Social Choice Around Decentralized Autonomous Organizations: On the Computational Social Choice of Digital Communities

Blue Sky Ideas Track

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ABSTRACT

Decentralized Autonomous Organizations (DAOs) are sovereign digital communities that are owned by their members and that are algorithmically-controlled, usually by encoding their rules of conduct as smart contracts. Even though such communities become more popular and influential, their governance capabilities are still limited and lacking in quality. We argue that the MAS community holds the keys to improving the governance capabilities of DAOs; and that the challenge of DAO governance constitutes an important, new application area for MAS research that has the potential to have both scientific and societal impacts. Concretely, we describe DAOs and their governance needs and highlight gaps between the state of the art of MAS research and the governance needs of DAOs.

KEYWORDS

Computational Social Choice; Decentralized Autonomous Organization; Coalition Formation; Continuous Optimization; Sampling Algorithms; Liquid Democracy; Prediction Markets

ACM Reference Format:
Nimrod Talmon. 2023. Social Choice Around Decentralized Autonomous Organizations: On the Computational Social Choice of Digital Communities: Blue Sky Ideas Track. In *Proc. of the 22nd International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2023), London, United Kingdom, May 29 – June 2, 2023*, IFAAMAS, 6 pages.

1 DAOS, DAO GOVERNANCE, AND MAS

Decentralized Autonomous Organizations (DAOs) are a new, emerging form of digital communities. Here we argue that the governance needs of such communities constitute a new application area for MAS research; and that the MAS research needed to address the challenge of DAO governance will push the state of the art of MAS while also having a significant societal impact.[1]

Next, we discuss decentralized autonomous organizations (DAOs) and their societal influence; existing governance solutions for DAOs and their limitations; and the suitability of computational social choice (COMSOC) in offering ways to overcome such limitations. Then, in subsequent sections, we describe corresponding opportunities for MAS research.

[1]Our focus is complementary to the Blue Sky paper of Grossi [47] that describes research opportunities for MAS research in the blockchain domain: while Grossi concentrates on challenges that relate to the infrastructure of blockchain protocols, we concentrate on challenges in the governance layer of DAOs that naturally operate on top of such infrastructures.

Proc. of the 22nd International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2023), A. Ricci, W. Yeoh, N. Agmon, B. An (eds.), May 29 – June 2, 2023, London, United Kingdom.

Decentralized Autonomous Organizations (DAOs). DAOs [50] are sovereign digital communities that are owned by their members and that are algorithmically-controlled, usually by encoding their rules of conduct as smart contracts [75], which are self-executed pieces of programming code. The roots of DAOs may be traced back to the 1990s, in the context of the Internet of Things (IoT) [30]. Today, however, their most natural habitat is the blockchain space [17], as advances in blockchain technology allow for sovereign execution of code. The first popular DAO, named *The DAO* [32], was launched in 2016 and was a decentralized autonomous venture capital fund that functioned as a permissionless platform for making joint monetary decisions (essentially, people could send funds to the DAO and then the community would vote on how to invest the capital).

Today, the DAO ecosystem is rapidly expanding, and includes DAOs that act as: (i) governing bodies for cryptocurrencies and other protocols (e.g., MakerDAO [61] and Uniswap [4]); (ii) grant agencies (e.g., MolochDAO [71] and GitCoin [66]); (iii) developer guilds (e.g., LexDAO [19]); (iv) social networks (e.g., Candao [20]); and more. DAOs are becoming more publicly visible, as is also apparent by their coverage in mainstream media outlets [48, 60, 65]. Moreover, DAOs are gaining in social and economical influence, and the DAO ecosystem, which handles billions of dollars already [5],[2] is expected to continue to grow (see, e.g., the discussion by Wright [76] as well as some evidence that the DAO ecosystem is relatively immune to crypto winters [43]).

