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Abstract	A typical gaming scenario, as developed in the past 20 years, involves a player interacting with a game using a specialized input device, such as a joystick, a mouse, a keyboard or a proprietary game controller. Recent technological advances have enabled the introduction of more elaborated approaches in which the player is able to interact with the game using body pose, facial expressions, actions, even physiological signals. The future lies in 'affective gaming', that is games that will be 'intelligent' enough not only to extract the player's commands provided by speech and gestures, but also to extract behavioural cues, as well as emotional states and adjust the game narrative accordingly, in order to ensure more realistic and satisfactory player experience. In this chapter, we review the area of affective gaming by describing existing approaches and discussing recent technological advances. More precisely, we first elaborate on different sources of affect information in games and proceed with issues such as the affective evaluation of players and affective interaction in games. We summarize the existing commercial affective gaming applications and introduce new gaming scenarios. We outline some of the most important problems that have to be tackled in order to create more realistic and efficient interactions between players and games and conclude by highlighting the challenges such systems must overcome.

Chapter 4
Multimodal Sensing in Affective Gaming

Irene Kotsia, Stefanos Zafeiriou, George Goudelis, Ioannis Patras, and Kostas Karpouzis

Abstract A typical gaming scenario, as developed in the past 20 years, involves a player interacting with a game using a specialized input device, such as a joystick, a mouse, a keyboard or a proprietary game controller. Recent technological advances have enabled the introduction of more elaborated approaches in which the player is able to interact with the game using body pose, facial expressions, actions, even physiological signals. The future lies in 'affective gaming', that is games that will be 'intelligent' enough not only to extract the player's commands provided by speech and gestures, but also to extract behavioural cues, as well as emotional states and adjust the game narrative accordingly, in order to ensure more realistic and satisfactory player experience. In this chapter, we review the area of affective gaming by describing existing approaches and discussing recent technological advances. More precisely, we first elaborate on different sources of affect information in games and proceed with issues such as the affective evaluation of players and affective interaction in games. We summarize the existing commercial affective gaming applications and introduce new gaming scenarios. We outline some of the most important problems that have to be tackled in order to create more realistic and efficient interactions between players and games and conclude by highlighting the challenges such systems must overcome.

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Introduction

The games industry has grown to be one of the mainstream markets in our days. In the beginning, the games industry constituted a focused market, highly depended on specialized input sensors to enable the interaction between a player and the game. In typical games, the user had to be familiar with an input device, such as a keyboard, a mouse, a joystic or a console, in order to properly communicate with the game. Furthermore, the game had a predesigned plot that would progress along with the players actions in a predefined way, giving the feeling of a non-existent, in reality, control over how the game evolves. Moreover, in such a gaming scenario several issues had to be tackled: the game had to be carefully designed and developed so as to allow real-time interaction with the player, ensure a high quality visual environment, so that the immersion of the player in the game environment would be as realistic as possible, and employ devices that would be of affordable cost.

Initial research approaches in the field of affective computing focused on processing the physiological cues of a player in order to correlate them with certain behavioural patterns that would assist in making the player-game interaction more realistic and meaningful. To achieve that, several physiological signals were employed, such as heart beat rate, skin conductivity etc., using obtrusive devices. The use of brain signals also defined a field on its own, leading in the creation of Brain Computer Interface (BCI) systems. The most recent approaches tried to create wearable systems that were built of portable devices/personal computers and thus eliminated the effect of sensors as they provided the player with extra degrees of freedom. However, the main problem with employing specialized sensors to extract behavioural cues is that they greatly affect the immersion of the player in the game. Even with sensors that are relatively easy to use, such as skin conductivity sensors, the player's actions are constrained by the space limitations of each sensor. This is of great importance as it usually leads the player to exhibit unusual behavioural patterns often attributed to the effect (even subconscious one) that the presence of a sensor has. An overview of the available sources of information is depicted in Fig. 4.1, along with the corresponding part of the body from which physiological signals are extracted.

Recent technological advances have opened new avenues towards more realistic human-machine interaction systems, thus enabling the introduction of games in which the player is not only able to control the game, but can also control the gameplot and player experience without using an input device, just by freely acting on his/her will. More specifically, the introduction of Microsoft Kinect [57] has enabled the robust extraction of body poses and joint locations in real-time, while at the same time being of low cost. By providing such a real time and robust solution to the tracking problem, research has been shifted towards affective gaming scenarios, in which the player's emotional states and actions will be used to define the way the game will progress.

The term affective gaming corresponds to the introduction of affect recognition in games. These approaches tried to incorporate emotion recognition in their systems

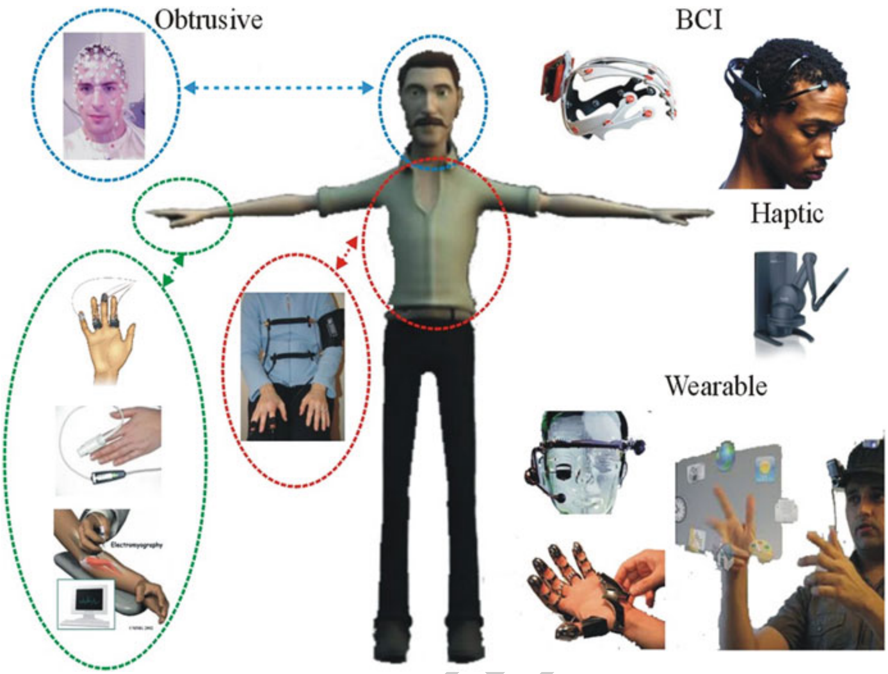

Fig. 4.1 An overview of the widely used sensors

in order to extract the emotional state of the player and use it to control the gameplot and gameplay experience. In this paper we will review the area of affective gaming. More precisely, we will briefly review existing approaches and discuss the recent technological advances. We will present the existing means for the extraction of behavioural cues and subsequently analyze existing approaches in affective gaming. Finally we will examine future trends in games by defining new affective gaming scenarios and also discussing their possible applications.

