Towards a Computational Approach to Emotion Elicitation in Affective Agents

Joaquín Taverner, Emilio Vivancos and Vicente Botti
Departamento de Sistemas Informááticos y Computación, Universitat Politècnica de València, Spain

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Abstract: Interest in affective computing is increasing in recent years. Different emotional approaches have been developed to incorporate emotions in multi-agent systems. However, most of these models do not offer an adequate representation of emotions. An internal representation of emotions allows to define emotions according to different affective variables. In addition, many of these approaches do not take into account factors such as culture and language when defining emotions. In this work we show the results obtained in an experiment carried out to design an affective model for a multi-agent system taking into account factors such as language and culture.

1 INTRODUCTION

Affective computing (Picard and Picard, 1997) is the area of computing related to the recognition, processing and simulation of different affective characteristics including emotions, personality or mood (Alfonso et al., 2014; Taverner et al., 2018a). One of the main goals in affective computing is to create computational systems capable of simulate human emotions. Currently, there is no consensus on the definition of the term "emotion". In general, an emotion can be defined as a rapid response to a given stimulus. Therefore, emotions have a fundamental importance in the modeling of intelligent affective agents. Considering that emotions influence the behavior of affective agents, credibility of agents simulating human behavior will depend heavily on the selected model of emotion.

Emotions depend on language and culture (Russell et al., 1989). A direct translation of emotions from one language into other can lead to errors that produce strange and artificial agent behaviors. When developing the affective processes in a multi-agent system, these factors we must be taken into account. However, despite the fact that in other domains, such as personal assistants, cultural and language factors are taken into account, to the best of our knowledge, in affective computing there are still no proposals that really take cultural and language factors into consideration. Furthermore, most proposals of affective agents use simple interpretations of psychological theories that are not generally proposed to be incorporated into computational models. However, currently there are very few models of emotions representation explicitly developed to be used by computers such as the Scherer's model (Scherer, 2010). In this paper we show the preliminary results of a method based on experiments to create a model of emotions for a multi-agent affective BDI architecture (Alfonso et al., 2017) adapted to different languages. This emotional model will improve the simulation of emotional human behavior in this multi-agent affective architecture.

This paper is structured as follows: Section 2 presents different psychological models developed to explain the structure of emotions. In Section 3, some related works on emotion modeling in affective agents are presented. In Section 4, we discuss about emotion modeling in affective agents. Section 5 shows the results of our method based on experiments to create a model of emotions for a multi-agent system. Finally, Section 6 presents the conclusions and future work.

2 PSYCHOLOGICAL MODELS OF EMOTIONS

From a psychological perspective, there are different theories to explain how emotions are elicited. The basic emotions theories (Ekman, 1992) hold that there is a limited number of emotions and that each event that can be detected by a human being produces an associated emotion. In addition, these theories suggest that emotions have a universal meaning.

On the other hand, appraisal theories (Lazarus, 1991; Ortony et al., 1990) consider that an emotion

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is the result of the evaluation process that is activated when an event is received. This process is executed through a set of variables known as *appraisal variables*. The number and type of appraisal variables usually vary depending on the psychological theory, but appraisal theories have been widely used in affective computing to create emotional agents (Gebhard, 2005; Gratch and Marsella, 2004).

Finally, the constructivist emotion theories (Russell and Barrett, 1999; Thayer, 1997), in contrast to the basic emotions theories, relate emotions to the language and culture used by humans. These theories explain the great differences using emotional terms in different geographical and cultural areas. For example, in the German language there is an emotion called "*Schadenfreude*" whose meaning is "pleasure for the suffering of others". However, in languages such as English or Spanish there is no word to define this emotion. One of the most well-known constructionist theorists is Russell (Russell and Mehrabian, 1977).

Russell proposes in his *Circumplex Model of Affect* (Russell, 1980) that emotions can be represented using two dimensions: pleasure and arousal. According to Russell's experiments (Russell et al., 1989), emotions represented by the same word in different languages and cultures, can be associated with different values of pleasure and arousal.

