Exploring Gaze-Activated Object With the CoffeePet

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ABSTRACT
The feeling of being looked back when we look at someone and that someone is also aware that we are looking at him/her is a basic fundamental during social interaction. This situation can only occur if both realize the presence of each other. Based on these theories, this research is motivated in exploiting the possibility of designing for a gaze sensitive object - how people can relate to object by depending on their eyes only. In this paper, we present a gaze-activated coffee machine called the CoffeePet attached with two small, OLED screen that will displays animated eyes. These eyes are responsive towards the user's gaze behavior. Furthermore, we used a sensor module (HVC Omron) to detect and track the eyes of a user in real time. It gives the ability for the user to interact with the CoffeePet simply by moving their eyes. The CoffeePet is also able to automatically brew and pour the coffee out of its spout if it feels appropriate during the interaction. We further explain the description of the system, modification of the real product, and the experimental plan to compare the user's perception of the CoffeePet's eyes and to investigate whether the user realizes or not that their gaze behavior influences the CoffeePet to react.

Author Keywords
Eye tracking; perceptual crossing; anthropomorphism; gaze-based interaction; gaze sensitive object; human-object interaction.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous.

INTRODUCTION
Developing a system that uses gaze behavior as an input method has been found to be the most effortless and straightforward interaction, we simply need to point with our eyes [6, 7]. However, interaction with eyes mostly leads to frustration and confusion [2, 8, 12] because people are not familiar to interact with a system simply by moving their eyes. Our first prototype, the interactive coffee cup [1] (Figure 1) that will react (by displaying human-like behaviours) if someone is gazing at it does not give much impact towards the user's perception. "*The cup perceived the participant's gaze, but the participants did not perceive the cup's reaction at the same time*" [2].

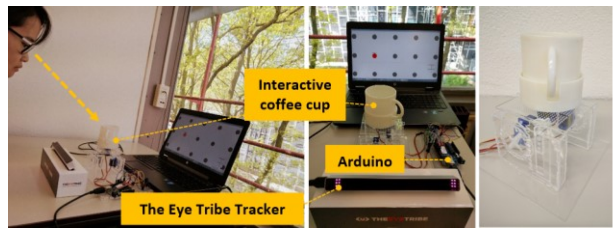

Figure 1. The interactive coffee cup.

We conclude that people are not used to interact with an object simply by gazing at it because they depend on their eyes to observe the surrounding and not to activate a command. To overcome these problems, we need to consider a situation where people already knew that their eye movements are crucial. For example, in face to face conversation, people spend most of their time looking at their partner's eyes to understand each other [5]. Based on this theory, we decided to anthropomorphize our next everyday object to solve the problem of unfamiliarity and eyes as double role (to observe and to activate a command).

MOTIVATION
In this paper, we extend our research by attaching a pair of animated eyes to a coffee machine. We hypothesized that the feeling of being looked back is important in designing for a gaze sensitive object, to make the user realize on their own that their gaze behavior influences the object reactions. To achieve this feeling, we believe that eyes need to be present in the user's view. Our main concern is to investigate whether the presence of eyes on the object will somehow make the user realize that they can also interact with the object by using their eye movements (like in face to face communication).

PROTOTYPE

The Animated Eyes
The development of the animated eyes was based on the design of the electronic animated eyes by Burgees et al. [11]. The gaze animation was inspired by the basic physiological structure of real eyes. We modified the animated eyes from the original version to make it more cartoonish and user-friendly by customizing the graphics of each part of the eye using Adobe Illustrator CS6 (see Figure 2).

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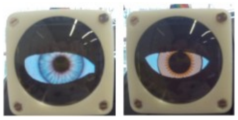

Figure 2. Left: original version. Right: modified version.

The eye animation displayed on the screen is controlled by a Teensy 3.2 microcontroller board and can be programmed to gaze in any directions. These animated eyes can also blink while gazing. We set the duration of a blink in a random manner between 30 ms to 75 ms [9]. Fukuyama et al. [4] stated that there are two conditions of gaze animation that we need to consider: directing the gaze towards the user and averting the gaze of the user. According to them, the most favorable gaze behavior must include a moderate amount of gaze with an average duration between 500 to 1000 ms. The gaze direction does not give much impact in differentiating a friendly or dominant gaze behavior. Only if someone is gazing downward, then it is considered as less dominant. The animated eyes displayed are based on the gaze timing described in [4], and [9].

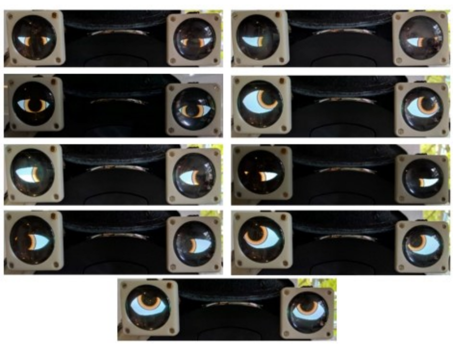

Figure 3. Animated gazing behavior.

