Neural-Symbolic Argumentation Mining: An Argument in Favor of Deep Learning and Reasoning

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Argumentation Mining

- Structured SVN/RNN with factor graphs:
  constraints and classes are represented as node of a graph

- Integer Linear Programming
  applied to the output of classifier to impose constraints

- Deep network + an argumentative reasoning system

What is missing?

- Logic-based language to define rules, constraints, and dependencies
- Not a pipeline scheme but joint training through a single learning process

Two different approaches

- **Computational Argumentation**: method of reasoning used to represent knowledge

- Argumentation as human activity linked to **Natural Language Processing**, where Deep Networks achieved impressive results

Reasonable to assume that this field would greatly benefit from a system capable of exploiting both => Neural Symbolic AM

Previous approaches

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Towards Neural-symbolic AM

Defeasible Logic Programming + Probabilistic Logic Programming:

- Argumentation framework with strict and defeasible rules
- Probability label assigned to rules

Sub-symbolic framework:

- Learns the probabilities

1) claim(Y) $\leftarrow$ supports(X, Y)
2) premise(X) $\leftarrow$ supports(X, Y)
3) $\sim$ attacks(Y1, Y2) $\leftarrow$ supports(X, Y1) $\wedge$ supports(X, Y2)
4) attacks(Y1, Y2): 0.8 $\leftarrow$ auth(Y1, R) $\wedge$ rep(R) $\wedge$ auth(Y2,D) $\wedge$ dem(D)

DeepProbLog

The computation of the weights assigned to soft rules is carried on by neural networks.

The networks are trained along the rest of the program in a two-way cycle:

- The networks predict a probability score
- The logic part of the program exploit that score to provide an outcome
- The logic part of the program adapts to the data and computes a target score
- The network is updated according to the target score

Grounding-Specific Markov Logic Networks

Extension of Markov Logic Networks.

Different weights can be associated to different groundings of the same formula, and such weights can be computed by neural networks.

The first 3 rules depends from the specific grounding of the weights.

```
w1(x)    Sentence(x,$fx) => Claim(x)
w2(x)    Sentence(x,$fx) => Premise(x)
w3(x,y)  Sentence(x,$fx) ^ Sentence(y,$fy) => Supports(x,y)
         Supports(x,y) => Claim(y).
         Supports(x,y) => Premise(x).
         Supports(x,y1) ^ Supports(x,y2) => !Attacks(y1,y2).
w4       Rep(r) ^ Dem(d) ^ MadeBy(y1,r) ^ MadeBy(y2,d) => Attacks(y1,y2)
```

Logic Tensor Network

Rules mapped into a tensorflow graph.

Rules based on **Fuzzy Logic**: no strict rules.

Each rule gives a contribution to the loss function of the training.

The framework will try to jointly minimize the error on the data and the violation of rules.

Conclusion

Benefit for AM:

- Easier interpretation
- Specify to express knowledge and uncertainty
- Complexity of potential distributions handled by sub-symbolic systems

Perfect testbed for frameworks:

- Challenging
- Crucial exploitation of background knowledge
- Largescale

Related Works

- Niculae, V., Park, J., and Cardie, C. (2017). "Argument mining with structured SVMs and RNNs."
- Persing, I., and Ng, V. (2016). "End-to-end argumentation mining in student essays."
- Cocarascu, O., and Toni, F. (2018). "Combining deep learning and argumentative reasoning for the analysis of social media textual content using small data sets."
- Manhaeve, R., Dumancic, S., Kimmig, A., Demeester, T., and De Raedt, L. (2018). "DeepProbLog: neural probabilistic logic programming."
- Lippi, M., and Frasconi, P. (2009). "Prediction of protein -residue contacts by Markov logic networks with grounding-specific weights."
- Serafini, L., and Garcez, A. D. (2016). "Logic tensor networks: deep learning and logical reasoning from data and knowledge."

Thank you

More on this in:

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