

Strategic Voting



Motivation:

As you know from the lectures, voting is considered an important group decision-making mechanism in multiagent settings. In this assignment, we explore strategic (tactical, insincere) voting, which can occur in any kind of non-dictatorial voting scenarios. Strategic voting means that at least one of the involved voters supports an alternative (possible outcome, candidate) other than her/his sincere (true) preference in order to achieve a voting outcome that is more desirable (in terms of voter happiness level) for this voter than the outcome that would result from non-strategic (honest) voting.

Strategic voting is common in political elections and there are various famous examples for this from different countries (see in References section). Moreover, because of the increasingly common usage of electronic voting and the risk of influencing the outcome through illegally manipulating the voters' preferences, the topic of strategic voting is receiving steadily growing attention for several years.

Description:

In honest voting, the outcome follows from the true voting preferences expressed by all voters. However, often there are situations in which some voters are not happy about the expected outcome they would get voting honestly. Then those voters might want to resort to strategic voting.

Strategic voting results in the change (increase or decrease) of the overall score of at least one alternative. This can be achieved in a number of ways, thus different types of strategic voting can be distinguished, such as:

- *Compromising* – ranking an alternative insincerely higher than another
- *Burying* – ranking an alternative insincerely lower than another
- *Push-over* (only in round-based voting) – ranking an “easy to beat” alternative insincerely higher than another in the first round(s) in order to increase the chance to win of the true preference in the final round
- *Bullet voting* – voting for just one alternative, despite having the option to vote for several

Goal:

Your task is to develop and implement a software agent called Tactical Voting Analyst (TVA) that analyzes the risk of strategic voting taking place for a given voting situation and a given voting scheme. Specifically, TVA gets as input:

1. A voting scheme.

We consider the following voting schemes:

- Voting for one (plurality voting). Using the positional voting notation (see Exercises 1 on “Making Group Decisions and Voting”), this scheme is described by the voting vector $\{1, 0, \dots, 0\}$.
- Voting for two. The corresponding voting vector is $\{1, 1, 0, \dots, 0\}$.
- Anti-plurality voting (veto). The corresponding voting vector is $\{1, 1, \dots, 0\}$.
- Borda voting. The corresponding voting vector is $\{m - 1, m - 2, \dots, 1, 0\}$.

2. A voting situation.

The voting situation is defined by a set of true preference lists of n voters for m alternatives. These lists together form a $m \times n$ preference matrix (for $m, n > 2$), see example below. In the matrix each column shows the true preference list of one particular voter. The preferences of each voter are assumed to be listed in decreasing order from top to bottom, and the alternatives are referred to by letters A, B, C, etc.

| | 1 st Voter | 2 nd Voter | ... | n^{th} Voter |
|----------------------------|-----------------------|-----------------------|-----|-----------------------|
| 1 st Preference | C | ... | ... | ... |
| 2 nd Preference | B | ... | ... | ... |
| ... | ... | ... | ... | ... |
| m^{th} Preference | F | ... | ... | ... |

The agent generates as an output:

- Non-strategic voting outcome O ;
- Overall voter happiness level $H = \sum_{i=1 \dots n} H_i$ (i.e. a sum of happiness levels of individual voters, definition of voter happiness is given in Remarks section) for non-strategic voting;
- Possibly empty set of strategic-voting options $S = \{s_i\}$, $i \in n$. A strategic-voting option for voter i is a tuple $s_i = (v, \tilde{O}, \tilde{H}, z)$, where v is a tactically modified preference list of this voter, \tilde{O} is a voting outcome resulting from applying v , \tilde{H} is an overall voter happiness level resulting from applying v , and z is a brief explanation stating why i prefers \tilde{O} over O (i.e., what the advantage is for i);
- Overall risk of strategic voting for this voting situation $R = |S|/n$ (size of strategic-voting options set over the number of voters).

Remarks:

For all voting schemes, the winner is the alternative, which received the highest number of points. There can be only one winner. In case of ties, preference is given to a candidate being named first in the lexicographical order (i.e. C is preferred to F , given their scores are equal). This way voting determinism is maintained.

Note that in most cases compromising one alternative takes place in parallel with burying another, and differentiation between the types is done on the level of intention a tactical voter had prior casting its vote. There are situations, in which one of them cannot take place. Such, compromising an alternative is not possible when it is already the top preference, and burying is not possible when the alternative is already the last in the true preference list. In this assignment you can assume that compromising and burying are equivalent.