The remainder of the chapter is organized as follows. We first discuss the term affective gaming and present in brief its involvement through time (Section "Affective Gaming"). We continue with presenting the different sources of affect information, categorizing them in those that involve vision based techniques (Section "Vision-Based"), those that involve haptics as an input and interaction modality (Section "Haptics") and those that employ specialized wearable devices (Section "Wearable Games"). We proceed with investigating several issues raised in affective gaming, such as affective evaluation of players (Section "Affective Evaluation of Players") and affective interaction in games (Section "Affective Interaction in Games"). We also summarize the existing affecting gaming commercial applications in section "Applications of Affective Games". We introduce new affective gaming scenarios (Section "Affective Gaming Scenarios") and discuss the challenges that affecting gaming systems must overcome (Section "Affective Gaming Challenges"). In section "Conclusions" we draw our conclusions.

Affective Gaming

The term affective gaming refers to the new generation of games in which the players' behaviour directly affects the game objectives and gameplay. More precisely, the emotional state and actions of a player can be correctly recognized and properly used in order to alter the gameplot and offer to the player an increased user experience feeling. In other words, the emotions and actions of a player are of extreme importance, as the behavioural cues extracted from them will define the way the game will progress.

Early approaches in the field of affective gaming focused on highlighting the importance of including emotional content in systems in order to make the user experience more satisfactory. Here the term 'emotion' corresponds to a variety of affective factors. Emotions are defined as short states (often lasting from seconds to minutes) that reflect a particular affective assessment of the state or self or the world and are associated with behavioural tendencies and cognitive biases [39]. They are further distinguished in universal (anger, disgust, fear, happiness, sadness and surprise [26]) and complex (guilt, pride and shame). Emotions are often defined in terms of their roles, thus being distinguished in those involved in interpersonal, social behaviour (e.g., communication of intent, coordination of group behaviour, attachment), and those involved in intrapsychic regulation, adaptive behaviour, and motivation (e.g., homeostasis, goal management, coordination of multiple systems necessary for action, fast selection of appropriate adaptive behaviours). They are usually manifested across four interacting modalities: the—most visible—behavioural/expressive modality (e.g., facial expressions, speech, gestures, posture, and behavioural choices), the somatic/physiological modality—the neurophysiological substrate making behaviour (and cognition) possible (e.g., changes in the neuroendocrine systems and their manifestations, such as blood pressure and heart rate), the cognitive/interpretive modality, directly associated with the evaluation-based definition of emotions and the experiential/subjective modality: the conscious, and inherently idiosyncratic, experience of emotions within the individual [39]. Emotions are most commonly characterized by two dimensions: valence and arousal [69]. The dimension of valence ranges from highly positive to highly negative, whereas the dimension of arousal ranges from calming or soothing to exciting or agitating. Affective computing has been directly linked with affective gaming in terms of emotion sensing and recognition, computational models of emotion, and emotion expression by synthetic agents and robots.

Emotion affect recognition has been widely researched in order to create human computer interaction systems that can sense, recognize and respond to the human communication of emotion, especially affective states such as frustration, confusion, interest, distress, anger, and joy. In [67], Picard highlighted the importance of recognizing affective states commonly expressed around computer systems: frustration, confusion, dislike, like, interest, boredom, fear, distress, and joy. If a system is able to successfully detect expressions of these states, and associate them with its functions and other environmental events, then it can proceed with improving its interactions with the user. In that way the gap between the human and the machine in HCI systems can be narrowed and more user-centered HCI systems can be created [38]. Affective arousal modulates all nonverbal communicative cues (facial expressions, body movements, and vocal and physiological reactions), making efficient affect recognition a core element for emotionally intelligent systems [23, 63]. Interested readers can refer to [93] and [18] for a survey on affect recognition methods proposed through the years. In [32] the authors proposed a system for affect recognition that combines face and body cues in order to achieve affect recognition. They employed computer vision techniques (Hidden Markov Models (HMMs), Support Vector Machines (SVMs) and Adaboost) to fuse the available facial (appearance, e.g. wrinkles or geometric feature points) and body (silhouette and color based model) cues. However, the database on which the experiments were conducted included recordings of subjects sitting in front of a camera and reacting to a provided scenario. Therefore, although the subjects were free to express themselves, no real body pose information was available. Moreover, the database included recordings of a single person, thus not being suitable for group behaviour research.

Early approaches also focused on defining the fundamentals of affective gaming from a physiological point of view. The link between neurobiological perspectives and models of play aiming to construct superior player satisfaction models built upon biological foundations has been presented in [7]. More precisely, it was found that connections exist between already recognized patterns of play and recent research on the brain (in particular, the limbic system). In [31], Gilleade et al. discuss some of the origins of the genre, how affective videogames operate, and their current conceptual and technological capabilities. Early biofeedback-based affective games were regarded and a novel approach to game design based on several high-level design heuristics was proposed. In [40] the author discussed the enhancement of social and affective complexity and realism of the game characters of a game, their interaction and the game narrative as a whole. A set of requirements for an affective game engine, capable of supporting the development of more affectively realistic, engaging, and effective games was also proposed.

