"I can feel it too!": Emergent empathic reactions between synthetic characters.

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Abstract

Empathy is often seen as the capacity to perceive, understand and experience others' emotions. This concept has been incorporated in virtual agents to achieve better believability, social interaction and user engagement. However, this has been mostly done to achieve empathic relations with the users. Instead, in this article we focus on empathy between synthetic characters and propose an analytical approach that consists in a generic computational model of empathy, supported by recent neuropsychological studies. The proposed model of empathy was implemented into an affective agent architecture. To evaluate the implementation a small scenario was defined and we asked a group of users to visualize it with the empathy model and another group to visualize it without the model. The results obtained confirmed that our model was capable of producing significant effects in the perception of the emergent empathic responses.

1. Introduction

Empathy is seen as a major element in social interactions between humans. Its purpose spans from ethical issues and pro-social behaviour, through cooperation [6, 7]. For this reason, a great effort of research has been devoted to implement empathic interactions in Synthetic Characters (SCs), trying to achieve different goals like believability, social interaction, or better user-machine engagement. Currently, there are several Interactive Virtual Environments (in training, education, and entertainment purposes), in which empathic SCs exist and interact among them and with users.

The idea of giving users the possibility to establish empathic interactions with the SCs, has been exploited in order to enhance cooperation, specifically on educational, training and counseling/helping perspectives [1, 2, 8, 12]. However, in current research applications, the focus of the empathic interactions is often in the relation between the user and the virtual characters. Empathy between the SCs themselves sometimes simply does not exist at all or when exists, is based on pre-scripted behaviours. This limits and narrows the nature of all the possible empathic interactions and responses of the synthetic characters.

In this paper, we propose a new general model of empathy for SCs that aims to enable emergent empathic interactions between them, in a way that is perceived by users as well. We believe our model can be used to facilitate the design of richer multi-agent environments, allowing a broader set of interaction experiences for all involved, and enabling a stronger user engagement.

To reach such objective, the definition of our proposed model was strongly based on current neuropsychological theories of human empathy [13, 16]. It was then integrated in an already existent affective architecture for SCs minds, based on the OCC theory of emotions [11].

Using the new architecture we designed a small scenario to demonstrate the implementation of the proposed model and to measure the degree users could notice the emergence of empathy between the SCs through their empathic responses. For this scenario, we reused the same virtual environment used by the FearNot! educational application [3].

Using the above scenario, we carried out an evaluation to analyze the impact of the model. The results show that users were capable to perceive the emergent empathic responses elicited by the model.

This paper is organized as follows. In Section 2 we present relevant findings on the empathy theory that we used in our model, followed by the related work that situates our approach, in the SC community. Then we introduce in detail the empathy model proposed and its integration into an agent architecture. In the subsequent section, we present an illustrative example of the implementation made, showing the emergence of the empathic reactions among the SCs. Finally we present and discuss the experimental results from an experiment carried out with users in order to evaluate if they could recognize empathic responses in the SCs.

2. Theoretical models of empathy

For many, the earlier concept of empathy was born in Germany in the late nineteenth century as Einfühlung meaning "feel into." The word was later coined by Titchener[14], as a translation of the German word. As most of the psychological constructs, empathy does not have a unique universal accepted definition despite

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being one of the most important glue components in intelligent social relations. Nevertheless, many agree that "Empathy is an affective response more appropriate to another's situation than one's own" [7].

Exact or even broadly accepted causes for empathy as well as its process are still not determined and understood, despite the huge amount of research devoted to it. Nevertheless, significant achievements were and are being made.

A recent work in this field is the Perception-Action Model (PAM) [13], which proposes a unified theory of empathy that tries to unify its different views and its nature: cognitive, emotional and conditioning views, grounded in its ultimate and proximate causes.

This model looks at empathy more as a process rather than a response from the empathizer. Taking this perspective it permits that all empathy related phenomena like emotional contagion, helping behaviour, sympathy and so on, can share the same base model that relies on the perception-action mechanism. In this model, the empathizer perception of the others' emotional state is linked with his own somatic and autonomic responses via his own neurological representations.

A set of factors that affect the empathic response, namely familiarity, similarity, learning, past experience and salience are identified in the model. All these factors influence the empathic response in a directly proportional way.

