Wide Viewing Angle Fine Planar Image Display without the Mona Lisa Effect

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Abstract

We propose simple method to construct face display without the Mona Lisa gaze effect. The display can convey appropriate gaze direction in accordance with viewer's position, and also high resolution and affordable cost.

Proposed display consists of 2 layer LCD, surface layer shows pupil and back layer shows face without pupil. Relative position of pupil and white of the eye appears to change in accordance with viewer's position, thus the display convey different gaze image for each person.

The method intended to be applied on digital signage with interactive character. Viewer dependent eye contact will attract people and increase social presence of the character. We exhibit technical demonstration, and also interactive character digital signage with proposed method, which can respond by eye contact for attendee's action.

Index Terms: Human-centered computing—Interaction devices—Displays and imagers; Computing methodologies—Computer graphics—Rendering

1 Introduction

Interactive characters as digital signages are expected to be virtual receptionists, salespersons, advertisements or even a new entertainment media in daily life. In addition to use appearance of popular characters, human-like interactions are keys of familiality and to provide enjoyable experience. Furthermore, image quality and affordable cost are both important factors as for digital signages.

Eye contact is one of the basics of human communication. Implementing eye contact function in interactive characters may be effective to realize human-like interactions. Eye contact from the character in appropriate situation and timing may cause sense of awareness from the character, and attract people attention.

Showing the character eye gaze to bystanders or passserby is also informative to attract and involve people into the interactive session naturally. They will understand content of ongoing interaction from social behaviours including eye contact, and will perhaps be interested in the intaraction. Those expressions of eye gaze are important to gain social presence of the interactive character.

Unfortunately, planar display has a great limitation to convey gaze direction, which is known as the Mona Lisa effect: frontal face image shown in planar display cause eye contact feeling to everyone regardless of viewing position, and nobody feel eye contact by non-frontal face image.

As for interactive characters, even in the situation that the character should stare at only one person, every other persons also feel eye contact by the Mona Lisa effect unintentionally. As for them, such gaze behaviour of the character looks unreasonable and may cause distrust sociality of the character. This will disrupt social presence of the character and also decrease power of eye contact to attract people.

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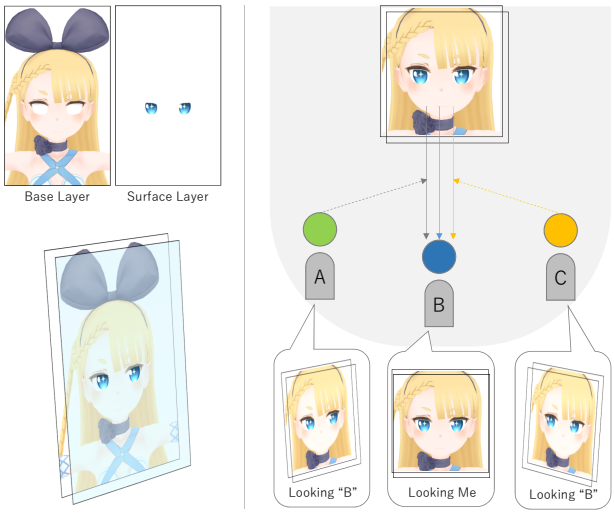

Figure 1: Principle

Display without Mona Lisa effect are developed in past telecommunication or display researches. However, those methods at least have one of following problems: high cost, small screen size, limited image quality, limited view angle or limitation of face position (See section 4 for detail).

In this paper, we propose simple but powerful method to construct face display with the expression of correct eye gaze direction dependent on each observer's position without Mona Lisa effect. The display has wide view angle without collapse image, and high resolution large screen display for digital signage can be achieved in affordable cost.

2 Proposal

Fig. 1 shows principle of the proposed method. Using 2 layered display, back layer shows face image without pupil and surface layer shows pupil image. In accordance with viewer's position, pupil image appears to change its position relative to white of the eye. Thus, pupil image locates in center of the eye only from particular viewing direction, and only the viewer at this direction can feel eye contact from the displayed face. Eye contact direction can be arbitrarily set by changing relative image position between white of the eye and the pupil.