In [42] the authors proposed an Affect and Belief Adaptive Interface System designed to compensate for performance biases caused by users affective states and active beliefs. It implemented an adaptive methodology consisting of four steps: sensing/inferring user affective state and performance-relevant beliefs, identifying their potential impact on performance, selecting a compensatory strategy, and implementing this strategy in terms of specific GUI adaptations. In [24] the authors developed a computational framework for exploring cognitive decision processes that reason about emotional actions as an integral component of strategy and control over emotions. They implemented a prototype gaming system that exhibited conscious use of the emotional state and negative emotional behaviours during a game of chess in an attempt to impair its opponents game play. In [50], an educational chess game was developed with which the authors studied the role of emotions and expressive behaviour in socially interactive characters employed in educational games. To this end they created a social robot named iCat functioning within a chess game scenario. In [39], Hudlicka discussed how affect recognition contributes to user experience and recognition of player emotion, and based on that, to tailoring game responses to recognised emotions, and generating affective behaviours in player and non-player characters. In [41] the link of affect recognition, as an efficient mean of generating appropriate behaviours in more complex environments, with cognition (attention, memory and language abilities) was also explored. Emotional states, moods and various other subjective experiences occurring just before a player engages with the game of or as a result of the gameplay or immediately after playing can be used to evaluate the player's experience [70] and possibly predict subsequent actions/decisions. Similar observations are made by Yannakakis and Togelius [91], where game content is generated procedurally, aimed to advance the player experience, while from the analysis point of view, Shaker et al. [75] investigate how affective expressivity, associated with game behaviour, can be used to predict player experience.

The ultimate goal of affective gaming systems is to create games that will be "intelligent" enough to understand what each player feels at each specific moment, using behavioural cues obtained either in an obtrusive way (e.g. using neurophysiological measurements), or in an unobtrusive one (e.g. observing facial expressions, body pose, actions, and behaviour). However, most existing scenarios employ sensors that limit the freedom of movement, for example the extraction of neurological cues requires the player to be sitting in front of the computer (game console). As a result, a poor quality/less realistic immersion of the player in the game environment may be achieved, due to the fact that the player may be conscious of the recording/measurement device and thus exhibit unusual behavioural patterns (not corresponding to spontaneous behaviour). Players tend to prefer less intrusive methods of physiological input for their games [60]. Therefore, the extraction of the necessary behavioural cues in an affective game scenario should be performed in a way that is not perceptible to players and does not limit their actions.

Affective gaming constitutes a field that aims at providing answers to a variety of different research questions. Issues regarding the player experience and how his/her affective and physiological evaluation can be performed, have to be discussed. Moreover, the measurement of interaction among players as well as the efficient modeling of their satisfaction remain open problems. Below we will briefly discuss all this issues in detail.

Sources of Affect

We will first describe the available sources for extracting affect information. These can be distinguished in three main categories: those that extract vision based information (such as facial expressions and body movements), those that extract information from brain signals (BCI applications) and those that extract physiological measurements employing specialized sensors.

Vision-Based

In this Section we will review the existing methods that extract affect information using vision-based techniques. This includes unobtrusive methods that do not limit the freedom of the player, allowing him/her to freely act on his/her will. These methods mainly attempt facial expression and body action recognition, as those are behavioural cues that can be easily obtained using a simple camera.

Facial Expressions

Although facial expressions recognition constitutes a well studied field on its own and its applications span several areas, among which games, a limited number of studies have been conducted targeted to affective gaming. An interested reader can refer to [71] and the references within for a brief introduction on recent advances of facial expressions and communicated affect.

In [6], the authors employ computer vision techniques to capture the player's behaviour in order to adapt the game and maximize the player enjoyment. More precisely, observed visual behaviour is associated with game events occuring at the same time; as a result, it is possible to reason about what caused each reaction (e.g. facial expression or facial cue) and whether that event was positive or negative with respect to the player's goal. This multimodal system makes it possible to differentiate between, for instance, an ironic smile when a player loses and a genuine smile after overcoming an opponent or finishing the level. In addition to face expressivity and head movement, body stance and movement also plays an important role in communicating a player's affective state. It has been shown that body expressions can reveal more information regarding the affective state of a person when nonverbal communication is considered [3].

In this section we look at some biological and cognitive aspects of facial expression recognition in humans. We should at this point stress that the subjective feeling of an emotion and its expression on the face are two different things, where the latter is one manifestation of the former among many bodily signals, like gestures, postures, and changes on the skin response. Thus, what we perceive from a face is either an involuntary manifestation of an emotional state, or the result of a deliberate effort at communicating an emotional signal. The urge to associate affect with faces is so great that we recognize expressions even on infants faces, even though they are not yet associated with the emotions they represent in adults (See Figure 2). This association partly relies on innate biases implicit in the human visual system, and partly on the efficient way humans represent facial information. In humans, the subjective experience of an emotion, the production of its somatic expressions, and its recognition in other subjects are all tightly coupled, and influence each other. This allows for a degree of feedback that is beyond current computer systems, and enables differentiation of very subtle affective cues.

The goal of facial affect recognition systems is to mimic humans in their evaluations of facial expression. If a computer can learn to distinguish expressions automatically, it becomes possible to create interfaces that interpolate affective states from these expressions and use this information for better interfaces. We open a little parenthesis here. When we talk about learning in the context of a computer, we usually mean a machine learning procedure, which is different from human learning. Here, what usually happens is that the computer is provided with a number of samples from a category to be learned (be it images of faces with a particular expression or any other numeric representation), as well as a method of categorization. The learning algorithm tunes the parameters of the method to ensure a good categorization on these samples. The ensuing system, however, depends crucially on the quality of provided samples, in addition to the data representation, the generalization power of the learning method and its robustness to noise and incorrect labels in the provided samples. These points are shared by all computer systems working on face images, be it for the recognition of identity or expressions. We bear these in mind when investigating what the brain does with faces, and how it can be simulated with computers. Recognition of relevant processes that partake in human recognition of faces and facial affect guides the designers of computer algorithms for automatic recognition of emotions from faces. For instance, it is known that humans have selective attention for the eyes and mouth areas, which can be explained by recognizing the importance of these areas for communicating affect and identity. Computer simulations by [51] have shown that feature saliency for automatic algorithms that evaluate facial affect parallels feature saliency for the human visual system. How humans determine identity from faces is a widely researched area. One reason for this is that both low-level neurological studies and high-level behavioural studies point out to faces as having special status among other object recognition tasks. Kanwisher et al. [43] have argued that there is an innate mechanism to recognize faces, and they have isolated the lateral fusiform gyrus (also termed the fusiform face area) to be the seat of this process. The proponents of the expertise hypothesis, on the other hand, argued that humans process a lot of faces, and this is the sole reason that we end up with such a highly specialized system [30]. The expertise hypothesis banks on a fundamental property of the human brain: the key to learning is efficient representation, and while we learn to recognize faces, the neural representation of faces gradually changes, becoming tailored to the use of this information. In other words, we become (rather than born as) face experts. But this also means that we are sensitive to cultural particularities we are exposed to, an example of which is the famous other-race effect. This is also true for affect recognition from facial expressions, which incorporate cultural elements. While the geometric and structural properties of a face might allow the viewer to distinguish the basic emotional content, cross-cultural studies have established that the cultural background of the viewer plays a large role in labelling the emotion in a face. Furthermore, perception of emotion-specific information cued by facial images are also coloured by previous social experience. In a recent study [68], a number of children who have experienced a high-level of parental anger expression were shown sequences of facial expressions.

