Affective Video Games: A Systematic Mapping Study

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Abstract. Human-Computer Interaction is expanding towards natural modalities of human expression. In this context, affective video games estimate the emotional state of the player to give a response according to some purpose, e.g., to adapt game difficulty. Advances in estimating emotional state and adapting game elements, allow us to have an idea of which are the best ways to develop adaptation in affective videogames and to explore the research gaps in the affective video games area. This paper presents a systematic mapping study of Affective Games. The Systematic Mapping is a simple five-step process followed to obtain an overview of the studies related to Affective Games, comprising many studies through the understanding of their summaries or, in some cases, their conclusions. Results show that the studies on the Affective Video Games area have increased during the last years. To construct the systematic map of the literature, we carried out a classification of the affective measures in five categories: direct physiological measures, indirect physiological measures, direct behavioral measures, indirect behavioral measures, and self-reported measures. The results show that 67.3% of the studies do not consider the adaptation of video games and 42.3% of the studies use direct physiological measures. Besides, there is a lack of research in the application of indirect physiological measures to estimate the affective state of the player and determine the video game adaptation elements.

Keywords: Affective video games · Affective measures · Emotional states · Systematic mapping study

1 Introduction

Human-Computer Interaction (HCI) is expanding towards natural modalities of human expression [1]. Within this context, affective and emotional approaches to HCI rise as new research methods [2]. Affective Games (AGs) are one of the emerging topics in the HCI field [3]. These games are mainly serious applications capable of determining the emotional state of the player and adapting some elements of the system according to his/her purpose. In this direction, one of the challenges in the AGs research area is to gather, in a non-invasive way, the affective state of the player to provide better adaptive mechanisms [4].

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Consequently, the state of art of the AGs was analyzed to learn from the evidence and get the design patterns and better practices to develop serious affective games with healthcare purposes. Along with it, the obtained information gave a general overview to identify gaps in the AGs area.

This paper aims to present the cover of the emerging field of AGs as a first step in the comprehension of this area. A Systematic Mapping Study of the literature was performed, applying a broadly used methodology in software engineering [5]. Each phase of the SMS provided information and details to build a map of the studies from the AGs area. Through the SMS methodology, information of interest was obtained to enrich the knowledge on the AGs area.

Section 2 introduces the systematic mapping methodology. Section 3 presents the systematic map of the literature in the Affective Video Games area, also proposing a classification schema of the affective measures. Finally, Sects. 4 and 5 present the discussion and conclusions of the study.

2 Methods

A Systematic Mapping Study (SMS) provides an information structure about a topic at hand. The SMS is a five-step process, starting with the definition of the research questions, followed by a search for primary studies. Next, the found papers are screened for including them in or excluding them out of the SMS. As a fourth step, key-wording of the abstracts is obtained to finally perform the data extraction and the mapping of the selected papers [5]. The methodology followed, and the results obtained in each phase are summarized in Fig. 1.

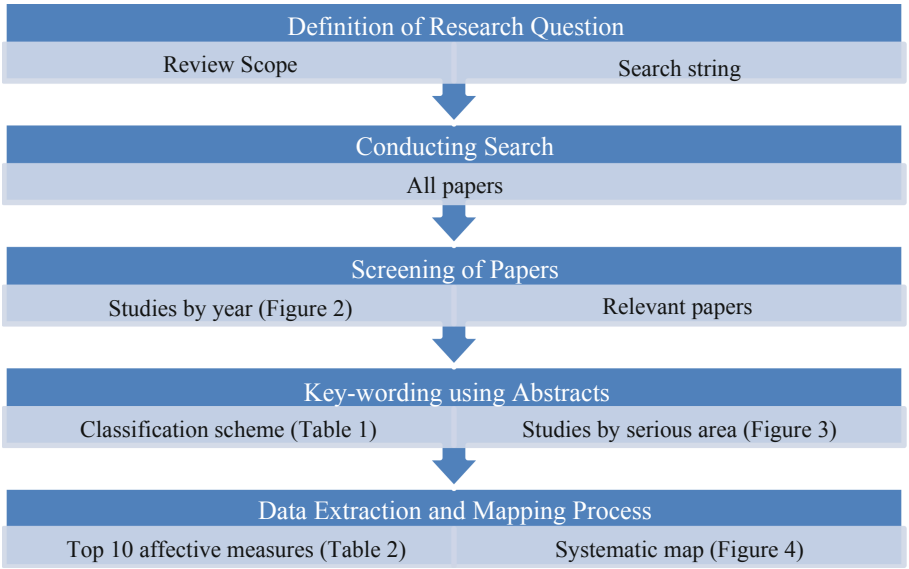

Fig. 1. The five phases of the Systematic Mapping

The specific research questions defined in the study are:

- Q1. Which application domains have been reported in the literature on AGs?
- Q2: What measures are used to determine emotional states of the players in existing AGs?
- Q3: Which adaptive elements have been reported in the analyzed literature?
- Q4: Which measures and adaptive elements have not been explored in AGs?

