Analysis of face direction by players in Indian-poker game

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Abstract

In this paper, we discuss the analysis of the interaction among the players in the Indian-poker game. In this game, the player can see other players' cards and the player cannot see their own card. Therefore, the players compare other players' cards and turn their eyes to other players. Here, we propose an image processing method which can detect the face direction from moving images recorded by a USB camera. Finally, we show results for the analysis of the behaviors by players based on the face direction for the two cases; (i) the difference between the cards is large, (ii) it is small.

1 Introduction

In daily life, the eye movement plays a very important role on looking at human faces and reading books [1]. Moreover, not only the eye movement but also human behaviors including the face movement and gestures are very important for the human communication. Especially, in the interactive type game using cards, the players try to guess the hidden cards from other players' changes of their face expressions. Indian-poker is one of poker games and is called blind man’s bluff. In this game, players place the cards on their forehead and each player can see others’ cards and cannot see their own card. It is very important for players to evaluate the relations of others’ cards and guess from others’ face movements.

The final goal is to extract the difference between behaviors by the winner and losers and to estimate the strength of the own card based on their behaviors in the Indian-poker game. In this paper, we discuss the analysis of the interaction among the players as an early stage for the final goal. Concretely, we analyze the frequency of the head movement by the players. In this game, each player can see others' cards and cannot see their own card. On the other hand, the player can detect the frequency with which other players are looking at their own card. Each player can detect the following behaviors by players; (i) how other players are looking at each other, (ii) how other players are looking at oneself.

Accordingly, the image processing method plays important roles in the extraction of the characteristics for the above behaviors by players. Here, we propose an image processing method which can detect the face direction from moving images recorded by a USB camera. Finally, we show the analysis results for behaviors by players based on the face direction according to the difference between card numbers.

2 Detection of face direction

As shown in Figure 1, three players (Player-A, B, and C) have CCD cameras (Resolution: 640 × 480 [pixels], fps: 10 [fps]) putting on their ears. When they turn to left and right, the cameras can record scenes images according to the face direction [3]. When the player-A turns to left, the camera putting on ear can record face of player-C. On the other hand, when the player-A turns to right, the camera putting on ears can record face of player-B. In this paper, the face direction can be detected based on images recorded by each camera putting on players.

When players look at other players’ cards, they can gaze at Region of Interest (ROI) by combination of head and eye movements. Though this type camera can not detect the eye movement, this camera can move according to the head movement by players. Therefore, this type camera can detect the global ROI by players.
2.1 Detection of face direction

The optical-flow and block-matching methods are adopted to detect for moving objects and the movement direction [2]. In this paper, we assume that the moving objects (other players’ face) and cameras are rotated on an axis. Here, when players rotate their faces, the cameras putting on their ears can record the images according to the rotation direction. Therefore, we adopt the block-matching method to images recorded by the cameras and proposed a method for the detection of gaze direction as shown in Figure 2.

In Figure 2 (a), the red-colored rectangle shows ROI (region of interest) in the template image (the (i-1)-th frame). By reference to the template image (the red-colored region) in Figure 2 (b), the position of the template image in the i-th frame can be detected. Concretely, the difference $D(\Delta_x, \Delta_y)$ between the template image $f_{i-1}(x + m, y + n)$ and the i-th image $f_i(x + \Delta_x m, y + \Delta_y + n)$ can be calculated by Eq. (1).

$$D(\Delta_x, \Delta_y) = \sum_{m} \sum_{n} (f_i(x + \Delta_x m, y + \Delta_y + n) - f_{i-1}(x + m, y + n))^2, \quad (1)$$

where $(x, y)$ denotes the left-upper position of the template image in the i-th frame and $\Delta_x$ and $\Delta_y$ denote the movement quantity of the template image. Moreover, $(m, n)$ denotes the coordinate in the template image.

Next, by searching the position $(\Delta_x, \Delta_y)$ so as to minimize the difference $D(\Delta_x, \Delta_y)$, the movement of the object can be detected. Here, we define the movement quantity as $(\Delta_x(i), \Delta_y(i))$ in the i-th frame. Furthermore, we define the accumulated movement quantity as $T_x(i)$ and $T_y(i)$ as follows;

$$T_x(i) = \sum_{j=1}^{i} \Delta_x(j), \quad T_y(i) = \sum_{j=1}^{i} \Delta_y(j).$$

2.2 Features for face direction

The accumulated movement quantity $(T_x(i), T_y(i))$ by the player-A is shown in Figure 3. This figure shows the change of by face direction by this player. Here, the blue point denotes the peak of the left and right turns by the player.

