

# C++ coursework report

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## 1 Description

### 1.1 Description of the program

Game rules: In the game, there are two players: one is the computer player and the other is the human player. Every player has a suit of cards from A - K. And there is a suit of shuffled cards from A - K used as prizes with one card showed up. Players should bid for the facing up card and the player could get the scores of the showed card if whose bidding is bigger.(same bidding then split the scores of that card). The cards used for bidding are discarded, and play continues with a new upturned prize card. It lasts for 13 rounds and higher scores player can win this game.

Implementation: The program consists of these files:

1. cpp files: Player.cpp, ManualPlayer.cpp, ComputerPlayer.cpp, Prizes.cpp, Game.cpp, main.cpp
2. h files: Player.h, ManualPlayer.h, ComputerPlayer.h, Prizes.h, Game.h

And five classes within the files:

1. Player class
2. ManualPlayer class
3. ComputerPlayer class
4. Prizes class
5. Game class

This program is a game of Goofspiel in C++ codes with correct object oriented techniques like encapsulation, polymorphism. Appropriate comments, standard naming style, appropriate interface and dealing with the invalid input are all implemented correctly. And the program can always give the correct output, no run time error nor memory leak.

### 1.2 Description of the algorithm

#### 1.2.1 Algorithm overview

The strategy of the computer player can be summarized as hybrid strategy consists of learning algorithm and semi-deterministic algorithm.

#### 1.2.2 Core of the learning algorithm

For the learning algorithm, the computer will calculate every time the card picked by the human player minus the prize card as a difference(human player card - prize card) to predict what will be picked next round.(Difference is 0 in the first round). Because the difference must be in the range of -12 to 12, I define that only the difference from -4 to 4 then it is valid. Other circumstances the computer will think that the human player picks randomly or makes a trick to it and by this could get a relatively accurate prediction in the next round. And add the valid difference every time and then divided by

the valid number of difference, so it gets a prediction I define it as 'habit'. (Habit is also 0 in the first round). The next time the computer wish to pick the least card that bigger than the prediction.

$$Difference = Human\ Picked\ Card - Prize\ Card$$

$$-4 \leq Valid\ Difference \leq 4$$

$$Habit_n = \frac{Valid\ Difference_1 + Valid\ Difference_2 + \dots + Valid\ Difference_n}{n} = \frac{1}{n} \sum_i^n Valid\ Difference_i$$

So the range of Habit is:

$$-4 \leq Habit \leq 4$$

### 1.2.3 Process of the algorithm

In this section, the procedure of the bidding algorithm of the computer will be described.

#### Preliminary treatment

1. If the prize is J Q K and the max of computer's is smaller than human's, then computer will pick the minimum card.
2. If the prize is 9 10 J Q K and the computer has several cards bigger than the max of human, then the computer will pick the smallest card from the cards that are larger than the max of human.
3. If the prize is A 2 3, then pick the smallest card.
4. Then judge the scope of habit.

**If  $0 < habit \leq 4$**

- The computer will pick the least card that bigger than the prediction. If the computer doesn't have that card then it will pick the smallest card and special circumstance is the computer's max card equals to the prediction then it will pick the max card.

**If  $habit \leq 0$**

- It picks the card with 2 bigger than the prize. If this card doesn't exist, then picks the card with 1 bigger than the prize. If this card doesn't exist either, then it picks the card with the same value. If this card still doesn't exist, then picks the minimum card.

