Strategic Voting

I. Motivation

As you know from the lectures, voting is considered an important group decision-making mechanism in multiagent settings. In simple words, voting is about choosing a winner from a set of alternatives or options. Voting is omnipresent in our daily life and is common in political as well as societal contexts (e.g., electing a parliament, deciding with your friends how to spend the evening, etc.). 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.

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 (tactical, insincere) voting**.

In this assignment, we explore strategic 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, honest) 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 (sincere) 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** in single-round voting settings can be distinguished, such as:

- *Compromising* – ranking an alternative insincerely higher than another
- *Burying* – ranking an alternative insincerely lower than another
- *Bullet voting* – voting for just one alternative, despite having the option to vote for several

(Another type of strategic voting that applies in round-based voting is *push-over*: 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. An example of a two-round voting is *runoff voting*. In this Lab we only deal with single-round voting and thus push-over strategic voting is not considered.)

Your task is to develop and implement a software agent called Tactical Voting Analyst (TVA) that analyzes strategic voting for given voting schemes and voting situations as described below. Specifically, you should explore the sensitivity of different voting schemes to strategic voting and compare different voting schemes different voting schemes in view of their sensitivity.

II. What a TVA gets as an input

A TVA gets two different two input data:

1. **A voting scheme**.
   We consider the following voting schemes:
   a. 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 $\{1,0,\dots,0\}$.
   b. Voting for two. The corresponding voting vector is $\{1,1,0,\dots,0\}$.
   c. Anti-plurality voting (veto). The corresponding voting vector is $\{1,1,\dots,0\}$.
   d. Borda voting. The corresponding voting vector is $\{m-1, m-2, \dots, 1, 0\}$ (where *m* is the number of alternatives).

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 $v_i$of one particular voter *i*. 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.

	1st Voter	2nd Voter	…	n^{th} Voter
1st Preference	C	…	…	…
2nd Preference	B	…	…	…
…	…	…	…	…
m^{th} Preference	F	…	…	…

III. What a TVA generates as an output

A BTVA generates the following output:

1. Non-strategic voting outcome O;
2. For each voter *i* his/her happiness level H_i . (It is your task to define an appropriate "happiness level" measure);
3. 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 part of your task) for non-strategic voting;
4. For each voter *i* a possibly empty set of strategic-voting options $S_i = \{s_{i1}, \dots, s_{ik_i}\},\ i \in \{1, 2, \dots, n\}$ and $k_i \in N$. A strategic-voting option for voter i is a tuple $s_{ij} = (\tilde{v}_{ij}, \tilde{O},\ \widetilde{H}_i, H_i,\ \tilde{H},\ H)$ with $j \in \{1, \dots, k_i\}$, where $\tilde{v}_{ij}$ is a tactically modified preference list of this voter, $\tilde{O}$ is a voting outcome resulting from applying $\tilde{v}_{ij}$, $\widetilde{H}_i$ is the happiness level of this voter resulting from $\tilde{v}_{ij}$, $\tilde{H}$ is the overall happiness level resulting from $\tilde{v}_{ij}$, and *H* is the "true overall happiness level" (as defined above);
5. Overall risk of strategic voting for the given input, i.e. voting scheme and voting situation. (It is your task to define an appropriate "risk of strategic voting" measure).

Note that the calculation of H and $\tilde{H}$ is based on the simplifying assumption that only one voter votes strategically; in other words, a BTVA does not consider concurrent tactical voting.

IV. Basic and Advanced TVAs

Note that a TVA, as described above, is limited in the following sense:

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.
4) In calculating H and $\widetilde{H}$, TVA only considers tactical voting by a single voter (i.e., it does not consider situations in which several voters vote tactically at the same time).

