

On the Relationship between Neural Networks and Quantitative Argumentation Frameworks

Nico Potyka

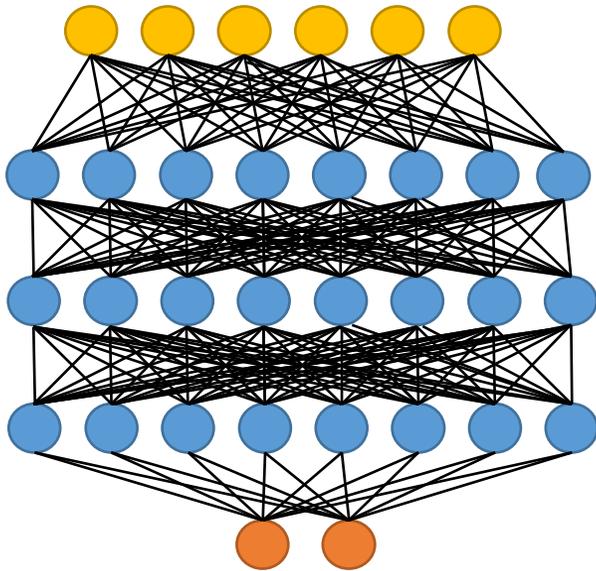
nico.potyka@ipvs.uni-stuttgart.de

explAIIn Workshop

8th July 2021

Overview

Multilayer Perceptrons



Directed Graph

Layered

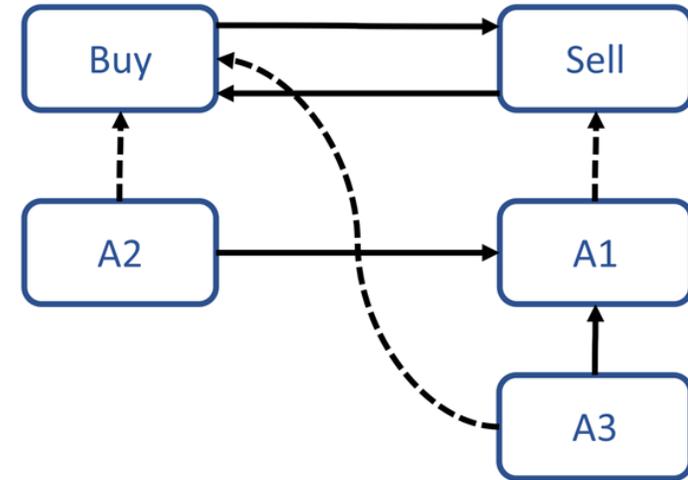
Weighted

Black-Box?