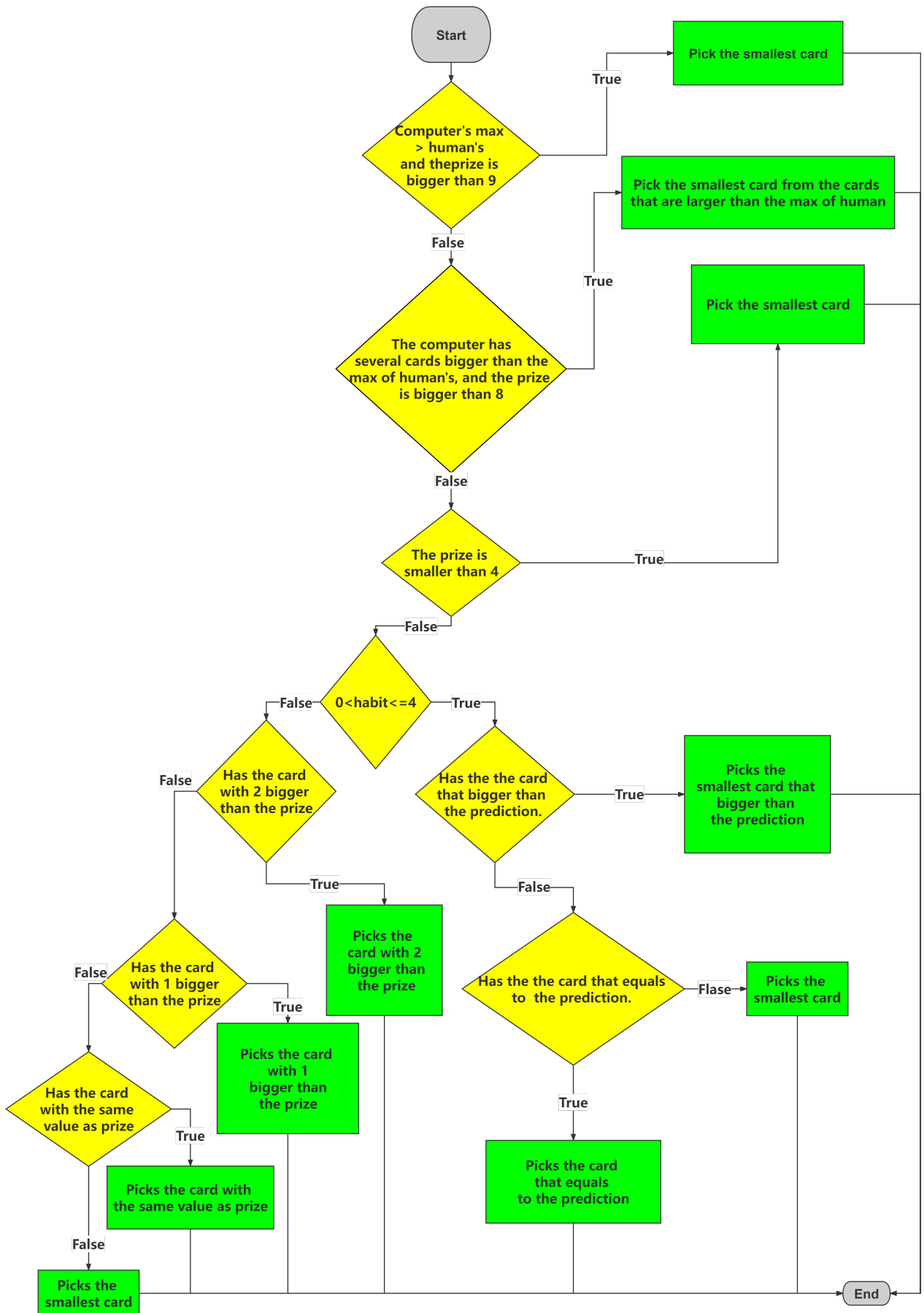


Figure 1: The process for the bidding algorithm for computer.

## 2 UML expression

The class diagram as Figure 2 shown. ComputerPlayer and ManualPlayer inherit from Player. ComputerPlayer depends the ManualPlayer and Prizes and ManualPlayer, Prizes and ComputerPlayer are in composition relationship with Game.