They were able to identify the anger expression in the sequence earlier than their peers, using a smaller amount of physiological cues. The traditional problems faced by face recognition researchers are illumination differences, pose differences, scale and resolution differences, and expressions (See Figure 3). These variables change the appearance of the face, and make the task of comparing faces non-trivial for the computer. While there is a consensus among brain researchers that recognizing facial identity and facial affect involve different brain structures (e.g. lateral fusiform gyrus for identity as opposed to superior temporal sulcus for emotional content, [33], these are not entirely independent [14]. Many aspects of facial identity recognition and affect recognition overlap. This is also the case for computer algorithms that are created for recognition of identity or affect from face images. Hence, it should be no surprise that computational studies also recognize the need for different, but overlapping representations for these two tasks. For instance Calder and colleagues [15] have investigated a popular projection based method for classifying facial expressions, and determined that the projection base selected to discriminate identity is very different than the base selected to discriminate expressions. Also, while facial identity concerns mostly static and structural properties of faces, dynamic aspects are found to be more relevant for emotion analysis. In particular, the exact timing of various parts of an emotional display is shown to be an important cue in distinguishing real and imitation expressions [22]. Similarly, the dichotomy of feature-based processing (i.e. processing selected facial areas) versus holistic processing (i.e. considering the face in its entirety) is of importance. Features seem to be more important for expressions, and while in some cases it can be shown that some expressions can be reliably determined by looking at a part of the face only [61], the dynamics of features and their relative coding (i.e. the holistic aspect) cannot be neglected. Before moving to tools and techniques for computer analysis of facial expressions, we note here that all emotions were not created equal. Brain studies suggest different coding mechanisms for particular emotions. According to the valence hypothesis there is a disparity between the processing of positive and negative emotions, as well as the amount of processing involved for these types in the left and right hemisphere of the brain [13]. This is an evolutionarily plausible scenario, as rapid motor response following particular emotions (e.g. fear, anger) is important for survival. Blair et al. [12] have found that the prefrontal cortex is more active for processing anger, as opposed to sadness. Different cortical structures show differential activation for different emotion types under lesion and functional imaging studies. On the other hand, specific emotions do share common neural circuitry, as disproportionate impairment in recognizing a particular emotion is very rare, as shown by lesion studies (the reader is referred to [1] for examples and references). This inequality is also reflected in displays of emotion. The configural distances from a neutral face are disproportionate for each emotion, with sadness and disgust being represented by more subtle changes (as opposed to for instance happiness and fear). In addition to this disparity, it is unlikely that emotions are encountered with the same background probability in everyday life. Thus, from a probabilistic point of view, it makes sense not to treat all six basic emotions on the same ground. The valence hypothesis suggests that happiness (as a positive emotion) is a superordinate category, and should be pitted against negative emotions (fear, anger, disgust, sadness and contempt). Surprise can be divided into fearful surprise and pleasant surprise; it has been noted that surprise and fear are often confused in the absence of such distinction. Also, disgust encompasses responses to a large range of socially undesirable stimuli. When it expresses disapproval for other people, for instance, it approaches anger. These issues require careful attention in the design and evaluation of computer systems for facial expression analysis.

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Body Expressivity

Changes in a persons affective state are also reflected by changes in body posture [56, 88], with some affective expressions being better communicated by the body than by the face [27, 28]. It has been shown that people tend to control facial expressions more than body expressions when trying to hide their emotions [28]. Conversely, people trust the expressions of the body more than the expressions of the face when the two are incongruent [34].

In [77, 78] the authors tried to categorize the affective behaviour of the child into a set of discrete categories by exploiting the information used by their body gestures. More precisely, they attached a motion capture system to the upper body part of the child in order to extract the coordinates of certain key points. A number of frames containing gesture information in the form of these points were selected and then used to an affective gesture recognition module that employed HMMs.

In [72] the authors extracted visual information of expressive postural features from videos capturing the behaviour of children playing chess with an iCat robot. To this end, they extracted the frontal and lateral view of the body of the subject (child) and used it to study several features, such as body lean angle, slouch factor, quantity of motion and contraction index. They classified these features using a set of different classifiers in order to identify the factors that reveal the player's engagement to the game.

In [19], Caridakis et al. utilised statistical measures of the movement of a user's hands and head to model affective body expression, and produced a five-dimensional representation termed "expressivity features". Despite the simplicity of this representation, which was robust to rotation and scaling or camera zooms, those dimensions (*overall activation*, *spatial extent*, *temporal*, *fluidity* and *power*) were found to be strongly correlated with human perception of affect in body expressivity in real (non-simulated) environments, showing that they can be utilised in human-computer interaction and game settings to perceive affective qualities from human movement, besides recognising actual gestures and postures. In [73], the authors used a similar approach, trying to recognize the affective states of players from non-acted, non-repeated body movements in the context of a video game scenario. To this end, they attached a motion capture system in order to collect the movements of the participants while playing a Nintendo Wii tennis game. They extracted several features from the body motion (*angular velocity*, *angular acceleration*, *angular frequency*, *orientation*, *amount of movement*, *body directionality* and *angular rotations*) and the most discriminative of those were used as an input to a recurrent neural network algorithm. In the end they were able to recognize a set of eight emotions (frustration, anger, happiness, concentration, surprise, sadness, boredom and relief).

In [47, 74], the authors attempted recognition of affective states and affective dimensions from non-acted body postures instead of acted postures. The scenario they used was a body-movement-based video game (Nintendo Wii sports games). Postures were collected as 3-D joint Euler rotations of the joints and were used to recognize the affective state of the player after having won or lost a point. In these works, the following affective states were regarded: *concentrating* (determined, focused, interested); *defeated* (defeated, give up, sad), *frustrated* (angry, frustrated), and *triumphant* (confident, excited, motivated, happy, victory). The classification was performed using a multilayer perceptron network.