A TVA that is based on these four limitations is called a **Basic TVA** (**BTVA** for short). Apparently these four assumptions tremendously reduce the complexity of analyzing strategic voting. Any TVA that drops one of these four assumptions is called **Advanced TVA (ATVA** for short**)**. There are four basic variants of an ATVA, depending on what limitation this ATVA drops. For the sake of unique naming, we refer to an ATVA that drops (e.g.) limitation **1** as **ATVA-1**, etc. We do NOT consider ATVAs that drop more than one limitation. Note that a BTVA as well as an ATVA is only dealing with single-round voting schemes (which in itself could be considered as a limitation).

V. Some additional remarks

For all voting schemes, the winner is the alternative that 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.

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 (i.e., not just for one alternative). 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.

Keep in mind: Tactical voting requires, by definition, that $\widetilde{H_i} > H_i$. Trivially, this implies that not every deviation from the true preference order is tactical voting.

VI. Organization/Timeline of your Work

This assignment is performed in groups of 5 students (+/- 1 in exceptional cases). The suggested timeline is as follows:

Week #	Key Tasks	Deliverable
1	**Familiarize yourself with the task:** Manually 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?). Start thinking about “voter happiness” and “tactical-voting risk”.	
2-3	**Work on your <u>BTVA:</u>** Decide on your definition/specification of “voter happiness” and “tactical-voting risk”, and possibly consider alternative definitions for comparison during your experiments. Integrate your definition(s) into your implementation. Run experiments by systematically applying your BTVA to different voting schemes and situations (varying number of alternatives and voters). Compare the voting schemes w.r.t. voter happiness and tactical-voting risk. START WITH REPORT WRITING.	
4-5	**Work on your <u>ATVAs</u>** (by extending your BTVA appropriately): Aim at implementing an ATVA for each limitation (i.e., ATVA-1, etc.). Run experiments by systematically applying your ATVAs to different voting schemes and situations (varying the number of alternatives and voters). For each limitation provide considerations on what it means in view of (additional) computational complexity to drop this limitation. Compare the voting schemes w.r.t. voter happiness and tactical-voting risk. (using the same preference matrices). CONTINUE REPORT WRITING.	
6	Complete your not-yet-finished tasks, finalize and submit your report.	Final Product; Report

VII. About the report:

In general, keep the following requirements in mind:

- Clearly describe and explain your definition of a voter's happiness level and risk of strategic voting.
- Discuss the achieved results in depth and draw conclusions (How do the voting schemes compare to each other with respect to the risk that strategic voting happens? What is the impact of the number of voters and the number of voting alternatives for different voting schemes? Are there any other insights and conclusions that can be drawn from your experiments and results? What impact do your definitions of "happiness level" and "strategic-voting risk" have on your results? Do you see alternatives for your definitions? etc. More generally: What can be seen from the results? Are the results as expected? If not, then what might be the reasons?).
- Describe in detail for each of the four limitations in how far your ATVA goes beyond your BTVA, that is, describe in detail in how far your ATVA goes beyond these limitations.
- Characterize the additional computational complexity induced by dropping each of the limitations.
- Motivate and explain all conceptual design decisions and experimental choices you made (i.e., briefly state the rationale behind these decisions and choices).

More details about the report formatting, structure and content can be found below and in the "Lab Task Assessment" document on Canvas.

Mandatory Structure and Desirable Content:

- Start with a title ("Strategic Voting") and list (1) your group number and (2) the names and student IDs of all group members.

- Structure your report into the following sections (1,. 2., etc.), subsections (a., b., etc) and subsubsections (i, ii, etc.) This structure is mandatory, but feel free to use different numbering.

