Approximate Reasoning with Abstract Argumentation Frameworks using Artificial Neural Networks

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Introduction

Reasoning:

- Infer knowledge from existing information/data
- Central subject in artificial intelligence

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- Infer knowledge from existing information/data
- Central subject in artificial intelligence
- **Argumentation:**
  - Computational models of *argumentation* focus on the interplay between arguments and counterarguments in order to reach conclusions.
  - *Abstract* and *structured* approaches
    - Focus of this work: abstract argumentation

Motivation

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Thus, there is a need for **practically feasible methods**.

Idea

Use *approximate* methods—which promise comparatively short runtimes.

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- However, the results of approximate approaches could be used as **heuristics** to accelerate exact methods.

Machine learning and knowledge representation/reasoning are mostly considered separately.

- Combining the two fields may help overcome their respective weaknesses

Background

Abstract Argumentation

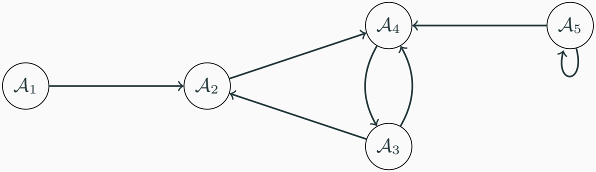
We are considering *abstract argumentation frameworks* in the sense of Dung [5].

Definition

An *abstract argumentation framework* $\mathsf{AF} = (\mathsf{Arg}, \rightarrow)$ consists of

- a set of arguments Arg
- and an attack relation $\rightarrow \subseteq \mathsf{Arg} \times \mathsf{Arg}$ between such arguments.

Example:



Semantics are given to abstract argumentation frameworks by means of **extensions**.

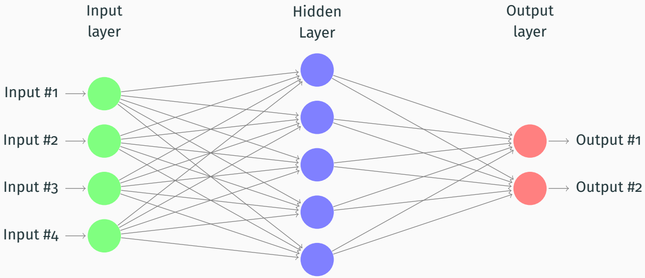
Intuition

An *extension* is a set of arguments that are mutually acceptable

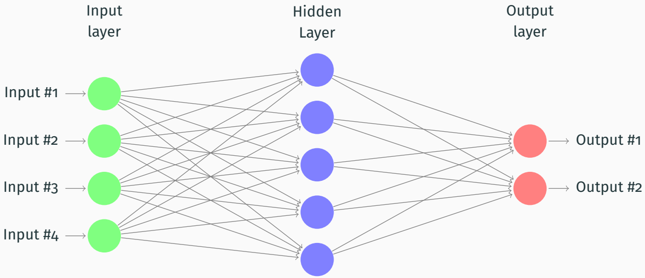
- provides a coherent perspective on the outcome of an argumentation

- There are different types of extensions, such as *grounded*, *stable*, or *preferred* semantics.

Artificial Neural Networks



Artificial Neural Networks



Supervised learning:

- Input: Labeled training data
- The network learns features from the data that are “typical” for each class
- When the training is done, the network is able to assign class labels to unknown (i.e., unlabeled) data

In the context of abstract argumentation, we can construct the following classification problem:

- Let $\mathsf{AF} = (\mathsf{Arg}, \rightarrow)$ be an abstract argumentation framework. Is an argument $\mathcal{A} \in \mathsf{Arg}$ acceptable wrt. a semantics σ?
  - Classes YES and NO

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Idea

Train a neural network to classify arguments as YES (i.e., acceptable wrt. semantics) or NO (i.e., not acceptable)

- Training data must somehow represent the graph structure
- Class labels (per argument) must also be included

Related Work

Overview

1. Kuhlmann and Thimm: *Using Graph Convolutional Networks for Approximate Reasoning with Abstract Argumentation Frameworks: A Feasibility Study* (2019) [8]
2. Malmqvist et al.: *Determining the Acceptability of Abstract Arguments with Graph Convolutional Networks* (2020) [10]
   - Will be presented at SAFA2020 (today)
3. Craandijk and Bex: *Deep Learning for Abstract Argumentation Semantics* (2020) [4]

Kuhlmann and Thimm (2019)

- Feasibility study
- **Goal:**
  - Determine acceptable arguments under preferred semantics
- **Method:** *Graph Convolutional Networks* (GCNs) (Kipf et al. [7])
- **Results:**
  - Accuracy of about 80%
  - Significantly increased runtime performance: ~ 1 hour vs. < 0.5 seconds (Compared to the CoQuiAAS solver [9])

Malmqvist et al. (2020)

- Extension of the GCN approach
- Introduction of a randomization technique for training, as well as a dynamic balancing of training data
- Both credulous and skeptical acceptance are considered
- More layers are added to the GCN
- **Results:**
  - Accuracy of up to 97.15%

Craandijk and Bex (2020)

- *Argumentation Graph Neural Network* (AGNN) is introduced
  - Learns a message-passing algorithm
  - Predicts the likelihood of an argument being accepted under multiple semantics
- All of Dung's classical semantics are utilized (grounded, preferred, stable, complete)
- Both credulous and skeptical acceptance are considered
- Extensions are also enumerated

Future Work

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Closely related ideas:

- Consider other types of neural networks
  - Or even other machine learning techniques

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- Consider other types of neural networks
  - Or even other machine learning techniques
- Consider different semantics
  - Classical Dung-style semantics: *grounded*, *stable*, *complete*, (*preferred*)
  - Other semantics proposed in the literature, e.g. *semi-stable* [2], *eager* [3], or *ideal* [6] semantics
  - Semantics based on weak admissibility (Baumann et al., 2020 [1])

Future Work

Further ideas:

- Apply the approach to probabilistic argumentation
  - Neural network predicts probabilities wrt. arguments
  - Regression problem

WeST People and Knowledge Networks

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- Use results from approximate approach as heuristics for exact methods
  - **Idea:** Neural network predicts whether an argument is included in an extension or not, given a *confidence value*

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- Apply the approach to probabilistic argumentation
  - Neural network predicts probabilities wrt. arguments
  - Regression problem
- Use results from approximate approach as heuristics for exact methods
  - **Idea:** Neural network predicts whether an argument is included in an extension or not, given a *confidence value*

Thank you for your attention!

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