Russell's model shares the Pleasure and Arousal variables with the PAD model (Pleasure, Arousal, and Dominance) (Mehrabian, 1996). This model is well known in affective computing and is often used to represent the mood and emotions. The PAD model adds the Dominance dimension to the representation of emotions. However, generally this dimension is usually used as an appraisal variable while the Pleasure and Arousal dimensions form what is known as the core affect that structures the basic feelings (Marsella et al., 2010; Russell, 2003).

3 RELATED WORKS

Over the last years, different proposals to use emotions in multi-agent systems have been made (Marsella et al., 2010; Esteban and Insua, 2017; Gratch and Marsella, 2004; Alfonso et al., 2015). These proposals adapt different theories of emotion to create affective agents capable of selecting one emotion when a certain event occurs. For example, Marsella (Marsella and Gratch, 2009) proposes EMA (a process model of appraisal dynamics) in which an appraisal process based on the Lazarus' appraisal theory (Lazarus, 1991) is used. Marsella defines different appraisal variables thresholds to elicit emotions.

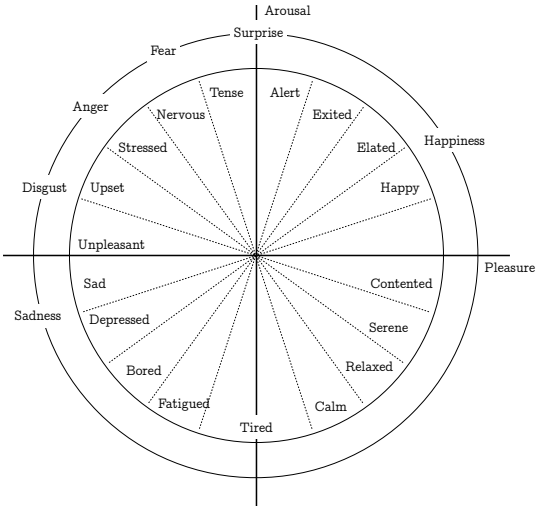


Figure 1: The circumplex model of affect. Source: (Russell and Barrett, 1999).

In EMA, emotions are represented as labels and the intensity is defined as the product of different numeric appraisal variables. The appraisal model proposed for the EMA agent is also used in other affective agent models such as *GenIA*^{3} (Alfonso, 2017).

Other proposals for affective agents use dimensional models of emotions. For example, Saldien (Saldien et al., 2010) uses Russell's Circumplex Model of Affect to represent emotions in the robot Probo. But in Saldien's model, the Russell's scheme (Fig 1) is used as a reference for the situation of the emotions without taking into consideration that this scheme was not designed for that purpose.

Gebhard (Gebhard, 2005) uses the PAD space in his emotional model. He defines an appraisal model based on the OCC appraisal theory (Ortony et al., 1990) called ALMA (A Layered Model Of Affect). In this model, emotions obtained as a result of the appraisal process are transformed into the PAD space. Gebhard proposes to use a mapping that turns each emotion into a point in the PAD space. Then, these emotions are used to estimate the agent's mood (Mehrabian, 1996). In addition, personality is used to define how the mood decay over time.

4 DISCUSSION

Despite the large numbers of proposals to model emotions in multi-agent systems, there is still much work to be done to obtain a realistic simulation of emotions. Most emotional models were proposed to interpret and analyze the way in which emotions are used by human beings. But there are few models explicitly developed to be used in computational systems (Scherer,

2010). In general, most affective computational models designed to create affective agents, adapt theories from psychology. However, in most of these models, emotions are represented as simple labels (as in most proposals in emotion recognition). This simplification may not be appropriate when modeling complex affective behaviors such as empathy, the effect of personality and mood on emotions, or the affect decay rate process (which is the process that reduce the emotion intensity over time). From a computational perspective, a dimensional representation of emotions, as Russell (Russell and Barrett, 1999) proposes, seems to be more appropriate to design this type of affective behaviors.

