Appraising Emotional Events during a Real-time Interactive Game

Matthieu Courgeon Céline Clavel Jean-Claude Martin

LIMSI-CNRS, B.P. 133
91403 Orsay Cedex
FRANCE
{courgeon,clavel,martin}@limsi.fr

ABSTRACT
Interactive virtual agents now commonly display facial expressions of emotions. Most of these expressions are triggered using a finite set of labeled emotions, e.g. the six basic emotions (a single expression being assigned to each emotion). However, theories of emotions suggest that emotion is a componential evaluation process, during which sequential facial expressions reflect various information about the ongoing evaluation. This paper presents an implementation of an event based facial animation system based on Scherer's Component Process Theory of emotions. Our application generates appraisal events during a real-time game interaction with a user. The MARC virtual character is used to displays sequential facial expressions reflecting the evaluation process of these game events in real-time.

Categories and Subject Descriptors
I.2.0 [**Artificial Intelligence**]: General - *Cognitive simulation*
I.3.7 [**Computer Graphics**]: Three-Dimensional Graphics and Realism - *Animation*

General Terms
Experimentation, Design, Theory.

Keywords
Event Appraisal, Facial Expressions, Real-time Affective Interaction

1. INTRODUCTION
"*Almost all theories of emotions assume, at least implicitly, that the specific kind of emotion experienced depends on the result of an evaluation or appraisal of an event in term of its significance for the survival or well-being of the organism*" (Scherer [16]). Emotions do not appear instantly. Instead, they might be the result of sequences of checks that trigger external visible signs.

In most virtual agents, external effects of such sequential evaluations of emotional events are not displayed. Single facial expressions of emotions are often triggered using predefined rules. Including signs of sequences of appraisals in virtual characters might improve how they are perceived by users. As MARC features detailed highly realistic head 3D model, is it relevant for studying subtle signs of appraisals.

Incorporating sequential appraisal checks in a virtual character raises several questions: how to integrate these in the software architecture (e.g. application, appraisal, behavior generation, animation). We developed the MARC system which until now, involved a dimensional approach to affect, based on the PAD framework [12]. MARC has been applied to several perceptive studies [4]. In this paper, we will explain how we extended MARC so that it is able to appraise emotional events sent by an interactive game application and display sequences of corresponding facial expressions.

Our system simulates the appraisal processes. It displays temporary signs of affect reflecting appraisals, and computes resulting emotion blends using probabilistic rules based on Scherer's work [16]. Affective events are generated during interaction with a Reversi game interaction.

Firstly, we review Scherer's theory of emotion and previous attempt to display such process in virtual agent systems. Secondly, we present the overall architecture of our interaction system. Then, we conclude and present future directions.

2. RELATED WORK
Emotion is a process involving several components, one of them being cognition. This component is a main focus of cognitive theories of emotion. Arnold and Lazarus [1, 9] introduced the first appraisal based theories of emotions during the 1960s. Since then, various theories were proposed, with more detailed descriptions of causes and consequences of appraisals.

2.1 Appraisals
Klaus Scherer argues that emotions are generated through cycles of events' multi-level evaluations. This is the *Componential Process Model* (CPM). Several different evaluations assess the significance of a particular event for the survival or well-being of the organism. Scherer proposes a set of appraisals [16], i.e. a set of different levels of event evaluations. Four main evaluation phases are distinguished: *Relevance*, *Implication*, *Coping Potential*, and *Normal Significance*. Each phase is decomposed in several appraisal sub-checks that may be shared between different phases. Scherer introduces 10 sub-checks (but his studies often focus on 5 to 7 items [15]). For several of these appraisals sub-checks, Scherer describes the corresponding effect on the different parts of the human body [16], such as the face, the body posture, the voice and internal systems. Timing and order of appraisal sub-check are key information for a

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.
AFFINE '09, November 6, 2009, Boston, MA, USA.
Copyright 2009 ACM 978-1-60558-692-2-1/09/11…$10.00.

proper implementation of a computational model of appraisal. Lanctôt *et al* [8] conducted a study showing that the *intrinsic pleasantness* sub-check is evaluated prior to the *goal conduciveness* sub-check. This study also provides muscles reactions delays for these sub-checks (about 400ms for *pleasantness* and 800ms for *goal conduciveness*). However, the average timing for all appraisal sub-check remains unmeasured. More recently, Grandjean and Scherer [6] conducted a study showing that CPM can be measured using EEG captures, but no timing is provided for facial reactions delay to appraisal process. In a recent study [17], they show that both emotions and their CPM components can be deduced from facial expression. Thus, we might wonder if displaying sequence of appraisals in virtual characters' facial expressions improves users' inference of the agent's appraisals. Moreover, Scherer's results [17] "*do not allow one to evaluate the positions of categorical discrete or basic emotion theories as compared to componential appraisal theories, as both postulate emotion as the mediating construct that organizes the expression pattern*". Thus, additional experiments must be led using different setups, in terms of emotions and appraisals display.

