Computational Social Choice

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• Preliminary research training for PhD in CS
• Doing research in computational social choice with Lirong
• A mini CS PhD in one semester
Today's schedule

• Introduction to the course
  – the social choice problem
  – course schedule, grading
  – briefly introduce yourself

• Two goals of social choice mechanisms
  – democracy
  – truth

• Examples
  – elections
  – crowdsourcing
  – matching
  – resource allocation (we will use this to assign papers)
  – peer prediction (we will use this to grade your projects)
Social choice

“social choice is a theoretical framework for analysis of combining individual preferences, interests, or welfares to reach a collective decision or social welfare in some sense.”

---Wikipedia Aug 26, 2013
Example: Political elections

Alice > >

Bob > >

Carol > >
Social choice problems

Profile

\[ R_1 \]
\[ R_2 \]
\[ \vdots \]
\[ R_n \]

Outcome

- Agents
- Alternatives
- Outcomes
- Preferences (true and reported)
- Social choice mechanism
Why this is social choice?

- Agents: \{Alice, Bob, Carol\}
- Alternatives: \{ , , \}
- Outcomes: \textit{winners} (alternatives)
- Preferences (vote): rankings over alternatives
- Mechanisms: voting rules
A very brief history of social choice

Ancient Greece: 4th C. B.C.

13th C.: LULL

French revolution: 18th C.

Modern: 20th C.

PLATO
BORDA
CONDORCET
ARROW
Computational social choice (COMSOC)

“Computational social choice is an interdisciplinary field of study at the interface of social choice theory and computer science, promoting an exchange of ideas in both directions.”

---http://www.illc.uva.nl/COMSOC/
Social Choice and Computer Science

Computational thinking + optimization algorithms

Strategic thinking + methods/principles of aggregation
Course at a glance

• Not a usual lecture course
  – lectures are like academic tutorials
  – expect a steep learning curve

• Try to
  – apply (computational) social choice to your research problems
  – improve computational social choice

• Participation is important
  – presentations, comments, grading, etc.
  – we will use piazza for discussions and announcements
Lifecycle of CS PhDs

- Learning
- Reading state-of-the-art papers
- Brainstorming for new ideas/topics
- Work it out
- Write papers
- Review others’ work
- Dissertation
## Schedule

<table>
<thead>
<tr>
<th>Part 1: Lectures (10-12 classes)</th>
<th>Topics</th>
<th>Your job</th>
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<tbody>
<tr>
<td>• Introduction to</td>
<td>• a few homeworks</td>
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<tr>
<td>- social choice</td>
<td>• prepare for paper</td>
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<td>- game theory</td>
<td>• presentation</td>
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<td>- mechanism design</td>
<td>• work on the project</td>
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<tr>
<td>- computation</td>
<td>START EARLY</td>
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<tr>
<td>• Computational social choice</td>
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<tr>
<th>Part 2: Students present papers (10-12 classes)</th>
<th>State-of-the-art research topics</th>
<th>Presenter</th>
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<tr>
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<td>• make slides</td>
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<td>• present the paper</td>
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<td>• lead the discussion</td>
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<td>Audience: ask/answer questions</td>
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<td>• participate in discussion</td>
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<tr>
<th>Part 3: Presentations (2-3 classes)</th>
<th>Your own project</th>
<th>Presenter: give the talk</th>
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<td>Audience: enjoy the talk</td>
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| Part 4: Evaluation | Grade a classmate’s project | Quality of grading is part of your final grade |
When you read the paper, think about the following questions

- **What** is the problem?
- **Why** we want to study this problem? How general it is?
- **How** was problem addressed?
- **Appreciate the work**: what makes the paper nontrivial?
- **Critical thinking**: anything you are not very satisfied with?

Prepare some “reading questions” for discussion
Project ideas

- Very encouraged to find your own topic
- Some quick ideas
  - Theory
    - design and analyze social choice mechanisms for topics of your own interest
  - Application
    - Online voting system for RPI student union elections
    - Matching and resource allocation (class slots, dorm slots, mentor application)
    - Mobile apps for preference handling
Awards

• A few possibility for awards
  – Best theory project
  – Best application project
  – Best presentation
  – Best participation

• NO bonus grade points
Your final grade

Objective: learning to apply
Expectation after the course

• This is a very technical and mathematical course
  – check out slides from last years

• After the course, you should
  – understand principles and methods in (computational) social choice
  – be able to apply what you learned to your own research
    – become an expert in Chinese accent

• More concretely
  – get some preliminary results for publication
  – develop a real-world preference-handling system
    – know what is Lirong talking about
Outcome of the previous year

- 2 published papers
  - AAMAS, UAI
- 3 in submission
- An online platform for sequential allocation (more to be done)
- An mobile app for voting
Some applications and social choice mechanisms
How to design a good social choice mechanism?

What is being “good”?
Two goals for social choice mechanisms

**GOAL1:** democracy

**GOAL2:** truth
Challenges

- **Evaluation**: fairness, efficiency, etc.
- **Truth**: accuracy

- **Computation**: how can we compute the outcome as fast as possible

- **Incentives**: what if an agent does not report her true preferences?
Recall: social choice

- Agents
- Alternatives
- Outcomes
- Preferences (true and reported)
- Social choice mechanism
Example 1: Political elections

A profile

Alice > >

Bob > >

Carol > >
Why this is social choice?