The Circumplex Model of Affect (Russell, 1980) explains the occurrence of emotions using a two-dimensional model based on the pleasure and arousal values. Through this model, Russell proves that emotions follow a circular pattern along the pleasure-arousal dimensions. In his experiments he provides an approximate model to relate each emotions to a pair of pleasure and arousal values. This model was designed to demonstrate the circular relationship of emotions with the pleasure and arousal levels. The resulting scheme (see Figure 1) uses a simplified location for each emotion, because its main purpose is to proof the circular relation between emotions and their pleasure and arousal levels. Apparently, a pair of values (pleasure, arousal) corresponds to one emotion in the circular representation of the Russell model and this interpretation of the circular representation is directly used in some affective agent models (Saldien et al., 2010). But that use was not the original purpose of the Rusell's model and therefore, this representation should not be translated directly into a computational model. For example, in the scheme proposed by Russell, all emotions have exactly the same area. That is completely unnatural, and consequently, an agent using this simplified representation of emotions will show an erratic behaviour, very different to the real behaviour of a human being.

Even more important than this misuse of the original Rusell's model, the enormous differences between emotions in different cultures, geographical areas, and languages must also be taken into consideration. When a literal translation of the English words used to represent emotions is used in other language, a high level of inaccuracies is introduced. When a human being uses a word to identify his/her emotion, this word cannot be directly translated into other language. But, how could we design an emotional agent interacting with people if its emotional model is based on experiments where people expressed their emotions using words in a different language? Obviously, a lot of inaccuracies will be introduced and the perceived behaviour of the emotional agent could look artificial and erratic. Consequently, we propose a method to adapt the Russell's Circumplex Model of Affect to be effectively used in multi-agent systems. This adaptation is ready to be used in a computational model and it is based on an experiment where human beings are expressing their emotions in the same language in which the agent will be recognizing and expressing emotions.

5 A CIRCUMPLEX MODEL TO REPRESENT EMOTIONS IN A CULTURAL CONTEXT

As we have argued before, one of the main challenges that arise when designing affective agents is to develop the process to select emotions. The behavior of the agent will depend to a great extent on this process. Therefore, a bad design can lead to unrealistic agents showing an artificial and strange behavior. We propose a computational model to represent emotions in a dimensional space similar to the one proposed by Russell's (Russell, 1980) but our model is adapted to a specific cultural environment. This representation is appropriate to be used in computational models because emotions can be easily and effectively represented using two numerical variables: pleasure and arousal. This bi-dimensional numerical representation uses variables instead of labels and therefore is more accurate and appropriate to be use in a computational model. Emotional processes can easily modify the pleasure an arousal values to simulate, in a more natural way, transitions between emotions. On the other hand, evidence shows that intensity is related to the pleasure and arousal values (Reisenzein, 1994). High levels of these two variables correspond to high intensity of emotions while, low values of these two variables correspond to a low emotional intensity. Very low levels of arousal and pleasure can be identified as absence of emotion. This variation in the pleasure and arousal values can be used to implement the affective decay rate function of an affective agent.

Contrary to other proposals based in Russell's model, our emotion representation model redefines the values of pleasure and arousal assigned to each emotion. As we mentioned in the previous sections, the circumplex scheme was proposed to support Russell's theory in which each emotion could be represented in a circle according to its levels of pleasure and arousal. This scheme can be easily criticized when used in a real computational system, because

