UNIVERSITÀ DEGLI STUDI DI BRESCIA

DII

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

PhD Program in Information Engineering

DRII Course
Introduction to Deep Learning and Constrained-based Reasoning

Lecturer: Prof. Marco Gori, Dipartimento di Ingegneria dell'Informazione e Scienze Matematiche dell'Università di Siena.

Dates: February 4–8, 2019
Timetable: Monday to Friday, from 9:00 to 13:00
Room: B0.3 via Branze 43, Brescia

Summary

In spite of the amazing results obtained by deep learning in many applications, intelligent agents acting in a complex environment can strongly benefit from prior knowledge on the environment, especially when it is expressed by logic formalisms. In this brief course, we give an introduction to deep learning and then we introduce a theory for modeling the agent interactions with the environments by means of the unified notion of constraint, that is shown to embrace machine learning and logic inferential processes within the same mathematical framework. Then, we present LYRICS (Learning Yourself Reasoning and Inference with ConstraintS), which can be regarded as a tool to assist the design of intelligent agents in a rich variety of application domains. LYRICS is implemented in TersorFlow (TF) and provides an input language to define arbitrary First Order Logic background knowledge, including clauses, groundings, and constants. The predicates and the functions can be bound to any TF computational graph, while the formulas are converted into a set of real-valued constraints by means of t-norms, that can be defined during the design. As a result, we end up into a unified framework for performing learning and inference that is especially useful when both data and structured knowledge are jointly available. A number of cases studies are illustrated to facilitate the acquisition of the theory.

Syllabus

1. Introduction to neural networks
2. Supervised, unsupervised, and semi-supervised learning as special cases of learning with constraints;
3. Deep architectures and computational capabilities
4. Backpropagation and related learning algorithms
5. Modeling environmental interactions by constraints, notion of individual;
6. Functional representations and constraint reactions, learning in the primal and dual space;
7. Logic constraints by t-norms;
8. Case studies, https://github.com/GiuseppeMarra/lyrics

Lecture plan

- 4 Feb. Introduction to machine learning and neural networks
- 5 Feb. Deep networks and Backpropagation
- 6 Feb. Convolutional nets, recurrent and graphical networks
- 7 Feb. Learning with constraints
- 8 Feb. Bridging logic and learning

References
- Marco Gori, "Machine Learning: A Constraint-Based Approach," Morgan Kauffman (Elsevier), 2018 (560 pp.);
- Michelangelo Diligenti, Marco Gori, Claudio Saccà: Semantic-Based Regularization for Learning and Inference, Artificial Intelligence 244: 143-165 (2017);
- Francesco Giannini, Michelangelo Diligenti, Marco Gori, and Marco Maggini, "Learning Lukasiewicz Logic Fragments by Quadratic Programming, Proc. of ECML-PKDD 2017: Machine Learning and Knowledge Discovery in Databases pp 410-426;
- Michelangelo Diligenti, Marco Gori, Marco Maggini, and Leonardo Rigutini, "Bridging Logic and Kernel Machines," Machine Learning, January 2012, Volume 86, Issue 1, pp 57–88.

Pre-requisites
In the first lecture, an introduction to deep learning will be given. A brief review will also be given on the notion of t-norm that plays a central role to the theory. Students are expected to have a basic background in logic, calculus and linear algebra.

Bio Sketch
Marco Gori received the Ph.D. degree in 1990 from Università di Bologna, Italy, working partly at the School of Computer Science (McGill University, Montreal). In 1992, he became an Associate Professor of Computer Science at Università di Firenze and, in November 1995, he joint the Università di Siena, where he is currently full professor of Computer Science. His main interests are in machine learning with applications to pattern recognition, Web mining, and game playing. He is especially interested in bridging logic and learning and in the connections between symbolic and sub-symbolic representation of information. He was the leader of the WebCrow project for automatic solving of crosswords, that outperformed human competitors in an official competition which took place during the ECAI-06 conference. As a follow up of this grand challenge he founded QuestIt, a spin-off company of the University of Siena, working in the field of question-answering. He is co-author of "Web Dragons: Inside the myths of search engines technologies" Morgan Kauffman (Elsevier), 2006, and "Machine Learning: A Constrained-Based Approach", Morgan Kauffman (Elsevier), 2018. Dr. Gori serves (has served) as an Associate Editor of a number of technical journals related to his areas of expertise, he has been the recipient of best paper awards, and keynote speakers in a number of international conferences. He was the Chairman of the Italian Chapter of the IEEE Computational Intelligence Society, and the President of the Italian Association for Artificial Intelligence.
He is a fellow of the IEEE, ECCAI, IAPR. He is in the list of top Italian scientists kept by the VIA-Academy (http://www.topitalianscientists.org/top_italian_scientists.aspx)

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