We used the following search string to obtain the documents for analysis from the Scopus, IEEE Xplore, ACM Digital Library, and Google Scholar databases:

"Affective games" OR "Affective gaming" OR ("Affective computing" AND videogames)

After performing the search, we obtained 187 papers. The screening of papers and application of the exclusion criteria resulted in the selection of 102 papers. Inclusion criteria included papers reporting some affective measure in the abstract or conclusions. Exclusion criteria included repeated papers, non-experimental studies, and non-affective video games.

3 Results

The data collected for responding to each one of the research questions are presented in this section.

– Q1. Which application domains have been reported in the literature on AGs?

From the 102 papers only 22 papers reported the application area in the abstract, within these we extract the application area registered and their percentage for the 22 articles (Fig. 2).

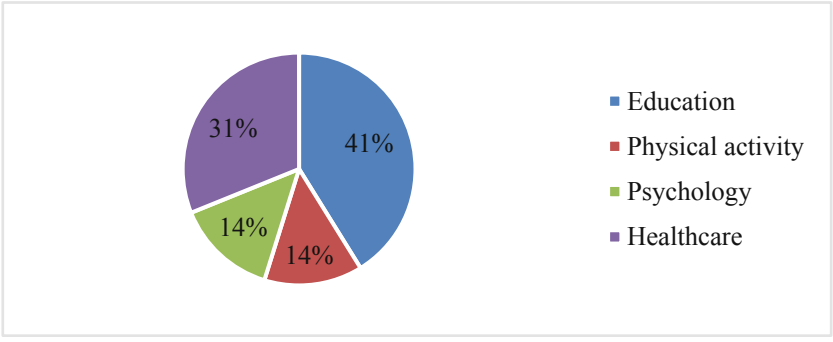

Fig. 2. Application areas of Affective Video Games reported in the literature

– Q2: What measures are used to determine emotional states of the players in existing AGs?

The most used measure is the Electrodermal Activity (EDA), also reported as Galvanic Skin Response (GSR), followed by Heart Rate and Heart Rate Variability, Face recognition, Electroencephalography (EEG), Temperature, respiration, Electromyography (EMG), Electrocardiography (ECG), Gamepad and user's questionnaires (Table 1).

Table 1. Top 10 affective measures during the last 10 years

Measure	Year										
	09	10	11	12	13	14	15	16	17	18	Total
EDA, GSR	–	4	1	–	3	–	3	2		5	18
HR, HRV		2	2	–	3	–	3	1	1	2	14
Face recognition	1	–	–	3	2	1	3	–	1	3	13
EEG	–	–	1	1	2	1	1	–	–	–	6
Temperature	–	1	–	–	1	–	1	1	–	2	6
Respiration	–	–	1	–	1	–	–	1	–	2	5
EMG	–	1	–	–	–	–	–	–	–	2	3
ECG	–	–	–	–	–	–	–	–	–	2	2
Gamepad	–	–	–	–	–	–	1	–	–	–	1
Questionnaire	–	1	–	–	–	–	–	–	–	–	1

Due to the diversity of measures to estimate emotional states, a classification scheme is proposed to organize the studies. Table 2 shows the proposed classification schema of the affective measures. The classification of the analyzed studies by category is presented in Fig. 3.

- Q3: Which adaptive elements have been reported in the analyzed literature?

The classification scheme in Table 3 presents the adaptation elements considered. Adaptation elements included: interface components, difficulty levels, non-player characters, and score flow. The classification of the studies according to the schema proposed for adaptation elements is presented in Fig. 3.

– Q4: Which measures and adaptive elements have not been explored in AGs?

Based on the two proposed classification schemes, the studies could be ordered and represented in a diagram that links the categories of affective video games and adaptation elements, with the number of studies. The graphical representation of these crossed categories is known as the systematic map (Fig. 3).

Information like the publication year was taken into account from a set of 102 papers. Figure 4 shows the statistics per year.