Directed Graph

Heterogeneous

Argumentation Frameworks

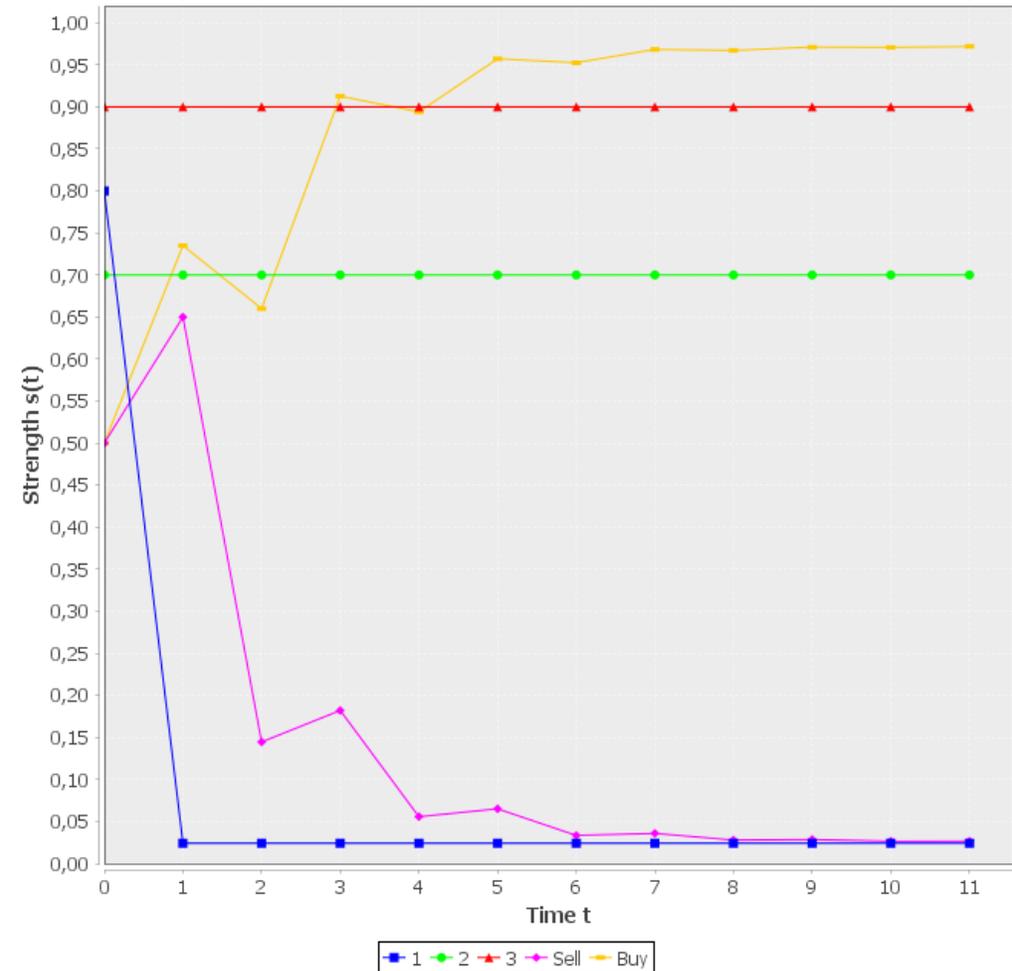
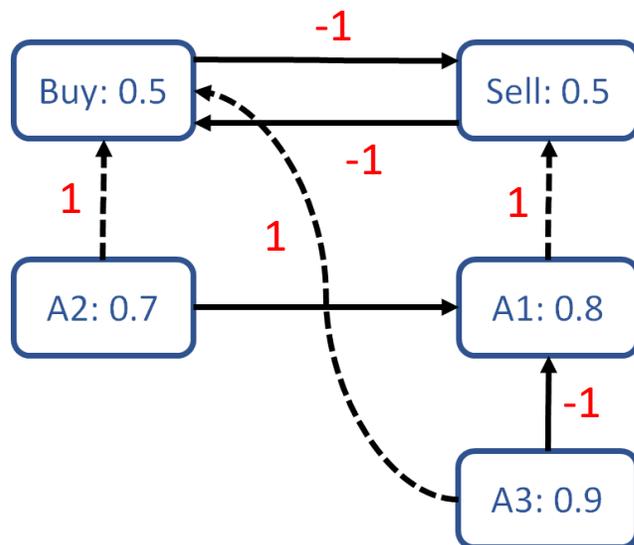


White-Box?

