"Feed the Fish": An Affect-Aware Game

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ABSTRACT

In this paper we report on an affective gaming interface and a user study which evaluates user response to affective gaming. "Feed the Fish" is an affect-aware game system which takes a player's facial expressions as input and dynamically responds to the player by changing the game elements. The goal of this system is to use human expressions to build a communication channel between the game and players so playing the game can be more enjoyable. We describe the implementation of the game system and discuss the result of the user study we have conducted with 22 participants. Participants enjoyed the game with the affect-aware system more than a non affective version of the game, and they felt it was more exciting since the game was more challenging and dynamic.

Categories and Subject Descriptors

I.4 **[Image Processing and Computer Vision]:** Applications; J.4 **[Computer Applications]:** Social and Behavioral Sciences

General Terms

Experimentation, Human Factors

Keywords

Facial feature tracking, Affect-aware system, Computer games, Computer vision

1. INTRODUCTION

The human face and facial expressions are a rich and powerful source of nonverbal communicative information about the human behavior and emotional state. This has inspired many Human-Computer Interaction (HCI) researchers to develop and design facial recognition techniques that can enhance a user's interactivity with computers.

Computer vision techniques have been applied to recognize gaze information [11], face pose [12] and emotional state [13]. Several facial feature tracking algorithms have been developed as a real-time input module for Human-Computer Interfaces [1]. A common goal is to control the computer interface by sensing and perceiving the user's affective or emotional state.

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Although there has been research on emotion recognition in computer interfaces there has been less work on evaluating these systems, particularly in an entertainment setting. In this paper we present the "Feed the Fish" game which uses the affective state of the user as an additional input for controlling the difficulty of game play. The main goal of the research is to investigate, by running a pilot study, the effect of an affect-aware system on the enjoyment level of the game.

In the rest of the paper we first discuss previous related work in the area, focusing on affective gaming and user studies evaluating affective entertainment systems. Next we present the "Feed the Fish" game and the emotion recognition system used in the game. Finally we describe the user study we have conducted to evaluate the affective interface and compared it to a non-affective system. We end with conclusions and directions for future research.

2. RELATED WORK

Affective Computing research focuses on developing interactive systems that recognize users' emotions by processing the affective information [7]. In the past, emotion researchers have used methods such as questionnaires, observation, and physiological measurements to collect data for assessing emotional states [14, 15]. Recently, affective computing has introduced new methods and technologies that support real-time, automatic, mobile, and less error-prone measurements for recognizing emotional information. These advances give human computer interfaces the ability to interpret and extract meaningful patterns that include speech, language, facial expressions, eyes gaze, posture and gesture [16].

Many systems have been developed which show the benefits of affective interfaces. For example, Klein, Moon and Picard [8] looked at the problem of user frustration while using a computer system. They designed a system supported by an interactive agent to help users recover from frustration. Their evaluation results showed that users interact longer with the system supported by an affective agent. Zakharov et al. [4, 5], researched how effective learning is with the help of affect-aware Intelligent Tutoring System. They used a computer vision based facial feature tracking approach to recognise the affective status of users and supported the system with an affect-aware pedagogical agent. Rani, Sarkar, and Liu [9] described an affect-aware computer based game, where they used biofeedback devices to recognize the player's affective state while playing the game. Their aim was to keep the player engaged with the game for longer periods of time, while at the same time modifying the game's difficulty level based on the player's affective state in real-time. Their results showed that affective state feedback was more effective than performance

feedback in providing greater challenge, lowering the anxiety and improving the performance of the player.

In many cases, the goal is to avoid the negative affective state, such as disappointment. Two approaches for avoiding negative affects include, (1) determining the cause of the negative affect and establishing a fix for this cause (2) preventing the negative affect from taking place at early stages [4, 5]. This is also described in the work of Jenova Chen on Flow in games [17].

As these works show, there have been a number of different technologies which have been used to measure affective state. While there have been some examples of games that respond to user's emotion, there have been few formal user studies comparing emotion based gaming to non-emotion based systems.

In the next sections we present our emotion-based game and describe a user study evaluating the game. Compared to previous work, the research reported here is novel because 1) our system uses only computer vision techniques to capture human facial expressions and predict emotional state while playing computer games 2) the captured facial expressions are directly input to the game logic system which changes the game elements in real time.

3. THE FEED THE FISH GAME

In order to evaluate how affective gaming compares to non-affective gaming we have developed a simple game which responds to the users emotional state. The game is called "Feed the Fish", and the goal is for the user to guide a fish around the screen and have it eat the other fish while avoiding predator fish. Figure 1 shows a screen shot of the game.

