SJMMA 2024　C 题

控制论合作者

想象一款非完全信息的合作类桌面游戏。其与大多数同类游戏的显著区别在于玩家的手牌信息仅对所有其他玩家公开，并在规则上限制了信息的内容和传递方式。

具体而言，一场该游戏的卡组由不同颜色的若干张 1 至 5 卡牌组成，牌背朝向自己抽取起始手牌后按玩家顺序，每位玩家必须选择弃置 1 枚提示指示物以向另一位玩家指出其手牌中所有某一颜色的卡牌或某一数字的卡牌，获取 1 枚提示指示物以从手牌中弃置 1 张手牌，或打出 1 张手牌，随后如选择打出手牌或弃置手牌则牌背朝向自己抽取 1 张卡牌。打出手牌时如该卡牌数字恰是已打出的同色卡牌中最高的数字的后继数，或该卡牌数字为 1 且为已打出卡牌中该种颜色第一张，则将其加入该色的打出堆，否则获得 1 枚错误指示物。当所有玩家共获得 3 枚错误指示物，玩家打出了所有颜色的 1 至 5 卡牌，或自一位玩家需要抽牌但卡组无牌可抽起所有玩家都进行了 1 回合时，游戏立刻结束，该场游戏的得分为玩家打出的卡牌数量。

在规则上，玩家不能通过前述行动以外的方式传递信息。但在实际游戏中，玩家有意或无意的动作常常传递出一些关键的信息。如一位玩家在进行提示时比往常花费了更多的时间进行思考通常表示这次提示和之前的提示有不同的特征，在复盘中明确表示自己在游戏中某次提示的含义则会让玩家之间达成此时尚不应存在的“协议”。这些动作在一定程度上改变了游戏的本质，导致鲜有玩家能够进行一场“标准”的游戏。一场玩家完全遵守规则的标准游戏应是如何的？在连续进行的一系列标准游戏中，玩家的行为会发生如何的变化？为解答这些问题，需要引入程序控制的电子玩家。

任务

为便于标准化测试，游戏的详细规则、标准游戏类、标准玩家抽象类及标准玩家类编写规范等必要的信息已在附件中给出。你的团队需要：

1. **开发自合作电子玩家类**：首先考虑所有电子玩家依照相同的行为特征进

行游戏的情况。建立一个或多个模型描述电子玩家的策略，并按编写规范在玩家类中实现，使得仅有该种玩家参与的游戏中最终得分尽可能高。

2. **完善程序以与任何玩家合作：**考虑一组行为特征各不相同的玩家连续进行一系列标准游戏的情况。完善步骤 1 中的模型并按编写规范在玩家类中实现，使得该种玩家可以在连续进行的游戏中获得尽可能高的总分（即每场游戏得分之和）。
3. **加入变体规则：**考虑附件中给出的变体规则。修正步骤 2 中的模型并按规范在玩家类中实现，使得该种玩家可以在连续进行的游戏中获得尽可能高的总分。
4. **编写自述文档：**为该游戏在线平台的开发者撰写一份自述文档，文档中需要包含：
   1) 玩家类的开发语言及库依赖
   2) 如何将你们的电子玩家引入一局游戏中
   3) 该电子玩家在单场及连续进行的游戏中的行为特征

提交

你的团队所提交的报告中应包含 1 页“总结摘要”，2 页的自述文档，其正文不可超过 20 页（总页数限于 23 页）。附录和参考文献应置于正文之后，不计入 23 页之限。附件中已包含需要额外提交文件的要求。

SJMMA2024 Problem C

Cybernetic Cooperator

Imagine a cooperative incomplete information card game. It differs significantly from most games of its kind in that players cannot see their own cards, instead they may check at any time all the cards in other players' hands. Yet how and what players may inform others of their hands is restricted.

Specifically, during setup, players form a deck consisting of a number of cards of different colors numbering 1 to 5. Players draw their starting hands with each card facing other players so that they cannot see their own cards. Then in player order, each player must choose to discard a hint token to perform a hint, which means pointing out all cards of a certain color or number in the targeted player's hand, or obtain a hint token to discard a card from his hand, or play a card in his hand. Then if a card is discarded or played, he then draws a card, facing other players. When playing a hand, if the number of the card is the successor of the biggest number among cards of the same color in the field, or if the number of the card is 1 and cards of that color do not exist in the field, it is added to the field, otherwise it is discarded, and players get a error token. The game ends immediately when players gain the third error token, when all 5's are in the field, or when all players have taken a turn since the first time a player was unable to draw due to empty deck. Players then calculate their score by adding the biggest number of all colors in the field.

By rules, a player may not pass information by any mean other than the actions described above. In actual games. However, players' motions, whether intentional or not, often send critical messages. Taking a longer time to decide how to hint than usual, usually means that the hint itself has a different pattern. Specifying the meaning of a hint in a replay can lead to an "agreement" between players that should not yet exist. These motions change the nature of the game to such an extent that few players are able to play a "standard" game. What would a game be like if the rules are strictly followed?

How would a player's action pattern change over the course of a series of standard games played in succession? To answer these questions, it is necessary to introduce program-controlled virtual players.

Requirements

In order to facilitate standardized testing, necessary information such as detailed rules, a standard game class, standard player interface and requirements on how standard player class should be written are given in the attachment. Your team is required to:

1. **Develop a self-cooperative virtual player class**: First consider the situation where all virtual players play their turns in the same pattern. Develop one or more mathematical models to describe the strategy of such virtual players to reach a score as high as possible, and implement them in a player class as required in the attachment.
2. **Refine the program to cooperate with any player:** Consider a series of standard games played in succession by a group of players with different behavioral patterns. Refine the model or models in Step 1 and implement them in a player class as required, so that that players can achieve the highest possible total score (i.e. the sum of all scores).
3. **Apply a rule variant:** Consider the variant given in the attachment. Modify the model or models in Step 2 and implement it in a player class as required, so that players can achieve the highest possible total score in consecutive standard games.
4. **Write a README document:** Write a README document for the developers of boardgame web platforms. Your README document should include:

1) Programming language used to develop your player class and library dependencies required to include an instance of your player in a game.
2) Specified steps to include an instance of your player in a game.
3) The behavioral pattern of your virtual player in single and continuous games

Submission

Your solution paper should include a 1-page Summary Sheet, a 2-pages README file.

The body cannot exceed 20 pages for a maximum of 23 pages with the Summary Sheet inclusive. The appendices and references should appear at the end of the paper and do not count towards the 23 pages limit. Requirements for the submission of additional files are included in the attachment.