DAO Governance. Several factors, however, prevent DAOs from becoming even more widespread and influential. Among these factors are political and legal reasons, immaturity of the infrastructure, limited availability of supporting tools, and—the focus of the current paper—lack of high-quality governance solutions [72]. The latter, namely the challenge of DAO governance, is indeed one of the pressing challenges for the DAO ecosystem; consider, e.g., the words of Vitalik Buterin, the inventor of the popular Ethereum blockchain, over which most of today's DAOs run:

> "One of the important trends in the blockchain space over the past year is the transition from focusing on decentralized finance (DeFi) to also thinking about decentralized governance (DeGov)." [18]

To articulate the governance needs of DAOs, consider a social network operating as a DAO: the members of such a DAO may be both its users, who wish to connect with other users, and its developers, who develop the platform itself. As the DAO members are its sovereign, decisions regarding development priorities, worker

[2]As of December 2022, according to DeepDAO (https://deepdao.io), a DAO research firm, there are 10577 operating DAOs, with 5M members combined, jointly handling more than $9.5B.

compensation, admission policy to the social network, and other user-centered issues such as banning of users need to be made jointly by the members of the DAO. The central challenge of DAO governance is in developing the governance mechanisms for such a DAO that could support such governance needs.

The most popular governance framework in use by DAOs today (e.g., Compound Governance [58]) can be described as a *reality-aware [70] proposal-based direct democracy*. Here, the current set of smart contracts (which defines the rules of conduct of the DAO) are viewed as the status quo, and DAO members can propose changes to this status quo, but each proposal must be accepted by a majority vote that may rely on a predefined, required quorum [7, 22]. This simple governance framework, however, becomes less effective when the DAO size and proposal frequency increase [31, 68]. In particular, many DAOs today suffer from low participation rates of DAO members in the decision-making process [38].

More advanced governance solutions used by DAOs today aim for enabling better decision-making capabilities and include: Aragon's *optimistic governance*,[3] in which proposals are accepted by default unless challanged by community members; DAOstack's *holographic consensus* [26] in which a market-based protocol that involves a decision market [21] is attached to each proposal; CommonStack's *conviction voting* [34], in which community members represent their preferences by locking funds on proposals; and Democracy.Earth [27] (as well as numerous other DAOs) that exploits liquid democracy [10], in which community members can either vote directly on proposals or choose another community member as their delegate to vote on their behalf, transitively.

Currently, though, no encompassing, principled study of DAO governance from a mathematical, algorithmic, or game-theoretic point of view has been done. Correspondingly, the available solutions are still inadequate; consider, e.g., the recent article by Buterin [18] and the recent hostile takeover of Steem [25], essentially an attack on the governance system of the DAO. This gap in knowledge in both research and industry hinders the ability of DAOs to be effectively self-governed, thus limiting their usage.

MAS, COMSOC, and DAO Governance. We argue that the challenge of DAO governance is essentially a challenge for the MAS community, as DAOs are agent communities; and, to a large extent, a challenge for the subfield of computational social choice (COMSOC) [11, 35], in which communal decision making mechanisms are investigated from an algorithmic perspective.

Currently, however, MAS and COMSOC cannot offer suitable solutions for DAO governance; as there are several research gaps between the peculiarities of DAO governance and the current state of the art in MAS and COMSOC research. Correspondingly, in each of the subsequent sections we discuss a different research gap, namely: the evolution of DAO communities (Section 2); the continuous nature of DAO decision making (Section 3); the need for making complex DAO decisions (Section 4); and the attention scarcity of DAO communities (Section 5). For each research gap, we describe the DAO governance need, the corresponding MAS research state of the art, and research opportunities that can close the research gap. Finally, in Section 6, we discuss cultural endeavors that shall be taken in parallel.