One of the well-known works is by Camurri et al. [16]. They examined cues involved in emotion expression in dance. The results ranged between 31 % and 46 % for automatically recognizing four emotions, whereas the recognition rate for the observers was considerably higher at 56 %. Berthouze et al. [48, 76] proposed a system that could recognize four basic emotions based on low-level features describing the distances between body joints. The system was tested on acted postures that were labeled by groups of observers from different cultures. The model built on observers that were from the same culture as most of the actors (Japanese) reached 90 % recognition. Using the same set of postures, similar performances were reached for observers from other cultures [48]. The same approach was used to automatically discriminate between affective dimensions, with performances ranging from 62 % to 97 %. Bernhardt and Robinson [8] built affect recognition models for nonstylized acted knocking motions using Pollick et al.'s database [52]. Their model takes into account individual idiosyncrasies to reduce the complexity of the modeling. After training, the classifier was tested on motion samples from a single actor. The results showed a 50 % recognition rate without removing the personal biases and 81 % with the biases removed. Picard's studies [44, 45] examine non-acted postures. Their multimodal system models a more complete description of the body, attempting to recognize discrete levels of interest [45] and self-reported frustration [44]. Of the input examined (facial expressions, body postures, and game state information), the highest recognition accuracy was obtained for posture (55.1 %). To conclude, most of the work has focused either on acted or stereotypical body expressions (e.g., dance), with the exception of the work presented in [45] and [44], where only a limited description of the body was considered. Low-level features have been shown to provide high-recognition performance. What is still lacking is an understanding of whether a similar approach can be used to create recognition models that automatically discriminate between natural expressions [88]. This is necessary to create automatic recognition systems that are usable in real contexts.

Haptics

Another mean widely used for feature acquisition in affective gaming scenarios is haptic technology. Haptics are devices that exploit the sense of touch by applying forces, vibrations, or motions to the user in order assist in the creation of virtual objects in a computer simulation, to control such virtual objects, and to enhance the remote control of machines and devices. The approaches that employed haptics in BCI systems are relatively new. More precisely, the first approach that employed haptics was presented in [62], in which the authors developed a low-cost and compact force feedback joystick as a new user interface to communicate with a computer. In order to achieve this, they adopted a joystick to create the illusion of force to human hand. They intercepted the interrupts reserved for mouse, colormap and keyboard input in a game and replaced them with a new interrupt service routine in which force effects are added for the new PC video games.

The use of haptics has been noticeably increased during the last decade. In the beginning it was used to aid people with disabilities. In [81] the authors presented a variety of simple games using haptics. The first one was a painting program for blind children, called ‘Paint with your fingers’. The player used a haptic device to choose a color from a palette. Each color on the palette had an associated texture that the user could feel when painting with it. By changing program mode the user could feel the whole painting, and also print the painting on a colour printer. Another game, ‘Submarines’ was a haptic variant of the well known battleship game. The player had to feel 10×10 squares in a coordinate system. His/her finger in the haptic device was a helicopter that was hunting submarines with depth charge bombs. A third game, ‘The Memory House’ consisted of 25 pushbuttons that produced a sound when pressed. The buttons disappeared when the player pressed two buttons (using a haptic device) with the same sound in sequence. In the Memory House the buttons are placed on five different floors. Between each row of buttons the user can feel a thin wall that helps him to stay within one set of buttons. Much later, in [29] the authors discussed feedback in pervasive games and presented their work on Haptic Airkanoid, an extension to Airkanoid using Haptic. Airkanoid is a ball-and-paddle game where the player hit bricks in a wall with a ball. When a brick is hit, it disappeared and the ball was reflected. When all bricks were cleared the player was advanced to the next level. A user controlled paddle prevented the ball from getting lost. Graspable Airbats were used as interfaces for controlling the virtual paddles. In [65] the authors presented a Virtual Reality application of a game of billiard game that allowed the user to interactively provide a force feedback by means of a commercial haptic interface. The haptic device was used to simulate the skittle which the players used to hit the balls. In [66] the authors introduced a haptic interface for brick games. They used a haptic dial to add tactile feedback to enhance game effects in addition to visual and sound effects. The user was able to change the position of the paddle by spinning the dial knob while simultaneously feeling various tactile feedbacks according to the game context. In [17] the authors discussed a multipurpose system especially suitable for blind and deafblind people playing chess or other board games over a network, therefore reducing their disability barrier. They used special interactive haptic device for online gaming providing a dual tactile feedback, thus ensuring not only a better game experience for everyone but also an improved quality of life for sight-impaired people. In [49] the authors created a multi-touch panel by using multi-touch technology in order to construct a suitable game interface and apply it to a game. In [90] the authors created a system model that helped dental students memorize fundamental knowledge as well as the processes and techniques in dental casting. To achieve that they have incorporated an Haptic interactive device in wireless vibration feedback for more lively and diverse learning methods in dental casting for learners. In [89] the authors measured playability of mobile games by comparing two different types of haptic interfaces, namely hard and soft keypad, for mobile gaming. In [37] the authors enhanced the open source Second Life viewer client in order to facilitate the communications of emotional feedbacks such as human touch, encouraging pat and comforting hug to the participating users through real-world haptic stimulation. In [79] the authors presented a haptic system for hand rehabilitation, that combined robotics and interactive virtual reality to facilitate repetitive performance of task specific exercises for patients recovering from neurological motor deficits. They also developed a virtual reality environment (maze game) in which the robot applied force fields to the user as the user navigated the environment, forming a haptic interface between the patient and the game. In [85] the authors reviewed the history of input methods used for video games, in particular previous attempts at introducing alternative input methods and how successful they have been. In [80] the author presented a set of recommendations for the more efficient use of haptic technology in computer interaction techniques for visually impaired people and those with physical disabilities. In [58] the authors proposed a situated communication environment designed to foster an immersive experience for the visually and hearing impaired. More precisely they utilized an input and output modality combination, using spoken keywords output, nonspeech sound, sign language synthesis output, haptic 3D force-feedback output, haptic 3D navigation, and sign language analysis input.