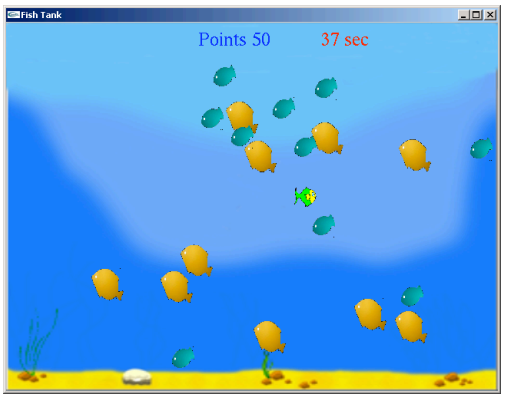

Figure 1. Screenshot of the game "Feed the Fish.

There are three types of fish: predator fish (bigger blue fish), eatable fish (smaller yellow fish) and a user controlled fish (light green). The user has two main tasks, the first is to make sure their fish doesn't get eaten by the bigger fish, and the second is to collect points by eating the smaller fish. The movement of the fish is controlled by keyboard input.

If the user's fish gets eaten by another fish, the user loses 20 points and if they eat a smaller fish, they collect 10 points for each fish caught. The goal is to reach the maximum points possible in a fixed amount of time.

There are three levels defined in the game; Easy, Normal and Hard, each with a different number of predator fish (see Table 1). As explained in the next section, the game system changes the game level dynamically in response to the user's emotional state.

Level	Number of Predator Fish	Number of Eatable Fish
Hard	10	10
Normal	6	6
Easy	3	3

Table 1. Game level and the corresponding number of predator fish.

3.1 Emotion Input

The moment a player starts playing a game, the computer vision based facial feature tracking software starts running in the background to capture the player's facial expression and then calculate affective state during game time. The detail of how to calculate the affective state is described in the following section.

The user's affective state is used dynamically to control the level of the game. A negative affective state changes the game to have fewer predator fish, while a positive affective state changes the game to gradually have more of the predator fish . Thus, as the user becomes unhappy the game level is lowered to be easier, while when the user is happy the game level changes to the harder level. Table 2 shows the users' emotional state and the corresponding change in the game level.

Emotional State	Game Level
Happy	Hard
Neutral	Normal
Frustrated	Easy

Table 2. User's Emotional Level and the corresponding change in Game Level.

3.2 Facial Feature Tracking

The "Feed the Fish" game uses computer vision based face tracking to infer the user's emotional state. The facial feature tracking algorithm is based on the work of Zakharov [3, 4]. His method was developed using a Hybrid approach, where facial features are detected using common image processing techniques available in the OpenCV library [10]. The face is tracked using the Haar object classifier [2] with a cascade trained to detect human faces. Determining the location of eyes and mouth is based on the anthropometric face proportions. Figure 2 shows the output from the facial feature tracking system used. The tracking runs at 25 frames per second (FPS). The tracking results are taken from eight best measurements of the distance between outer eye corners and outer mouth corners. The final result is calculated by taking average of these eight values and sending them to the client system to calculate the user emotional state.

Figure 2. The Facial feature tracking system.

The affective state detection is based on the idea of normalising facial animation parameters as described in the work of Pandzic and Forchheimer [5]. Using their idea, Zakharov [4] measured feature displacement based on a set of facial parameters for a neutral expression. Figure 3 shows the facial feature distance measures. Using those measures, three ratios are collected to determine the change in facial expression; (a) The distance between the outer eyes and the mouth corners to the distance between pupils, (b) the distance between outer mouth corners divided by the distance between pupils and (c) the distance between eyebrows divided by the distance between pupils [4]. These ratios are measured and computed regularly, and then compared with previous ratio to determine the current status of the user's affective state. In our system, we measured the distance between outer mouth corners and the outer eye corners. The typical ratios for neutral expression are gained by averaging measurements from 22 people's expression tracked by the system. Thus, we can determine a person has positive expression if a captured ratio is above the neutral ratio and vice verse for negative expression. Table 3 shows the ratios for each affective state.

Affective state	Ratio Value
Positive	> 0.85
Neutral	0.75 – 0.85
Negative	< 0.75

Table 3. Typical ratios for each affective state.

The accuracy of the system depends on several external factors. First, lighting can easily affect the tracking system. In the experimental setup, a green background was placed behind the player and a normal light was turned on. This configuration helped the tracking system to find the player's face accurately. The second factor is the users' facial expressions. From the observation in the pilot study, some people did not have significant facial expressions while playing the game. This might "cheat" the tracking system. However, most of people expressed themselves naturally when playing the game.