[3] https://aragon.org/

Remark 1. *Due to space constraints as well as personal taste, we concentrate mainly on a COMSOC point-of-view of voting-based solutions to the challenge of DAO governance. We acknowledge that other topics within COMSOC and MAS are relevant. Furthermore, indeed we only touch the surface regarding some of the topics discussed below. Also, note that the topics described here are applicable to other digital communities besides DAOs; however, we argue that solving all of them is a prerequisite to having high quality DAO governance.*

2 EVOLUTION OF COMMUNITIES

Following the concept of *code is law* [59], it is useful to view DAOs as evolvig constitutional communities. In particular, DAOs are usually initiated with rather simple constitutions and gradually evolve into communities that utilize more involved decision-making processes. Furthermore, the DAO ecosystem is essentially a free market of communities and their permissionless nature means that, in particular, DAOs can merge and split. Research in COMSOC, however, has been mainly concentrating on a single community; thus merging and splitting of communities are not studied – even though these do occur in real life and also have the potential of improving the ecosystem by evolution; and the literature on evolution of constitutional communities is at its infancy. We thus identify two directions for MAS research: the study of settings with many, possibly interacting communities; and (2) the study of evolution of constitutional communities, including the process of bootstrapping and evolving the decision making capabilities of a community.

Multicommunal Settings. In contrast to the standard model in COMSOC that concentrates on a single community, the DAO ecosystem includes many communities that interact. We mention a recent paper [1] that models a certain kind of interactions in a multicommunal setting; in particular, that paper considers the phenomenon of *forking*, in which a community splits, usually into two communities, and offers a principled, albeit rather limited, social choice approach to such phenomenon. There is still, however, no model for multicommunal settings that captures richer scenarios such as those that involve both merging and splitting of communities as well as the possibility of splitting into several communities at once and the overall dynamics that occurs in such settings. The subfield of MAS that deals with coalition formation (and, more generally, the subfield of cooperative game theory) is a natural candidate for a more involved, principled study of multicommunal settings. In this context, we mention a recent study on a process of deliberation within a single community in which coalitions—that can be viewed as ad-hoc communities—merge and split during the process [33].

Constitutional Bootstrapping. Most DAOs are initiated with a simplistic constitution that is usually oligarchic and only later the DAO community tries—and not always succeeds—to evolve the constitution to a more democratic one. In contrast, the sheer amount of works in COMSOC consider a static decision-making mechanism; and, as such, neglect the initiation and evolution of constitutions and decision making processes. We mention some recent work that axiomatizes the formation and amendment of constitutions [2, 3]. However, a more detailed treatment of this subject that will ultimately lead to concrete suggestions on how to form and evolve constitutions in effective ways is still largely missing.

3 CONTINUOUS DECISION MAKING

In most DAOs, decision making happens continuously over time, as usually community members can make proposals and vote o proposals to change the status quo at any point in time. Furthermore, some DAO governance solutions also explicitly utilize time to enrich their decision-making processes (e.g., *conviction voting* [34], in which DAO members can propose binary proposals to change the status quo at any time; the intensity of voter preferences increases as long as they lock up stakes in favor or against certain proposals; and, finally, when a certain threshold passes for some proposal, its fate is decided).

Current research in COMSOC, however, mainly deals with a one-time decision-making instance for some given, static community. We do mention the recent model of *perpetual voting* [55, 56], in which a community is making several, consecutive decisions (more work have been done on perpetual voting since the introduction of the model [15, 49, 57]).

In the context of DAO governance, however, work on perpetual voting is limited in two aspects, namely: (1) it considers a static community in which the set of voters is fixed, in contrast to the dynamic nature of DAO communities; and (2) it offers a discrete view on time, in contrast to the continuous nature of decision making in DAOs. Correspondingly, what is needed is a theory that allows for continuously-changing voter preferences as well as aggregation mechanisms that output continuous functions.

Dynamic Communities. A natural generalization of perpetual voting to be better applicable to DAO governance is such in which the set of voters can change from a voting instance to its subsequent instance. A different, promising direction for enlarging the standard model of COMSOC to encompass dynamic communities, is the direction taken by Poupko et al. [67] (albeit for a different context) that considers how an algorithmic "admission committee" can be implemented and models the community dynamics as a sequence of graphs.

Continuous Decision Making. The use of time within perpetual voting is discrete; a corresponding, continuous counterpart of perpetual voting may operate by modeling continuously-changing voter preferences, possibly along these lines:

- Assume a continuous time axis T; for simplicity, normalize it so that $T = [0, 1]$ and use $t \in T$ (i.e., $0 \leq t \leq 1$) to denote different points in time.
- Assume a decision space, say $S = [0, 1]$, which corresponds to selecting a value between 0 and 1 at any point in time.
- Assume a set $V = \{v_1, \ldots, v_n\}$ of community members, where each v_i provides her ideal point for each point in time; formally, $v_i : T \to S$, where $v_i(t)$ is the ideal point of v_i at time t.
- Given such n voters, a solution may be some aggregated $w : T \to S$.

