Abstract—The authors propose an augmented reality application system for Mahjong. The idea of this application is that visual augmentation by means of the AR method will help a Mahjong beginner play games, learn rules from his/her game experiences under the support of the system, and thus become an experienced player who can play without any support. The system captures Mahjong tiles (cards in our implementation) via a USB camera, recognize the current state, and visually augment tiles to guide the user perform desirable actions (e.g., discard an unnecessary tile). Our implementation and evaluation of the system are reported in this paper.

I. INTRODUCTION

Applications of computer technologies to various entertainments have been researched, known as “entertainment computing” (e.g., kinds of researches have been reported in annual international conferences on this topic, ICEC [1],[2]). Our research aims at evaluating the effectiveness of augmented reality (AR) user interface for playing table games. Players need to know rules of the game; beginners cannot play by themselves until they learn the rules well (or, need help from experienced players). Our idea to solve this problem is a computer system with AR user interface which intuitively guides game plays in the beginners’ view. The authors expect that the system enables a beginner to play games even if s/he does not know rules well and learn the rules as s/he plays games with the system (i.e., learn by their game experiences). The authors have applied the idea to several card games (including Seven Bridge, Mate and Bohemian Schneider) and evaluated effectiveness by experiments with beginner players [3]-[5].

This paper reports an application of our idea to Mahjong. Szalavari et al. [6] previously applied AR to Mahjong, but their system did not aim at supporting (navigating) Mahjong beginners, and no evaluation of their system was reported. The authors evaluated our AR application to Mahjong by experiments with Mahjong beginners.

II. AUGMENTED REALITY APPLIED TO MAHJONG

A. System Configuration

Fig. 1 shows hardware configuration of our system. The system captures the image of user’s view via a camera at a specific frame rate, processes the captured image on the PC, augments the image with CG objects and shows the augmented image to the PC screen so that a user of our system can see what the user should do for playing the game. To make the augmentation more intuitive for the user, it is better for the system to employ a see-through head mounted display (so that the CG objects can be optically overlapped to user’s actual view). Our current system employs a standard LCD monitor because of the ease of system implementation. Visual recognition and augmentation in our system are achieved by utilizing ARToolkit [7].

Printed cards shown in Fig. 2 are used as Mahjong tiles; each printed pattern rounded with the black border works as an ARToolkit marker.

Our system is currently for the two-player Mahjong variant; in our experiment reported later in this paper, an experimenter (one of the author) and a participant played two-player Mahjong games. To make game plays in our experiment more efficient (i.e. for a player to create a winning hand faster), only the tiles shown in Fig.2 are used in our experiment.

There are many kinds of Mahjong winning hands, and a desirable action by a player (e.g., a desirable tile to discard from the player’s current hand) depends on the goal winning hand for the player in the round. Thus, to navigate a beginner for a desirable action, the goal winning hand has to be determined. Our idea is that it will be appropriate for Mahjong beginners to learn some basic types of winning hands first. This is because the aim of our system is not to let beginners win games with as higher scores as possible but to help beginners learn game rules as they play games so that, after a
certain amount of game experiences, they become able to play games by themselves. As the basic winning hands, the authors selected four kinds of hands: All Simples, Dragon Pong, All Pongs and a concealed hand with “Ri-chi”. The All Simples hand, “Tan-yao” in Japanese, contain no terminals or honors (it only contains numbered tiles from 2 through 8). The Dragon Pong hand includes one or more dragon pongs where a dragon pong is a three identical dragon (“Haku”, “Hatsu” or “Chun” in Japanese) tiles. The All Pongs hand, “Toi-toi-ho” in Japanese, is composed of four pongs/kongs and a pair. A concealed hand with “Ri-chi” is a hand in which all tiles are self-drawn except for the last tile which is discarded, where the player must declare “Ri-chi” when a specific single tile will complete his/her winning hand. After the player declares “Ri-chi”, s/he must discard any tile drawn from the wall unless it constitutes a win.

