Undergraduate Minigrant Application

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Qualifications

Background

As a dual major in Computer Science and Math, with a planned minor in Organizational Communication, I've had the opportunity to experience topics within several subfields of both the physical and social sciences during my time as an undergraduate at Utah State University. I articulated my interest in Discrete Math, and particularly Graph Theory, to Dr. David Brown of the Math department in 2014.

Since then, I have done research with tournaments and graph ranking with Dr. Brown. Using my Computer Science background, we have been able to take in statistical data to try to better understand how these abstract structures behave in different contexts.

Qualifications

Before coming to USU, I worked as a programmer at Workers Compensation Fund for three years, and have continued working as a programmer since my freshman year through USU Extension. As a result, I'd like to think that I have a lot of practical knowledge relating to Computer Science through my work experience.

Due to my previous work in industry, I was able to skip the first two semesters of Computer Science classes and immediately jump into Algorithms and Data Structures, which gave me insight on how to write better programs for non-trivial data structures, such as graphs. Since that class, I have done no worse in any CS prefixed course than an A-.

Within the Math portion of my academic career, I earned a 5 on the AP Calculus BC exam, but I wanted to ensure that I truly was familiar with the material. As a result, I re-took Calculus from Dr. Larry Cannon, which gave me a much deeper understanding of mathematical principles that I've since been able to use over and over in subsequent classes.

Later, I was able to take Discrete Math from Dr. David Brown, which really fused many of the concepts touched on in Algorithms and Data Structures with the mathematical rigor expected from Dr. Cannon. In many ways, I see the statistical analysis of tournaments that Dr. Brown and I have been studying as a continuation of that fusion.

As a whole, I believe that my GPA (3.81) also reflects my dedication to coursework, and I hope that the professors who have had me as a student would describe me as tenacious in my desire to learn the material.

Relation to Previous Research

This project is my vison of where I'd like the direction of the research that Dr. Brown and I have been doing to go this summer. My hope is that I can further extend the preexisting scholarly work in graph theory and apply it in a tangible way to a problem outside of the theoretical. In doing so, I would like to think that the computational mathematics I'm working on could better inform decision makers on policies that have a salient effect on others.

With that said, I feel it's worth noting that this is my first research project undertaken at a collegiate level. It's been an exhilarating ride so far, and I plan on continuing working with Dr. Brown into the summer.

Long Term Career Goals

Although credit wise I'm a super senior, I've decided to take the traditional four years of undergraduate coursework. After I graduate in the spring of 2017, my dream is to be admitted to a graduate program in either Computer Science or Applied Mathematics, particularly at the University of Washington. Once I've obtained either a Master's or a PhD, I envision myself working in industry for a time. At some point, though, I plan to come back to higher education in some capacity and "pay it forward" by teaching either Math or Computer Science.

Proposal

Overview

The overarching question we have is this: how can political systems, or social decision-making processes be manipulated, or at least analyzed in a mathematical way? Although superficially simple, we feel that there is a complexity to our question which requires the perspective of three positions: from that of theory, tournament data, and political data.

Theory

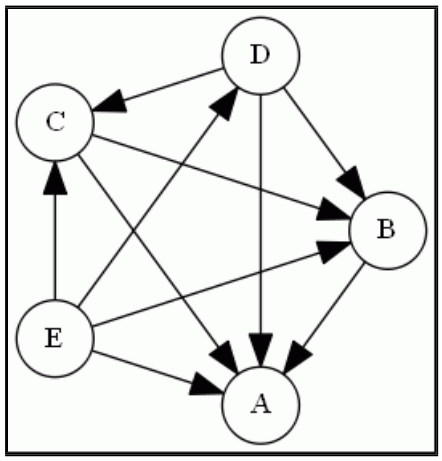
Our question derives from voting a social choice theory, which fortunately has a great deal of preexisting literature for us to draw on. We know that every political system has flaws in its voting structure that allow for manipulation. One of the more common examples of this include a choice between "sophisticated" and "sincere" voting when at the ballot box. Sincere voting is simply that, the individual select the candidate for which they sincerely feel is the best qualified for the position. Sophisticated voting, on the other hand, means voting for a candidate you don't want in order to insure that your truly preferred candidate wins.