Wearable Games

Wearable games are games that employ specialized devices incorporating computer and advanced electronic technologies. During the last decade, due to the rapid progress of technology wearable devices have greatly attracted the interest of game researchers/developers. More precisely, one of the first approaches reported was in [11] in which the authors explored how computer games can be designed to maintain some of the social aspects of traditional game play, by moving computational game elements into the physical world. They constructed a mobile multiplayer game, Pirates, to illustrate how wireless and proximity-sensing technology can be integrated in the design of new game experiences. Pirates was implemented on handheld computers connected in a wireless local area network (WLAN), allowing the players to roam a physical environment, the game arena. In [84] the authors presented an outdoor/indoor augmented reality first person application, namely the ARQuake, which was of the desktop game Quake in an attempt to investigate how to convert a desktop first person application into an outdoor/indoor mobile augmented reality application. A preliminary version of this work can be found in [21]. The player wore the wearable computer on his/her back, placed the Head Mounted Display (HMD) on his/her head, and held a simple two-button input device, a haptic gun. In [2] the authors presented an example of how the gap between virtual and physical games can be bridged using sensing technology from a wearable computer. To this end they proposed Unmasking Mister X, a game which incorporates sensor data from all the players. Each player was equipped with a sensing device and a personal digital assistant (PDA) (palmtop computer) or a head-mounted display. The game was played by walking around and approaching people to find out who is Mister X. In [35] the authors conducted an initial experiment with inexpensive body-worn gyroscopes and acceleration sensors for the Chum Kiu motion sequence in Wing Chun (a popular form of Kung Fu). In [20] the authors described the efforts on designing games for wearable computing technology taken by the 23 students of the project PEnG—Physical Environment Games. In [9] the authors used a Global Positioning System (GPS) device to extract the coordinates of the players position and create a game that explored the ability of one player competing with the others. The developed game was based on Dune 2 [83] in which the players fight for the dominance of a resource rich desert planet Dune.

Affective Evaluation of Players

Another important issue in affective gaming is the affective evaluation of players, closely related to the so-called player experience. The term player experience is quite ambiguously defined as the interaction with a game design in the performance of cognitive tasks, with a variety of emotions arising from or associated with different elements of motivation, task performance and completion, or as the structures of player interaction with the game system and with other players in the game. Its goal is to provide a motivating and fun experience for the player. Gameplay experience consists of three factors: the game quality (game system experience), the quality of player interaction (individual player experience), and the quality of this interaction in a given social, temporal, spatial or other context. Game system experience is controlled by game developers through software and game testing. Individual game experience can be assessed through psychophysiological player testing [36], eye tracking [4, 75], persona modeling, game metrics behaviour assessment [5], player modelling [86], qualitative interviews and questionnaires and Rapid Iterative Testing and Evaluation. Player context experience is assessed with ethnography, cultural debugging, playability heuristics, qualitative interviews, questionnaires and multiplayer game metrics [25]. Martinez and Yannakakis in

[55] argue that, when trying to assess which of the game levels that the player went through was more fun, interesting or less frustrating, questionnaires should *compare* game levels, instead of directly *rating* them. This approach has been shown to eliminate subjectivity across ratings from a particular player and from across different players who fill in the questionnaires and was put to use while recording the Platformer Experience Database (PED) [46], one of the few freely available datasets which combines visual, affective and game behaviour data.[1] In [25] the authors proposed an approach that formalizes the creation of evaluating methods as well as a roadmap for applying them in the context of serious games. They focused on physiological and technical metrics for game evaluation in order to design and evaluate gameplay experience. In [59] the authors extracted psychophysiological recordings of electrodermal activity (EDA) and facial muscle activity (EMG) and combined them with a Game Experience Questionnaire (GEQ) in order to measure reliably affective user experience (UX). They also introduced sound and music control in order to measure its influence on immersion, tension, competence, flow, negative affect, positive affect, and challenge. More recently, in [10] the author tried to understand engagement on the basis of the body movements of the player and connect it with the player's engagement level and affective experience.

Affective Interaction in Games

As mentioned in the previous Section, players interaction constitutes an important factor in measuring gameplay experience. To this end, various approaches have been proposed to measure the affective interaction in games. More precisely, in [54] the authors presented a method of modeling user emotional state, based on a users physiology, for users interacting with play technologies. Their modelled emotions captured usability and playbility, and exhibited the same trends as reported emotions for fun, boredom, and excitement. In [53] the authors extended their previous work in order to model emotion using physiological data. They proposed a fuzzy logic model that transformed four physiological signals into arousal and valence and a second fuzzy logic model that transformed arousal and valence into five emotional states relevant to computer game play: boredom, challenge, excitement, frustration, and fun, proposing in that way a method for quantifying emotional states continuously during a play experience. In [82] authors introduced the Koko architecture, which improved developer productivity by creating a reusable and extensible environment, yielded an enhanced user experience by enabling independently developed applications to collaborate and provided a more coherent user experience than currently possible and enabled affective communication in multiplayer and social games. The Siren game [92] utilised affective information in two ways: directly, via questionnaires filled-in by players during gameplay and

[1]Database available at http://institutedigitalgames.com/PED/

after each game turn, and via web cameras which estimated facial expressions. In the first case, players self-reported the perceived level of conflict, when trading virtual resources with other players; an objective of the game was to maintain perceived conflict levels between pre-set minimum and maximum values, so as to engage and not frustrate players, so this information was used to procedurally generate game quests predicted to fulfil that requirement. Similarly, facial expressions and cues (e.g. visual attention [4]) were used to estimate player involvement in the game, when associated with player behaviour (progress in the game and completing the game quests).

Existing Commercial Games

In this Section we will discuss existing commercial games that use the physiological and neurological cues measured using the sensors presented above. The commercial affective games that have been developed include the following:

- *Bionic Breakthrough* (Atari 1983), a bounce the ball into a brick wall game. The player wears a headband on his head whose sensors are supposed to pick up any facial movements or muscle twitches, in order to control the movements of the paddle and use is as input instead of an ordinary joystick.
- *Missile Command* (Atari 1980), in which the player has to destroy moving targets. The heart beat rate of a player is measured and used to change the nature of the challenge the game presents. The aim is to keep engagement within an optimum range.
- *Oshiete Your Heart* (Konami 1997), a Japanese dating game. The heart beat rate and sweat level of a player is measured. The goal is to use the measurements in order to influence the outcome of a date.
- *Zen Warriors*, a fighting game where players have to calm and concentrate in order to perform their finishing move.
- *Left 4 Dead 2* (Valve 2008) a first person shooter video game, where the player's stress level, measured as the electric response of the player's skin, determines the pace of the game. The goal is to make the game easier if the player is too stressed.
- *Nevermind* (Flying Mollusk 2015) is a horror game that lets you use biofeedback to affect gameplay and make the game scarier.
- *Journey to Wild Divine* (Wild Divine 2005) a biofeedback video game system promoting stress management and overall wellness through the use of breathing, meditation and relaxation exercises.
- *Throw Trucks With Your Mind* (Lat Ware 2013) a first-person puzzler in which players must use a combination of concentration and mental relaxation to pick up objects, and throw them at enemies, obstacles and other players.