    1. Happiness

        a. Description and Explanation
        → Describe and explain your definition(s) of a voter's happiness level and of the risk of strategic voting for a voting situation
        b. Illustrations
        → Illustrate your definition(s) with simple examples that show how your definition(s) "work in practice"
        c. Discussion
        → Discuss (potential) advantages and disadvantages of your happiness function(s)

    2. Risk

        a. Description and Explanation
        → Describe and explain your definition(s) of the risk of strategic voting for a voting situation
        b. Illustrations
        →Illustrate your definition(s) with simple examples that show how your definitions "work in practice"
        c. Discussion
        → Discuss (potential) advantages and disadvantages of your risk function(s)

3. BTVA

- **a.** Experiments
  → Describe your experiments and results in a well structured and clear way (e.g., by describing all parameter settings you experimented with, by using separate subsections and by including appropriate tables, figures and/or graphs). Show your most interesting/relevant results only, other (less interesting) results can be presented in an Appendix (after Section 8).
- **b.** Underlying Rationale
  → Describe the rationale underlying the choices you made w.r.t. your experiments (e.g., in view of number of voters, number of alternatives, etc.)
- **c.** Insights Gained
  → Describe the insights you gained from your experiments and results and, in particular, describe the insights you gained for the different voting schemes w.r.t. voter happiness and tactical-voting risk
- **d.** Discussion
  → (1) Provide possible explanations of unexpected/surprising/remarkable results; (2) Comment on (potential) limitations of your experiments/results; and (3) Identify promising future research (e.g., additional experiments you consider as relevant)

4. ATVAs

- **a.** ATVA-x (x = eliminated limitation)
  - **i.** Avoided Limitations
    → For each of the four limitations, describe how and to what extent your ATVA-x handles the elimination of the limitation x
  - **ii.** Experiments conducted with your ATVAs
    → Describe your experiments and results in a well structured and clear way (e.g., by describing all parameter settings you experimented with, by using separate subsections and by including appropriate tables, figures and/or graphs). Show your most interesting/relevant results only, other (less interesting) results can be presented in an Appendix (after Section 8).
  - **iii.** Underlying Rationale
    → Describe the rationale underlying the choices you made w.r.t. dropping the limitation and w.r.t. your experiments (e.g., in view of number of voters, number of alternatives, etc.)
  - **iv.** Insights Gained
    → Describe the insights you gained from your experiments and results and, in particular, describe the insights you gained for the different voting schemes w.r.t. voter happiness and tactical-voting risk
  - **v.** Discussion
    → (1) Provide possible explanations of unexpected/surprising/remarkable results; (2) Comment on (potential) limitations of your experiments/results; (3) Identify promising future research (e.g., additional experiments you consider as relevant), and (4) Comment on the (additional) computational complexity that is caused by drop each of the four limitations.

- **b.** ATVA-y
  → structured in the same way as 4.a.

- **c.** **…**

5. Implementation Details

   a. General remarks
      → Describe any relevant details (e.g., programming language and environment) and/or highlights of your final code/program, list 3rd party software you used, etc.
   b. Happiness and Risk Function Code
      → Code is shown for calculation of happiness and risk of strategic voting

6. Output Examples

   → For your BTVA and for one of your ATVAs, provide the output generated by your program for at least one voting scheme and one voting situation (if needed, add text to clarify what the shown numbers mean)

7. Literature

   → List any related material – articles, websites, etc. – you looked into

8. Who Did What

   → Sufficiently detailed overview of who did what in your group

Formatting Requirements:

- max 10 pages for Sections 1 to 4, no page limit for the other sections
  (BUT keep in mind: qualitative content matters, not page numbers!)
- font type: Times Roman
- font size 11pt
- top/bottom/left/right margin: 2cm each

VIII. 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 single 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** as described above.

IX. Grading:

Grade of this lab assignment corresponds to 3 points of the final course grade. The overall grade is given on a 0 to 10 scale. 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.

X. References:

- Wikipedia on Tactical voting
- https://electowiki.org/wiki/Tactical_voting
- Blais, and Nadeau, “Measuring strategic voting: A two-step procedure", 1996 https://www.sciencedirect.com/science/article/pii/026137949400014X
- Pedro Riera, “Tactical Voting”, 2016, https://academic.oup.com/edited-volume/41327/chapter/352326364