the other hand, semantic segmentation refers to the task of assigning labels to each pixel in an image in such a way that regions corresponding to different objects/entities (e.g. different land usage in a satellite image, different types of cells in microscopic image, different organs in a medical image etc.). Semantic segmentation is a supervised classification task which can benefit of the ensembling of several deep learning models. *Aim:* Analyze several ensembling strategies in the context of semantic segmentation using as component models some state-of-the-art deep learning architectures for semantic segmentation (e.g. U-Net, ResNet, DeepLabV3, ConvLSTM etc.) and testing them for a semantic segmentation task (at your choice). *References:* 1. S. Akodad, S. Vilfroy, L. Bombrun, C. C. Cavalcante, C. Germain and Y. Berthoumieu, ”An ensemble learning approach for the classification of remote sensing scenes based on covariance pooling of CNN features,”, 27th European Signal Processing Conference (EUSIPCO), 2019. 2. W. Bousselham et al., Efficient Self-Ensemble for Semantic Segmentation, 2022 3. P. Iyer, A. Sriram, S. Lal, “Deep Learning Ensemble Method for Classification of Satellite Hyperspectral Images”, Remote Sensing Applications: Society and Environment, 2021. https://github.com/shyamfec/DL-Ensemble-Method	AIDC, Big Data

		4. G.Huang, Y. Li, G. Pleiss, Z. Liu, J.E. Hopcroft, K.Q. Weinberger, "Snapshot Ensembles: Train 1, get M for free", ICLR 2017. 5. L. Nanni et al., An Empirical Study on Ensemble of Segmentation Approaches, Signals, 2022	
2	Machine Learning Methods for Predictive Maintenance / Metode de învățare automată pentru estimarea activităților de mentenanță	*Context:* Usually, in production environments are collected monitoring data that reflect how the production equipments work. Such data can be used to predict potential failures, thus they could be exploited to construct models aiming to predict the risk of machine faults, and to assist the decision in the context of Predictive Maintenance (which refers to maintenance activities which are executed before a fault appears). *Aim:* Implementation and analysis of various machine learning models trained to predict risk of failure or to estimate appropriate date of maintenance activity such that the downtime and associated costs are minimized. *References:* ***1.*** Susto, G. A., Schirru, A., Pampuri, S., McLoone, S., & Beghi, A. (2015). Machine Learning for Predictive Maintenance: A Multiple Classifiers Approach. IEEE Transactions on Industrial Informatics, 11(3), 812-820. 10.1109/TII.2014.2349359 ***2.*** T.P. Carvalho et al., A systematic literature review of machine learning methods applied to predictive maintenance, Computers & Industrial Engineering, 2019 ***3.*** O. Merkt, On the Use of Predictive Models for Improving the Quality of Industrial Maintenance: an Analytical Literature Review of Maintenance Strategies, 2019 ***4.*** Y. Ran, A Survey of Predictive Maintenance: Systems, Purposes and Approaches, 2019	AIDC, BigData, IS
3 - 5	Graph Neural Networks/ Retele neuronale pentru procesarea datelor de tip graf	*Context:* Graph Neural Networks (GNN) are models aiming to process graph like data (unlike standard neural networks which are designed to process vectorial data), i.e. data which describes interactions between entities (e.g. molecule structures, social networks communication patterns). In the case of graph data the features might be related to nodes, edges or the entire graph and the GNN extracts these features by aggregating information corresponding nodes and edges. GNNs have been used in designing recommender systems, natural language processing, discovering molecular structures (e.g. for new	AIDC, Big Data, SC, Bioinformatică

	(up to 3 topics – depending on the application: scheduling, molecular structure prediction, botnet detection)	antibiotics), botnet detection (Ref 5), combinatorial optimization (Ref 4) etc. In the context of optimization problems, GNNs are used to represent problem instances and guide the search process of heuristics toward feasible/high-quality solutions. *Aim:* Study of current GNN architectures, design and implementation of a variant corresponding to a practical problem (e.g. combinatorial optimization problems like planning/scheduling (Ref 4)). *References:* 1. J. Zhou, Graph neural networks: A review of methods and applications, 2018, https://arxiv.org/abs/1812.08434 2. W.L. Hamilton, Graph Representation Learning, 2020, https://www.cs.mcgill.ca/~wlh/grl_book/ 3. Z. Zhang et al. Deep Learning on Graphs: A Survey, IEEE TRANSACTIONS ON KNOWLEDGE AND DATA ENGINEERING, VOL. 34, NO. 1, 2022, https://arxiv.org/abs/1812.04202 4. Q. Cappart et al., Combinatorial Optimization and Reasoning with Graph Neural Networks, 2021, https://arxiv.org/pdf/2102.09544.pdf 5. J. Zhou et al., Automating Botnet Detection using GNNs, 2020, https://arxiv.org/pdf/2003.06344.pdf 6. Libraries: https://www.dgl.ai/ , https://github.com/openai/gym	
6	Fitness Landscape Analysis using Complex Networks / Analiza suprafeței funcției obiectiv utilizând rețele complexe	*Context:* One of the key issues in understanding the behaviour of optimization methods (particularly population-based metaheuristics) is to be able to collect information about the fitness landscape and to adapt the search process to it. In the last years there have been proposed different methods to analyze the way a metaheuristic „visits" the search space and, consequently, can collect information on the fitness landscape. Some of these approaches rely on the construction of complex networks and on using tools specific to the analysis and visualization of complex networks. *Aim:* Analyze and extend the approach proposed in Ref.1 in order to better understand and compare the behaviour of two metaheuristic algorithms (e.g. Particle Swarm Optimization and Differential Evolution). *References:*	AIDC

