Multi-Agent Systems: Final Project
Mafia game simulation

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1 Introduction

In this project we are going to simulate the *Mafia* game, also known as *Werewolf*. The research question in this case will be to determine a required ratio of mafiosi to innocents in the game to make the game balanced. Previous research has been conducted on a very limited amount of roles (mafia against townfolk). In our project, player roles will be expanded to include special roles, such as investigators, doctors, and lovers, which have different abilities. We will also introduce a set of properties that determine players as *careless* or *mistrustful*, and experiment with different player strategies.

2 Mafia game

Mafia is a popular party game that models a conflict between an informed minority, the mafia, and an uninformed majority, the innocents (Wikipedia). At the start of the game, each player is secretly assigned a role affiliated with one of these teams. The game has two alternating phases: night, during which the mafia may covertly "murder" an innocent, and day, in which surviving players debate the identities of the mafiosi and vote to eliminate a suspect. Play continues until all of the mafia members have been eliminated or until the mafia outnumbers the innocents, in which case the innocents no longer have a chance to win. To make the game more challenging, special roles can be assigned to some of the innocents. In our research we will consider three special roles:

- *policeman* - may wake up at night and find out the identity of one of the players.
- *doctor* - may protect one person during the night. If the mafia choose to kill that person, they survive.
- *lover* - may "sleep" with another player every night. If the mafia kills the chosen player both that player and the lover are killed. If the mafia chooses to kill the lover, then the lover survives (because they are not "at home").

3 Multi-agent system formulation

The mafia game players can be viewed as two opposing teams of agents, each of which wants to win the game by eliminating enough agents from the opposing team. The environment in which the agents live is partially accessible for the mafioso agents, who know from the start who their teammates are but do not know the identities of the special characters, while it is inaccessible for the "innocent" agents. It is nondeterministic, as an agent's action may have more than one effect. For example, if the policeman agent decides to share his beliefs, the other agents are not guaranteed to adopt those beliefs. The environment is also static, since the only changes come from the actions of other agents, and discrete, as there are a finite number of possible actions for each agent, based on the two possible game phases. Agents, which are not mafiosi, are allowed to communicate only during the day phase of the game. They can fully or partially share their beliefs with other agents to try to convince them in their own beliefs. The mafiosi agents are also allowed to communicate during the night, when they conspire to kill somebody. Moreover, during the day they are allowed to share fake beliefs, othwerwise they would be sharing their identities with the opposing team.

We continue by further discussing the hyperparameters of the simulation, and scetching a draft for the agents' beliefs, desires, intentions and strategies.

4 Simulation hyperparameters

- Amount of players (at least three)
- Amount of people for each role:
    1. At least one mafioso
    2. At most one policeman
    3. At most one doctor
    4. At most one lover
    5. At least two innocents
- Level of mistrustfulness determines the probability that one player can convince another that he is not a mafioso.

5 Beliefs

Each agent has beliefs about the roles of the other agents. At the beginning of the game, beliefs are initialized as follows:

- Mafiosi know each others identities.
- Innocents only know their own roles.

Beliefs will be updated after each round of the game, dependent on the player's observations. For example, players can change their beliefs after the day's vote. Additionally, the policeman updates his beliefs depending on his checks. If the policeman decides to share some of his beliefs with the other players, then each player can decide on their own wether to believe that he is the policeman or not, and concequently update their beliefs.

6 Desires

Desires are structured depending on the goal of the particular agent:

- For mafiosi: "Kill innocents", "Hide" (dependent on the chance to be observed).
- For innocents and the policeman: "Find mafia"
- For the doctor: "Treat innocents"
- For the lover: "Sleep with mafia"

7 Intentions

Based on desires we derive the following intentions for each role:

- For mafiosi: "kill person A", "convince person B"
- For innocents: "vote against person A", "convince person B"
- For the policeman: "vote against person A", "convince person B", "share knowledge" (in this case other people may choose to believe that he is the policeman or not, and decide whether to incorporate the obtained knowledge or not).
- For the doctor: "treat person A", "vote against person A", "convince person B"
- For the lover: "Sleep with person A", "vote against person A", "convince person B"

8 Strategies

There may be several strategies that mafia can choose:

- To kill random person that is not mafia.
- To kill person that has a high chance to observe mafia.

The policeman can choose:

- To never share his insights
- To share immediately his insights (but then the mafia will know who he is).
- To share information when at least one mafioso has been killed.

The innocents may decide whom to trust based on:

- a simple majority vote - trust the most trusted people.
- a highest commulative reward strategy - trust poeple with high rate of success so far.

The proposed strategies can be evaluated to determine their efficiency in the Mafia game.

References

Wikipedia. Mafia (party game). URL https://en.wikipedia.org/wiki/Mafia_(party_game).