Multi-Agent Ranked Delegations in Voting

Doctoral Consortium

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ABSTRACT

We generalise liquid democracy, a voting model where an agent can either vote on an issue or delegate to another agent who votes on their behalf. As delegations are transitive, delegates can choose to vote directly or to delegate their votes further. Transitivity can cause delegation cycles, making it unclear how to determine these votes. Our generalisation allows for ranked delegations in order to break delegation cycles. Agents can also give more expressive delegations than in liquid democracy, being able to state how their vote should be determined from the votes of others. For example, an agent may want their vote to correspond to the majority opinion of a group of trusted experts. We focus on how to gain a collective decision in this setting; we propose six unravelling procedures that find a standard voting profile, from the complex ballots, that can be aggregated. We study the properties of these unravelling procedures, including the complexity of finding an outcome, as well as axiomatic properties of the procedures. Following this, we lay out some future research directions.

KEYWORDS

Social Choice Theory; Social Networks; Reasoning in Agent-Based Systems.

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1 INTRODUCTION

Interactive democracy explores the space between direct democracy, where agents vote on every issue, and representative democracy, where agents elect a representative to vote on their behalf. The former is time-consuming, as every citizen must be informed on every issue. The latter can pose problems of voters not being adequately represented, due to the compromise of allowing a single person represent a diverse group of people. Proxy voting allows agents to vote on any issue or to pass their vote to an agent who votes on their behalf for that issue [10, 11]. Thus, it can be thought of as choosing a representative for every issue, removing the compromise of one long-term representative. Liquid democracy differs from proxy voting in that delegations are transitive, i.e., those who have received delegations can delegate their own vote and any other votes that they have received [1, 7]. However, this can lead to delegation cycles, in which a delegation returns to the original voter. In this case, it is unclear how these votes should be determined.

This research proposes a model called *smart voting*, extending classical liquid democracy in two aspects: allowing ranked delegations to avoid cycles, and generalising delegations to be more expressive. The first is done by enabling agents to submit a linear order of delegations, where less preferred delegations can be used to break cycles (which has already been studied in the context of liquid democracy, see e.g., [2, 7, 9]). The second allows agents to not only delegate to a single agent but for their vote to be determined by the votes of many agents. For example, when an agent is unsure of how to vote on a issue, they can let their vote coincide with the majority opinion of a group of agents that they collectively trust on this issue. Degrave [6] extends liquid democracy in a similar way by allowing for a delegating vote to be split among multiple delegates. In a similar manner, Gölz et al. [8] allow for agents to submit a group of trusted delegates for which their vote will be distributed among by their fluid mechanics procedures. The model of Brill and Talmon [3] allows agents to delegate to multiple other agents to complete a preference ordering of alternatives in a pairwise manner.

2 MULTI-AGENT RANKED DELEGATIONS

Our *smart voting* model with multi-agent ranked delegations [5] allows agents to express an ordering of complex delegations for a single issue. *Smart ballots* are linear orders possibly consisting of delegations yet always ending with a direct vote on the issue (note that this could be an abstention). Delegations can be expressed by: a standard voting rule (e.g., the majority rule); a boolean function, evaluated under the votes of the agents in the delegation; or a liquid democracy delegation. The ranked delegations allow an agent's vote to be determined by a lower preference when more preferred delegations are unable to be determined. For example, when an agent's first preference causes a delegation cycle, a lower preference can be used to break this cycle. Furthermore, the final direct vote ensures that every delegation cycle can be broken. Checking that these ballots are valid has been shown to be a NP-complete problem[5], when ballots are restricted to to be contingent DNF boolean functions, we call this language `Bool`. Note that `Bool` encompasses many of the other languages that we explore.

The question then is how to gain a collective decision from these complex ballots. To answer this question, we need to determine how ballots should be assigned a vote; once this is completed, a standard judgment aggregation rule can find our collective decision. An *unravelling procedure* selects a preference level for each agent, according to its design, and then uses these preferences to find a vote for every agent. We study six unravelling procedures, of which two are optimal and four are greedy polynomial alternatives.The

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first optimal unravelling procedure, MinSum, finds outcomes that minimise the sum of the agents' preference levels used in the unravelling. The second, MinMax, takes a more egalitarian approach, in that it finds the outcomes that minimise the highest preference level used for any agent. We showed a decision problem variant of these optimal unravelling procedures are NP-complete when restricting the delegation language to be Bool. However, optimal unravellings are tractable when ballots are restricted to be ranked liquid democracy ballots.

The final unravelling procedures resemble greedy algorithms, in that they try to add votes from a preference level as low as possible; only moving to a less preferred level when delegation cycles are found. These four unravelling procedures are distinguished by the presence or absence of two properties, *random voter selection* (R), and *direct vote priority* (D). Random voter selection picks one agent at random from those whose vote can be determined at the highest available preference level, minimally breaking the delegation cycling. Direct vote priority gives priority to accepting the final direct votes of agents over the computable delegations at a given preference level. The intuition is that those giving a direct vote will be more certain than delegating agents at this given preference level, thus cycles are broken with more certain votes. This gives the unravelling procedures: **U**, **DU**, **RU**, **DRU**. These four unravelling procedures have been shown to always terminate and do so in a polynomial number of time steps[5].

A small axiomatic study has been carried out on the four greedy procedures, following two properties from Kotsialou and Riley [9], namely, *guru-participation* and *cast-participation*, that are defined for ranked liquid democracy. Thus, we inspect these four unravelling procedures when ballots are ranked liquid democracy ballots. Guru-participation holds with respect to an unravelling procedure and an aggregation rule when any non-delegating voter always benefits from receiving delegations from other agents. Cast-participation holds for an unravelling procedure and aggregation rule when any non-delegating voter is always better off by voting directly rather than delegating. These four unravelling procedures are shown not to have cast-participation when paired with any monotonic aggregation rule; yet, they have guru-participation when paired with the relative majority rule.