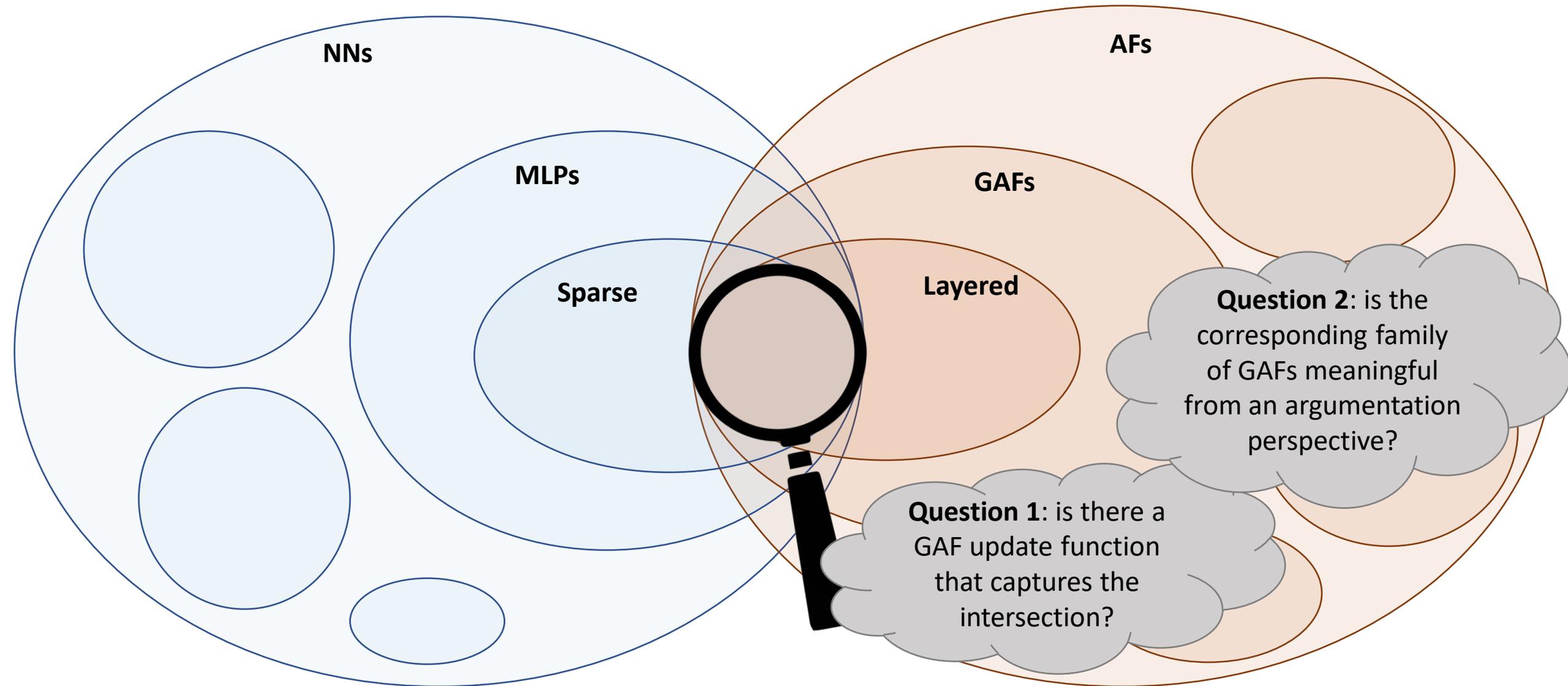
Edge-Weighted GAFs

- Ingredients

- BAG
- Base Scores (Argument Weights)
- Edge Weights
- Update Function

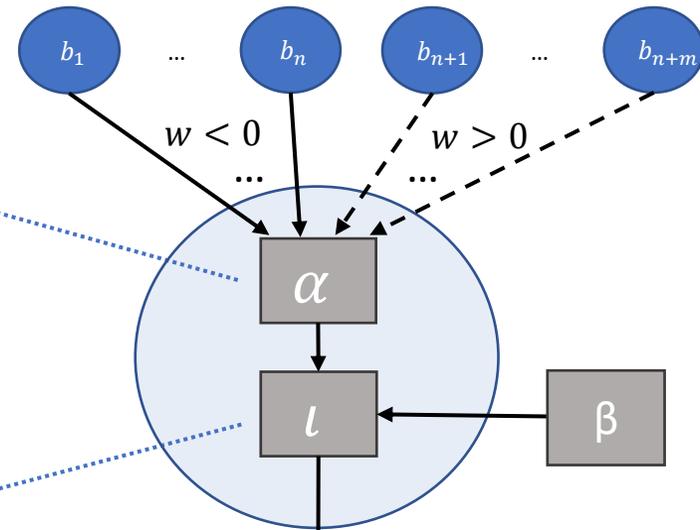
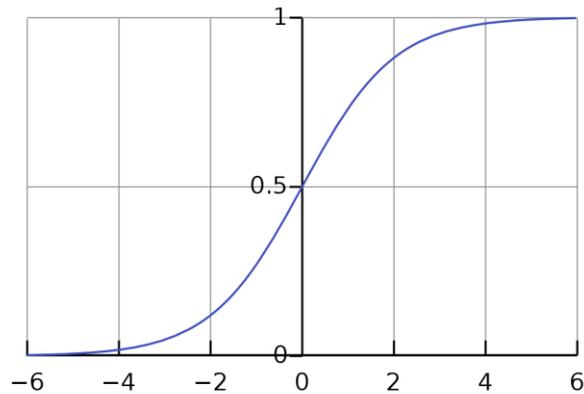