In each round, after the 13 cards are dealt to each player, our system select one of the four winning hands as the goal for the beginner player. The goal selection is achieved by our heuristics based on the combination of the starting 13 cards in the beginner’s hand:

1. If the starting cards include two or more cards of identical dragons then Dragon Pong is selected
2. else if the starting cards include four or less terminals or honors then Tan-yao is selected,
3. else if the starting cards include five or more pairs of the same card then Toi-Toi-ho is selected,
4. else Ri-chi is selected,

as the goal in the round. Experienced players may change their goal hands context-sensitively during a round, but our current system does not change the selected goal because of the expected ease of learning desired actions for beginners to achieve the selected goal.

B. Design of Visual Augmentations

This section illustrates our design of visual augmentations for navigating beginners, with example screenshots of our system.

Fig. 3 shows a screenshot of the augmented display which shows the system guides the user to draw a card from the card pile. The message in the bottom area tells the guidance in Japanese, and the yellow arrow visually prompts to draw a card and place it in the user’s hand (the card pile is set at the upper left white area). The 13 cards in the lower area consist of the user’s current hand. The user is guided to draw a card as this example each time the opponent player ends his/her turn (except the situation that it is better to call Pong or Chow than to draw a card from the pile), so that the user is expected to learn the action.

The system determines a card which is recommended to discard based on our heuristics. The heuristics consist of the following eight filters. Cards in the user’s hand are filtered by using some of the filters: any card which meets a filter is excluded and the remaining cards are candidates to be recommended.

Filters:
F1: Pong melds.
F2: Chow melds.
F3: Pairs of the same number and suit (i.e., pairs that are ready to compose new Pong melds).
F4: Pairs of the same suit and sequential numbers (i.e.,
pairs that are ready to compose new Chow melds
F5:  Cards of the most suits (dots or bamboos).
F6:  Isolated cards except for dragons.
F7:  Pairs of the same dragon.
F8:  Cards except for terminals or dragons.

- If the goal is Dragon Pong then the filters F1, F7, F2-F6 are applied to the hand in this order.
- If the goal is Tan-yao then the filter F8 is first applied to the hand. If any cards remain after the filtering with F8 then the remaining cards are the candidates. Else, the filters F1-F6 are applied to the hand in this order.
- If the goal is Toi-toi-ho then the filters F1, F3, F5 and F6 are applied to the hand in this order.
- If the goal is a concealed hand with Ri-chi then F1-F6 are applied to the hand in this order.

For example, suppose the current user’s hand is:

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7 4 6 7 8 8 1 4 11
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and the goal is a concealed hand with Ri-chi. In this case:

- F1 excludes the 9 dots Pong meld,
- F2 excludes the 6/7/8 bamboos Chow meld,
- F3 excludes the 8 dots pair,
- F4 excludes the pairs of {4/5 dots} and {7/8 bamboos},

and the remaining cards after the filtering by F1-F4 are the 1 and 4 bamboos. If the filter F5 is applied next to F4, no card remains in the hand so that no card can be recommended to discard. Thus, F5 (and the next F6) are not applied and the candidates are the 1 and 4 bamboos.

In the example of Fig.4, the yellow arrow visually prompts to move the red dragon in the user’s hand to the upper area in which our system recognize a card as discarded. At the time a card is recognized in this area, the user’s current turn is completed. The recognized card as the discarded one is then moved to a predefined area in which the card is out of the camera sight but in the sights of both players, because the number of cards to be recognized at a time is limited (so many cards cannot be placed inside the camera sight). Although the system recommends a card to discard, the system allows the user to discard another card: any card which is moved to the area to discard is accepted as the discarded one.

The display in the upper left area in Fig.4 tells to the user that the goal hand in this round is the All Simples which contain no terminals or honors. The area is designed to show the name and short explanation of the goal hand, which will contribute for the user to learn about the hand. In the case where the goal is a concealed hand with “Ri-chi”, the system shows in this area the guide which tells that: do not call Pong and Chow, call “Ri-chi” when the user’s hand reaches to a ready hand, and no change is allowed after the “Ri-chi” call.

Fig. 5 shows a screenshot of the augmented display which shows the visual expressions of Pong and Chow melds.

![Screenshot of the augmented display to show Pong/Chow melds.](image)

In this example,

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2 2 4
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is a Pong meld which is visually augmented with the red borders, and

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3 3 5
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are Chow melds which is visually augmented with the blue borders. Cards that do not compose a meld, which are candidates to be recommended to discard by the system, are shown with the green borders. These visual expressions will help the user learn: the same three cards and three cards of the same suit and the sequential numbers compose a useful set to win the game, and it is better to discard a card which does not compose such kinds of useful sets.