Due to overwrapping pupil image on white of the eye image, surface layer display should be attenuation panel (e.g. LCD). In contrast, any type of display can be used for back layer: LCD, OLED, projection screen, etc.

Distance of each displays affects shift amount of pupil in accordance with viewer's position change. Too much distance will cause

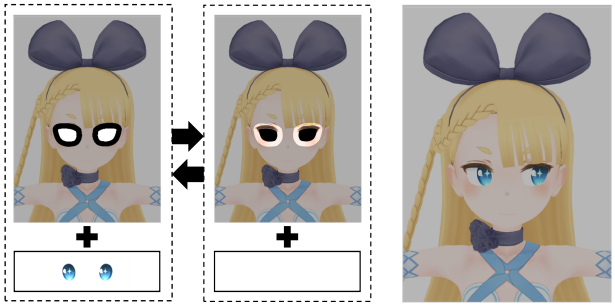

Figure 2: Time Division Display

excessive eye movement, and the eye direction which is percepted by the viewer will overshoot intended gaze target person. Optimal display distance for maximum gaze direction accuracy may depend on scale of the face image, pupil distance of image and perhaps shape of the eyes. Psychological experiment to achieve them is a future task.

With straightforward use of layered display, the pupil image may protrudes from the eye area when the display is seen in oblique view. Time-division display is effective to avoid this. Fig. 2 shows the principle. While surface layer showing pupil image, face area around the eye is darkened. Thus, pupil image out of eye area becomes invisible. Face area around the eye is displayed in following frame instead. Using high refresh-rate display ($\gtrsim$120Hz) is necessary to avoid flickering, which is affordable as gaming monitors recently.

With time-division display method, displayed face image is fine and consistent from wide field of view (more than 120°, apparently).

3 Exposition

We demonstrate interactive character digital signage with proposed display. When a person approaches, the character notice and respond with eye contact. When the person wave hand, the character also wave hand with looking at the person who waved hand.

We also provide demo of the display itself. Attendees can arbitrarily set eye and head direction. The display has 2 face images for comparison, one with using proposed technique and another without using it.

4 Related Works

Depth Fused Display(DFD) [4] is a 2 layered depth image display utilizes the effect that the difference of image brightness between surface and back layer creates depth sensation. DFD-based face display overwraps face only image on head without face image, and also have an ability to transfer accurate gaze direction without Mona Lisa effect. However, from oblique viewpoint, boundary of face and head image appears not correctly connected, and finally face image protrudes from head image area. Therefore, field of view with consistent head and face image is narrow.

Mitsumetronics [9] [3] is a Japanese toy with paper printed character face. It also uses face layer and eye layer. Face layer has eye shaped hole and eye layer is in behind it, so it is different from our method in layer order. The eyes in Mitsumetronics also appears to move in accordance with viewer's position. In that respect, Mitsumetronics can show fine planar face without Mona Lisa effect. However, eye movement direction is opposite because eye layer is in behind, and it creates inconsistent eye direction sensation between viewing positions.

Multi view display [8] including light field display can show different image for each person in different view angle simultaneously. Therefore it has an ability to convey correct eye direction in accordance with viewing angle. Light field display with lens array [2] or parallax barrier [1] are becoming popular due to recent development of high resolution display like 8K LCD. Because it requires several times more dence panel than result resolution, image is still coarse at this moment. Moreover, rendering computation cost of many view at once is high. We hope this will be affordable solution after a decade.

Projector array [6] is also used to construct light field display. Image resolution is kept fine as each projector is, but cost of multiple projectors are very high, and take large space for projection.

Mechanically rotating screen [5] or light-source [10] based light field displays have 360° field of view and suitable to display human head rather than planar panel or screen. However, in addition to cost, mechanical hardware tends to inferior in refresh rate and durability than electronic display.

Projection on face shaped display [7] is also known to be a solution to eliminate Mona Lisa effect, but it requires robotic mechanism to move or even rotate face. Without it, face image position is quite limited.

In contrast with most of prior researches, our proposed method is not intended to be a 3D display: i.e. it will not show face in profile even from oblique view, but only eyes shift. It is a limitation of our method, but at the same time, this is also the reason why our display can show fine and consistent face image for larger view angle.

Acknowledgments

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