Neural Networks and BAFs



Question 1: Update Function (AAAI 2021)

$$\alpha_a^{(i+1)} := \sum_{(b,a) \in E} w(b,a) \cdot s_b^{(i)}$$



$$\iota(\beta, \alpha(a_1, \dots, a_n, s_1, \dots, s_m))$$

$$s_a^{(i+1)} := \varphi_l\left(\ln\left(\frac{\beta(a)}{1-\beta(a)}\right) + \alpha_a^{(i+1)}\right)$$

Question 2: Semantical Guarantees (AAAI 2021)

Desirable properties

- Adding attacker should weaken argument
- Adding supporter should strengthen argument
- Attack and support should have symmetric effects
- Adding attackers should make argument arbitrarily weak
- Adding supporters should make argument arbitrarily strong
- ...

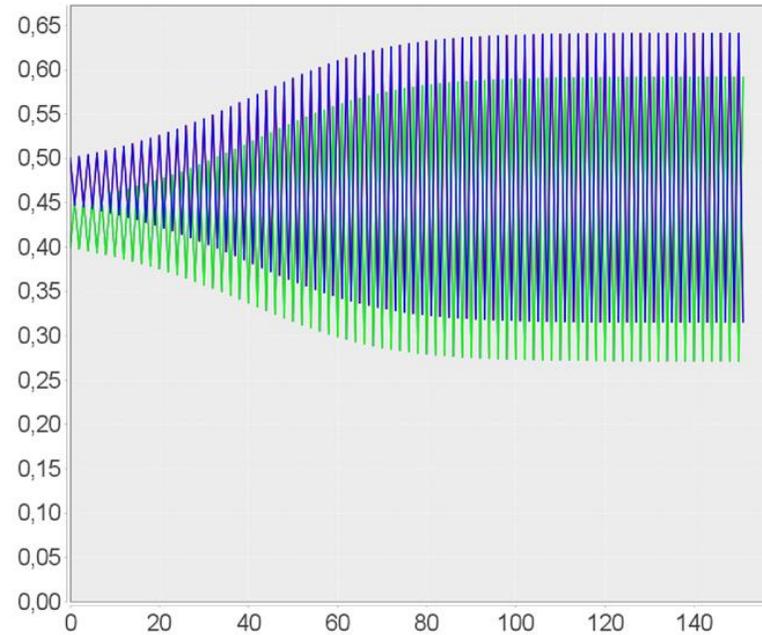
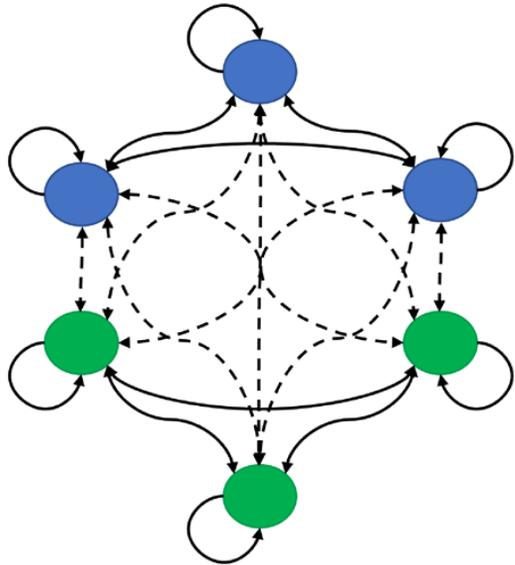
Property	DfQ	Euler	QEM	MLP
Anonymity	✓	✓	✓	✓
Independence	✓	✓	✓	✓
Directionality	✓	✓	✓	✓
Equivalence	✓	✓	✓	✓
Stability	✓	✓	✓	✓
Neutrality	✓	✓	✓	✓
(Strict) Monotony	(✓)	✓	✓	✓
(Strict) Reinforcement	(✓)	✓	✓	✓
Resilience	(✓)	✓	✓	✓
Franklin	✓	✓	✓	✓
Weakening	(✓)	✓	✓	✓
Strengthening	(✓)	✓	✓	✓
Duality	✓	✗	✓	✓
Open-Mindedness	✗	✗	✓	(✓)