Marsella *et al* [11] present a computational model of appraisal dynamics, involving knowledge representation, cognitive operators and appraisals process simulation, influencing evolutions of the emotional state over time. Like Scherer, they consider that appraisals are a cause of emotional response. Thus, the appraisal system is one of their key components of their computational model for emotion.

2.2 Facial expressions of appraisals

Paleari et al. [14] developed a facial animation system using Scherer's descriptions of facial reactions to appraisals. Their system displays temporary expressions during appraisals checks. A similar work was achieved by Malatesta et al. [10]. They also address dynamic issues using two kinds of animation modes. In both cases, they use Scherer's prediction tables for facial parameters computations. As a first approach, they perform additional combination of appraisals expressions, i.e. each appraisal expression is added to the current facial expression. Their second approach is to use sequential facial expressions of appraisals, i.e. each expression fades out when the next appraisal check is performed.

These systems only deal with facial animations resulting from appraisals checks, and do not actually appraise events occurring during interaction with real-time applications. For a complete affective process simulation, Scherer proposed a schematic architecture of his complete theory. His architecture, involving issues such as knowledge representation, is totally independent from a specific application. In our work, we chose to use a game application, as they were shown to be a relevant framework for studying affects and their dynamical expressions [2]. In addition, games provide a restricted set of events and situations, that is appropriated for controlled studies.

2.3 Challenges of appraisals implementation

Designing a system appraising affective events during real-time interaction with a user remains a challenge. Apart from generating and appraising the events, real-time applications imply a long-term management of the agent's affective state, i.e. how the different appraisals of several sequential events combine over time [11]. Our system provides a real-time game generating and appraising such affective events.

3. SYSTEM DESCRIPTION

The architecture proposed by Scherer involves sophisticated reasoning modules. We chose to implement a simplified model, using 7 appraisal registers, and a finite set of possible emotions. Our system is composed of three different parts:

(i) the game application from which events are generated

(ii) the appraisal module which evaluates these events and generates animation parameters.

(iii) the animation module displaying dynamical expressions of appraisal and emotions.

3.1 Global Architecture

Our three modules communicate through UDP messages complying with the emotionML language [18] for appraisal content, and with the BML language [7] for animation parameters content. Figure 1 shows the system architecture. The three modules are independent which makes it easier to use a different application or a different animation module. In the following, we detail each of the three modules.

Our appraisal system deals with 7 appraisal sub-checks: *expectedness*, *unpleasantness*, *goal hindrance*, *external causation*, *copying potential*, *immorality*, and *self consistency*. We chose these 7 sub-checks because several emotions were evaluated with those criteria in the literature.

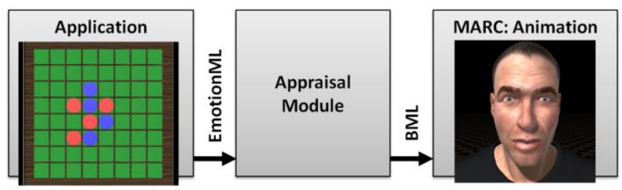

Figure 1. Main System Architecture

Figure 2 shows the interaction setup, using a touch screen device to interact intuitively, and a 24" high definition screen to display the virtual agent face.

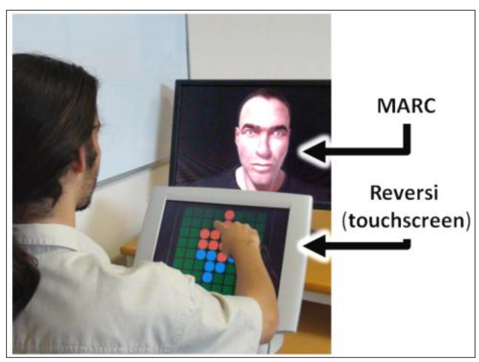

Figure 2. Interaction setup

3.2 Application module

The application that we selected and implemented is a game named *Reversi*. "*Reversi is a board game played by two players on a board with 8 rows and 8 columns and a set of distinct pieces for each side. The player's goal is to have a majority of their colored pieces showing at the end of the game, turning over as many of their opponent's pieces as possible" [20]*. This application enables a short learning phase for the users, and generates games' dynamic affective content. Such an application is relevant for our research by enabling to focus on a limited set of situations, varied with respect to their appraisal profile.

