Budget-constrained Recommendation of a Set of Alternatives for Common Use

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Applying ComSoc in a News Media Setting

We want to devise a transparent, principled method to select a common core of issues which is broadly acceptable to a diverse readership.

Motivation: A problem with the News Media

- People's biases affect their media content consumption.
- Media tend to feed their consumers' bias.
- This can entrench division and erode the commonly accepted factual base.
- Conversely, if the serious media do not take their readers' concerns seriously, they might lose some part of their readership to less credible sources.

Scenario I: An Essential Readings News Recommendation Algorithm

Online social networks often recommend news articles to their users based on an algorithm that infers preferences from user's past behavior and demographic properties. Such a News Feed may have little overlap for people belonging to different social or political spheres.

Imagine a news aggregator that asks users for an amount of time they want to read every day, scrapes their social network accounts and based on this information creates a list of essential readings of the desired length.

Scenario II: A Newspaper Page

A newspaper with a diverse readership has recently lost readers on one side of the political spectrum who feel that the medium does not report on the issues they care about. Responding to this criticism they would like to create a page that reflects preference data they collect from their readers.

How can they fill the page in a way that is a good compromise given their voters diverse preferences over issues?

Outline

In general, our project was to find good ways for a group of agents to spend a limited budget on a set of alternatives which they all have to consume and over which they have different preferences.

Our starting point was the literature on multiwinner rules and budgeted social choice.
References here

Outline

Formal Framework

We work in a framework familiar from this course...

- A set of *news items* $A = \{a_1, ..., a_m\}$
- A set of *recommended items* $W \subseteq A$
- A set of *consumers* $N = \{n_1, ..., n_n\}$
- A *profile of preferences* over the set of items $\mathcal{R} \in \mathcal{L}^n$

...which we additionally enrich by...

- A utility function $u_i : \mathcal{L}^n \times N \times A \to \mathbb{N}$ assigning each news item its Borda score for the preference order of reader i.
- A *cost function* $C : A \to \mathbb{N}$

Outline

Axioms

We devised budgeted variants of the following multiwinner axioms:

- Non-Imposition
- Consistency
- Homogeneity
- Monotonicity
- Committee-Monotonicity
- Unanimity

Reference

Elkind, Edith and Faliszewski, Piotr and Skowron, Piotr and Slinko, Arkadii: "Properties of multiwinner voting rules", *Social Choice and Welfare*, Vol 48, n 3, 2017, pp.599-632.

Budgeted Utility Maximization

Let $\mathcal{W}_{\mathcal{B}}$ be the set of all elements of $\mathcal{P}(A)$ s.t. $C(W) \leq B$. Extend the utility function to sets by putting $u(a) = \sum_{i=1}^{n} u_i(a)$ and $u(W) = \sum_{a \in W} u(a)$ for $W \in \mathcal{P}(A)$. Utility is maximized if:

$$W = \underset{W' \in \mathcal{W}_B}{\arg\max}(u(W'))$$

θ-Minority Consistency

A recommendation set has a least general threshold θ if

$$a \in W \text{ whenever } \frac{\mathcal{N}_{a \succ b}}{N} \geq \theta \text{ for all } b \in A \setminus \{a\}$$

δ-Equality

For $\delta \in [0, 1]$, a recommendation set is δ-egalitarian if its Gini-coefficient $G(W)$ is smaller than δ.

Outline

Budgeted Utility Maximization (BUM)

This rule takes the voters preference orders and maximizes utility given the budget:

$$\max_{W \in \mathcal{W}_{\mathcal{B}}} u(W)$$

Least General Budget-compatible Threshold (LGBT)

We define a news item's θ-score as follows:

$$\theta(a) = \min_{b \in A \setminus \{a\}} \frac{\mathcal{N}_{a \succ b}}{N}$$

The General Budget-compatible Threshold committee is then chosen as follows:

$$W_1 = \{\arg\max_{a \in A} \theta(a)\} \cap \mathcal{W}_B$$

$$W_n = W_{n-1} \cup (\{\arg\max_{a \in A \setminus W_{n-1}} \theta(a)\} \cap \mathcal{W}_{B - C(W_{n-1})})$$

$$W = W_{|A|}$$

Further Rules

Further we tested budgetized versions of the k-Plurality (BP), k-Borda (BB) and k-Copeland (BC) rules.

Outline

Proofs & Data-Generation

We proved satisfaction or failure of satisfaction of the axioms. In addition we simulated the behaviour of the voting rules with respect to the desirable properties and the failed axioms.
For this purpose, since unfortunately good real world data was hard to find, we generated datasets randomly to our needs. We generated one dataset of small profiles with 5000 readers and 10 news items and one dataset of large profiles with 5000 readers and 100 news items. In addition, for each dataset we used various procedures to generate fully random profiles as well as profiles of several degrees of "fragmentization" from 1 to 100 clusters of preference orders.

Statistical Analysis

Greg should write something here.

Outline

Axioms

Table 1: Axiom Satisfaction

Axiom \ Rule	BP	BB	BC	BUM	LGBT
Non-Imposition	×	×	×	×	×
Consistency	?	?	?	?	?
Homogeneity	✓	✓	✓	✓	✓
Monotonicity	✓	✓	✓	✓	✓
Committee-Monotonicity	×	×	×	×	×
Unanimity	×	✓	✓	×	✓

Budgeted Utility Maximization

θ-Minority Consistency

δ-Equality

An Overall Best Rule?

Future Work

- The cost and utility functions could be used to express dependencies (some items form series of articles, cost might vary depending on reader)
- Implement slack: in many application leftover budget also has a utility
- Find, collect or mine real data (webscraping...).
- Build a ready-to-use implementation!

Conclusions