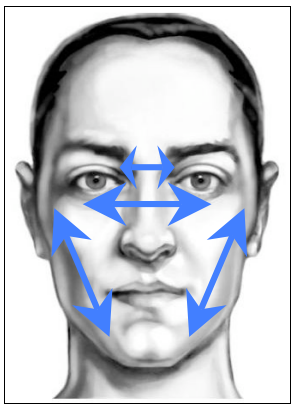

Figure 3. Facial feature distance measures[1].

3.3 Game Implementation

The Feed the Fish game was developed and implemented in C++ using the OpenCV, OpenGL and WinSocket libraries. The hardware specification for the system includes a Logitech QuickCam 5000 and a Pentium IV computer machine running the Windows XP operating system with 2 GB memory storage, 20 GB hard disk memory and NVIDIA GeForce 8800GT video card.

The system employs a client-server architecture. The Facial Face Tracking (FFT) system acts as a client sending data through to the actual game which act as the server. The data contains figures calculated from the player's facial features such as the length between eye corner and mouth corner. After receiving the data, the game (server) compares the figure values with the predefined thresholds that determine the difficulty level of the game.

Figure 4 shows the system software stacks and the client-server based architecture. The system only requires one way communication between the server and the client so that FFT system can be easily deactivated if the game does not require FFT system.

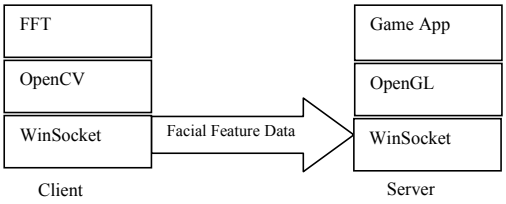

Figure 4. The system architecture and software stacks.

4. USER EVALUATION

A user study was conducted to compare the enjoyment of the game with and without the affect-aware system. Each participant had two rounds of game play, where each round lasted for two minutes. Participants played the first round with the Non-Facial Feature Tracking (NFFT) system turned on, whereas the second

[1] Image adapted from www.artnatomia.net [6].

round was played with the Facial Feature Tracking (FFT) system on. We recorded the players' scores in both game rounds, and also asked each of the participants to answer a questionnaire after each of game play rounds. Participants were giving a trail run for one minute to become familiar with the keyboard controls before the actual game play.

The game was designed to have equal number of small edible fish and big predator fish. The player needs to catch as many small fish as they can in just 2 minutes. In the NFFT round, the game has a constant number of fish, i.e. 6 small eatable fish and 6 big predator fish whereas during the FFT round, the game changes the number of fish dynamically according to the player's emotional change.

A total of 22 players participated in the user study. They were not told there was a facial tracking system running in the background until they have finished the user study. Most participants enjoyed playing the second game round (FFT) more than the first game round (NFFT) because the game appears more challenging and dynamic.

The participants answered one questionnaire for each game round. At the end the participants were asked to compare the two conditions A and B, where A is the game without the affect-aware system and B has the affective-ware system. The questions were designed to focus on the player's enjoyment and performance. Some sample questions are listed below.

Q1 Are you satisfied with the accuracy of the system?
Q2 How easy was the game to play?
Q3 How enjoyable was the game?
Q4 How exciting was the game?
Q5 How well do you think you played the game?

Each question has a scale from 1-7, where 1 means not very satisfied and 7 means very satisfied.

4.1 Results

We conducted the user study with a total of 22 players. There were 13 men and 9 women aged from 20 to 35 years. Most of them use computers regularly, i.e. between 20 to 30 hours a week. Most male participants played computer games 5 to 10 hours a week.

For each of the players we collected data about their game performance (the score achieved) and subjective survey results. The game performance data is represented by the maximum score achieved, the final scores achieved, as well as the player's general score and emotional change over time. For the subjective survey participants were asked questions following each of the game conditions (NFFT and FFT). After the completion of both game conditions participants were also asked to answer several questions for comparing between the two game conditions.

Figure 5 shows the average of the maximum scores and the average of the final scores achieved by the players for each of the game conditions (NFFT and FFT). Using a one factor ANOVA we found no difference between conditions in the maximum score achieved ($F(1,42) = 0.34$, $p = 0.56$), or in the final score achieved ($F(1,42) = 0.65$, $p = 0.43$). Thus although emotion was used to change the game difficulty it seemed to have no effect on the final player scores.

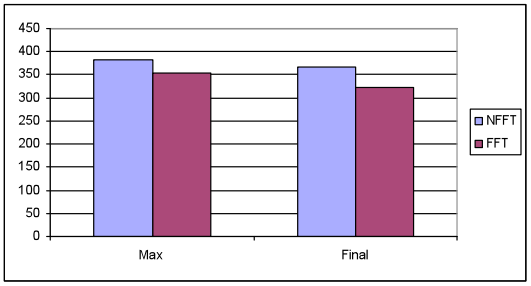

Figure 5. The maximum and final game scores.

