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Short Communication

On the Combination of Deep Learning and Knowledge Representation and Reasoning Techniques

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Abstract

Nowadays, the world of Artificial Intelligence continuously poses researchers to face new challenges. Several contexts have been extensively studied, such as Deep Learning, which helped the research community sheds light on the intricate core of various problems. However, to tackle new challenges with only a single tool does not allow to study them from different points of views. In this short communication, we borrow the context of Knowledge Representation and Reasoning and the techniques therein involved, such as declarative formalism, and we highlight how the combination of Deep Learning with them helps researchers addressing new challenges in several different ways.

Keywords: Deep Learning; Logic Programming; Knowledge Representation and Reasoning; Answer Set Programming; Bioinformatics

In recent years there has been an extensive number of studies, both theoretical and practical, on Machine Learning (ML), and more specifically on Deep Learning (DL). In particular, the latter context has attracted a huge concentration of researchers from all over the world, regardless of the scientific field. In fact, the amount of work produced by the study of DL techniques has also found a place in contexts apparently far from the classical computer science one, such as medicine, physics, biology, and so on [1].

DL can be considered as a branch of Artificial Intelligence (AI). It is represented by a subclass of machine learning techniques, based on the use of Artificial Neural Networks (ANN), often structured with multiple levels, which has proved to be very useful in many tasks, such as image classification [1,2].

In the great cauldron of AI, however, DL is not the only ensemble of techniques and methodologies to implement the vision, more or less articulated, that is at the base of the AI world itself. Indeed, in recent years particular attention has been paid to deductive formalisms. These formalisms are useful in the context of Knowledge Representation and Reasoning (KRR) and they allow performing automatic deduction tasks in contexts which can be represented by logical structures [3]. Deductive formalisms and related contexts have an intense and old story [4]. Starting from Prolog, declarative logic programming languages have been extended to cover a wide range of contexts, including data integration, information extraction and program analysis [5,6].

Clearly, both approaches do not represent the ultimate solution to all possible problems arising in AI. In the last years, a fair amount of attention has been devoted to the study of methodologies, concerning different tasks, that combine these two approaches. These types of methodologies, innovative in themselves, exploit on the one hand the pros offered by deep learning techniques, and on the other hand the expressive power articulated in declarative formalisms. An interesting context in which this type of approach has been experimented with is bioinformatics, and in particular the study of neurological disorders. In [7], a methodology combining deep learning and logic programming has been presented. The idea is to define a framework in which to study the evolution of some neurological disorders by simulating variations in the brain

connectome. The framework is based on two components: an ANN, able to classify the evolutionary stage of the disorder, and a logic program, expressed in Answer Set Programming (ASP), that allows to make non-deterministic variations on a given connectome. The framework iterates between the ANN and the module ASP to simulate the possible evolutions of a neurological disorder.

Combining DL with KRR can help researchers tackling new and intriguing problems from different points of views. The research community is moving toward this direction, and in the next years we might observe the results of such fruitful combination.

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