Therefore, the number of peaks (left and right turns) plays an important characteristics in behaviors by players. The peak can be extracted by the following conditions:

- Peak for the left turn:
  $$T_x(i) < T_x(i-k) - \Delta_T, \quad T_x(i) < T_x(i+k) - \Delta_T, \quad (2)$$

- Peak for the right turn:
  $$T_x(i) > T_x(i-k) + \Delta_T, \quad T_x(i) > T_x(i+k) + \Delta_T, \quad (3)$$

where $k$ denotes the range for the detection of peaks and $\Delta_T$ denotes a threshold for the detection of changes of the accumulated movement quantity $T_x(i)$. Moreover, we calculate the number $C_L$ and $C_R$ of peaks per the range $T$ based Eqs. (2) and (3). In this paper, we adopt the averages $C_L/T$ and $C_R/T$ of the number of peaks per the range $T$ as features for players.
As mentioned above, this type of camera can move according to the head movement by players. In experiments, each player sits in position for each vertex of an equilateral triangle. Therefore, we assume that players have to move their faces in order to look at others’ cards.

3 Experimental results
Experimental conditions are as follows; (i) the number of players: 3, (ii) the number of matches: 10. Each player sits in position for each vertex of an equilateral triangle as shown in Figure 4.

![Figure 4: Sitting position of players.](image)

Here, the Indian-Poker can be executed by the following rule [4]:

1. One card is distributed to each player.
2. Players place the cards on their forehead. Each player can see others’ cards and can not see own card.
3. The order of the strength of the card is as follows: [strong] K, Q, J, · · · , 3, 2, 1 [weak]. If the numbers of the two cards are same, the order of the strength is as follows: [strong] Spades, Hearts, Diamonds, Clubs [weak].
4. One of players becomes the dealer. The dealer raises the betting point and invites players to the continuation of the game.
5. Players except the dealer can select whether to bet or to descend the game.
6. The dealer can request that players show their cards to all players.

In this experiments, the matches are analyzed without distinguishing between the dealer and other players.

Figure 5 shows the accumulated movement quantity $T_s(i)$ and the averages $\bar{C}_L = \bar{C}_L/T$ and $\bar{C}_R = \bar{C}_R/T$ of the number of peaks per the range $T$. From this figure, we can see that the peaks (blue-colored line) of the left and right turns by the player can be detected.

![Figure 5: Accumulated movement quantity $T_s(i)$ and the averages $\bar{C}_L$ and $\bar{C}_R$ of the number of peaks.](image)

Table 1 shows the averages $\bar{C}_L$ and $\bar{C}_R$ of the number of peaks per the range $T$ by three players for 10 trials. For example, in the third trial, the card numbers of each player are 13, 4 and 8 respectively. In this trial, $\bar{C}_L$ and $\bar{C}_R$ by player-B are 6.85 and 7.84. On the other hand, $\bar{C}_L$ and $\bar{C}_R$ by player-C are 7.59 and 5.48. Therefore, player-B tends to look at right hand (player-C) and player-C tends to look at left hand (player-B).

![Table 1: Averages $\bar{C}_L$ and $\bar{C}_R$ of the number of peaks per the range $T$ by all players (A, B, and C).](image)

In Table 1, we can see that the difference between players’ cards is large and/or small in each trial. For example, in the 3rd trial, the card of player-A is 13 and the card of player-B is 4. In this case, the averages $\bar{C}_L$ (for player-B) and $\bar{C}_R$ (for player-A) by player-C are 5.83, 7.59 respectively. In the following sections, we analyze the behaviors by players according to the differences among their cards.
3.1 Face direction in the case of (The difference between cards is large)

Figure 6 shows the cases that the difference between the cards’ numbers is large. Here, The number in the square is the card number of each player.

![Diagram](image)

Figure 6: Averages $\bar{C}_L$ and $\bar{C}_R$ of the number of peaks per the range $T$ by all players (A, B, and C) in the case of large difference between cards’ numbers.

The behaviors by players in the cases that the difference between the cards’ numbers is large can be summarized as follows; Here, the number in the bracket is the card number of each player.