Figs. 6 and 7 show screenshots of the augmented displays which guide a Pong/Chow action respectively with a card discarded by the opponent player.

The messages shown in the bottom area tell to declare “Pong” or “Chow”, and the yellow arrows guide to move cards related to the Pong/Chow actions to the designated area. These guidances will help the user learn that s/he can use the discarded card to create a useful set of three cards if s/he has two cards which are i) the same as the discarded or ii) the same suit as the discarded and the numbers become sequential with the discarded. Similar to the action to discard a card from the hand, the three cards that are moved to the designated Pong/Chow area and recognized as a Pong/Chow meld are then removed from the area.
Fig. 8 shows a screenshot of the augmented display which guides a Ron action with a card discarded by the opponent player. In this case, the user’s hand requires an additional 3-dots or 4-dots to compose the goal winning hand (Tan-yao) and the 4-dots (shown in the upper area in Fig.8) is discarded so that the user can win the round by declaring “Ron”. The messages shown in the bottom area tell this action. As the user has several experiences of the Ron action under such navigation by our system, the user will learn the action.

III. USER EXPERIMENT

A. Objective and Method of the Experiment

As explained in section I, the goal of our system is that a Mahjong beginner can learn game rules from his/her game play experiences and s/he becomes to able to play games by him/herself after several games played under the guidance of our system. The authors evaluate how well our system achieves this goal by user experiment.

Each participant was asked to play six rounds of games against an experimenter who knows well the Mahjong rules, where a round was finished when either of the two players created some winning hand (either of the four kinds of hands in section IIA) or neither of the two players created any winning hand (“Ryu-kyoku” in Japanese). The experimenter did not use our system, but he was not allowed to win by any winning hand other than the four kinds of hands for the purpose of fair games in terms of winning hands. Each participant played games with our system for the first four rounds and then played games without our system (i.e., by him/herself) for the last two rounds. Each of the players including the experimenter could see cards in his own hand but not in the hand of the opponent player (cards in the participant’s hand were laid out on the tabletop to show them to the camera, but the cards were hidden from the experimenter by a paperboard used as a screen). Discarded cards and opened cards with Pong/Chow actions were visible for both players. Game logs were recorded by our system so that the time for each action and the player who won each
The authors have developed a Mahjong beginner support system with an augmented reality user interface, and evaluated the effectiveness of the system by a user experiment. In the experiment, the two Mahjong beginners could play games under the support of our system even though they didn’t know the rules before they participated in the experiment. After the four game rounds with our system, they could determine actions by themselves in their turns within acceptable time intervals. It was not confirmed that the beginners could learn about the winning hands and learn actions to appropriately create them well, but the beginners subjectively evaluated our system very useful and felt amusing/fun to play with the system. Future work includes extensions of the system implementation (e.g., employment of a see-through HMD for displaying visual augmentations) and additional experiments with more beginners and more “learning” rounds.

To evaluate how well the beginners could learn actions to create the four winning hands, the ratio of rounds the the beginners won was investigated. If the beginners could learn well in the first four rounds, they could appropriately win rounds to a certain extent in the last two rounds by themselves. Table I shows the ratio of rounds the the beginners won. For the two beginners, the ratio was relatively larger (75%) in the first four rounds, but was smaller (25%) in the last two rounds. On the contrary, the four non-beginners could win 66% in the last two rounds. This result indicates the two beginners could not learn actions to win well, i.e., our system could not effectively support the beginners to learn the actions from their experiences. A possible reason was that the number of rounds (four in this experiment) with our system was too small to learn. Additional experiments with more beginners and more “learning” rounds, and investigations on improvements in the design of visual augmentations and guidance messages, should be included in our future work.

Table II shows mean scores of the 5-scale subjective evaluations, where 5 is the best positive and 1 is the worst negative. The questions #2 and #3 were rated only in the 2nd evaluation. The mean score was not so high (3.5) for the question #3, which again indicates that the beginners could not learn actions to win well. However, the mean scores were the highest (5.0) for the questions #4 and #5, which indicates that our idea of AR application is promising.
REFERENCES