DfQ: Rago, A., Toni, F., Aurisicchio, M., & Baroni, P. *Discontinuity-free decision support with quantitative argumentation debates*. In *Fifteenth International Conference on the Principles of Knowledge Representation and Reasoning (KR 2016)*. 2016.

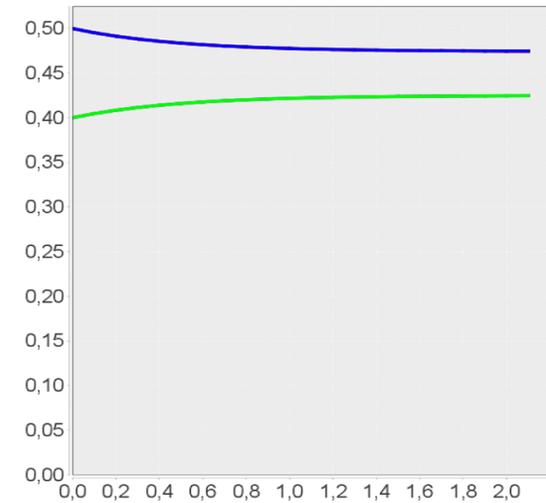
Euler: Amgoud, L., Ben-Naim, J. *Evaluation of arguments in weighted bipolar graphs*. In *Fourteenth European Conference on Symbolic and Quantitative Approaches to Reasoning with Uncertainty (ECSQARU 2017)*. 2017.

QEM: Potyka, N. *Continuous dynamical systems for weighted bipolar argumentation*. In *Sixteenth International Conference on Principles of Knowledge Representation and Reasoning (KR 2018)*. 2018.

Beyond Layered Graphs (AAAI 2021)