In general, bullet voting can be performed by voting for less alternatives than allowed. However, that brings ambiguity. In this assignment we limit bullet voting to assigning points only to one alternative. Also note, that the

number of points the voter assigns is always the highest possible (i.e. $m - 1$ points for Borda voting, and 1 for other voting schemes). Note that Bullet voting cannot be applied to plurality scheme.

Tactical voting is successful only when the happiness level of the tactical voter is improved.

We provide you with a definition of happiness level of tactical voter i . First of all, we assume that there is a uniform weighting between the alternatives in the tactical voter's true preference list, which is formalized by assigning weights $w_j = j$ for every alternative, where j is a position of an alternative in a true preference list (indexed from the bottom of the list, starting from 1). (For example, if a true preference list is $\{C, A, B, D\}$, the weight of alternative A is $w_3 = 3$.) Then, for each alternative in the voting outcome we determine the distance between its current position (in the voting outcome) and its "desired" position (in the voter's true preference list): $d_j = k - j$, where k is a position of alternative in the voting outcome (indexed as for j). Such distance is positive if the current position of the alternative is higher than the "desired" position, otherwise the distance is negative. (For example, for the true preference list $\{C, A, B, D\}$ and voting outcome $\{A, B, C, D\}$ the distance for alternative A is $d_3 = 4 - 3 = 1$.) Total distance between the voting outcome and the true preference list is a sum of distances of all alternatives times their respective weights: $d = \sum_{j=1}^m w_j d_j$. Note that when a true preference list matches a voting outcome the distance is zero, whereas when a voting outcome is a reverse of the true preference list the distance is maximum. Finally, the happiness level of the tactical voter for a given voting outcome is calculated as $H_i = \frac{1}{1+|d|}$. Happiness score thus is bounded to $[0,1]$ range. For the example above happiness level is $H_i = \frac{1}{1+|-3|} = 0.25$.

We apply three important simplifications with respect to the experiments:

- 1) TVA only analyzes single-voter manipulation, voter collusion is not considered;
 - 2) TVA does not consider the issue of counter-strategic voting.
 - 3) TVA has perfect knowledge, i.e. it knows the true preferences of all voters
- (These issues are, however, to be considered in the report – see Deliverables section.)

Organization:

This assignment is performed in groups of **maximum** 4 students. The suggested timeline is as follows:

| Week # | Key Tasks | Deliverable |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| 1 | Familiarize yourself with the task. Apply tactical voting in basic voting situations (How do voters reason? Under what conditions may voters vote tactically? What tactical-voting possibilities do voters have?). | |
| 2 | Implement a first version of TVA and iteratively improve it. Start drafting a report. Start thinking about complexity issues of an extended TVA (see Deliverables section). | |
| 3 | Run experiments. Apply TVA to different voting situations, thereby vary the voting scheme and the preference matrix systematically. Compare the voting schemes (using the same preference matrices). Deepen your complexity analysis. Work on the report. | |
| 4 | Finalize implementation, perform final experiments and complete the report. | Final Product; Report |

In the scope of this lab assignment you are required to:

- reason about your choices: research on what techniques/methods/approaches/etc. are suitable for solving a given key task of the week, compare them and select the preferred one – be clear why this approach was preferred by you;
- conduct experiments in a systematic way: perform simulations and tests in order to validate your solution and evaluate its performance; and
- analyze the obtained results (What can be seen from the results? Are the results as expected? If not, then what might be the reasons?).

Deliverables:

All deliverables are submitted by a group as a solution to the corresponding assignment on Canvas:

1. **Final Product**: software binaries (+ source code) or executable scripts in any programming language. Please create a structured .zip file with your code. Please make sure that the interface of your software accepts input and generates output in accordance with the specifications given in the Goal section.
2. **Report** describing your solution and experiments. Discuss the achieved results and draw conclusions (How do the voting schemes compare to each other with respect to risk that strategic voting happens, are there any other conclusions that can be drawn from your experiments and results?). Motivate and briefly explain any choices you made.
Include analytic considerations on the difficulty and complexity of extending your TVA towards capturing: 1) voter collusion; 2) counter-strategic voting; 3) both voter collusion and counter-strategic voting; and 4) all of the above in case when TVA does not have perfect information. More details about the report formatting and structure can be found in “Lab Task Assessment” document on Canvas.

Grading:

Grade of this lab assignment corresponds to 1 point of the final course grade. The grade is awarded to a group and thus applies to all its members.

More details on how the grade is computed can be found in “Lab Task Assessment” document on Canvas.

References:

- Wikipedia on Tactical voting
- Electorama on Tactical voting
- Electology on Tactical Voting Basics
- Blais, and Nadeau, “Measuring strategic voting: A two-step procedure”, 1996
- Pedro Riera, “Tactical Voting”, 2016