The user plays against an artificial player, represented by our virtual character. During a game, all actions are recorded, and emotional events are generated using this dynamic context. Next user's actions are anticipated. This technique enables unexpected events. For example, if the user plays somewhere which was anticipated as the worst possible user's action, an event with negative *expectedness* will be generated.

In our application, the relevant actions used to trigger appraisal events are: (1) the user plays, (2) the artificial player plays, and (3) the game is over. A set of predefined rules are then used to compute appraisal values for each sub-check. These rules are based on the current event, and on the game history, and anticipation user. Every sub-check is evaluated for each event. Rules to compute sub-check values might vary according to our experimental goals, thus a precise list will be part of the protocol specifications of our planned experimental study.

Once every appraisal sub-checks are evaluated, an EmotionML tag is generated and sent to the Appraisal Module. All events do not trigger an appraisal event. If an event is appraised as with neural unexpectedness, pleasantness, and goal hindrance, this event is assumed as non relevant (*Relevance Detection Check* [16]). Consequently, the corresponding appraisal check sequence is cancelled.

3.3 Appraisal module

As shown in Figure 1, the Appraisal Module receives messages from the application containing appraisal values for a single event. For each message, the Appraisal Module runs through a complete appraisal cycle.

3.3.1 *Labeled emotions relevance*

The first function of the Appraisal Module is to determine the probability of each possible emotion, following the notification of an event by the Application Module. The Appraisal module is initialized with a set of possible emotions, each emotion associated with 7 attributes, corresponding to configurations for the appraisal sub-checks adapted for Scherer [16]. (This list is contained in a configuration file to easily add and remove emotions.) We selected the following set of emotions: Joy, Sadness, Anger, and Guilt. This set was selected because 1) the literature provides suggestion for their appraisal profile [16]; 2) they are prototypical emotions generally solicited during a game.

Some parts of the CPM are underspecified, and need to be detailed for proper implementation. The CPM proposes discrete prediction values for each sub-check (*open, very low, low, medium, high,* and *very high)*; except for the *external causation* that takes different values (*open*, *external*, *internal*). If a sub-check of an emotion is set to "*open"*, it means that this sub-check is not discriminant in the relevance computation of this emotion.

Using discrete values implies several limitations (e.g. an emotion can only be totally relevant or totally non-relevant). Thus, we used these discrete values to defined Gaussian curves. Figure 3 shows the mapping between possible sub-check discrete values and the corresponding Gaussian curves. Gaussian curves are used because they provide a linear quantification of discrete values. This enables us to evaluate appraisal sub-checks on a continuous scale, and not only on a small set of discrete values.

Using this correspondence table, each possible emotion is associated with 7 Gaussians, one for each of its sub-check. Discrete values are extracted from experimental data of the *Componential Process Model* [16] (Table 5.5).

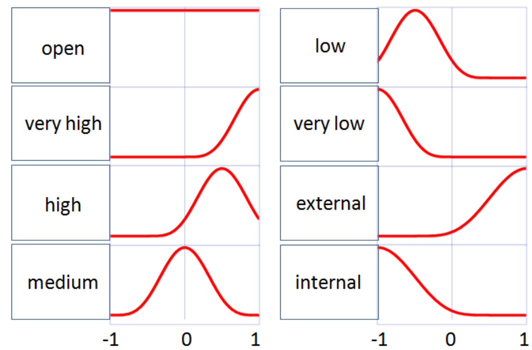

Figure 3. Corresponding Gaussian of Appraisals attributes of emotions.

When an event occurs, we evaluate relevance of each emotion for the event that just occurred. For each emotion, we sequentially multiply its relevance with the emotion's Gaussian value of all its sub-checks (with a short delay between checks). Figure 4 provides a detailed explanation of *Anger* relevance computation following a single affective event. This event description is: "the user just plays somewhere unexpected, and the agent knows that the user just made a mistake. The agent is now able to win the game". This event is highly unexpected, pleasant, and goal conductive. Its origin is external. Its coping potential is neutral, because no adaptation is needed. The event is has a neutral morality and self-consistency. As a result, this event will generate *joy* rather than *anger*. The figure 4 explains how the *anger* relevance is set to zero.

3.3.2 *Temporary facial clue of appraisal process*

The second function of the Appraisal System is to display temporary facial expression reflecting the internal appraisal process. This part is achieved using literature description of appraisals effects on the face [16]. Facial animation is achieved using FACS Action Units [5]. Thus, the Appraisal System outputs are AU's facial descriptions. Using Scherer's description of temporary facial expressions during appraisal, Behavior Markup Language [7] messages are successively generated and sent to the Animation Module.