But while some try to find a unified view of empathy, as above, other researchers prefer to narrow the concept of empathy in order to make it more tractable. The work by Vignemont and Singer [16] is an example. According to them, empathy only exists if: (i) the empathizer is in an affective state; (ii) this state is isomorphic to the target affective state; (iii) this state is elicited by the observation of the target affective state; (iv) the empathizer knows that the target is the source of his own affective state. This view leaves out common related concepts of empathy such as sympathy, emotional contagion, personal distress and cognitive perspective-taking.

Vignemont and Singer [16] also extend the factors that modulate the empathic response and group them in four categories: (1) Features of emotions - Valence, Intensity, Saliency, Primary versus secondary emotions; (2) Relationship between empathizer and target - Affective link and nurturance, Familiarity and similarity, Communicative intentions; (3) Situative context - Appraisal of the situation, Display of multiple emotions; (4) Empathizer - Mood arousal, Personality, gender and age, Emotional repertoire, Emotional regulation capacities. In our model several of these factors are used to modulate the emergent empathic responses between the SCs.

3. Related Work

Empathy in synthetic characters can be modeled using two different approaches: empirical and analytical [9]. Given the lack of rich computational models of empathy to support the analytical approach, much more attention has been devoted to empirical models, as shown in the following examples.

In his seminal work [4], Elliot made a major breakthrough by implementing an affective reasoner based on the OCC model [11]. Among the three social relationships modeled, there was one, an "*empathetic unit*", where an observing agent could take another agent's concerns and then generate an appropriate emotion as if those concerns were his or her own. Nevertheless, the emphatic emotions generated were directly derived from the OCC model. They did not emerge as a result of any empathy model implementation and thus were restricted to those specific ones.

More recently, Prendinger and Ishizuka [8] implemented empathic behaviour in a life-like character companion, within a job interview scenario web-based application. This empathic companion aimed to help users to feel less stressed in the course of an interview, by providing real-time empathic feedback based on his/her elicited emotions, through dialog only. The work has shown, that "the presence of a character that 'cares' can have a positive effect", in lowering the levels of arousal and stress.

In the same line of investigation, the work by Burleson and Picard [2], Elliot at al. [5], McQuiggan and Lester [9] also apply empathy in pedagogical agents. The latter uses a data-driven approach where training data is gathered during a mandatory learning phase held by human trainers. The data is then used by companion agents in user's interactions. Despite the fact that this empirical approach can be applied in other environments, it is highly dependent on the collected training data (resource consuming) and thus tied to the applied contextual application.

Bickmore [1], proposes his theory of relational agents where he aimed to explore long-term socio-emotional relationships between users and virtual agents, in this case Laura, an exercise advisor virtual agent that helps users participating in a fitness program. One of the dimensions used to achieve that kind of relationship by the virtual agent was empathic behaviour, yet implemented through scripting.

In the work of Paiva et al.[12], a pedagogical system that addresses the bullying problem in schools, the main focus relies on synthetic characters that are able to evoke and establish empathic relations with learners (users) in a virtual environment. This work goes further on using some theoretical elements of empathy, like the use of the idea of proximity ("how close the learner will feel with the synthetic characters developed both in terms of situation, behaviour or even physical appearance"), as an enhancer factor for empathic relations.

Ochs et al. [10], also follow a human-machine interaction approach, but instead, they propose a virtual agent that uses empathic emotions towards a user. A computational representation of the user emotions during a human-machine dialog is proposed in order to eventually fire an empathic emotional response towards the user, and an implementation of this, is said to be underway. Also in this work, a global theoretical empathy model does not exist, but only some empathy elements that support it.

As we have described, most often in current systems empathy is handled on a human-agent relation, where the agents are developed with characteristics to encourage empathy by the user or to show empathy to the user. Even when agents are the empathizers in agent-agent relations, empathy is supported by an empirical approach. In this paper, we take a different approach and propose a general computational model of empathy for virtual characters, where empathic interactions emerge from the created model and at the same time can be perceived by users.