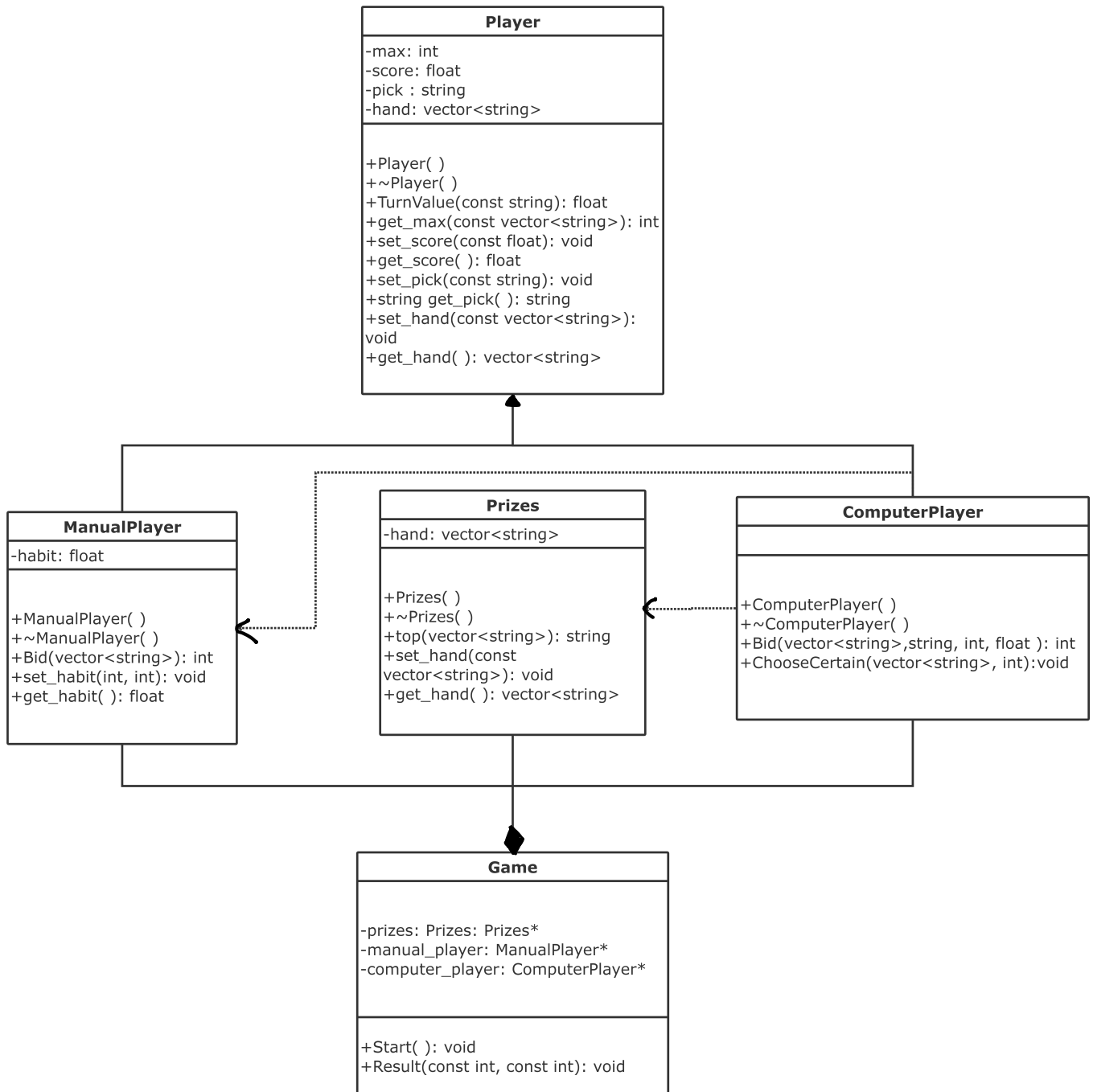


Figure 2: The class diagram of the project.

## 3 Evaluation of the algorithm

The algorithm is a hybrid algorithm consists of learning algorithm and semi-deterministic algorithm.

### 3.1 Advantage

#### 3.1.1 Preliminary treatment

- If the prize is J Q K and the max of computer's is smaller than human's, then computer will pick the minimum card

This can make computer avoid entering a no-win race. And use the smallest card to waste a much bigger card of the opponent so that the computer could have more cards with higher values.

- If the prize is 9 10 J Q K and the computer has several cards bigger than the max of human, then the computer will pick the smallest card from the cards that are larger than the max of human.

Computer use the smallest card that bigger than its opponent's max card to make the rounds later be easier.

- If the prize is A 2 3, then pick the smallest card.

This denotes that the computer doesn't pay high cost to win the cards that have little contribution to get scores. Abandon these cards to have higher bidding for the cards that have more contribution to the scores.

#### 3.1.2 Learning algorithm

The habit is an average number and it could be more and more precise through the game goes on so that more predictable. The computer will use different strategy according to the value of habit.

If habit is bigger than 0 and less than or equals to 4(This means that the human player is likely to use a card that larger 'habit' value than the prize card): So it is easy for computer to beat a player with deterministic approach. And use the smallest card that bigger than the prediction makes sure cost less to get the scores. And use the smallest card to waste opponent's higher card if it doesn't have a card bigger than the prediction to make the rounds later be easier. And it has a judgment for the difference is that abandon the big gap bid to used as reference to make sure that the habit relatively accurate.

#### 3.1.3 Semi-deterministic algorithm

If the habit is less than or equals to 0(This means that the human player is playing randomly or picking the card that with the same value with the prize card all the time or use the card that less than the prize and I consider it is also randomly play):

- It picks the card with 2 bigger than the prize. If this card doesn't exist, then picks the card with 1 bigger than the prize. If this card doesn't exist either, then it picks the card with the same value. If this card still doesn't exist, then picks the minimum card.

Because it always wish to choose the card that bigger a little than the prize the card, it has more probability to beat the player who plays randomly. And it is always beating the player that use the deterministic approach to plays the same value card.

#### 3.1.4 Advantage overview

This algorithm has better chance to beat random algorithm or deterministic algorithm. And due to it can observe the player's habit, it did well with the competition with human player. During the test, it beats 80% of the human player tester.

## 3.2 Drawback

- In the first several rounds, the habit could be changed hugely and the prediction could be less accurate.
- If the human player like to pick cards bigger than the prize and next time pick the smaller one and change every round, the computer will consider that the human like to pick stably and make inaccurate prediction.
- If the human player always keeps the max card that larger than computer's, when it comes to big value card in prize, all these cards are high probably won by human because the computer will pick the smallest card.
- The semi-deterministic algorithm seems to easy in logic and it might be beaten easily if the opponent finds its regularity.
- It lacks kind of random pick to confuse the opponent when it comes to some unimportant card. Or it could randomly pick when make sure the victory of the game.