SPECIALIZED COURSES AND SEMINARS offered for the Academic Year 2021/2022

SEMINARS on Scientific Research Writing (10 hours).

Teacher: Prof. Antonietta Bagnardi (antonietta.bagnardi@uniba.it)

SPECIALIZED COURSES of Computer Science offered for the Academic Year 2021/2022

Advanced Machine Learning Techniques for Cyber Defence (3 CFU - 24 hours)

Teachers: Dr. Giuseppina Andresini (giuseppina.andresini@uniba.it)
Prof. Annalisa Appice (annalisa.appice@uniba.it)

Course Schedule: not yet defined. The course is planned in June 2022.

Course description
With the growing processing power of computing systems and the increasing availability of massive datasets, along with novel concepts and architectures for Deep Learning (DL), Machine Learning (ML) algorithms have led to major breakthroughs in many different areas including cybersecurity. Nowadays ML, and in particular DL, has become one of the key enablers to studying and addressing cybersecurity-relevant problems at large in several application domains such as for intrusion detection, malware detection and spam detection. However, it is important to consider that ML can be used also by attackers to continually improve their techniques and refine their offensive capabilities. Studying the effectiveness of ML is thus critical to ensure modern cybersecurity equipped to face the emerging threats allowed by malicious uses of ML. In this course we will showcase several examples of recent progress in applying ML and DL into cyber-threat detection problems. We will describe several supervised and unsupervised DL architectures recently adopted in threat detection and classification. We will introduce the most recent ML techniques for handling specific challenges like zero-day attacks, imbalanced data, concept drift on evolving data, explainability of decisions. We will introduce the concept of adversarial learning and present some techniques to protect the system against the adversarial attack (e.g., adversarial training, defense distillation). Finally, we will provide a glimpse into exciting future directions that promise to have a profound impact on cybersecurity.

Exam Modality:
Two alternatives are available to the student to pass this exam:

1) Paper presentation. Students will illustrate 1 paper suggested by the teachers by discussing novelties and issues and identifying possible relationships with their research projects. No groups are allowed
2) Project. Students will implement and experimentally validate a ML technique for cyber-defence suggested by the teachers. Projects can be done in groups of 1-3 students, depending on the complexity of the technique.

Automatic Multistrategy Reasoning (3 CFU, 24 hours)

Teachers: Prof. Stefano Ferilli (stefano.ferilli@uniba.it),
Dr. Domenico Redavid (domenico.redavid@uniba.it)

Course Schedule: not defined yet. The course is planned in Feb-Mar 2022

Course description
After the boost of research in sub-symbolic Artificial Intelligence approaches, notably Deep Neural Networks, a new awareness is arising that, at least for critical applications, AI systems must be able to explain their decisions. Norms and regulations are being issued that call for this feature. Explainable AI (XAI) is the branch of research aimed at ensuring this requirement.

The best way for explaining a decision is being able to trace back the reasoning carried out to reach that decision. This is quite straightforward for symbolic AI applications, that work by applying the same high-level inference strategies applied by humans. There are different such strategies, useful for different purposes. Complex problems require powerful reasoning mixing and combining these different strategies.
This course will introduce and describe the inferential strategies that have been more deeply investigated in the literature, along with their basics, implemented systems and possible applications thereof: Deduction (aimed at making explicit information that is only implicitly present in the knowledge base), Induction (at the basis of learning), Abstraction (aimed at simplifying descriptions in order to improve efficiency), Abduction (aimed at tackling missing information), Argumentation (aimed at tackling conflicting information), Probabilistic Reasoning (aimed at tackling uncertain information), Ontological reasoning (aimed at inferring information by inheritance and at consistency checking), Analogy (aimed at transferring information across different domains)

Exam Modality
Two alternatives are available to the student to pass this exam:
1. Paper presentation. Students present the content of 2 papers suggested by the teacher. No groups are allowed.
2. Project. Students implement and experimentally validate an algorithm or its variation from a paper suggested by the teacher. Projects can be done in groups of 1-3 students, depending on the algorithm.