4. Empathy Model

Our computational model of empathy is grounded on two recent neuropsychological theories: (1) the Perception Action Model (PAM) [13] and (2) the work by Vignemont and Singer [16]. In accordance to these theories, we view empathy as a process. As illustrated in Figure 1, our process involves the reactive perception of others' affective state and the subsequent generation of an empathic response (also congruent with the aforementioned theories).

One of the problems our model also tries to address is: When does an emphatic response occurs? If we only consider the emotional cues perceived from others, then each synthetic character would always empathize with every emotion felt by the other characters. However this clearly does not happen with humans [15].

To explain why humans only empathize in certain situations, Vignemont and Singer propose a contextual approach of empathy [16]. In this approach, empathy is based on various modulation factors, determined by appraisal processes at an automatic level [16]. For this reason, we defined in our model a self-projection appraisal that is essential to both understand other agents' emotions and to determine one of these factors: similarity. Moreover, we included three other important factors that are also considered to modulate empathic responses: affective link, mood, and personality. The following subsections focus on the two main phases of the process: Empathic Appraisal and Empathic Response.

1.1. Empathic Appraisal

The empathic appraisal takes place when an agent perceives a new event that raises an emotional cue in another agent. For example, a possible event is "agent A witnessing agent B being told he is about to be a father, which then raises a big smile on B's face". Note that an emotional cue is any perceptible signal that indicates the arousal of an emotion, such as a facial expression, body posture or voice tone.

After the perception of such emotional cue, the empathic agent uses an emotional recognition component to associate emotional cues to possible emotions that are being felt by the other agent. Of these candidate emotions, one is set as default: the one that is defined as more strongly related to the emotional cue itself. For example, if agent A observes a smile in B, he possibly selects as candidate emotions the ones that are congruent with a smile, such as Joy, Love, Pride, or Satisfaction, with Joy being the default.

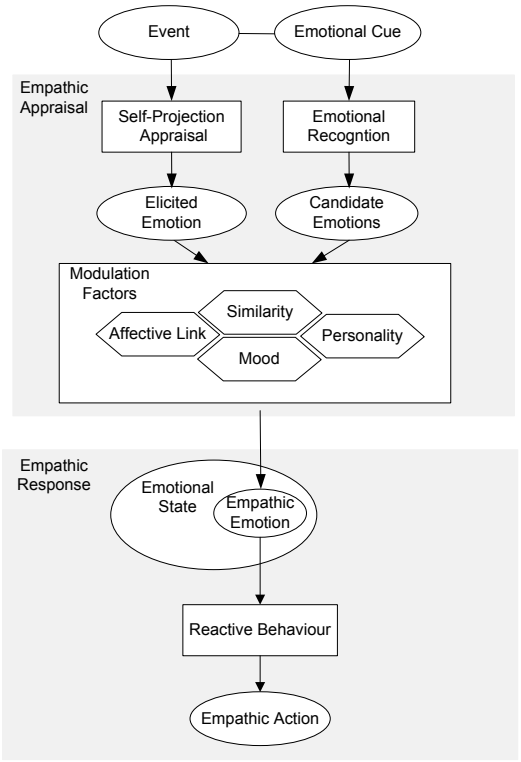

Figure 1 – Empathy Model Diagram

Concurrently, the empathic agent also appraises the event that caused the emotional cue, but assuming the other agent situation by self-projection (this means that the agent A appraises the same event but as if he was the one who his going to be a father). The strongest emotion elicited by this appraisal is compared with the candidate emotions in order to decide the potential empathic emotion. Empathic emotions are the ones that result from the empathic appraisal.

The selection for the potential empathic emotion is based on the following criteria: if the elicited emotion is contained in the group of candidate emotions, then the elicited emotion is selected. But if not, the default emotion from the candidate emotion list is selected instead. For example, imagine that agent A elicits Pride when simulating the appraisal of going to be a father.

Since Pride is congruent with a smile, A will presume that B is feeling Pride and his potential empathic response would be to feel Pride as well. But before the potential empathic emotion is added to the emotional state, its intensity is determined by the following modulation factors [13, 16]:

Similarity - represents the existent overlap between the agents of the empathic interaction, specifically in their emotional appraisals. It is determined by the degree to which the emotion elicited by the self-projection appraisal is congruent with the candidate emotions. The higher/lower the similarity, the stronger/weaker the empathic emotion will be.