- Agents: \{Alice, Bob, Carol\}
- Alternatives: \{ , , \}
- Outcomes: winners (alternatives)
- Preferences (vote): rankings over alternatives
- Mechanisms: voting rules
- Goal: democracy
The Borda voting rule

• Input: profile of rankings over alternatives
• Output: a single winner
  – For each vote $R$, the alternative ranked in the $i$-th position gets $m-i$ points
  – The alternative with most total points is the winner
• Use some tie-breaking mechanism whenever there is a tie
Example of Borda

Alice > Bob > Carol

Bob > Carol > Alice

Carol > Alice > Bob

Total scores: Alice: 2+2+0=4, Bob: 1+1+1=3, Carol: 0+0+2=2
Other voting rules?

• Many other voting rules beyond Borda will be discussed in the next class

• Which one is the best?
  – Hard to compare. Criteria will be discussed in the next class
Example 2: Crowdsourcing

Turker 1

Turker 2

Turker n
Why this is social choice?

- Agents: Turkers
- Alternatives: \{a, b, c\}
- Outcomes: rankings over the pictures
- Preferences: pairwise comparisons
- Mechanisms: Maximum likelihood estimator
- More in the “statistical approaches” class
- Goal: truth
Example 3: School choice

Kyle

Stan

Eric
Why this is social choice?

• Agents: students and schools
• Alternatives: students and schools
• Outcomes: matchings between students and schools
• Preferences:
  – Students: rankings over schools
  – Schools: rankings over students
• Mechanisms: Stable matching (Nobel Prize 2012)
• More in the “matching” class
• Goal: democracy or truth?
Example 4: Resource allocation

1 > 2 > 3 > 4 > 5 > 6

1 > 6 > 2 > 3 > 5 > 4

6 > 5 > 4 > 3 > 2 > 1
Why this is social choice?

• Agents: { }

• Alternatives: { 1 2 3 4 5 6 }

• Outcomes: allocations of papers to students

• Preferences: rankings over papers

• Mechanisms: sequential allocation

• More in the “fair division” class

• Goal: democracy or truth?
Sequential allocation

- Given
  - $n$ students’ preferences over $2n$ papers, and
  - an order $O$ over the students
- $SA_O$ has $2n$ rounds
  - In the first $n$ rounds,
    - for each $t = 1$ to $n$, the $t$-th student in $O$ selects her most preferred paper that is available
  - In the next $n$ rounds,
    - for each $t = n$ to 1, the $t$-th student in $O$ selects her most preferred paper that is available
Example

Kyle: 1 > 2 > 3 > 4 > 5 > 6

Stan: 1 > 6 > 2 > 3 > 5 > 4

Eric: 6 > 5 > 4 > 3 > 2 > 1

Step 1 | Step 2 | Step 3 | Step 4 | Step 5 | Step 6
--- | --- | --- | --- | --- | ---
1 | 6 | 5 | 4 | 2 | 3
Is it a good mechanism?

• Sounds good
  – Efficient: if we have different preferences, then we will all (almost) get what we want
  – Fair: (1\textsuperscript{st} pick, last pick), (2\textsuperscript{nd} pick, 2\textsuperscript{nd} to last pick)…

• How can we formalize these arguments?
Sequential allocation for you

• We will use sequential allocation to come up with an initial assignment of papers
  – Each team reports a full ranking over the papers
  – The earlier a team reports, the higher it will be ranked in $O$

• You will have better chance to get your favorite paper
The second phase

• Each topic is assigned a date
• You can exchange the dates on piazza
  – e.g. using the top trading cycle mechanism
• More in the matching class
Project grading

• Step 1. Everyone is assigned 2 or 3 projects of your classmate’s using sequential allocation
• Step 2. Your grading performance will be evaluated against other grades including mine
• Your final grade for project is p% of the aggregated grades and (100-p)% of your grading performance
• What is p? Let’s vote after the drop deadline!
Wrap up

- Expectation: learn how to apply computational social choice to your own research area
- But be careful and keep in mind the two goals
  - democracy
  - truth
Before the next class

• Sign up at piazza (link on the course website)
• Say a few words about yourself
• Participate in discussions on piazza
  – Try to name some other applications of social choice
  – In your applications, will you design a mechanism to achieve democracy or truth?
Why different from MOOC (e.g. coursera)

- Credits
- More interaction
  - Do feel free to interrupt with questions
- Hands-on research experience
- No similar course online
- I will be back to school eventually…
Change the world: 2011 UK Referendum

• The second nationwide referendum in UK history
  – The first was in 1975
• Member of Parliament election:
  Plurality rule ➔ Alternative vote rule
• 68% No vs. 32% Yes
• Why people want to change?
• Why it was not successful?
• Can we do better?
Example 2: Multiple referenda

- In California, voters voted on 11 binary issues (✓/✗)
  - $2^{11} = 2048$ combinations in total
  - $5/11$ are about budget and taxes

- Prop. 30 Increase sales and some income tax for education
- Prop. 38 Increase income tax on almost everyone for education
Why this is social choice?

- Agents: voters
- Alternatives: $2^{11} = 2048$ combinations of / /
- Outcomes: combinations
- Preferences (vote): Top-ranked combination
- Mechanisms: issue-by-issue voting
- More in the “combinatorial voting” class
- Goal: democracy