Co-Design of ML-mediated Crowd Sensing Experiences for the Citizen Science (2 CFU, 16 hours)

Teacher Dr. Marco Zappatore

Course Schedule: not defined yet. The course is planned in Mar-Apr 2022

Course description:
Citizen Science (CS) is a fast-growing paradigm that supports the involvement of the general public into scientific research tasks, usually under the guidance of professional scientists. In the majority of cases, the participation of citizens is enabled by supplying them with dedicated mobile apps, according to the Scientific Mobile Crowd Sensing (SMCS) approach. However, the collaboration between scientists and citizens is often matter of debate and achieving a reliable scientific quality requires considering carefully a series of aspects, which range from data quality to adopted methods and models. Moreover, the role of Machine Learning (ML) in CS is gaining momentum (as a way to improve the effectiveness of CS activities) and it should be considered as a significant component of this scenario.
Therefore, this course will address, during its first part, the analysis of core design principles, theoretical bases and typical approaches in CS, along with the contribution of SMCS. Then, in the second part, the role of ML techniques will be examined, by considering opportunities and challenges of the human-to-machine interaction in CS. A cross-disciplinary, multi-criteria examination of successful CS projects deployed worldwide will be proposed: types and purposes of ML solutions applied in those projects will be discussed, as well as the importance of targeting algorithm fairness in CS so that explainable, interpretable and transparent approaches can be used.
In the final part of the course, the participants will be introduced to a set of reference scientific papers on CS and, starting from them, they will be required to co-design a fair, ML-based CS experience that could be applied to a scientific research area at their choice.

Exam Modality
Project: the students, organized into groups of 1-3 components, will be required to co-design a FAIR (Findable, Accessible, Interoperable, Reusable), ML-based CS experience suitable for a scientific research area of their choice. The groups will present the design outcomes during the last lesson of the course.

Deep Learning for Natural Language Processing (3 CFU, 24 hours)

Teachers: Dr. Marco Polignano (marco.polignano@uniba.it),
Dr. Pierpaolo Basile (pierpaolo.basile@uniba.it)

Course Schedule: not defined yet. The course is planned in Feb-Mar 2022

Course description
The recent years have witnessed a surge of interest in knowledge discovery from natural languages through machine learning techniques. The intent of Natural Language Processing (NLP) or computational linguistic area is to study algorithms and methods for building computational models that can analyze natural languages for performing useful tasks like enabling communication between humans and machines, improving communication among humans or simply doing the processing of text or speech. In order to resolve ambiguity in the discovered linguistic knowledge various NLP tasks e.g. POS, NER, SBD, word sense disambiguation and word segmentation are carried out using machine learning and deep learning models.
The course will cover the main topics concerning Deep Learning (DL) for Natural Language Processing (NLP) approaches and techniques. Basics concepts of NLP will initially be provided: text normalization, tokenization, pos-tagging, parsing, and linguistic levels of analysis. Basic notions will be followed by the explanation of text representation models useful for DL architectures, such as word/sentence embedding, and contextualized embeddings based on state-of-the-art large language models such as BERT. Several deep learning architectures will be explained: classical neural language model, Convolutional Neural Network (CNN), Recurrent Neural Networks (RNN), LSTM/GRU, attention level, and Transformer. Finally, applications in text classification, sentiment analysis, named entity recognition, question answering will be presented. Theoretical lessons will be integrated by practical sessions using Python and Google Colab as developing environment.

Exam Modality:
project

Explainable Artificial Intelligence (2 CFU - 1 lectures, 1 practice - 23 hours)

Teacher: Prof. Corrado Mencar (corrado.mencar@uniba.it)

Course Schedule: not defined yet. The course is planned in May-Jun 2022

Course description:
Artificial Intelligence has pervaded our daily lives with an overwhelming number of technological artifacts that are changing the way we approach problems. Unsurprisingly, the European Commission has recognized AI as one of the most strategic technologies of our century. But, like all technological revolutions, AI comes at a price, and people must decide whether they want to be effectively assisted by AI and under what conditions.
There are many situations where the introduction of AI technologies cannot be done lightly. For example, is a judgment partially determined by AI-based decisions the result of due process? What is the scientific value of an AI system that can predict a physical phenomenon? These are just a few of the thorny questions that are driving the scientific, policy, and other institutional communities toward responsible AI adoption when automated decisions have far-reaching impacts.
One of the characteristics invoked for AI systems that make critical decisions is explainability, i.e., people need to understand why a decision was made and how reliable it is. eXplainable Artificial Intelligence (XAI) is an attempt to evolve AI methodologies and technology by focusing on the development of agents capable of both generating decisions that a human could understand in a given context, and of explicitly explaining those decisions.
The course will give an overview of XAI, with the goal of understanding what is meant by explainability and why it is so important in Computer Science. The main challenges that characterize the design of XAI systems will be briefly presented and some successful cases will be illustrated. In fact, XAI system design requires a careful rethinking of all the typical phases of intelligent system development: people

must be at the center of every design decision. Finally, since XAI research is young and flourishing, some promising research directions will also be summarized.