The reason why and how sophisticated voting works is dependent on the rules for a particular voting system. One individual, Dr. K.B. Reid of California State University, has worked on addressing these questions of why and how for various systems. Reid has proved using graph theory that voting with sophisticated or sincere methods usually result in the same outcome when using amendment procedure, which is the system used in the U.S. Congress and in many national legislatures throughout the world.

Indeed, Reid claims in a 1997 article that "[The underlying mathematical model of the voting system] admits an agenda so that the sincere and sophisticated decisions are identical if and only if [the model does not contain an unusual attribute]. As a result, most ... sincere and sophisticated decisions are identical."[1]

While we agree with Reid's conclusion in a general sense, we can't help but wonder if the electorate knew a certain quanta of data about how others were voting before casting their own ballot, if sophisticated voting decisions would change the outcome. We ask, what are the possible outcomes of sophisticated voting given a certain set of quanta? Right now, the question remains unanswered and we want to change that.

Tournament Data



A tournament on five vertices

A Few Definitions

- **Tournament** A graph where there is an edge connecting every vertex-pair, and each edge has a direction. For example, the figure above is a tournament on five vertices. A tournament is equivalently the result of a paired comparison.

- **Complete Graph** A graph with an edge between each vertex-pair. Tournaments are often called directed complete graphs.

- **Mixed Graph** A graph where some edges have a direction associated with them and others don't.

Ultimately, every ballot and election under almost any voting system in use today can be modeled either by a tournament, complete graph, or a mixed graph. This is due to an aggregation of a voters choice. Given options A, B, C, D, and E, the voter must choose whether they prefer A to B, B to C, and so forth for all options. These 10 (5 choose 2) paired comparisons can then compiled into one tournament, such as in the figure. It's within this structuring that Reid and many others in the field extrapolate inferences and proofs.

Today, there is no one place where statistical data related to tournaments is found. Although some resources exist (such as Brendan McKay's combinatorics data located at http://cs.anu.edu.au/~bdm/), the data that is in existence is raw. Resultantly, one of our focuses is to take this tournament data in its current limited form and extract attributes from it.

One example of this that we've found use for already is in the enumeration of Hamiltonian paths within tournaments. For example, by plotting the occurrence of Hamiltonian paths of length 'n' on all isomorphically distinct tournaments on 'm' vertices, we have discovered an identical correlation to the number of outcomes of unlabeled m-team round-robin tournaments (OEIS A000568). This sequence directly corresponds to the height of the spanning trees that Reid uses as a key component in his proof about the outcomes in sophisticated and sincere voting patterns.

Furthermore, we intend to collect data about the regularity or uniformity of tournaments. This is useful because the more regular a tournament is, the more computationally difficult it is to extract a ranking from its adjacency matrix. Since voting systems are, at their core, ranking systems, this statistic is invaluable when deciding which tournaments to focus on.

Political Data

In addition to the results we plan on finding through extension of existing theory and the compilation of tournament attributes, we also plan to verify our findings through testing with real world data.

We intend do this by mapping publicly available electoral data from Latin American nations to the modeling structures backed by tournaments. Since Latin American nations tend to have a few shared commonalities in history and culture, the differing outcomes in their elections could be comparable enough for us to control for various factors, even though each nation has a distinct voting system.

With that said, neither Dr. Brown nor I are experts in Latin American politics. However, we've reached out to Dr. Jason Gilmore who is. He's expressed interest in guiding us where we have areas of concern. Due to Dr. Gilmore's advice, we plan to gather statistics from the governments of Brazil, Chile, and Mexico as we prepare to apply their systems to our models. As Brazil just completed national, gubernatorial, and statewide elections in 2014, we intend to focus our efforts there first.

The Bottom Line

There's a lot of work to be done in answering our initial question of "How can political systems, or social decision-making processes be manipulated, or at least analyzed?" Ultimately, working on any of those three fronts of theory, tournament data extraction, and political data verification requires time and resources.

So far, Dr. Brown and I have been lucky in that all of the work accomplished has been done pro-bono and on donated server time. We hope that the selection committee sees the potential in this project, and I thank them for their consideration.

References

[1] Reid, K.B. *Equitable Agendas: Agendas Ensuring Identical Sincere and Sophisticated Voting Decisions* 1997: Social Choice and Welfare.

Honors, Awards, Scholarships, and Recognition Received at USU

- Two year scholarship awarded at entrance
- Acknowledged on the Dean's list for every semester attended at USU