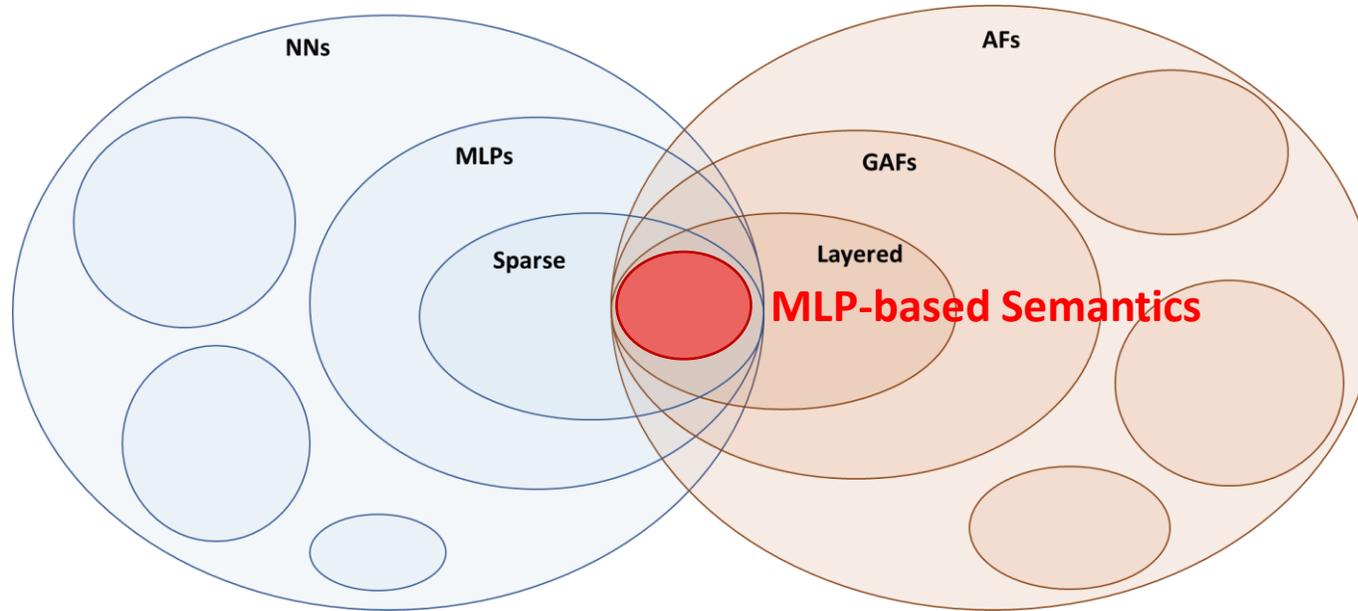


Discrete Updates



Continuous Updates

Conclusions

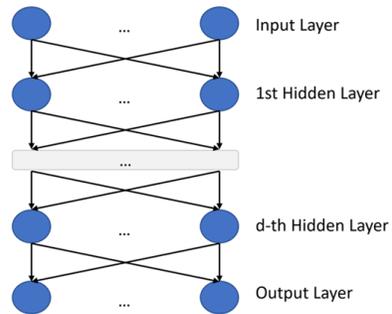


Multilayer Perceptrons

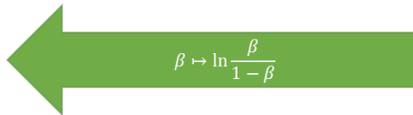
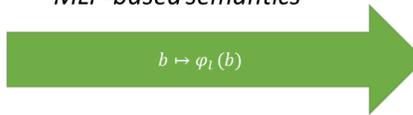
Gradual Argumentation Frameworks