Affective Gaming Scenarios and Challenges

In this Section we will first examine new gaming scenarios and present some of their applications. We will also elaborate on the challenges that such scenarios raise.

Affective Gaming Scenarios

The future in affective gaming lies in sensorless systems that will enable the system to extract the players' behavioural clues without employing specialized equipment. In that way the issues raised regarding the realistic immersion of the players in the gaming scenario are resolved, as the players are now free to act as they wish, not being constrained by sensors that limit their actions. Below we present three such scenarios in detail. More precisely, we begin with the special case of these scenarios that involves a group of people residing in the same space and proceed with a scenario that allows the use of such games from players with special needs. The most general case involves any kind of players that do not reside in the same space. In more detail:

- The first scenario is that of a game played among a number of players residing in the same space. The aim is to enable the players interaction and recognize human behaviour in an individual and social group level. The players under examination play with a games machine (for example Microsoft Kinect [57]). For such a scenario, a number of low cost cameras (RGB and depth) is used to create a multicamera scenario in which the entire scene (360°) is recorded. In that way, several issues raised by occlusions (either due to space limitations or caused by the co-existence of many people in the same space) and clutter are tackled as the information from different viewpoints is provided. Computer vision techniques are applied to extract and efficiently recognise each player's facial expressions, body pose and actions, in order to properly fuse them and acquire each player's emotional state. The extracted emotional state, recognized within an action context, is then combined with the behavioural patterns exhibited by the rest of the group to define the possible interactions of the groups members, as well as the relationships formed among them, exploiting simultaneously the time dynamics. The individual actions and emotional state, as well as the group interactions and relationships are used to predict future individual actions and emotional states, but also subsequent groups behaviour. Those behavioural cues are then used to alter the gameplot and offer a more realistic and satisfactory gameplay.
- The second scenario is derived from the first one, if we consider now that the players may be constricted by physical limitations, as in the case of players with special needs (for example a person being in a wheelchair). In such a case the players are not free to act as they wish, but are constrained by the use of

specialized equipment that will allow them to freely navigate in space. In such cases, wearable devices have to be included in the scenario. For example, the use of HMDs and PDAs will enable us to extract the player's position in the game, in order to model more effectively the interaction among players. Moreover, possible occlusions and clutter have to be modeled in a different way, so as to take under consideration the existence of a wearable device. Furthermore, such a device may obscure part of the face/body from the cameras. Therefore, the behavioural cues extracted from the player's visible body parts, as well as his/her actions should be emphasized to compensate for the lack of other missing input feature sources. Due to physical limitations being imposed, the actions may be restricted, thus making affect recognition especially important. Moreover, the techniques that will be used to fuse the available sources of information should be able to weight the available sources taking under consideration the constraints having been imposed by the players needs. For example, in a games scenario in which the players are in a wheelchair, thus having their actions restricted, the effect emotions have in the gameplot, gameplay and game outcome should be emphasized.

- The third scenario is the general case of the two previous scenarios, lifting all possible space limitations appearing in a game. The players in such a scenario can be of any kind (with or without special needs), while most importantly, may or may not reside in the same space. It will be possible, for example, for players to be in their own living rooms while playing. Therefore the game should be now able to construct a virtual environment in which all players will be effectively immersed and in which they will be able to freely interact with each other. 'Virtual' space limitations in terms not only of occlusions and clutter, but also of space limitations due to the use of wearable devices have to be imposed by the system. The game should be therefore able to not only recognize each players emotional state, but also combine their physical presence in a virtual world, thus reconstructing an environment in which each player's actions will affect the entire group not only emotionally, but also in a physical way. The players, although being in different for example rooms should experience the feeling of being a part of the same virtual environment, in order to ensure maximum immersion. Summarizing, the role of affect recognition in such a scenario will be of greatest importance, as the possible actions/interactions/relationships observed will be controlled by the game through the recognized emotional states.

A schematic representation of the proposed scenarios is depicted in Fig. 4.2. Summarizing, we can see that the need of incorporating affective gaming in modern control of games is crucial, not only for the simple cases (first scenario) but for more elaborated ones (second and third scenarios) in which the physical presence of a player is limited or not even required. However, typical computer vision techniques do not suffice for such applications, as several issues are raised that remain to be solved. In the next Section we elaborate on the issues raised in such scenarios in detail.