During event appraising, facial expression of the current internal affective state is attenuated. Thus, temporary facial clues of appraisal can be displayed, and ambiguous affective states –as the appraisal sequence is not complete– are not displayed. Once the ongoing appraisal sequence is complete, the agent's affective state modifications are achieved. Thus, the facial expression reflects the new internal affective state.

3.4 Facial animation module

MARC, our MPEG-4 based facial animation system, has been extended to support Action Units based animation and BML external control. All AUs are defined using MPEG-4 key-points, and blended in real time using BML specifications received from the appraisal system. Side effects of AUs, such as wrinkles [4], are automatically generated by MARC's animation system.

4. CONCLUSION

In this paper, we have presented an interactive affective game application using our platform MARC as a visual output. Affective computations are based on Scherer's theory of sequential evaluation checks. Our system provide a new approach to perform cycles of automatic generation of appraisal events, evaluation of such events into appraisals dimensions, and computation of temporary facial expressions and dynamic facial expressions of emotions. The application that we used restrains the amount of possible events and enables us to control the emotional content.

5. FUTURE DIRECTIONS

5.1 Evaluations

The system described in this paper enables us to perform various perceptive studies on appraisal theories. More precisely, we intend to assess the impact of temporary facial expressions of appraisal on user perception of the virtual agent. Our main hypothesis is that displaying appraisal facial clues modifies user's perception of the virtual agent. We also hypothesize that more complex facial behavior might suggest to the user that the agent is also playing more strategically, and that it might influence user actions: the user might play more strategic too, and take more time to think before he plays. Both subjective and objective measurements will be performed, using game logs and a subjective questionnaire.

To test the influence of appraisal facial clues, we will use three conditions: (1) an agent using appraisal facial clues and emotions, (2) an agent displaying only final emotions, and (3) a neutral agent as a control condition.

5.2 Platform evolutions

In terms of interaction, the only user inputs are the action performed during the game. We can assume that some users might also display facial expressions of emotions [19]. Thus, using a facial expressions recognition software like FaceReader [13] would give additional information to generate appraisal values. FaceReader plug-in is already connected to MARC [3].

We might also consider other affective states, re-appraisal cycles, and individual differences in appraisal and expression of emotions. Our goal is to use MARC as a platform for integrating and validating several models/theories of affective interaction.

6. REFERENCES

[1] Arnold, M. B. Emotions and Personality. *Psychological Aspects*, 1960).

[2] Becker, C., Prendinger, H., Ishizuka, M. and Wachsmuth, I. Evaluating affective feedback of the 3d agent max in a competitive cards game. In *Proceedings of the The First International Conference on Affective Computing and Intelligent Interaction (ACII-05)* (Beijing, China, 2005)

[3] Courgeon, M., Martin, J.-C. and Jacquemin, C. MARC: a Multimodal Affective and Reactive Charater. In *Proceedings of the Workshop on Affective Interaction on Natural Environment* (Chania, Greece, 2008)

[4] Courgeon, M., Buisine, S. and Martin, J.-C. Impact of Expressive Wrinkles on Perception of a Virtual Character's Facial Expressions of Emotions. In *Proceedings of the 9th International conference on Intelligent Virtual Agents* (Amsterdam, The Netherlands, 2009). Springer LNCS

[5] Ekman, P., Friesen, W. V. and Hager, J. C. *Facial Action Coding System - The Manual*. A Human Face, Salt Lake City, UT, 2002.

[6] Grandjean, D. and Scherer, K. R. Unpacking the cognitive architecture of emotion processes. *Emotion*, 8, 3 (08/2008 2008), 341-351.

[7] Kopp, S., Krenn, B., Marsella, S., Marshall, A. N., Pelachaud, C., H., P., K.R, T., Vilhjalmsson, H., N., B. and Johnstone, L.: http://www.mindmakers.org/projects/BML (2006)

[8] Lanctôt, N. and Hess, U. The Timing of Appraisals. *Emotion*, 7, 1 2007), 2007-2212.

[9] Lazarus, R. S. Emotions and Adaptation: Conceptual and Empirical relations. *Nebraska Symposium on Motivation*, 161968), 175-270.

[10] Malatesta, L., Raouzaiou, A., Karpouzis, K. and Kollias, S. Towards modeling embodied conversational agent character profiles using appraisal theory predictions in expression synthesis *Applied Intelligence*, 2007), 58-64.

[11] Marsella, S. and Gratch, J. EMA: A process model of appraisal dynamics. *Cognitive Systems Research*, 10(March 2009 2009).