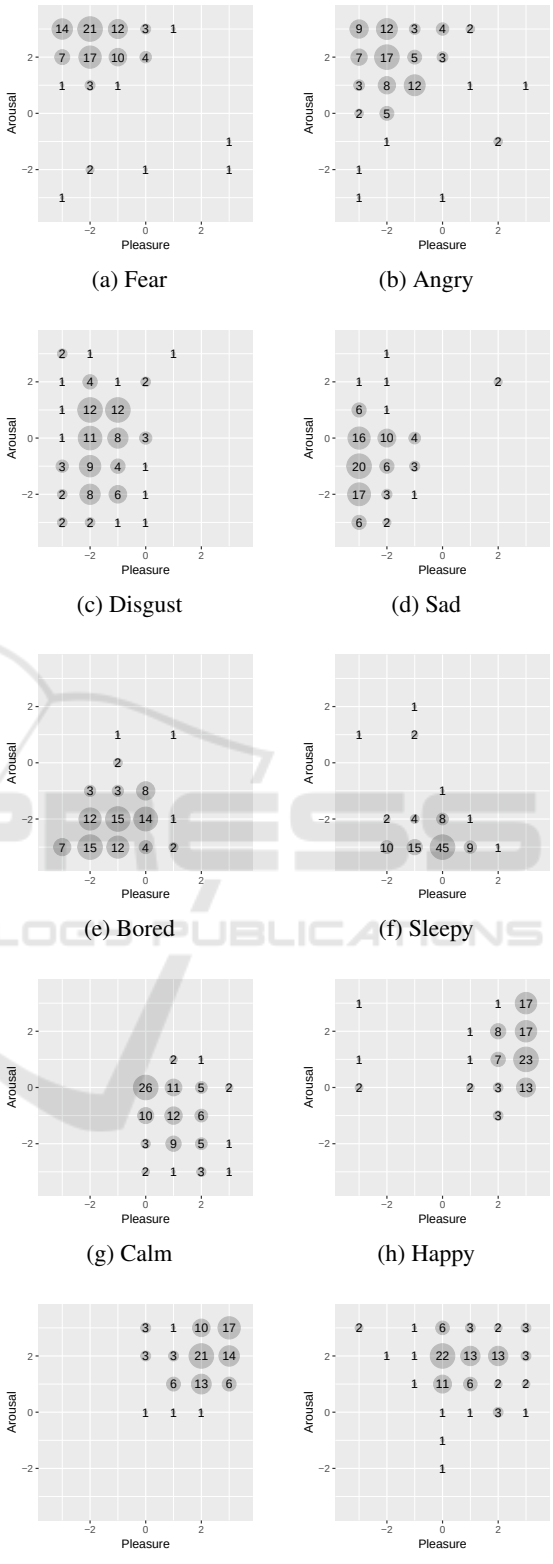
that was not the original use of this model. The first unjustified decision is the size of the areas assigned to each emotion. In the original model, every emotion receives exactly the same area of the circle, but this decision looks very artificial and, as shown in our experiment, it does not correspond to the mental representation in real humans. The second important problem of this model, when used to represent human emotions in an agent, is the identification of emotions in the borders between the areas assigned to each emotion. We know that these borders are artificial because they do not exist in the mental representation of emotions in humans, but this fact is frequently ignored. Finally, Russell's model is based on the results obtained in experiments in which British English-speakers identifies emotions represented by English words. However, when designing an agent to interact with human expressing their emotions in a different language, a new level of inaccuracy is introduced. Our method uses an experiment to adapt the emotional vocabulary and mental representation of emotions to the language and culture of the environment in which the agent will be located.

The first step of our methodology to represent emotions is the data acquisition. The data acquisition allows us to learn the levels of pleasure and arousal related to different emotions in the environment (language and cultural area) in which the agent will be located. In our experiment we analyze European Spanish-speakers because our agent will be located in this environment. In this experiment 10 emotions are identified by the participants according to their pleasure and arousal levels: fear, angry, disgust, sadness, boredom, sleepiness, calm, happiness, excitement, and surprise.[1]

Methodology. A hundred volunteers from different age, sex, and cultural level, were asked to assign a level of pleasure and arousal to the 10 selected emotions.

Participants assigned to each emotion a pleasure value using an integer number between 1 and 7 (from "very misery" to "very pleased") in a questionnaire. Note that the value 4 corresponds to a neutral value for this variable. On the other hand, participants assign an arousal value between 1 and 7 (where 1 corresponds to "very sleep" and 7 to "very aroused") to the same set of 10 emotions.

Results. The results of the experiment are summarized in Figure 2. These results show how the 10 emo-



(a) Fear (b) Angry

(c) Disgust (d) Sad

(e) Bored (f) Sleepy

(g) Calm (h) Happy

(i) Excited (j) Surprise

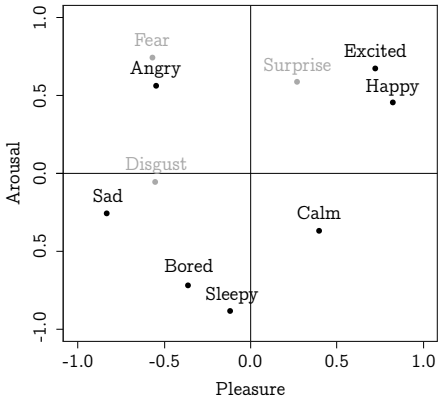
Figure 2: Number of people who selected each value of pleasure and arousal for the ten emotions.