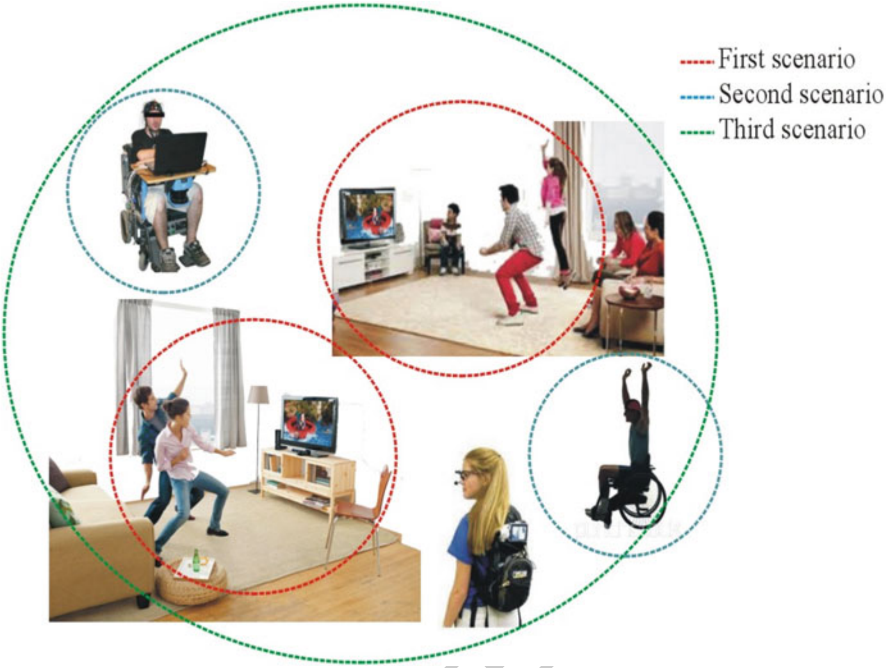

Fig. 4.2 A diagram of the three scenarios

Affective Gaming Challenges

Several issues have to be tackled in affective gaming scenarios in order to achieve a realistic interaction of the player with the game. Regarding the first and simplest scenario, in an individual level, the first step involves the real-time detection of a player and of his/her body parts. Additionally, the problem of recognizing his/her actions and emotions has been widely studied in the past, but involving a set of predefined classes under examination. Therefore, the introduction of spontaneity, as the player may express himself/herself in any way that he/she wishes, constitutes an extra challenge. Moreover, the proposed scenario employs many cameras so as to extract information from different viewpoints. Although the information from different viewpoints aids in correctly detecting the player and recognizing his body pose and emotions, finding efficient methods to fuse those pieces of information remains an open problem. In a group level, the goal is to extract the social group behaviour. Several extra challenges exist, for example several occlusions due to space limitations but also to the presence of many people in the same space. The free interaction among the players and the way that affects their subsequent emotions and states is also a novel field of research. After having efficiently recognized the emotional state of each individual player within an action context as performed in the single-player game scenario, the next step is to study the players as members of a social group, that is to identify the way each player interacts with each other and also to identify relationships built within this interaction framework. For example, do a player's actions reveal a friendly/aggressive mood towards the other players? Can we use the player's actions to predict subsequent actions? When it comes to the whole group, do players choose a leader, even subconsciously, whom they tend to mimic? Are cohesion (i.e. tendency of people to form groups) relationships formed? How are all of the aforementioned interactions and relationships developed in time? Can we exploit the information their dynamics have to offer?

Regarding the second scenario, several issues are raised by the use of wearable devices. First, the wearable device can obscure a significant part of the face/body. Moreover, its presence may lead the player to exhibit unusual behavioural parts due to the, even subconscious, limitations imposed by the use of the device. This also affects the interaction among players and of course their subsequent actions. Therefore novel methods to model and predict those behavioural patterns have to be proposed.

The problem becomes more complicated for the third scenario, in which space limitations are eliminated. The players may not now be limited by the presence of other players, since they may not reside in the same space. The game however should be able to 'combine' the presence of multiple players in one 'virtual' environment, in which their interaction will be possible. And of course, this has to be performed in a realistic way, so as to ensure maximum immersion to the game, offering at the same time a better gameplay experience.

Summarizing, as we can see, such scenarios involve many interdisciplinary fields. Besides the obvious computer vision techniques that have to be employed in order to extract behavioural cues, input from psychologists has to be provided. More precisely, input from psychologists is required in order to properly define the scenario under examination in terms of the emotions and actions that are more likely to be observed during the game (emotions and personality traits). Which is the role that the expressed emotions play in the overall gameplay experience? How realistic should the expressed emotions be in order to maintain player engagement? The pool of possible interactions among the players as well as the relationships that they are most likely to form while in the game should also be defined. Which modalities (speech, gestures, facial expressions) should be used and to which should the game emphasize? How should the gameplay be adopted to the players affective states? Input from psychologists is also required to extract the ground truth concerning the emotional state of each player and to explain the way it affects his/her actions as well his/her interactions with other players and the relationships built among them as member of a social group. The challenging nature of the proposed scenarios regarding behaviour understanding, in combination with the scarcity of available datasets, constitutes the proposed research a novel field, even for psychologists.

Applications of Affective Games

Creating games that will be able to understand the players' emotional states and actions will enable the creation of games in which the progression of the gameplot will correspond to the players needs, thus ensuring more realistic and satisfactory gameplay experience. More versatile ways of human computer interaction will be developed and more player-friendly applications will be addressed. Indeed, such gaming scenarios can be widely applied to many fields leading to applications that greatly enhance the interaction of the players with the games. More specifically some possible applications include:

- *Serious games*, that is games with an initial purpose other than pure entertainment, usually used to teach something to the player. They are especially useful in helping younger players develop collaborative skills, while engaging their focus. They are used to teach math, language, science, social skills [92], etc. Moreover, they can be massively used in "virtual" universities, providing education through electronic media (typically the Internet). They offer flexibility to students that cannot attend physical courses due to distance or require flexible time schedules. This type of games also includes training games. A typical example is the earthquake simulation games, in which the player learns how to safely evacuate a building in the case of an earthquake [87].
- *Multimedia annotation* via games, enabling players to implicit tag multimedia content, aiming at providing fast and accurate data retrieval. The annotation of multimedia data can be performed using either the typical way (text tags) of by using the players nonverbal reactions (e.g., facial expressions like smiles or head gestures like shakes, laughter when seeing a funny video etc.) [64].
- *Entertainment*, that is for the production of interactive applications or virtual worlds, in which realistic avatars exist. These can be used not only in games, but also for movies production. The entertainment industry is greatly affected by games and vice versa.

Conclusions

The existing games scenarios seem to have undergone a major transformation through the past 5 years, due to the recent technological advances that allow for robust, sensorless and real-time interaction of the players with the game. Indeed old-fashioned games required from the player to use a specialized input device in order to interact with the game. The player had a non-existent, in reality, feeling of controlling the game, even though the game plot and game responses to him/her were predefined. In order to create more realistic games in which the player's emotional state/actions/needs would be used to progress the gameplot and alter the gameplay experience accordingly, several more elaborated methods were proposed. The interest of the scientific community has been shifted towards affective gaming during the last few years, as the incorporation of affect recognition in games scenarios allowed for a more realistic gameplay experience for the players. In this paper we elaborated on the existing approaches regarding affective computing and discussed the recent technological advances that progressed the field. We reviewed the different sources of acquiring affect information and investigated issues that arise in affective gaming scenarios, such as the affective evaluation of players and the affective interaction in games. We presented the e existing commercial affective gaming applications and introduced new gaming scenarios. Last, we discussed about the challenges that affective gaming scenarios have to tackle in order to achieve a more realistic gameplay experience.

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