When the user is fixating at the CoffeePet's eyes, it will try to establish eye contact with the user for about 1 s to 2 s. If the user and the CoffeePet manage to stay in contact with for more than 3.5 s, the CoffeePet's eyes will avert its gaze by looking down to let the user know that it will start to brew and pour the coffee into the cup. When the user is not looking at the CoffeePet, the CoffeePet's eyes will look at the user for 2 s and avert its gaze away from the user for 4 s. Figure 3 shows the animated gazing behavior that can be displayed on the OLED screen.

Building the Gaze Activated Coffee Machine

For our design, the first step that we need to do is to disassemble the coffee machine. Our goal is to find any electronic boards or switches that we can bypass to allow our system to control the coffee machine automatically. We found a pair of LEDs that can light up the coffee machine and two push buttons to prepare the coffee (hot and cold) (see Figure 4). Hence, we decided to use these elements in developing the CoffeePet. We modified the mechanical push button and rewired it to a relay module (see Figure 5). The relay module and the LEDs are connected to the same microcontroller board that controlled the animated eyes.

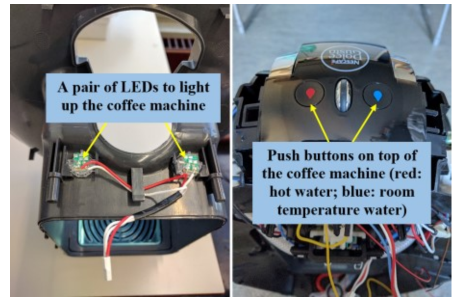

Figure 4. Left: A pair of LEDs. Right: Two push buttons.

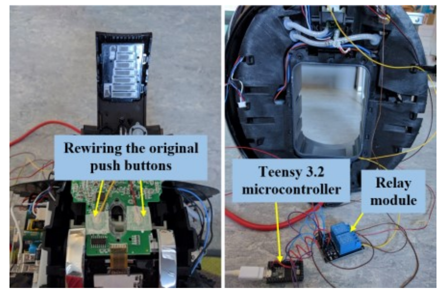

Figure 5. Rewiring the mechanical push buttons.

To mount the eyes on the surface of the coffee machine, we drilled one hole on each side of the coffee machine's casing. We also decided to cover the coffee machine with fur to avoid the user looking for buttons when interacting with the CoffeePet. Furthermore, we used a sensor module (HVC Omron) to detect and track the eyes of a user in real time and place it on top of the coffee machine. This sensor is connected to the same microcontroller board which gives the benefit of our system to control the coffee machine to start brewing the coffee automatically by depending on the user's gazing behavior.

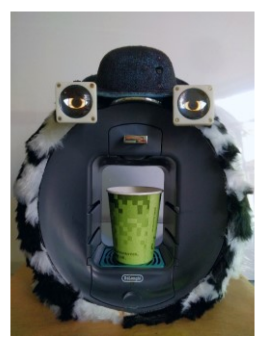

Figure 6. The CoffeePet.

Since our objective is to let the user figure out on how to interact with the CoffeePet, we hide the sensor underneath a small hat. We wanted to avoid the user from constructing an internal interpretation regarding the function of the sensor. Figure 6 depicts the final prototype of the CoffeePet.

Sensing: Eye Tracking

We used an Omron HVC sensor module that has the capability to estimate the gaze by calculating the gaze yaw and pitch angle of the detected face. The yaw angle will estimate whether the user is looking left or right (a negative value when a person is looking left, a positive value when a person is looking right). The pitch angle will estimate whether the user is looking up or down (a negative value when a person is looking down, a positive value when a person is looking up). Compared to our previous setup [2], the benefit of using this sensor module is that its ability to compensate head and body movements while estimating the participant's fixation point. Furthermore, the distance between the sensor and the participant can be up to 1.3 meters. With these features embedded in this sensor module, the user can be more relax and calm without restraining their head and body movements. We also programmed the system to record the user's gaze fixation to get a better understanding of where the user is looking while interacting with the CoffeePet.

Processing and Behaviour

Figure 7 shows the overview of the system. The sensor module will provide the gaze data, the system will measure and process the gaze data and let the microcontroller to display the appropriate behaviors to the user during the experiment. The LEDs will turn on only when the CoffeePet started to brew the coffee. In idle state, the microcontroller will control the gaze behavior in random manners. If the user shows interest in the CoffeePet by staring at it, the system will measure the fixation duration, and the CoffeePet will try to establish eye contact with the user.

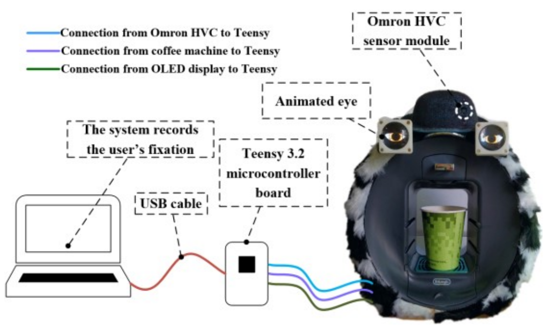

Figure 7. Overview of the systems.

