Pnyx: a Powerful and User-friendly Tool for Preference Aggregation

(Demonstration)

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ABSTRACT

Pnyx is an easy-to-use and entirely web-based tool for preference aggregation that does not require any prior knowledge about social choice theory. The tool is named after a hill in Athens called Pnyx, which was the official meeting place of the Athenian democratic assembly and is therefore known as one of the earliest sites in the creation of democracy. Pnyx is available at pnyx.dss.in.tum.de.

Categories and Subject Descriptors

H.4.2 [**Information Systems Applications**]: Types of Systems—*Decision Support*; J.4 [**Social and Behavioral Sciences**]: *Economics*; H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces—*Collaborative Computing, Computer-supported Cooperative Work*

Keywords

Preference aggregation; collective decision making; social choice theory; voting; web services

1. INTRODUCTION

Preference aggregation and collective decision making are common tasks in real life and computational multiagent systems. Apart from the well-known example of political elections, there are a number of more mundane settings that require the aggregation of preferences. This includes joint decisions such as where to have lunch or a company retreat, or how to make best use of a scarce resource such as a meeting room.

While computational social choice, a novel field of study in the area of multiagent systems, has added a significant amount of insights about the algorithmic properties of voting rules, the development of *practical* and *user-friendly* IT-support for the problem of preference aggregation has found little attention. (A rare exception is the fair allocation platform `spliddit.org`, which was launched in November 2014.) Apparently, there is a practical need for such tools and we would like to contribute to fulfilling this need for the domain of preference aggregation.

Often preference aggregation is conducted using inferior aggregation methods such as plurality rule (see, e.g., [9]) and using unsuitable tools such as `doodle.com` (which was originally intended for *scheduling* a joint activity).[1] The goal of this work is to build a tool for preference aggregation that takes into account theoretical insights from social choice theory and does so without expecting the user to possess any knowledge of the underlying mechanisms. More concretely, we have created a first version of a web-based and user-friendly application that supports the whole process of collective decision making from setting up the poll/election to the communication of the aggregated outcome to participants. The user who sets up a poll only has to select the desired input (e.g., preference relations, sets of approved alternatives, or simply most-preferred alternatives) and output (e.g., single alternatives, rankings of alternatives, or lotteries over alternatives), and the tool then automatically selects the most appropriate aggregation method. There is also support for periodic polls (for instance, lunch polls that are conducted daily before lunchtime), for which users only need to update their preferences if desired.

2. PRACTICAL PERSPECTIVE

The overall visual impression and users' workflows are probably best described in a 5-minute screencast, which can be watched at `vimeo.com/118576213`. Figure 1 shows a screenshot of the creation of a new poll.

Implementation Pnyx is an entirely web-based application that was developed in *Python*, with the core of the application being built using the web framework *django*. We tried to rely on further development frameworks and open-source packages as much as possible. For the front-end, these are the HTML, CSS, and JS framework *Bootstrap* as well as the JavaScript libraries *jQuery* and *jQuery UI*. For the back-end, the aggregation engine partially relies on linear and integer programming, respectively,[2] and makes use of further Python packages for scientific computing (*NumPy* [11], *PuLP*). The underlying database structure is currently supported by *SQLite*.

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[1] Problematic features of Doodle for preference aggregation include the restriction to di-/trichotomous preferences (yes/no/maybe) and incentives for strategic misrepresentation of one's willingness to attend certain activities.

[2] Currently implemented via *GLPK*

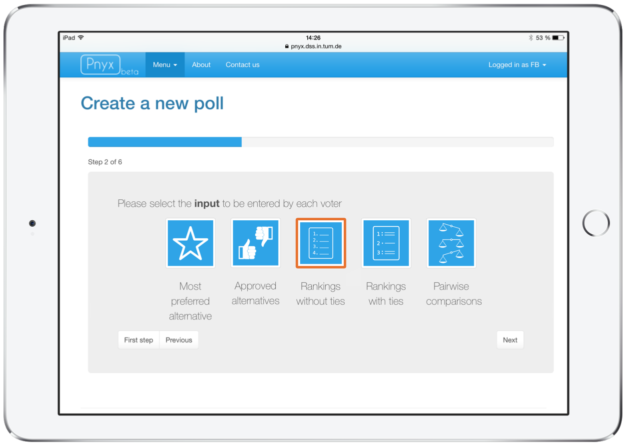

Figure 1: Screenshot of our web-based tool for preference aggregation called Pnyx.