Figure 6 shows the average for the results of the five questions asked after each condition. As can be seen there is little difference between the participate opinions about the two game conditions. Participants felt they played very well (Q5) with an average score of 4.6 (NFFT) and 4.5 (FFT) out of 7, and they also felt that the game was very enjoyable (Q3) with an average score of 4.2 (NFFT) and 4.9 (FFT) out of 7. Using a one factor ANOVA there was no significant difference between these conditions. However although the result for Q4 (*"how exciting was the game?"*) was nearly significant ($F(1,42) = 2.99$, $P = 0.09$).

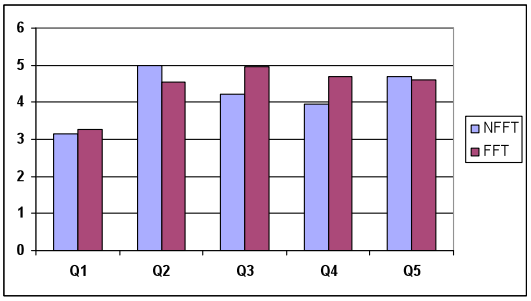

Figure 6. Subjective survey results.

At the completion of playing under both conditions the following question were asked:

Q1 How easy was the game to play?
Q2 How enjoyable was the game?
Q3 How exciting was the game?
Q4 How well do you think you played the game?

They were asked to select on a scale from 1 to 7 (1 = not very easy, 7 = very easy). In this case they had now experienced both conditions. The results of the comparisons (shown in Figure 7) show that participants felt that the affective condition (FFT) was significantly more enjoyable to play than the NFFT condition, and it is also more exciting to play. Using a one factor ANOVA we found a significant difference between answers to Q2 ($F(1,42) = 6.65$, $p < 0.05$.), and to Q3 ($F(1,42) = 5.34$, $p < 0.05$). There was no significant difference between the results for Q1 ($F(1,42) = 0.64$, $p = 0.43$) and Q4 ($F(1,42) = 0.11$, $p = 0.74$).

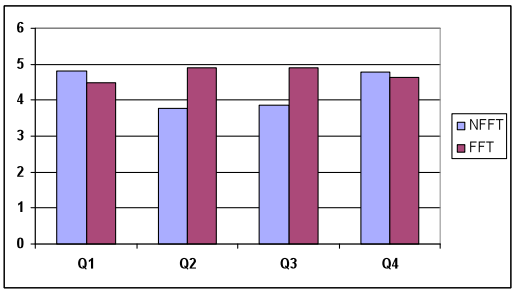

Figure 7. Comparative survey results.

The subjects were also asked the following forced choice questions:

Q1: Which was the game condition that you enjoyed the most [condition Affective or Non-Affective]?

Q2: Which was the game condition that you played best in [condition Affective or Non-Affective]?

The results (Table 4), shows that users overwhelmingly thought that the affective condition was more enjoyable than the non-affective condition, but were more split over which condition they thought they played best in.

	Q1: Enjoyable	Q2: Played Best
Affective	18	9
Non Affective	4	13

Table 4. Forced choice question results.

The results show that the affective state indicated by the human facial expression can play an important role in building a communication channel between the game and its players. In addition, the results show the possibility of using the affective state feedback to make the game more challenging and enjoyable.

The following is some of the comments from users as to how to improve the game:

- Make the player fish react faster for key press.
- Facial tracking was not responsive enough
- Audio feedback could improve the game!
- It would be fun to know how my face the system can handle during the game play.
- Probably need to calibrate the emotion tracking before the game starts.

In addition, there were some comments about how useful the emotion feedback was for enjoying the game:

- I was trying not to laugh during the second game, it was funny.
- The game was unpredictable!
- It was fun but it might feel stupid to sit in front of the PC and try to smile all the time.
- Negative impact.
- It increased the difficult but the challenge is an important thing otherwise the game becomes boring after a while. An issue is that I noticed is that I smile when I 'am in trouble and I am not happy!
- Very useful but I don't know how the emotion measured
- Not too sure. It's kind of fun if the game had an indicator for the reaction from the facial tracking.

5. CONCLUSION AND FUTURE WORK

In this paper we presented a computer vision based affect-aware system and its application in a simple computer game. We also discussed the results of our user study which showed that while the affect-aware game can be more challenging people have more enjoyment and excitement about computer games with affect-aware systems, which provides a new communication channel between human players and computer games.

There is still space for improvement in our system. For example, the current affect-aware system depends heavily on computer vision input. There are limitations of computer vision system such as poor lighting conditions and the accuracy of human face recognition.

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