[12] Mehrabian, J. A. R. a. A. Evidence for a three-factor theory of emotions. *Journal of Research on Personality*, 1977), 273–294.

[13] Noldus-Information-Technology: http://www.noldus.com/content/facereader (2009)

[14] Paleari, M., Grizard, A. and Lisetti, C. Adapting Psychologically Grounded Facial Emotional Expressions to Different Anthropomorphic Embodiment Platforms. In *Proceedings of the FLAIRS Conference 2007* (Key West, Florida, USA, 2007)

[15] Scherer, K. R. On the Sequential Nature of Appraisal Processes: Indirect Evidence from a Recognition Task. *Cognition & Emotion*, 13, 6 1999), 763 - 793.

[16] Scherer, K. R., Schorr, A. and Johnstone, T. *Appraisal considered as a process of multilevel sequential checking*. Oxford University Press US, 2001, City, 2001.

[17] Scherer, K. R. and Grandjean, D. Facial expressions allow inference of both emotions and their components. *Cognition & Emotion*, 22, 5 2008), 789-801.

[18] Schröder, M., Baggia, P., Felix Burkhardt, F., Martin, J.-C., Pelachaud, C., Peter, C., Schuller, B., Wilson, I. and Zovato, E.: http://www.w3.org/2005/Incubator/emotion/XGR-emotionml-20081120/ (2008)

[19] Wang, N. and Marsella, S. *Introducting EVG: An Emotion Evoking Game*. City, 2006.

[20] Wikipedia: http://en.wikipedia.org/wiki/Reversi (2009)

Relevance is expressed between ***0.0*** (not relevant) and ***1.0*** (totally relevant)
Initial value is ***1.0***

Appraisal Sub-checks	Event values	Anger: Discrete value	Anger: Associated Gaussian	Anger: Gaussian multiplier	Anger: Resulting emotion relevance	Explanations
Expectedness	*-0.9*	***Open***	-1 0 1	***x1.0*** →	*1.0*	The *expectedness* of the event is *"-0.9"* : "Highly unexpected" The green doted line represent the event value in the Gaussian curve. It indicates where to read to Gaussian curve to obtain the Gaussian Multiplier *Expectedness* is not discriminant for Anger: Gaussian multiplier = *"1.0"*
Unpleasantness	*-0.7*	***Open***	-1 0 1	***x1.0*** →	*1.0*	The unpleasantness of the event is *"-0.7"* : "Pleasant" Again, *Unpleasantness* is not discriminant for Anger. The relevance is multiplied using the Gaussian Multiplier : Anger relevance is still *"1.0"*.
goal hindrance	*-1.0*	***High***	-1 0 1	***x0.0*** →	*0.0*	*Goal Hindrance* is discriminant for Anger. The *Goal Hindrance* of the event is *"-1.0"*: "Goal conducive" The Gaussian multiplier at value *"-1.0"* is *"0.0"*. Anger relevance is multiplied by *"0.0"*, and thus, is then equal to *"0.0"*. Anger relevance is thus already set for this event, but the appraisals continue.
external causation	*1.0*	***Extern.***	-1 0 1	***x1.0*** →	*0.0*	*External causation* is discriminant for Anger. The *external causation* of the event is 1.0 : "External" The Gaussian multiplier at value *"1.0"* is *"1.0"*. Anger relevance is multiplied by *"1.0"*, but remains equal to *"0.0"*.
copying potential	*0.0*	***High***	-1 0 1	***x0.2*** →	*0.0*	*Copying potential* is discriminant for Anger. The *copying potential* of the event is 0.0 : "Neutral" The Gaussian multiplier at value *"0.0"* is *"0.2"*. Anger relevance is multiplied by *"0.2"*, but remains equal to *"0.0"*.
Immorality	*0.0*	***High***	-1 0 1	***x0.2*** →	*0.0*	*Immorality* is discriminant for Anger. The *immorality* of the event is 0.0 : "Neutral" The Gaussian multiplier at value *"0.0"* is *"0.2"*. Anger relevance is multiplied by *"0.2"*, but remains equal to *"0.0"*.
self consistency	*0.0*	***Low***	-1 0 1	***x0.2*** →	*0.0*	*Self consistency* is discriminant for Anger. The *self consistency* of the event is 0.0 : "Neutral" The Gaussian multiplier at value *"0.0"* is *"0.2"*. Anger relevance is multiplied by *"0.2"*. **Thus, Anger relevance is finally equal to "0.0" which sound correct for an event that is Pleasant and Goal Conducive.**

time

Figure 4. Relevance computation: Detailed example.