A Model for Social Networks with Subjective Logic

What we have until now

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1 Introduction

At [1], Alvim, Knight, and Valencia developed a formal model for group polarization in social networks, and show possible future directions. Here, we are trying to develop a quantitative logic for reasoning about beliefs in social networks. With a logic, we can provide a formal way of making statements about knowledge.

2 Subjective logic

Subjective logic [3] is a extension of probabilistic logic expressed by opinions with *uncertainty* about the probability distribution and *subjectivity* by assigning an agent or source for the opinion. The following topics about subjective logic are important for this research.

- Elements of subjective logic
  - Domains and hyperdomains
  - Random variables and hypervariables
  - Belief mass distribution and uncertainty mass
  - Base rate distribution
  - Probability distribution
- Opinion Representation
  - Opinion classes
  - Aleatory and epistemic opinions
  - Binomial opinions
  - Multinomial opinions

  - Hyper-opinions
  - Mapping between opinions and Dirichlet PDF
- Principles of subjective logic
  - Comparison with related frameworks for uncertain reasoning
  - Subjective logic as a generalization of probabilistic logic
- Belief fusion
  - Interpretation and criteria for fusion operator selection
  - Cumulative belief fusion
  - Averaging belief fusion
  - Weighted belief fusion
- Computational trust
  - Notion of trust
  - The trust-discounting operator
  - Trust fusion

3 The model so far

This is a very short summary. Let $\mathscr{R}(\mathbb{X})$ be a hyperdomain and X be a hypervariable over $\mathscr{R}(\mathbb{X})$. Let $A_1, \cdots, A_n$ be agents. All agents have a hyperopinion $\omega_X^{A_i}$. Also, for every $i \in 1, \cdots, n$ and for every $j \in 1, \cdots, n \setminus i$, the agent A_i has a trust opinion about A_j, $\omega_{A_j}^{A_i}$.

The idea is that an agent A_i learns a new opinion by interaction with everyone else considering trust-discount and trust fusion. Then, we should merge A_i previous opinion with the new learned opinion. Since there are several belief fusion operators, **we need to choose which suits best for our case**. Some of the question are the following:

- If an agent learns from two equal opinions, should the new opinion have more confidence? That is, should our belief fusion operator be idempotent or non-idempotent. If it should be non-idempotent, we choose cumulative belief fusion. It means that we are taking the sum of the amount of evidence from the two opinions. Otherwise, we move to the next question.
- If an agent learns from two opinions with uncertainty, should the uncertainty of the new opinion increase? That is, should our belief fusion operator not have a neutral opinion. If so, then we choose averaging belief fusion. It means that we are taking the average of the amount of evidence from the two opinions.

- Otherwise, by having a neutral opinion, we choose weighted belief fusion. It means that we are taking average of the two opinions weighted by confidence.

The operator that we will choose has to be n-ary, because it allows us multiple interactions in a single iteration. The book [3] shows only binary fusion operators. The paper [2] defines n-ary belief fusion operators.

4 Next steps

We need to choose with belief fusion operator suits better for our model. It is possible that the operator for fusing all trust-discounted opinions and the operator for fusing the new opinion with the old opinion are different. Simulations with different operators could hep the decision. The repository on GitHub at [4] implements some of the operators and it will be used for simulations.

References

[1] Mário S. Alvim, Sophia Knight, and Frank Valencia. "Toward a Formal Model for Group Polarization in Social Networks". In: *The Art of Modelling Computational Systems: A Journey from Logic and Concurrency to Security and Privacy - Essays Dedicated to Catuscia Palamidessi on the Occasion of Her 60th Birthday*. Ed. by Mário S. Alvim et al. Vol. 11760. Lecture Notes in Computer Science. Springer, 2019, pp. 419–441. DOI: 10.1007/978-3-030-31175-9_24. URL: https://doi.org/10.1007/978-3-030-31175-9%5C_24.

[2] Audun Jøsang. "Categories of Belief Fusion". In: *Journal of Advances in Information Fusion* 13.2 (2018), pp. 235–254. URL: https://folk.universitetetioslo.no/josang/papers/Jos2018-JAIF.pdf.

[3] Audun Jøsang. *Subjective Logic - A Formalism for Reasoning Under Uncertainty*. Artificial Intelligence: Foundations, Theory, and Algorithms. Springer, 2016. ISBN: 978-3-319-42335-7. DOI: 10.1007/978-3-319-42337-1. URL: https://doi.org/10.1007/978-3-319-42337-1.

[4] Jose C. Oliveira. *Subjective Logic Python Library*. GitHub, 2021. URL: https://github.com/joseoliveirajr/subjective-logic-library.