3 FURTHER DIRECTIONS

One area of further research is to extend the axiomatic study of the six unravelling procedures. The first axiomatic extension could extend the notations of guru-participation and cast-participation to account for all smart voting ballots rather than just ranked liquid democracy ballots. Moreover, guru-participation reflects the benefits of a direct voters, rather than the entire electorate; however, we can extend this notion for any agent benefiting from receiving delegations. This would further distinguish the unravelling procedures, giving support as to which procedure is right for a given situation.

An addition to our model would be to measure how much power certain direct voters have in deciding the outcome. One of the main criticisms of liquid democracy is that some agents gain a lot of power in the decision-making process, a power index would be an appropriate way of measuring this. Zhang and Grossi [13] introduce a generalisation of the Banzhaf index for liquid democracy, measuring the power of a guru as the voting power that they have accrued by the transitive delegations to them. This can be seen as a weighted voting game. The Banzhaf index in liquid democracy measures the proportion of coalitions for which the addition of a guru changes the outcome in the gurus favour. Thus, it measure the influence of a guru on the collective decision. The use of this power index highlights that in models of liquid democracy, a few gurus can have a large proportion of the power in deciding the outcome. In relation to my own research, a similar power index can be used to asses the smart voting model and differentiate the unravelling procedures. Furthermore, the power index could give better results for models with multi-agent delegations than in classical liquid democracy, as delegations may not give power to a single agent. Results of these studies could lead to introducing more unravelling procedures, potentially in the spirit of the fluid procedures of Gölz et al. [8] to avoid agents accruing too much power.

There are two types of agent manipulation in this model: first, can direct voters alter their ballot to change the final collective decision; second, can delegating agents change their ballot in order to force the unravelling procedure to use their most preferred delegation. Currently, the model has two restrictions on the ballots to stop some manipulation of the unravelling procedures. The first, restricts agents from including themselves in their delegation, creating delegation cycles of size one. The second restricts agents from giving the same delegation at multiple preference levels. It is clear, however, that these two restrictions do not stop agents from being able to manipulate; thus a study of manipulation in the smart voting model is required.

A key future direction of this research is the implementation of our model. *Statement voting*, a model from Zhang and Zhou [12], is a general model of interactive democracy with a focus on the creation of ledger-based protocols that remove many of the implementation problems. They leave the voting stage undefined, allowing for models such as liquid democracy and STV. More generally, as they allow ballots to contain conditional votes, we could consider ballots with complex delegations such as in the our model.

A final question this research could explore is if the smart preferences expressed by agents could be used for other problems. For example, if the complex delegation function could be used in opinion diffusion to dictate when an agent's opinion changes. Alternatively, we could use the smart preferences to connect multiple issues on an individual level as done by Christoff and Grossi [4].

4 CONCLUSION

This research proposes a voting model that generalises liquid democracy in two ways. First allowing for multi-agent delegations gives agents a more expressive way for their vote to be determined. Second, allowing ranked delegations gives more opportunity for their vote to be determined when delegations cycles arise. The unravelling procedures are the main focus of this research, they take complex ballots and finds a collective outcome. The aim of this research is to provide a comprehensive study of the procedures, including their complexity and axiomatic properties. Furthermore, the model can be studied from a game theoretic approach, including a power index and a study of agent manipulation.

REFERENCES

[1] J. Behrens, A. Kistner, A. Nitsche, and B. Swierczek. 2014. *Principles of Liquid Feedback*. Interacktive Demokratie.

[2] Paolo Boldi, Francesco Bonchi, Carlos Castillo, and Sebastiano Vigna. 2011. Viscous democracy for social networks. *Commun. ACM* 54, 6 (2011), 129–137.

[3] Markus Brill and Nimrod Talmon. 2018. Pairwise Liquid Democracy. In *Proceedings of the 27th International Joint Conference on Artificial Intelligence (IJCAI)*.

[4] Zoé Christoff and Davide Grossi. 2017. Binary Voting with Delegable Proxy: An Analysis of Liquid Democracy. In *Proc. of the 16th Conference on Theoretical Aspects of Rationality and Knowledge (TARK)*.

[5] Rachael Colley, Umberto Grandi, and Arianna Novaro. 2020. Smart Voting. In *Proceedings of the the 29th International Joint Conference on Artificial Intelligence (IJCAI)*.

[6] Jonas Degrave. 2014. Resolving multi-proxy transitive vote delegation. *arXiv preprint arXiv:1412.4039* (2014).

[7] Bryan Alexander Ford. 2002. *Delegative democracy.* Technical Report.

[8] Paul Gölz, Anson Kahng, Simon Mackenzie, and Ariel D Procaccia. 2018. The fluid mechanics of liquid democracy. In *International Conference on Web and Internet Economics (ICWIE)*.

[9] Grammateia Kotsialou and Luke Riley. 2020. Incentivising Participation in Liquid Democracy with Breadth-First Delegation. In *Proceedings of the 19th International Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*.

[10] James C Miller. 1969. A program for direct and proxy voting in the legislative process. *Public choice* 7, 1 (1969), 107–113.

[11] Gordon Tullock. 1992. Computerizing politics. *Mathematical and Computer Modelling* 16, 8-9 (1992), 59–65.

[12] Bingsheng Zhang and Hong-Sheng Zhou. 2019. Statement voting. In *International Conference on Financial Cryptography and Data Security*. Springer, 667–685.

[13] Yuzhe Zhang and Davide Grossi. 2021. Power in Liquid Democracy. *Proc. of the 35th AAAI Conference on Artificial Intelligence (AAAI)* (2021).