Exam Modality
Two alternatives are available to the student to pass this exam:
1) Paper presentation. Students present the content of 1-2 papers suggested by the teacher. No groups are allowed.
2) Project: Students work on an experimental project provided by the teacher. Groups may be allowed

---

Formal Methods for Socio-Technical Security (2 CFU, 16 hours)

Teacher: Prof. Luca Viganò (luca.vigano@kcl.ac.uk)

Course Schedule: not defined yet. The course is planned in Jun-Jul 2022

Course description
Experience over the last thirty years has shown that the design of protocols and services for Internet security is highly error-prone and that conventional validation techniques based on informal arguments and/or testing are not up to the task. It is now widely recognized that only formal analysis can provide the level of assurance required by both the developers and the users of the protocols and services. This is especially true not only when one considers the automated reasoning techniques and tools that have been proposed for the analysis of Internet security protocols (like Kerberos, IKE, or TLS) but also when one considers security ceremonies, which are extensions of protocols to explicitly consider the presence of human user. I is not enough to consider the security of technical systems (built only from software processes, communication protocols, crypto algorithms, etc.), but one needs to consider the security of socio-technical systems with people at their hearts.
In this course, Luca will provide an overview of how formal methods can be successfully applied for the analysis of socio-technical security.

Exam Modality
To be defined

Linked Data (3 CFU - 2 lectures, 1 practice - 31 hours)

Teacher: Dr. Miguel Ceriani (miguel.ceriani@uniba.it)

Course Schedule: not defined yet. The course is planned in Apr-May 2022

Course description
From the original web of documents, a web of data has emerged, composed of structured information from a variety of sources, including governmental entities, community-curated resources, research products, and user-generated content.
Achieving interoperability at web scale is now crucial, as an increasing number of applications rely on data from multiple distributed data sources.
The linked data initiative, in some way evolution of the semantic web idea, proposes a decentralized solution to the interoperability requirement, where data can be shared using a common basic data model (RDF) on top of which different communities define their own vocabularies.
In this course the main relevant standards and technologies are presented, including RDF(S), basics of OWL, the query language SPARQL, web API protocols (Graph Store Protocol, Graph Store Protocol, LDP, Solid), mapping languages (R2RML, RML).
Tools for managing linked data are presented, with a focus on the research of user interfaces to explore, query, update, and transform linked data.

Exam Modality: either discussion of relevant papers suggested by the teacher or a group project involving usage of some of the techniques presented in the course.

Practicing the User-Centred Design Sprint (2 CFU - 1 lectures, 1 practice - 23 hours)

Teacher: Prof. Marta Larusdottir (marta@ru.is)

Course Schedule: not defined yet. The course is planned in Apr-May 2022

Course description
Developing software systems is a complex task. Especially, if the idea for the system is brand new, and a similar system has not been developed before by the development team. A user-centred design sprint (UCDS) process has been developed by Marta Larusdottir and colleagues [1]. The objective of the process is to assist development team members to understand the users and their needs. Additionally, the objective is to assist the development team members in understanding how the particular software system could help the users to achieve their goals with a good user experience.
The course will introduce the User-Centred Design Sprint process, and participants will practice the methods from the process during the course. By the end of the course, participants will have gained skills in involving users for understanding the context of use, designing according to their needs and evaluating the designs. The participants will also discuss why, when and how to use User-Centred Design Sprint.

Exam Modality
Project. It includes both individual and group work activities to design an application according to the UCDS approach.

Process Mining (2 CFU, 16 hours)

Teacher: Dr. Pasquale Ardimento (pasquale.ardimento@uniba.it)

Course Schedule: not defined yet. The course is planned in May 2022

Course description
The course will introduce the core analysis techniques in process mining that allow users to automatically learn process models from raw event logs (process discovery) and check if reality, as recorded in the event logs, conforms to the models and vice versa (conformance checking). In the context of process discovery and conformance checking, well-established techniques available in the literature will be presented, as well as more recent advances that are currently investigated in the process mining community, such as process mining with declarative specifications or BPMN. In addition, the course will discuss how recent process mining techniques suggested by the University can be employed to enhance software development practices, by assessing efficiency and unveiling unknown process insights, thus, contributing to the creation of novel models within the software development analytics realm. Finally, the course will provide easy-to-use software, real-life data sets, and practical skills to directly apply the theory in a software development domain but also in a variety of application domains.