3. THEORETICAL PERSPECTIVE

Pnyx is based on three preference aggregation rules: Borda's rule, Fishburn's maximal lotteries, and Kemeny's rule. Which of these mechanisms is selected depends on the *output type* chosen by the poll creator:[3]

Single alternative: Borda's rule Borda's rule is a simple scoring rule that is particularly intuitive when preferences are linear orders [4]. When there are m alternatives, each voter assigns a score of $m-1$ to his most-preferred alternative, $m-2$ to his second most-preferred alternatives, etc. The alternative with the highest accumulated score wins. We consider a natural extension of Borda's rule to arbitrary binary relations where the score each voter assigns to alternative x is the number of alternatives that x is preferred to minus the number of alternatives that are preferred to x.

Lottery over alternatives: Fishburn's rule The rule that we call Fishburn's rule here was first considered by Kreweras [8] and independently rediscovered and studied in much more detail by Fishburn [6]. The rule returns a so-called *maximal lottery*, i.e., a probability distribution over the alternatives that is weakly preferred to any other such probability distribution. Maximal lotteries are equivalent to mixed maximin strategies (or Nash equilibria) of the symmetric zero-sum game given by the pairwise majority margins, which allows us to use linear programming for their computation (see, e.g., Algorithm 1 by Brandt and Fischer [2]). For more details on Fishburn's rule, we refer to Brandl et al. [1].

Ranking of alternatives: Kemeny's rule Kemeny's rule [7] is an aggregation rule which returns a ranking of the alternatives that maximizes pairwise agreement, i.e., a ranking in which as many pairwise comparisons as possible coincide with the preferences of the voters. Alternatively, Kemeny's rule can be characterized using maximum likelihood estimation [12] or a consistency property for electorates of variable size [13]. We implemented the NP-hard problem of finding a Kemeny ranking via integer programming (following a formulation of Conitzer et al. [3]).

All of Pnyx' rules belong to Fishburn's class of C2 functions [5]. There is a long and ongoing debate in social choice theory about the advantages and disadvantages of certain aggregation rules. While it has become increasingly clear that there is no optimal rule for all purposes, there is strong evidence that some rules are inferior to others in terms of desirable axiomatic properties that have been proposed in the literature. We tried our best to preselect three rules that, in our view, represent a decent compromise between various of these properties.

As *inputs*, Pnyx supports five different choices of individual preference types:

Most preferred alternative Each voter can only select a unique most-preferred alternative among all alternatives. With these individual preferences, all three aggregation rules coincide with *plurality rule*.

Dichotomous preferences Each voter may approve an arbitrary number of alternatives and automatically disapproves the remaining ones. There is no distinction between alternatives within the set of approved or non-approved alternatives, respectively. With these individual preferences, all three aggregation rules coincide with *approval voting*.

Linear order Each voter has to provide a ranking of the alternatives *without* ties.

Complete preorder This input format is a generalization of *linear orders* where ties between alternatives are now allowed.

Complete binary relation This is the most general form of preferences supported by Pnyx. Voters may specify each individual pairwise comparison among alternatives. By default, indifference between any pair is assumed. Note that transitivity of the preferences is no longer required.

4. CONCLUSION AND OUTLOOK

While the system is fully operative with its core features already, there are further ideas of how it could be extended:

Verification of randomness A particularly challenging problem for probabilistic methods will be to conduct randomizations in a user-verifiable way. To this end, we intend to review and employ cryptographic protocols developed in the e-voting and cryptography communities.

Anonymous preference collection There is an increasing demand for practical preference collection, which, for instance, the *PrefLib* library [10] aims to satisfy. Pnyx could contribute to such a library by means of anonymized preference data.[4]

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[3] Note that, when *inputs* are simply given as unique most-preferred alternatives or sets of approved alternatives (dichotomous preferences), all three rules coincide with the well-known *plurality rule* and *approval voting rule*, respectively.

[4] PrefLib's data format is already supported as an export option for poll administrators.

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