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** 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
- *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

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. TVA gets as an input:

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, … ,0}.
   b. Voting for two. The corresponding voting vector is {1,1,0, … ,0}.
   c. Anti-plurality voting (veto). The corresponding voting vector is {1,1, … ,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. A basic TVA generates as an 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 basic TVA does not consider concurrent tactical voting.

IV. Simplifying assumptions underlying a basic TVA:

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).
5) TVA does only consider single-round voting schemes, and does not consider round-based voting (e.g., two-round voting schemes such as runoff voting).

Apparently these five assumptions tremendously reduce the complexity of analyzing strategic voting. Any TVA that goes beyond these assumptions (i.e., drops any of these assumptions) is called an **Advanced TVA**.

Note: Even if you only experiment with a basic TVA (thus a TVA that sticks to these simplifying assumptions), you should discuss these assumptions in your report ("Complexity considerations").

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.

Important: 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 **maximum** 6 students. The suggested timeline is as follows:

Week #	Key Tasks	Deliverable
1-2	Conceptually 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?). Start thinking about "voter happiness" and "tactical-voting risk".	
3-4	Implement a first version of your basic TVA (and iteratively improve it in the upcoming weeks). 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 initial experiments. Start thinking about complexity issues of an extended TVA (see above).	
5-6	Refine your implementation and systematically run experiments. Consider possibilities to extend your basic TVA towards an advanced TVA, and implement extension(s). Systematically apply your TVA to different voting schemes and situations (varying the number of alternatives and voters). Compare the voting schemes (using the same preference matrices). Deepen your complexity considerations. Start drafting your report (in week 3) and continuously work on the report.	
7	Finalize implementation, perform final experiments, and complete the 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 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?).
- If you explore an Advanced TVA (in addition to a basic one), describe in detail in how far your Advanced TVA goes beyond a basic TVA.
- Even if you investigate only a basic TVA, 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, structure and content can be found below and in the "Lab Task Assessment" document on Canvas.
- Very important: Motivate and briefly explain any experimental choices and decisions you made.

Mandatory Structure and Desirable Content:

- Start with a title ("Strategic Voting") and list names and student IDs of all group members.
- Structure your report into the following sections:
    1. Abstract (→ compact overview of the conducted experiments and the main results and insights gained from your experiments)
    2. Happiness and Risk (→ describe and explain your definition of a voter's happiness level and of the risk of strategic voting for a voting situation, illustrate your definitions with simple examples that show how your definitions "work in practice" and what their advantages and disadvantages are)
    3. Experiments and Results (→ for basic TVA and – if implemented – for an Advanced TVA, conducted experiments, their setting and the experimental results are described, some results for a given voting scheme may be averaged over different experiments, results should be clearly arranged (e.g. in subsections) and nicely presented (e.g., in tables, figures and graphs))
    4. Discussion and Conclusions (→ main main insights and conclusions are highlighted, explanations of unexpected/surprising/remarkable results are provided, limitations of your results and your overall experimental setting are critically analyzed, suggestions for follow-up experiments are made, complexity considerations (see above) are provided, etc.)
    5. Literature (→ list any related material – articles, websites, etc. – you looked into)
    6. Who Did What (→ short but sufficiently detailed overview of who did what in your group – this section is obligatory, report without this section will not be accepted)
    7. Implementation Details (→ relevant details and highlights of your final code/program, sample code is shown for calculation of happiness and risk of strategic voting)
    8. Output Examples (→ examples of output generated by your program for different voting schemes and voting situations, the selected examples should be representative but need not be exhaustive, make sure that each of your examples is well arranged and easily understandable (e.g., add text to clarify what the numbers mean), just providing unstructured lists of difficult-to-interpret numbers would be not sufficient)

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 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
- 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