Table 2. Categories of affective measures

Classification	Description
Direct physiological measures	Are measures attaching a sensor to the body of the player, e.g., Heart Rate (HR), Galvanic Skin Response (GSR), or Electroencephalogram (EEG)
Indirect physiological measures	Measures of signals from the body that can be measured by pointing a camera to the player like Face Emotion Recognition or pupil size
Direct behavioral measures	This type of affective measure depends on what the player express explicitly, e.g., how the player presses the gamepad buttons, or how the player manipulates the touch screens
Indirect behavioral measures	Measures achieved in an implicit manner such as game screen recording or some visual artifact mechanism interpreting the visual language of the player
Self-reported measures	Are taken by the player's externalization of his/her feelings regarding their affective state; these measures can be taken using surveys, think-aloud methods, interviews, among others
Multiple measures	Multiple measures include more than one direct, indirect, physiological or behavioral measure

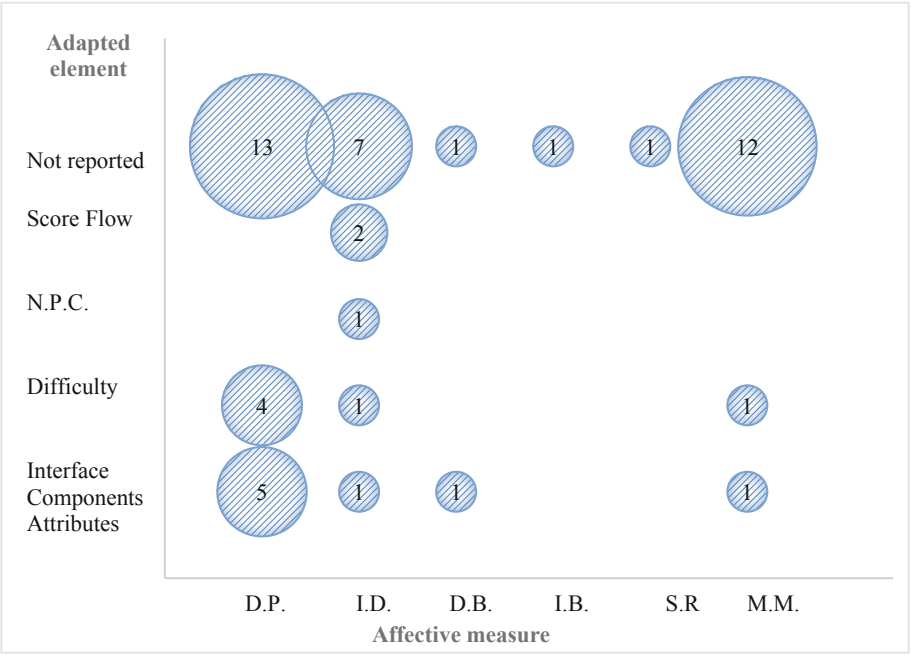

Fig. 3. Systematic map: In the affective measure dimension, Direct Physiological Measures (D.P.), Indirect Physiological Measures (P.I.), Direct Behavioral Measures (D.B.), Indirect Behavioral Measures (I.B.), Self-Reported Measures (S.F.), and Multiple Measures (M.M.)

Table 3. Categories of adapted elements

Adapted element	Description
Interface components attributes	It refers to all elements in a single game scene that change their visual features like size, color, and form according to the affective state of the player
Difficulty	It refers to the change in the dynamics of a game which implies greater skills on the part of the player. Some of these are more speed or more complexity in the challenges
Non-player characters	It is noteworthy that several games are focused on characters that interact with the player either as allies or, in serious games, as agents for a specific purpose in which they are required to react to the player's emotions to make the player have an enhanced experience
Score flow	When the score or awards of the game are not only limited to the performance and are influenced by the affective reaction; those studies were added to this group
Not registered	Many articles do not give details of elements adapted according to the affective state of the player. However, they did have affective measurements registered