Affective Link - represents the social bond that the empathic agent has with the other agent, namely how much he likes and cares for him. Like similarity, it enhances (in the case of a positive bond) or decreases (in the case of a negative bond) the intensity of the empathic emotion.

Mood - represents an overall valence (positive or negative) of the agent's affective state. A negative mood increases the potential of a negative empathic emotion, and decreases the potential of a positive one. On the other hand, a positive mood works in an opposite manner.

Personality - indicates the agent's resistance to feel certain emotions. Empathic emotions to which the agent has a weaker/stronger resistance will be more/less likely to be added to the emotional state.

To exemplify the interplay of these factors, let's consider again the same "imminent parenthood" scenario with agent A and agent B. What can happen to Agent A in terms of empathy towards B? When A projects himself into B's situation, if a Joy emotion is elicited they have a high similarity with one another. This will likely causes A to feel an empathic Joy emotion. However, imagine that A strongly dislikes B; i.e. A has a negative affective link to B. In this case, it's more unlikely that A will empathize. This is also true if A is in a really negative mood or his personality has a strong resistance to feel Joy.

1.2. Empathic Response

In our model, an empathic response starts with an emotion generated by the empathic appraisal. These emotions can also trigger empathic actions in the same way that other emotions trigger specific reactive behaviours. For example, when agent A feels Joy for B, it can potentially trigger the empathic action of congratulating B.

Since the appropriateness of these actions can be highly dependent on the situational context, they are defined by a set of action rules that are domain-dependent. These rules have the following properties:

Action – the name of the empathic action that is triggered;

Eliciting Empathic Emotion – the specific eliciting empathic emotion that triggers the action;

Cause Event – the event that caused the empathic emotion.

5. Integration into an Affective Agent Architecture

The proposed model was integrated into an affective agent architecture [3] that is capable of generating emotions to strongly influence the behaviour of synthetic characters. The emotions are synthesized by an appraisal of events that stems from the OCC cognitive theory of emotions [11].

For each character, the architecture allows the manual specification of goals, personality traits and social relationships with others. This allows the characters to appraise the same events very differently. Moreover, the architecture also has a dynamic mood model which is used in the appraisal as well.

These characteristics led us to choose this particular architecture for our model since it already provides appraisal processes that depend on the agent's defined personality and mood (two of the modulation factors we use to determine empathic responses). Figure 2 shows the final agent architecture.

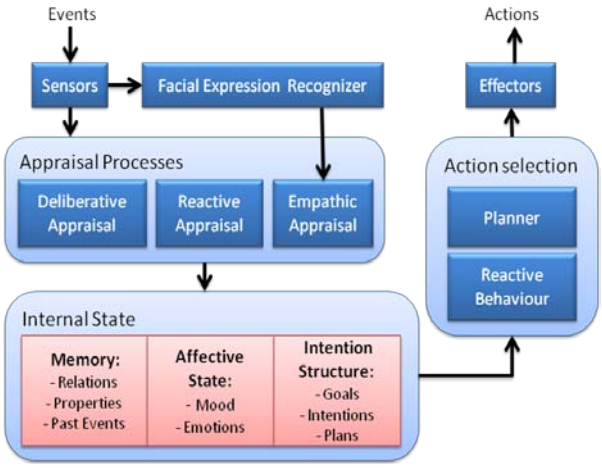

Figure 2 – Empathic Agent Architecture

In this architecture, events are perceived from the environment using the sensory apparatus of the agent. For the perception of emotional cues, a basic facial expression recognizer is applied. It uses a predefined mapping to associate facial expressions to specific emotion types (each facial expression has a unique label). When an agent changes his expression, every other agent in the environment is notified. This simple

approach was used since the focus of our work is not on emotional recognition.

Regarding the appraisal processes, we maintained the already existent deliberative and reactive appraisals. The first elicits prospect-based emotions that are associated to the relation between events and the agent's goals. These emotions are used to influence the agent's deliberation and planning. On the other hand, the reactive appraisal elicits all other types of emotions by using predefined reaction rules, specific to each character. These emotions are used by the reactive behaviour component to generate quick emotional reactions.