[1]In the experiment, we use the Spanish words corresponding to these English words.

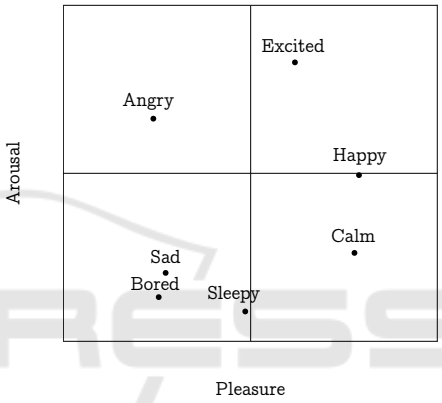
tions are related with the pleasure and arousal dimensions, as assumed in the circumplex model. For example, the *fear* emotion is related to high levels of arousal and low levels of pleasure, while the *happy* emotion is more related to high levels of pleasure and arousal.

Figure 3a shows the means obtained in the experiment for the emotions expressed by Spanish words (emotions that Russell did not represent in his experiments with British Engish-speakers are shown in gray). Figure 3b shows the means obtained by Russell for emotions expressed by English words. Some differences can be easily detected. For example, for British English-speakers *happiness* is related to a lower level of activation than for European Spanish-speakers. This corroborates the results obtained by Russell in his cross-cultural experiment (Russell et al., 1989), in which he appreciated significant differences between emotions in different languages. On the other hand, these results agree with the constructivist theories in which emotion depends on factors such as language and culture.

These results confirm the importance of our proposal to create a specific emotion representation for affective agents depending on the environment in which the agent will be located. This method allows to adapt the emotional model to the language and culture of the humans that will be interacting with the affective agent. From these results we can easily approximate the regions where emotions are most likely to occur in the emotional model. Therefore, these results can be easily used to create a computational model that represents emotions using their levels of pleasure and arousal. Moreover, the results can also be used to train a model to classify emotions according to the levels of pleasure and arousal. This model can be useful to map emotions onto the pleasure and arousal dimensions using sentiment analysis or facial expressions.



(a) Results obtained for the 10 emotions translated into Spanish.



(b) Results obtained by Russell.

Figure 3: Comparison between the results obtained by our experiment (emotions expressed in European Spanish) and the Russell's experiment (emotions expressed in British English).

6 CONCLUSIONS AND FUTURE WORK

Most of the models proposed to create affective agents are approximations of psychological theories. In general, these models use emotions as simple labels. Having a dimensional representation of emotions can help to understand and develop the emotional behavior of affective agents. This allows to design emotional processes such as the continuous process to evolve one agent from one emotional state to other, or the affect decay rate process.

In this paper we have shown the preliminary results of a method to create a model of emotions for a multi-agent system adapted to a specific language and cultural area. The results demonstrate the importance of performing this type of emotional analysis to adapt affective psychological models to the environment in which the emotional agent will be located. We have shown how emotions can be interpreted in a very different way depending on the language used. From the obtained data we can deduce the values of pleasure and arousal associated to the different emotions. This association can be used by agents to determine what emotion must be shown according to the level of pleasure and arousal detected.

Using the experiment results, we can determine the levels of pleasure and arousal corresponding to each emotion. Therefore, given a pair of values for pleasure and arousal, the agent can deduce the expressed emotion. On the other hand, when an emotion is detected, the emotion can be represented in the

pleasure and arousal space. Using the same representation for agent and human emotions, we facilitate the development of affective abilities such as emotional contagion or empathy.

Currently we are implementing an emotional appraisal model based on the results shown in this article. This model will use a dimensional representation of emotions based on the pleasure and arousal variables. In addition, our appraisal model will take into consideration the influence of personality and mood when selecting the emotion (Taverner et al., 2018b). As part of our future work, this model will be incorporated into the affective agent architecture *GenIA*^{3} (Taverner et al., 2016). The incorporation of this emotion representation into *GenIA*^{3} will facilitate emotion recognition, empathy, or emotional contagion.

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