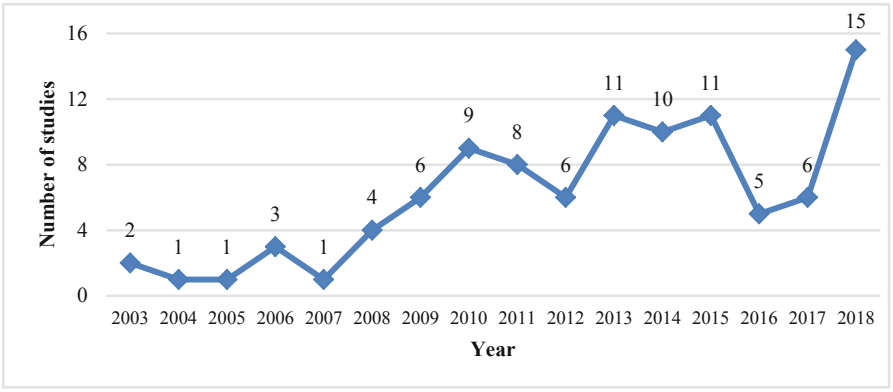

Fig. 4. Number of affective games studies per year

4 Discussion

The Systematic Mapping Study of the literature provided a map of the current studies in the AGs area, characterizing the measures used to determine emotional states of the players and the adaptation elements reported in some of the studies. With the obtained results, several points regarding the SMS research questions are discussed.

- Application domains reported in the literature on AGs

During the last two years, there was a growth in studies about the AGs area. Education is the area with more serious video games available, with 40% of the studies reported, followed by healthcare applications, and other health-related areas such as physical activity and physiology. Some of the papers not dealing with specific application domains included theoretical papers not referring to a product of presenting development or experimental results; instead, they reported the introduction of concepts or the description of best practices or design patterns from previous research works [6]. In addition to the theoretical studies, enhancing user experience was the purpose of other relevant papers; it was seen that uses of AGs characteristics in serious videogames improved their outcomes [7] and in the field of entertainment AGs provoked expected emotions in the players [8]. Measures used to determine emotional states of the players.

Some authors have suggested a classification of measures as direct and indirect [4], while others mention physiological and behavioral type measures [9]. In this study, these two classifications were considered within the affective measures found, and it was decided to combine them, e.g., a measurement such as the heart rate measured by a monitor was considered a direct measure because it is necessary to connect a device to the body and it is a physiological measure. With the combination of categories of direct-indirect and physiological-behavioral type, the measures that are not automatically taken but require the player to express them were also considered as a separate group. One of the interests in the exploration of these studies is to guarantee the measure of the affective state of the player most accurately and straightforwardly. Studies with multiple measures offer a higher precision; however, they are not easy to implement outside a laboratory setting. This type of studies was left in a separate group, focusing on studies with individual measures. The affective measures can also be classified by accuracy, complexity, objectivity, and intrusiveness. With these classification types, any practitioner could have better criteria to select affective measures by convenience or interest; there is much to improve in the proposed classification schema by keeping these considerations in mind.

After applying the classification schema, EDA was found the most used direct physiological measure (31.74%), and the facial recognition was the most used indirect physiological measure (88.23%). Similarly, the measure of behavior that was most used was the gamepad entry (33.33%), and the questionnaire was the most used tool as for how the player expresses his/her emotions (50%). The face emotion recognition can be categorized as a physiological measure and a behavioral one, depending on the control that a person has to express their emotions towards the game.

- Adaptation elements reported in the analyzed AG

From the few studies that report having adapted some game element, the interface components attributes are the most adapted element (15.38%), followed by difficulty (11.54%). From the adaptive elements, we expected to find and were not visible in the explored documents include the adaptation of content, such as scenarios, history, characters, educational content among others. Some studies that did not fit within the classification scheme included design patterns, best development practices, AGs engines, models of emotions and others.

- Map of measures and adaptive elements in AGs

From the systematic map, most studies have focused on determining the best way to identify the affective state of the player. There is a lack of research focusing on the adaptability of games, and 67.3% of the studies do not consider the adaptation of video games. So far, there has been a great interest in finding the best way to determine the emotional state of the player, so that practitioners adapt the elements of the game according to their purpose; 42.3% of the studies used measures of a direct physiological type. Many of the studies that performed physiological measures to determine the affective state of the player tested their results with the opinion of how the same players felt (ground truth), only one study took this measure as its gold standard.

5 Conclusion

This paper aims to present the cover of the emerging field of AGs as a first step in the comprehension of this area. The classification scheme together with the systematic map could help in finding gaps and suggesting ways to solve problems by analyzing relationships between affective measures and adapted elements within affective video games. Many studies use direct physiological measures as a more accurate way to determine the affective state of the player. With the increasing use of wearable devices, there is a smooth, non-intrusive, and more objective manner to determine the affective state of the player. The study does not pretend to be entirely conclusive; it allows to see ways to continue exploring in more specific areas (it could be with a more in-depth methodology like a systematic review) and to see advances and tendencies until the moment.

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