- Trial-3: $\bar{C}_L$ is 7.59 (from player-C to player-B [4]) and $\bar{C}_R$ is 5.83 (from player-C to player-A [13]).
- Trial-4: $\bar{C}_L$ is 4.59 (from player-C to player-B [13]) and $\bar{C}_R$ is 1.58 (from player-C to player-A [8]).
- Trial-7: $\bar{C}_L$ is 1.43 (from player-A to player-C [11]) and $\bar{C}_R$ is 2.82 (from player-A to player-B [4]).
- Trial-7: $\bar{C}_L$ is 1.48 (from player-B to player-A [3]) and $\bar{C}_R$ is 1.72 (from player-B to player-C [11]).
- Trial-8: $\bar{C}_L$ is 0.98 (from player-B to player-A [1]) and $\bar{C}_R$ is 1.33 (from player-B to player-C [11]).
- Trial-9: $\bar{C}_L$ is 0.71 (from player-A to player-C [13]) and $\bar{C}_R$ is 2.54 (from player-A to player-B [3]).
- Trial-9: $\bar{C}_L$ is 0.51 (from player-B to player-A [1]) and $\bar{C}_R$ is 0.10 (from player-B to player-C [13]).
- Trial-10: $\bar{C}_L$ is 4.11 (from player-B to player-A [1]) and $\bar{C}_R$ is 5.78 (from player-B to player-C [1]).
- Trial-10: $\bar{C}_L$ is 4.56 (from player-C to player-B [3]) and $\bar{C}_R$ is 8.56 (from player-C to player-A [11]).

From the above comparison $\bar{C}_L$ with $\bar{C}_R$, we can confirm that players tend to look at the smaller card for the two players except the two cases (i) trial-8 (from player-B to player-C and from player-B to player-A) and (ii) trial-10 (from player-C to player-A and from player-C to player-B).

3.2 Face direction in the case of (The difference between cards is small)

Figure 7 shows the cases that the difference between the cards’ numbers is within 2.

![Diagram](image)

Figure 7: Averages $\bar{C}_L$ and $\bar{C}_R$ of the number of peaks per the range $T$ by all players (A, B, and C) in the case of small difference between cards’ numbers.
The behaviors by players in the cases that the difference between the cards’ numbers is within 2 can be summarized as follows:

- **Trial-1**: $\bar{C}_L$ is 6.37 (from player-C to player-B [9]) and $\bar{C}_R$ is 6.61 (from player-C to player-A [7]).
- **Trial-2**: $\bar{C}_L$ is 7.65 (from player-C to player-B [6]) and $\bar{C}_R$ is 5.77 (from player-C to player-A [7]).
- **Trial-2**: $\bar{C}_L$ is 0.00 (from player-B to player-A [7]) and $\bar{C}_R$ is 4.87 (from player-B to player-C [9]).
- **Trial-5**: $\bar{C}_L$ is 5.28 (from player-A to player-C [10]) and $\bar{C}_R$ is 4.14 (from player-A to player-B [9]).
- **Trial-5**: $\bar{C}_L$ is 6.05 (from player-C to player-B [9]) and $\bar{C}_R$ is 1.97 (from player-C to player-A [7]).
- **Trial-7**: $\bar{C}_L$ is 5.20 (from player-C to player-B [1]) and $\bar{C}_R$ is 3.80 (from player-C to player-A [3]).
- **Trial-9**: $\bar{C}_L$ is 7.06 (from player-C to player-B [3]) and $\bar{C}_R$ is 5.47 (from player-C to player-A [1]).
- **Trial-10**: $\bar{C}_L$ is 5.76 (from player-A to player-C [1]) and $\bar{C}_R$ is 8.00 (from player-C to player-A [3]).

From the above comparison $\bar{C}_L$ with $\bar{C}_R$, we can confirm that players tend to look at the cards for the two players similarly except the two cases ( (i) trial-2 (from player-B to player-A and from player-B to player-C) and (ii) trial-5 (from player-C to player-A and from player-C to player-B) ).

### 4 Conclusions

In this paper, we have discussed the analysis of the interaction among the players in the Indian-poker game. We have shown from experimental results; (i) when the difference between the cards is large, players tend to look at the smaller card, (ii) when the difference between the cards is small, players tend to look at the cards similarly.

As future works, we would like to confirm these analysis results for many games and players. Moreover, we would like to develop a method for the estimation of the strength of the own card based on behaviors by players.

### References