Note that the simple model described above is indeed a continuous generalization of a simple model of perpetual voting.

4 GENERAL DEMOCRATIC COLLABORATION

The development of COMSOC research can be viewed in accordance with the types of decisions that tools developed by COMSOC enable a community to make. In particular, COMSOC has evolved from concentrating on single-winner elections [11], in which a single candidate (such as a president) is elected; to considering also their generalization of multiwinner elections [37], in which a committee (such as a parliament) is elected; to considering also their generalization of participatory budgeting [8], in which budgeting decisions are decided upon. Correspondingly, while COMSOC currently can offer tools for a community to democratically choose presidents, parliaments, and collaborate on budgeting decisions; still, the knowledge on how an agent community can democratically collaborate on more involved tasks is still largely missing. (Some works on aggregation methods for more involved tasks do exists [52, 54].) However, DAOs are in need for tools to enable their members to collaborate democratically on increasingly complex tasks.

Democratic Collaboration. Various collaboration platforms are popular within the DAO ecosystem: (1) collaboration platforms such as Wikipedia,[4] Google Docs,[5] and Notion[6] allow a community to jointly create text documents; (2) collaboration platforms such as Google Sheets[7] allow a community to jointly create spreadsheets; and (3) collaboration platforms such as Google Draw[8] and Miro[9] allow a community to jointly create a drawing or other, structured illustrations. The collaboration platforms that exist today are, however, either autocratic – where a distinguished community subset governs the collaboration process (such as in a Google Docs document in which one collaborator has editing permissions while the rest of the community can merely suggest edits to the document); or anarchic – where no agent governs the collaboration process and any agent can freely change the output (such as in a Google Docs document in which all collaborators have editing permissions). At the core, what is missing towards truly democratic collaboration platforms are effective processes that utilize methods that aggregate voter preferences regarding the possible outcomes of involved tasks such as the joint creation of textual documents.

Unified Collaboration. Some works aim at offering the foundations for more general, unified tools for collaboration. E.g., by embedding complex collaborative tasks in a metric space in which sets of points can be then aggregated [16]; this point of view may enable a unified process that can be used for the aggregation of different types of voter preferences for a variety of collaboration tasks.

5 ATTENTION SCARCITY AND ECONOMICS

Many DAOs suffer from low participation rates and low quality of preference elicitation and decision making [25, 69]. One cause for these problems is the use of reality-aware proposal-based direct democracy and the fact that community members have limited resources—time, knowledge, and attention—to actively and meaningfully participate in the decision-making processes [40, 41].

[4] http://wikipedia.org
[5] http://docs.google.com
[6] http://notion.com
[7] http://sheets.google.com
[8] http://draw.google.com
[9] http://miro.com

The standard model of COMSOC, however, implicitly assumes that community members participating in such communal decision-making mechanisms participate in the corresponding processes willingly and in meaningful ways—usually by submitting their preferences regarding the possible outcomes of such processes to a pre-designed aggregation algorithm.

Some works do consider the effort needed from community members to truly submit their preferences [6]. Related, the study of uncertainty in elections [63] can be utilized to develop aggregation methods that are useful for settings in which the elicitation is of low quality. Below we briefly discuss several solution approaches to the problem of the scarcity of the joint attention of DAO communities, namely: sampling-based methods, delegation-based methods, and market-based methods.

Sampling-Based Methods. These are methods in which randomly-chosen subsets of community members act as ad-hoc committees for certain decision making tasks. The most popular form of such methods is a trial by jury [45] (as is practiced, e.g., in the US); there, a population sample is chosen and their decision is being used as is, as the decision of the overall community. Essentially, sampling-based methods may be adequate solutions for attention-aware social choice as, with many communal decisions to be taken, sampling-based methods may allow each community member to actively participate only in a fraction of those decisions, therefore directing their limited attention to directions that may be more fruitful. Works on sampling-based methods for social choice settings do exist, however without considering the scarcity of the community joint attention [9, 28, 29, 39, 42, 44, 64].