Exam Modality
Two alternatives are available to the student to pass this exam:
1) Paper presentation. Students present the content of 2 papers suggested by the teacher. No groups are allowed.
2) Project. A short project on process mining with which the participants must demonstrate the ability to put into practice the activities illustrated or carried out during the course. Projects to be held individually or in a group of a maximum of 3 students.

Transfer Learning (2 CFU, 16 hours)

Teacher: Dr. Paolo Mignone (paolo.mignone@uniba.it)

Course Schedule: not defined yet. The course is planned in Mar-Apr-Mar 2022

Course description
Machine learning and data mining techniques have been used in numerous real-world applications. Traditional machine learning methods assume that the data are taken from the same domain, such that the input feature space and data distribution characteristics are the same. However, in some real-world machine learning scenarios, this assumption does not hold. There are cases where training data is expensive or difficult to collect. Therefore, there is a need to create high-performance learners trained with more easily obtained data from different domains. This methodology is referred to as transfer learning. In this course, we will cover advanced topics in transfer learning that allow us to achieve such results, including i) homogeneous transfer learning; ii) heterogeneous transfer learning; iii) multi-task learning. Furthermore, the setting of transfer learning raises the problem of handling a huge amount of data coming from different sources. Therefore, the analysis of iv) big data analytics methods will be covered by considering distributed transfer learning methods that could be fruitfully considered to handle big data. For each topic, we will analyze relevant code and create a channel for discussions of papers among participants.

Exam Modality
Students implement and experimentally validate an algorithm or its variation. Projects can be done in groups of 1-3 students, depending on the algorithm. (Teacher(s) may choose other modalities)

SPECIALIZED COURSES of Mathematics offered for the Academic Year 2021/2022

Control of Degenerate and Singular Parabolic Equations (2 CFU, 16 hours)

Teacher: Prof. Genni Fragnelli (genni.fragnelli@uniba.it)

Course Schedule: not defined yet. The course is planned in Feb-Mar-2022

Course description
Controllability issues for parabolic problems have been a mainstream topic in recent years, and several developments have been pursued: starting from the heat equation in bounded and unbounded domain, related contributions have been found for more general situations. In details: given an initial condition, the associated equation is said to be null controllable at time $T>0$ if there exists a control such that the solution u of the associated problem satisfies $u(T) \equiv 0$ in the space domain. Due to degeneracy or singularity, classical null controllability results do not hold in general. Thus, a good notion is the so called 'regional null controllability': we can drive the solution to rest at time T on a subset of the space domain, contained in the set where the equation is nondegenerate. However, the notion of global null controllability is stronger than the regional one and in general it is the useful one. A common strategy in showing this type of controllability is to prove that certain global Carleman estimates hold true for the operator which is the adjoint of the given one, and, from them, to find related observability inequalities for the solution of the initial problem. In this course we follow this approach, focusing on some classes of degenerate and/or singular parabolic operators. The interest in this kind of equations is due to the fact that many problems coming from Physics, Biology, and Mathematical Finance are described by parabolic equations which admit these types of degeneracy and/or singularities.

Exam Modality:
The student will present a paper between two papers suggested by the teacher. No groups are allowed.

Joint numerical and spectral radii for tuples of operators – a non-commutative probability approach (2 CFU, 16 hours)

Teacher: Prof. Janusz Wysoczanski (jwys@math.uni.wroc.pl)

Course Schedule: not defined yet. The course is planned in Apr-May 2022

Course description
The aim of this mini course is to get the audience familiar with the concepts of joint numerical radius and joint spectral radius defined for tuples of operators.
The fundamental work for this is the paper by Gelu Popescu [1], in which he formulated these notions in relation with the toy model of free probability, using the free creation operators on the full Fock space. In the joint work with Anna Kula [2] the lecturer proposed a general approach in this context by replacing the free creation operators with other ones, which are related to other notions of independence in non-commutative probability. In particular, this applies to the case of monotone and boolean independences.
The plan of the mini course is as follows:
(1) Classical notions of numerical radius and spectral radius of and operator on a Hilbert space, and their properties.
(2) Free joint numerical and spectral radii by Popescu and their properties.
(3) Monotone and boolean joint numerical and spectral radii and their properties.
(4) von Neumann type inequalities for joint numerical and spectral radii.