Supposing that the user is looking away from the CoffeePet, the system will reset the fixation duration, and the CoffeePet's eyes will look towards the user and avert its gaze while waiting for the user to fixate on it again. If the CoffeePet manages to establish eye contact with the user, this indicates that the user is showing interest to interact more with it. Hence, the system will trigger the microcontroller. The microcontroller will send a signal to activate the relay module. Once it is activated, the CoffeePet's eyes will look down, and at the same time, the LEDs will turn on until the CoffeePet finish brewing and pouring the coffee out of its spout. This behavior is to notify the user that the CoffeePet is preparing him/her with a cup of hot coffee.

EXPERIMENTAL DESIGN

We have planned an experiment to find out how a person will perceive the CoffeePet and the effectiveness of the animated eyes gestures in guiding them to realize that their gaze behavior influenced the CoffeePet to start brewing the coffee automatically. We hypothesize a significant difference in user's perception towards the CoffeePet with different gaze patterns. We decided to approach a between-participants design, and it involved one manipulated independent variable with three conditions, (1) watching eyes (static direct gaze), (2) interactive gaze model, and (3) interactive mirroring gaze. In interactive gaze model, the CoffeePet established eye contact with the user in between 1 to 2 seconds and averted its gaze randomly for about 2 to 6 seconds [3]. In interactive mirroring gaze, the CoffeePet will always look to where the user is fixating. For example, when the user is looking away and move his/her attention to a new target, the CoffeePet will also avert its gaze and look at the user's current attention. Only by making a prolonged eye contact with the CoffeePet's eye, the CoffeePet will start brewing the coffee.

Participants and Setup

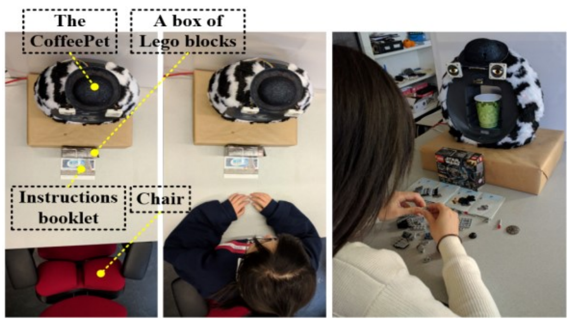

Figure 8. Overview of the experimental setup.

In the experiment, we place the CoffeePet on a table, and the participant will sit in front of it. Figure 8 shows the overview of the experimental setup. As mentioned before, in our previous setup, we always needed to remind the user not to make any sudden head or body movements. Otherwise, the eye tracker will lose its ability to track their current point of gaze. The environment was too controlled for them to explore the installation which we believed contributed to the failure of the user to understand the underlying mechanisms of the system (eyes as input). With our new design, the user can behave as they please and we do not have to tell them where they should position themselves. We simply give them the flexibility to explore the installation without any rules that they need to follow in order to interact with the CoffeePet. We will let them know that the Coffeepet will start to prepare them a cup of hot coffee if they manage to interact with it. Moreover, we decided to ask the user to assemble a set of Lego blocks by following the provided instructions booklet while interacting with the CoffeePet. We want the user to be busy with their hands and to encourage them to interact with the CoffeePet by using their eyes.

Measurements

Subjective Measurements

We will use a scale developed for evaluating life-like interface agents [10] to measure the user's perception towards the CoffeePet. The questionnaire involved eight items and was made on 7-point Likert-type scales. Four items attributed to the CoffeePet's appearance: human-likeness, attractiveness, sociable, and intelligent. Two items attributed to the partnership with the CoffeePet: mutual liking and trustworthiness. Two items attributed to the level of interaction with the CoffeePet: difficultness and enjoyment.

Objective Measurements

We programmed the system to record the user's gaze data, and the system will calculate the fixation duration while the user interacts with the CoffeePet. We define the CoffeePet's eyes as the area of the interest (AOI). Based on these collection data, we want to measure and differentiate the users' interaction performance with the CoffeePet.

Also, we plan to do a manipulation check using open-ended questions, and we will ask the users to list any nonverbal behavior that they depend on while interacting with the CoffeePet. The most crucial part is to investigate whether the user realizes or not that their gazes influence the CoffeePet to react. We also plan to conduct a semi-structured interview to gain a richer understanding of user's experience with the CoffeePet and to confirm the user's answer and its relation to the recorded gaze data.

CONCLUSION

We view the work described in this paper as our plan in exploring the possibility of eye movements as a new mode of interaction when engaging with a product. With the profound amount of data provided by the sensor module that can convey the gazer's attention, it gives us the opportunity to form a new user experience between a person and an everyday object. We hypothesize that the feeling of being look back is important in developing a gaze sensitive object. By putting eyes, we want to make sure if the users could realize that their gazing behaviour influences the object reactions. Furthermore, we intend to explore how people could relate their eyes with a product, to make the user realize on their own that their gaze behavior influences the object reactions and we also intend to develop a framework for designing a gaze-sensitive product.

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