CS280r Final Project Report
Project Name

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Abstract

1. Introduction

Communication is a costly resource in human-human and human-computer interaction [references]. Given a medical setting, Amir et al. (2015) report that study participants could not review necessary information in a timely manner, nullifying the effect of obtaining complete and correct information. Similar problems arise in the crowdsourcing setting. Hahn et al. (2016) show that crowdsourcing vendors consistently struggle to balance the amount of information needed convey to a worker to equip the worker to excel at his/her job without overburdening the process with too much information. An added complication is that in many settings, the ideal contextual information that is shared is subjective. Therefore, multiple parties have competing interests in having their contributions addressed. One possible solution is to allow for a single contributor or an outside controller to make these subjective decisions. However, experiences with content generators like Wikipedia with a strong hierarchical or dictatorial leadership (Benkler et al., 2015) have shown that the resulting content is often suboptimal from the viewpoint of the whole and heavily skewed to conform to the opinion(s) of the decision-maker(s). Schwartz (2015) stresses that those situations in which group members have different information and the actions of individuals are interdependent are the most critical to be collectively assessed.

Under these conditions, we see a strong case for adopting social budgeting techniques to crowdsource contextual points. As shown in Boutilier et al. (2015), if we assume adopt a utilitarian framework in which we hope to maximize the satisfaction of all group members, properly chosen voting rules can ensure that we minimize the maximum difference between the optimal possible satisfaction to all members and that selected by the voting rule in expectation (the regret), whereas it is clear that for a dictatorial selection this could be trivially equal to the worst case if the size of the alternative set is larger than two times the size of the set of options to be selected.

In particular, we will seek to test the effectiveness of the subset selection algorithm generated by Caragiannis et al. (2017), which approaches the problem as a variation on the maximin rule. In particular, the authors show that it is possible to derive an explicit utility function which maximizes regret while maintaining consistency with the votes, leading to the following expression for maximum regret for a subset selection T:

$$\max_{S \in A_k} \sum_{i=1}^{n} \frac{\mathbb{1}[S \succ_{\sigma_i} T]}{\sigma_i(S)} \tag{1}$$

Where $S \succ_{\sigma_i} T$ indicates that there is no alternative in T preferred to every alternative in S given the utility function σ_i, and $\sigma_i(S)$ is the ordinal ranking of the best alternative in set S in the ranking determined by the utility function σ_i.

Intuitively, any term in this maximization captures the lost satisfaction to the voters of not having the given set S_i chosen rather than T, weighted by how much he or she liked his or her best option in S_i. This will lead to a greater penalization for sets T that do not give many participants at least one of their top choices.

We seek the set T that minimizes this quantity.

$$\mathrm{argmin}_{T \in A_k} \max_{S \in A_k} \sum_{i=1}^{n} \frac{\mathbb{1}[S \succ_{\sigma_i} T]}{\sigma_i(S)} \tag{2}$$

Shah et al. show that this can be solved through an ILP with nm variables and $nm^2 + \binom{n}{m}$ constraints, where n is the number of voters and m is the number of alternatives available.

For comparison, we also use plurality/knapsack voting, which has been used in real-world participatory budgeting programs (likely in part because of its computational simplicity and ease of understanding) (Goel et al., 2015) and is shown in Shah et al. to have empirical regret approaching that of the subset selection algorithm above for subset sizes greater than three, which will be the case in our experiment and should be generally true for problems of this nature.

We apply these different voting rules to the problem of subset selection and conclude that in practice the success of a voting rule may depend heavily on the difficulty (cognitively or subjectively) one has in comparing options.

2. Experiment Design

Three voting rules are compared to evaluate the success of the subset selection. To test the voting rules we pose a setting where participants are requested to select a number of points that may be relevant to a given topic. The authors compiled a set of 10 points from popular *New York Times* opinion pieces, and used a web-based survey form to allow participants to make subset selections. The topics were presented in a 'debate prompt' style and the participants were asked to select the points that would contribute the most value to the presented argument.

The interface [1] was designed to present participants with thee question (on three different arti-

[1] Accessed at: http://nick-and-sophie-harvard-cs280r.s3-website-us-east-1.amazonaws.com/index.html

cles) and each question would display a different subset selection protocol. The different sections consisted of

- 'ranking' selection by dragging and dropping alternatives into the correct order from most useful to least useful for the given argument.
- 'plurality' selection, where check-boxes are selected until 5 selections were made.
- 'ordinal' selection where each point was given a score out of 10 independently of the others.

The study consisted of 37 respondents and 111 subset choices over the three different voting rules. We solve 2 using integer linear programming as described in Caragiannis et al. (2017) to aggregate the ranking and ordinal results into an optimal subset. We ran a ranking selection on the ordinal results to obtain ranked values to use in the subset selection algorithm. For the plurality results, we selected the subset greedily using a majority rule approach.

Finally, selected subsets were presented to a different group of () participants. These participants were simply asked to select the most relevant subset, also given the same topic. This data was also collected through a web-based survey [2].

3. Results

3.1. Citations

Here are two examples of how to cite a paper properly:

- **?** shows that ...
- Prior work has shown that ... (**?**).

4. Related Work

Discussion of previous important, similar work in the area with comparison to the particular approach taken and results of the paper. Avoid simply providing a laundry list of other work that is somehow related to the subject of the paper. This section should contain brief, in depth discussions of the work most similar to your project, i.e., to research that takes an approach to the problem or produces results with which your project should be compared. As is always the case with written work, throughout the paper you should have citations to work that you draw on. For example, if you have adapted a system, include a citation to the system when you first mention it; if you are extending a formalization, include a citation to the original on first mention. If you are unclear about whether a simple citation suffices or an extended discussion is needed in the Related Work section,

[2]Accessed at: http://nick-and-sophie-harvard-cs280r.s3-website-us-east-1.amazonaws.com

look at the papers read for class this semester for models. If you are still unsure, check with the teaching staff.

5. Conclusion

Describes the insights that can be taken away from the work reported in the paper.

6. Future work

Suggests extensions or challenges raised by the project.

O. Amir, B. J. Grosz, K. Z. Gajos, S. M. Swenson, L. M. Sanders, From care plans to care coordination: Opportunities for computer support of teamwork in complex healthcare, in: Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, ACM, 1419–1428, 2015.

N. Hahn, J. Chang, J. E. Kim, A. Kittur, The Knowledge Accelerator: Big picture thinking in small pieces, in: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, ACM, 2258–2270, 2016.

Y. Benkler, A. Shaw, B. M. Hill, Peer production: A Form of collective Intelligence, Handbook of Collective Intelligence 175.

R. Schwartz, How to Design an Agenda for an Effective Meeting, Harvard Business Review .

C. Boutilier, I. Caragiannis, S. Haber, T. Lu, A. D. Procaccia, O. Sheffet, Optimal social choice functions: A utilitarian view, Artificial Intelligence 227 (2015) 190–213.

I. Caragiannis, S. Nath, A. D. Procaccia, N. Shah, Subset selection via implicit utilitarian voting, Journal of Artificial Intelligence Research 58 (2017) 123–152.

A. Goel, A. K. Krishnaswamy, S. Sakshuwong, T. Aitamurto, Knapsack voting, Collective Intelligence .