		1. G. Ochoa, K. Malan, Christian Blum (2021) Search trajectory networks: A tool for analysing and visualising the behaviour of metaheuristics, *Applied Soft Computing, 2021* 2. B. Yazmir, M. Shir, Toward an ImageNet Library of Functions for Global Optimization Benchmarking, 2022 3. M. Kerschke, M. Preuss, Exploratory Landscape Analysis, Tutorial GECCO 2019 4. K. Malan, A Survey of Advances in Landscape Analysis for Optimisation, Algorithms, 2021 5. Resources: https://github.com/gabro8a/STNs	
7	Metaheuristic Algorithms for Scheduling Problems / Algoritmi metaeuristici pentru probleme de planificare	*Context:* Production planning or job scheduling lead to difficult combinatorial optimization problems which require the usage of heuristics or metaheuristics to obtain schedules (not necessarily optimal) in a resonable amount of time. Depending of the characteristics of the jobs to be executed and of the working environment, there are several classes of scheduling problems which are different with respect to the precedence constraints on the execution of different operations and with respect to the way the operations are assigned to the machines/workstations on which they can be executed: flowshop, (flexible) jobshop, (flexible) assembly scheduling etc. For each class of problems there have been proposed different approaches but it is still difficult to identify an appropriate method without testing/comparing several approaches. *Aim:* Implement a software platform (Python + Cython) which allows to specify all characteristics of the scheduling problem, select the encoding and the metaheuristic to be used. The platform should allow the comparison between different strategies. *References:* 1. W. Lin, An effective algorithm for flexible assembly job-shop scheduling with tight job constraints, Intl. Trans. in Op. Res. 29 (2022) 496–525 DOI: 10.1111/itor.12767, 2022 2. S. Zhang et al, Multi-objective optimisation in flexible assembly job shop scheduling using a distributed ant colony system, 2020 3. N. V. Thieu, S. Mirjalili, MEALPY: An open-source library for latest meta-heuristic algorithms in Python, Journal of Systems Architecture, 2023 4. Resources: https://pypi.org/project/mealpy/	AIDC, Big Data, IS

8	Hyper-parameter Adaptation in Metaheuristic Algorithms using Machine Learning / Adaptarea hiper-parametrilor algoritmilor metaeuristici utilizând învățare automată	*Context:* Most of metaheuristic algorithms require the usage of some control parameters, but their choice is not trivial. Therefore different automatic algorithm configurations relying on systematic search of the parameter space have been implemented (see for instance https://www.cs.ubc.ca/labs/algorithms/Projects/SMAC/) . On the other hand, different adaptive strategies have been proposed, most of them being based on some probabilistic distributions constructed using historical data concerning the performance of the algorithm. Recently, there is a high interest in using machine learning tools, particularly reinforcement learning, to predict values of the control parameters that are appropriate for a specific stage of the search. *Aim:* Conduct a comparative study on several control parameters adaptation strategies (based on reinforcement learning). *References:* 1. Reijnen, R., Zhang, Y., Bukhsh, Z., & Guzek, M. Deep Reinforcement Learning for Adaptive Parameter Control in Differential Evolution for Multi-Objective Optimization. In The 2022 IEEE Symposium Series on Computational Intelligence (IEEE SSCI) IEEE Press. 2. M. Sharma et al., Deep Reinforcement Learning Based Parameter Control in Differential Evolution, GECCO 2019 3. J. Sun et al, Learning Adaptive Differential Evolution Algorithm from Optimization Experiences by Policy Gradient, 2021 4. Software tools for automatic algorithm configuration: https://www.cs.ubc.ca/labs/algorithms/Projects/SMAC/ https://www.ml4aad.org/automated-algorithm-design/performance-prediction/epms/ 5. Parameter adaptation with Double Duelling Q Network: https://github.com/mudita11/DE-DDQN	AIDC, Big Data
9	Topics related to data mining - proposed by students	If you have a dataset and you want to analyze it by applying data mining tools please send a short description of the dataset and of the problem to daniela.zaharie@e-uvt.ro	AIDC, Big Data, SC, IS, Bioinformatica