Delegation-Based Methods. These methods are methods in which community members can delegate their vote to other members of the community. The most popular form of such methods is used by modern democracies that utilize representative democracy [74]; there, community members delegate their voting rights to a chosen, fixed committee. Recently, liquid democracy [10], in which delegations can be transitive, has started to gain traction in DAOs. Essentially, delegation-based methods may be adequate solutions of attention-aware social choice as a community member that selects a delegate need not spend attention on those decisions that her delegate is making on her behalf (as those decisions are, roughly speaking, being outsourced to the delegate). Some MAS works on delegation-based methods do exist, however without explicitly considering the issue of attention scarcity [13, 14, 23, 46, 51, 53]. We also mention the Blue Sky paper of Brill [12] that argues for the importance of performing MAS research on liquid democracy.

A more radical generalization of liquid democracy is *smart voting* [24, 77], which is still a largely unexplored territory. Here, agents can specify complex directives as their preferences: e.g., an agent can state that its vote should be the majority decision of a certain agent subset. The main challenge here is in the aggregation of complex voting directives: in its most general description, an agent using smart voting can specify a Turing-complete computer program whose output decides on the ballot of the agent and may depend—possibly in a cyclic fashion—on the computer programs and preferences of other agents.

Market-Based Methods. These are methods that allow a community to utilize a resource—e.g., money—to help in its decision-making process. Most DAOs issue their own token and jointly control a treasury, thus possess their own economy. Market-based methods may be used as adequate solutions of attention-aware social choice as the utilization of economic incentives may help in the decision making processes.

To the best of our knowledge, no works consider market-based methods as solutions of attention-aware social choice. Some market-based methods are, however, already used by some DAOs today, such as: *holographic consensus* [40, 41], in which a reality-aware [70] proposal-based setting is augmented with a per-proposal prediction market to signal the community on the market prediction regarding its decisions; *Optimistic voting*, in which a proposal is accepted by default after a certain time limit, unless agents object to it by placing stakes against it; and *conviction voting* [34], in which preference intensity is viewed as a function of the time and the amount of staked tokens. Having a deeper understanding of the properties of such methods as well as exploring the use of money for general social choice settings is of theoretical and practical importance.

6 DISCUSSION

We have described DAOs, DAO governance, and articulated the MAS research that is needed to allow for high-quality governance solutions for DAOs. In particular, we have concentrated on concrete directions for MAS research needed to offer the mathematical foundations for such solutions. Lastly, we wish to highlight the need for complementary data-related and culture-related endeavors needed to tackle the challenge of DAO governance.

Data Repositories. The value of transparency is inherent to the DAO ecosystem [36] and so, many voting operations are recorded publicly. Furthermore, there are complementary services, such as the DAO voting platform Snapshot,[10] that includes a data API (also relevant are individual projects like Cardano Catalyst[11] and Gitcoin,[12] that essentially operate as granting agencies for research regarding DAOs and related subjects). We argue that, to allow for fruitful research regarding DAO governance, it is useful to have a data repository on DAO governance that includes real-world voting scenarios. Naturally, such a data repository can follow the design principles of Preflib [62] and Pabulib [73].

Engagement with the DAO Ecosystem. We view the DAO ecosystem as a huge playground of evolving constitutional communities that have complex, demanding governance needs. To better appreciate the governance needs of DAOs and—symmetrically—to improve the flow of information from the MAS community to DAOs, it is imperative to strengthen the mutual connections between these communities. In particular, such connections will help in validating the mathematical models to be developed by the MAS community with empirical studies to be run on real DAOs as well as evaluating the quality of the algorithms and game-theoretic protocols to be developed by the MAS community based on their usage as governance mechanisms for real DAOs.

[10] https://snapshot.org
[11] https://cardanocataly.st
[12] https://gitcoin.co

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