Our added empathic appraisal works concurrently to the other appraisal processes. When an event is perceived, the agent projects himself as if he was the agent who triggered the event and uses a simulated version of his own reactive appraisal for that projection. From this simulation, an emotion is elicited. The similarity factor is calculated by seeing if the facial expression associated to this emotion matches the other agent's facial expression. On the other hand, the affective link value corresponds to the "like" relationship that is parameterized for every agent.

After calculating both these factors, a new potential empathic emotion is created. The type of this emotion is equal to the type of the perceived emotion. Its base intensity however, is determined by the average of the similarity and affective link scores. Before the emotion is added to the emotional state, its base intensity is also affected by the character's mood and personality as it is in the other appraisal processes of the architecture. This entire process is then repeated for the other agent to whom the event was directed.

The empathic emotions that are added to the affective state of the character are then used by the reactive behaviour component to generate empathic actions, based on the action rules predefined for them.

6. Case Study

To evaluate the empathic architecture, we designed a small scenario with four characters (see Figure 3).

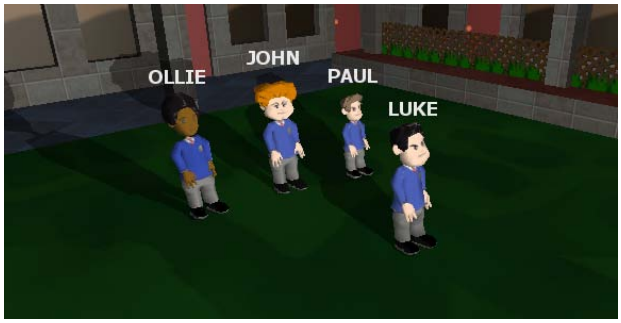

Figure 3 – The characters in the schoolyard

The characters in the scenario have these interrelations between them: Luke and John dislike one another; Ollie likes John; and Paul likes Luke. These interrelations are important because they correspond to the affective link factor used in the model.

The scenario consists in a short story where one character (Luke) has the goal of teasing characters he dislikes, John in this case. The story begins with the four characters standing in the schoolyard and with Luke making a compliment to John. Then John, becoming emotionally happy, reacts by expressing his gratitude for the compliment. Quickly Luke denies his initial compliment and criticizes John with cruelness. This makes John sad, since to be teased is an action that all characters appraise as distressful; i.e. Luke, Ollie and Paul also would likely become sad if they were teased. However, asides from Luke, Paul is the only character that appraises joy when he teases someone.

For this scenario we also defined an empathic action rule to trigger a speech act of consolation. This rule is triggered when a character empathizes with another trough an emotion of Distress and when the causing event is a tease. Neither Paul nor Ollie have any goals associated to them.

7. Evaluation

1.3. Design and Procedure

The previously described scenario was implemented in two different control conditions regarding the empathic behaviour:

i) Without the empathy model.

ii) With the empathy model.

It is important to emphasize that all the specifiable elements of the scenario (agents, relations, goals, personality, emotional profile, etc), are exactly the same in both conditions. However, when using the empathy model, empathic responses in Ollie and Paul emerge. Ollie becomes sad and comforts John and Paul feels happy for Luke and smiles.

We recorded two videos one for each of the above control conditions. Then we asked 44 subjects to participate in a survey to determine the effectiveness of the proposed model of empathy. Roughly half (twenty three) of the participants visualized the first video and the other half the second one, through a random assignment.

After observing the assigned video each participant had to answer to a set of questions about it. The first group of questions asks which characters the user liked/disliked the most. Then the second group consists in statements about the emotions felt by the user and by Ollie and Paul (towards John and Luke), and statements about their friendships with John (see Table 1). For each statement, the users had to choose the most appropriate value in a 7-point discrete scale, from -3 (strongly disagree) to 3 (strongly agree).

Finally we asked users their gender and age. We had 44 participants aged between 19 and 50 years old, of which 5 were female and 39 were male.