Learning Algorithms

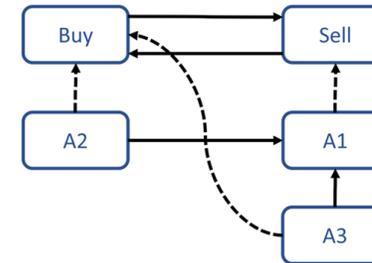
Learning Theory



- *MLPs with Logistic Activation function are GAFs under MLP-based semantics*



- *Layered GAFs under MLP-based semantics are sparse MLPs*

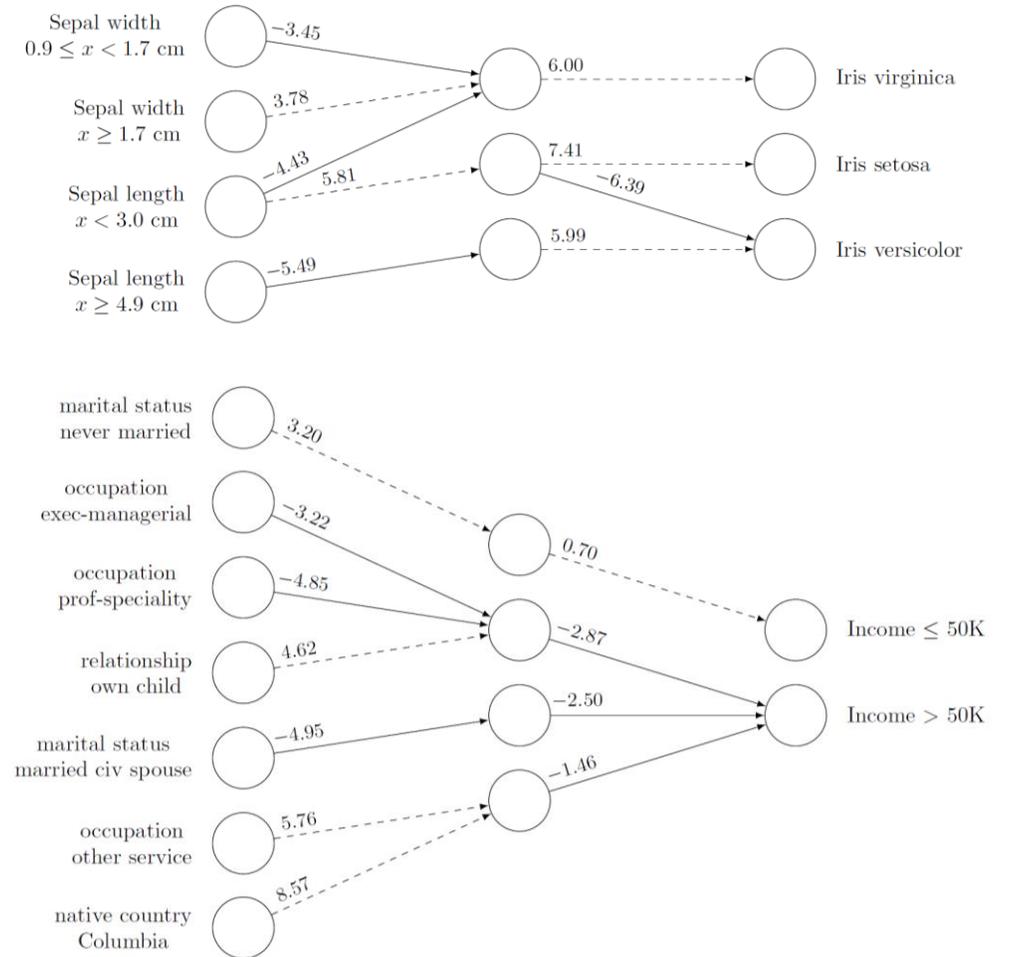
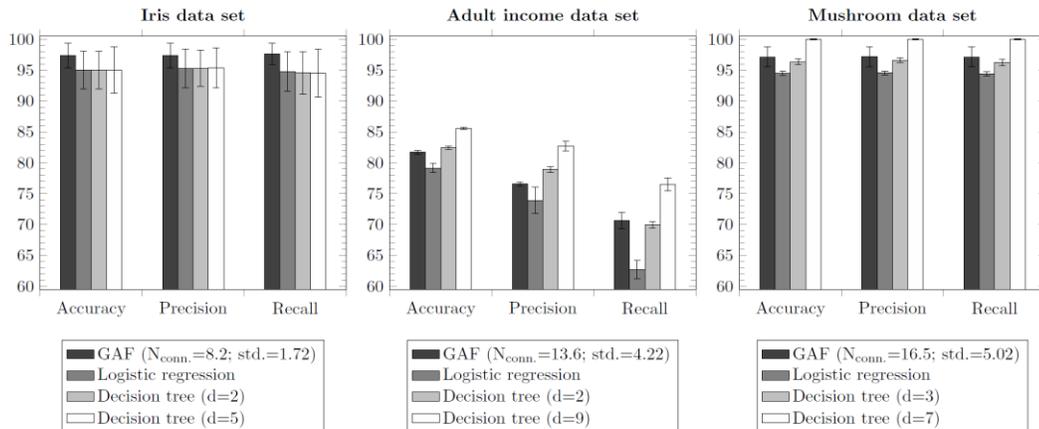


Analytical Guarantees

New Structure?

Future Work: Interpretable ML (XI-ML 2020, Arxiv)

Learning GBAFs
(sparse MLPs with
binarized/fuzzified
inputs)



More Details

- *Nico Potyka: Interpreting Neural Networks as Quantitative Argumentation Frameworks. AAI 2021: 6463-6470.*
- *Jonathan Spieler, Nico Potyka, Steffen Staab: Learning Gradual Argumentation Frameworks using Genetic Algorithms. CoRR abs/2106.13585 (2021).*
- *Nico Potyka: Foundations for Solving Classification Problems with Quantitative Abstract Argumentation. XI-ML@KI 2020.*

nico.potyka@ipvs.uni-stuttgart.de