Exam Modality
To pass the exam, each student will present a seminar on some topics related to the course, and suggested by the teacher.

Large Deviation Theory and Applications (2 CFU, 16 hours),

Teacher: Prof. Marco Zamparo (marco.zamparo@uniba.it)

Course Schedule: not defined yet. The course is planned in Mar 2022

Course description
Large deviation theory - a part of probability and statistics - deals with the description of rare events, where a random variable deviates from its mean more than a "normal" amount, i.e. beyond what is described by the central limit theorem. This course aims to provide the basics of large deviation theory, and to discuss applications to statistical mechanics. Basic probability theory is an important prerequisite.
Moving from some elementary large deviation results for i.i.d random variables, where explicit calculations are feasible, the notions of weak and full large deviation principles will be introduced and some general theorems will be presented. Cramér's theorem for i.i.d random variables will follow, and a first application to fluctuations in the Curie-Weiss model of ferromagnetism will be proposed. The Gärtner-Ellis theorem will be the next step, together with an application to finite state Markov chains. Subsequently, large deviation principles for renewal-reward processes will be discussed, and used to characterize large fluctuations in the Poland-Scheraga model of DNA denaturation. Finally, large fluctuations for lattice spin models will be considered, and ensemble equivalence will be formulated in the framework of large deviation principles.

Exam Modality
Oral exam

Mathematics of Swarm Intelligence (2 CFU, 23 hours),

Teacher: Dr. Antonella Falini (antonella.falini@uniba.it)

Course Schedule: not defined yet. The course is planned in May-Jun 2022

Course description
Swarm Intelligence (SI) refers to those Artificial Intelligence techniques that are inspired by the collective behaviours exhibited by social insects and animals, as well as human societies. An SI system typically consists of a population of individuals, agents, i.e., a swarm, that communicate with each other by acting on their local environment giving rise to complex global patterns. The course will start by revising the basic of the deterministic 1D optimization strategies, both under theoretical point of view (i.e., convergence properties, design of the algorithm) and practical point of view (i.e., Python codes examples). Later on we will introduce the concept of metaheuristic and hence data search, path search and solution search will be the three main objectives to be explored in the context of Particle Swarm Optimization (PSO). The course aims to give a broad overview also on the main variations of the classical PSO, like Inertia weighted and constricted PSOs, Fully Informed PSO, SPSO-2011. Every algorithm will be presented theoretically by analysing the statistical-numerical foundations and some typical benchmark, coded in Python, will be discussed. Moreover, some of the main nature inspired optimization algorithms will be presented, mainly focusing of the details of the Ant Colony Optimization process.

Exam Modality
Two alternatives are available to the student to pass this exam:
1) Paper presentation. Students present the content of 1 paper suggested by the teacher. No groups are allowed.
2) Project. Students implement and experimentally validate an algorithm from the state-of-the-art literature, or its variation suggested by the teacher. Projects can be done in groups of 1-3 students, depending on the algorithm.
(Teacher(s) may choose other modalities)

Random Matrices (3 CFU, 24 hours)

Teacher: Dr. Fabio Deelan Cunden (fabio.cunden@uniba.it)

Course Schedule: not defined yet. The course is planned in Mar-May 2022

Course description
This course is an introduction to the theory of random matrices, one of the most active research topics in contemporary mathematical physics and probability. In addition to its intrinsic mathematical appeal, interest in random matrices has been spurred by the scientific hypothesis that large random matrices yield models for complex systems comprised of many highly correlated components. Such systems are ubiquitous in mathematics and nature (energy levels of heavy nuclei or chaotic quantum billiards, zeros of L-functions, random growth models, etc.) but are not within the purview of classical scalar probability theory, whose limit theorems usually apply to systems of weakly correlated components. Topics covered will include: brief history of random matrix theory; basic objects and questions; the main limit theorems; connections to other areas of mathematics and science; classical matrix models (Gaussian and unitary); semicircular law; determinantal point processes, orthogonal polynomials and scaling limits; gap probabilities; statistics of the largest eigenvalue and Tracy-Widom distributions; log-gas and the equilibrium measure; non-hermitian random matrices.

Exam Modality: Two alternatives are available to the student to pass this exam:
1) Paper presentation. Students present the content of 2 papers suggested by the lecturer.
2) A small project to present and implement ideas on a topic or from a paper suggested by the lecturer.