1.4. Results

Regarding the question about the users' preferred characters, the results are shown in Figure 4. To make sure the result was not obtained by chance, we applied a Chi-Square test. The value obtained was highly significant (p=0,003). As the figure illustrates, with the addition of our empathic model Ollie becomes the user's favorite character by a large margin. Although it's hard to draw conclusions from this result, we believe that the empathy model helped in portraying Ollie's friendship and concern with John. This in turn made viewers relate more with Ollie. On the other hand, in both scenarios Luke was the character most disliked: selected by 65% of the users with the empathy model and by 76% without the model.

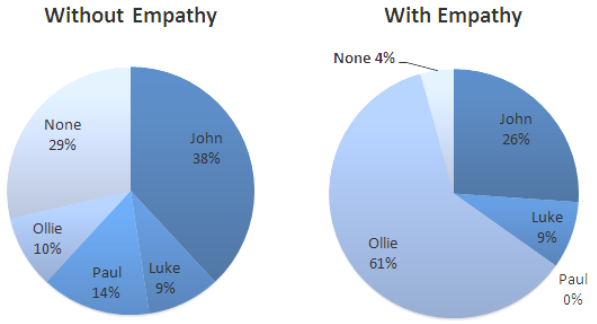

Figure 4 – "Which character did you like the most?"

To check the impact of the empathy model (the independent variable), in the users' perception of the characters' empathic emotions and relationships, a Mann-Whitney test was applied. Table 1 summarizes the results.

Statement	Empathic Model?	Avg.	Differences
You felt sorry for John	No	1,57	|ΔAvg| = 0,01 p = 0,724
	Yes	1,56	
You felt happy for Luke	No	-2,05	|ΔAvg| = 0,4 p = 0,415
	Yes	-1,65	
Ollie felt sorry for John	No	-0,14	|ΔAvg| = 2,09 p = 0,000
	Yes	1,95	
Ollie is a friend of John	No	1,00	|ΔAvg| = 0,09 p = 0,001
	Yes	2,04	
Paul felt happy for Luke	No	-0,57	|ΔAvg| = 1,4 p = 0,006
	Yes	0,83	
Paul is a friend of John	No	0,38	|ΔAvg| = 1,43 p = 0,195
	Yes	-0,30	

Table 1 – Results for the statement questions

Regarding the user's empathy towards John and Luke, the model had no significant impact (p=0,724 and p=0,415). In both videos, the users empathized with John and not with Luke.

More interestingly, our empathy model had a significant positive effect in the perception of Ollie's empathy towards John (p=0,000), and of Paul's empathy towards Luke (p=0,006). However, the effect is much stronger with Ollie. We believe this can be explained by the fact that when Ollie empathizes with John, not only he has an emotional response but he also speaks to John to comfort him. Instead, Paul's empathic response towards Luke is only emotional. These results indicate that both empathic responses originated by our model were clearly understood by the users.

Finally, there was a significant effect in the user's agreement with Ollie being a friend of John (p=0,001). The level of agreement was higher with the presence of the empathy model. This result is in concordance with the theoretical views that regard empathic responses as a sign of friendship [7].

8. Conclusion and Future Work

Each passing day synthetic characters are capable of more and more rich behaviours that contribute to their greater autonomy. In this paper, we have argued that empathic behaviour is another fundamental concept that we must be aware when developing them.

Reviewing the literature we tried to identify the process that lies behind empathy and its main elements in order to build a generic computational model. The model was inspired by a perception-action paradigm. With our empathy model, SCs are able to perceive emotional cues and elicit empathic emotions, which emerge by the modulation of various factors (similarity, affective link, mood and personality). These emotions can then trigger empathic actions.

The proposed model of empathy was then integrated into an affective agent architecture. To measure if it enables the perception of empathic interactions between the SCs we created a small scenario and derived two control situations from it: one where we used the empathy model and the other without it.

We performed an evaluation with a group of 44 participants, showing them only one control situation randomly chosen. Their responses to a small questionnaire were then analyzed. From this analysis we could verify that when using the empathic model, the users' favorite character became the one with the strongest empathic response. More importantly, we could confirm that the model had significant and positive effects on the users' perception of the empathic interactions, which is an encouraging result.

Since the scenario used for this evaluation was very short and simple, it would be interesting to perform another evaluation with a richer scenario, involving more characters and allowing user interaction. Also, we would like to explore other modulation factors in the model we did not considered, in particular as familiarity and past experience.

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