A Model for Social Regulation of User-Agent Relationships

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Abstract. Conversational agents have been subject of extensive research. An increasingly wider number of such agents simulate affective behavior in order to convey familiarity and increase believability. Nevertheless, the evolution of social relationships among people occurs gradually and the degree of intimacy associated with such relationships regulates people's behaviors. Similarly, we must take into account the progressive growth of relationships when modeling user-agent interaction. In this paper we present a model that regulates the development of user-agent relationships, articulating the Social Penetration Theory with personality modeling. User tests showed that gradual relationship building achieved through the implementation of our model makes an agent more interesting, while increasing its believability, engagement and fun.

Keywords: Conversational agent, socially intelligent agents, user-agent relationships, social regulation

1 Introduction

Embodied artificial agents have become popular over the last decade [5] [4]. A wide number of such agents rely on user-agent conversation [9] [15] [24], since it plays a major role in these interactions [7]. It has been proven that affect is very important in the creation of relationships among people and even other species [18]. Agents with affective behavior, besides being more believable, are likely to have increased probabilities of building social-emotional relationships with users [5]. The simulation of affective behavior, however, does not simply rely on written dialogue, but it takes advantage of other modalities as well, such as facial and body expressions. Interaction with agents that provide such features is potentially richer and more satisfactory [3]. Affect must be simulated with regard to believability so that relationships between the user and the agent are created and maintained. As a result, we need to take into account the development of social relationships among humans, which goes through several stages and occurs in a gradual, progressive way. In order to do so, we have combined results derived from the Social Penetration Theory [1] with personality modeling based on the Five Factor model [10] to regulate the development of user-agent relationships.

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We present a model that allows user-agent relationships to evolve in a natural, progressive way. Agents that implement this model have the potential to engage users in longer interactions, while maintaing believability.

This paper is organized as follows. In the next section we discuss some research that situates our approach. We then present our model for social regulation of user-agent affective relationships and briefly describe the user-agent interaction. Lastly, we present and discuss the results of user tests.

2 Related Work

Given the importance of conversation in building user-agent relationships [7] and the role that affect plays in creating agents that are both believable and engaging [3], considerable research has been conducted on affective artificial agents. However, the expression of emotion must be carefully taken into account when creating a conversational agent [6]. Particularly, an agent that has an associated model of emotions is likely to better understand the user, thus adapting its responses accordingly [13]. A popular model of emotions for agents is the OCC model [17], according to which emotions are the result of the agent's interpretation of events, other agent's actions and object's features, as well as the agent's reaction to these aspects. Many studies base their work on this model. In order to create a dynamic behavior, the FLAME model [13] represents emotions by intensity through fuzzy logic and, regarding emotional states and behaviors, it maps events and expectations accordingly. Another interesting model for agent behavior is PAR [2], which takes into account the agent's own actions, as well as other agents', and allows acting, planning and reasoning on these actions. It combines the OCC model for emotion analysis and generation with The Five Factor Model of personality traits (OCEAN) [10]. Even though these models allow the simulation of affective actions and study emotion expression to improve relationships, they do not model any form of either social behavior regulation of emotion or gradual relationship development. Actually, several research studies rely on social regulation mechanisms for relationships using the Social Penetration Theory. One such study is Cassel and Bickmore's research [8], which takes into account several concepts underlying this theory as a strategy to obtain collaboration. Another example is Schulman and Bickmore's [22] conversational agent that persuades users to perform physical exercise. A strategy is followed in which superficial topics are discussed, followed by slight self-disclosure by the agent and self-disclosure eliciting. Then, only after empathic actions are performed and conversation status is assessed does a persuasive dialogue take place. All aforementioned models and systems either research the user-agent affective relationship in some way or explore the development of more personal relations with regard to a particular practical goal. However, none of them articulates personality modeling and affect with social regulating mechanisms to create and further develop relationships. We have attempted to bridge these two very important aspects of social behavior with a model that associates the regulation of social relationship gradual building with personality and emotion.

3 A Model for Social Regulation of User-Agent Relationships

In order to endow social user-agent relationships with human-like, gradually developing relationships, our model relies on social regulation of social connections which, consequently, restricts affect expression as well. Our approach thus consists of an articulation between a perception-action paradigm [21] and the Social Penetration Theory [1]. Regarding the first, it is inspired in the studies performed by Rodrigues et al. [21], which is grounded both in the Perception Action Model (PAM) [19] and in Vignemont and Singer's research [11], stating that the agent has to choose an action regarding the perception it builds upon input stimuli. As a result, that action also causes changes in the agent's surrounding environment. These changes are processed, leading to new actions, making up an interaction cycle. The Social Penetration Theory [1] describes the gradual development of social relationships. We have adopted this theory to create a representation for relationship evolution over time. To do so, we took two different definitions into account: *Affinity* and *Intimacy*. The first is related to the establishment of aspects in common during superficial interaction and is more associated with initial stages of a relationship. As for *Intimacy*, it consists of disclosure and exploration of deeper subjects in conversations and is of uttermost importance to the development of deeper relationships. These two concepts are used in our model for the simulation of Social Penetration Theory's four stages [25]: we have defined two variables, aff (affinity) and int (intimacy), that model each of these concepts. Both scores after an interaction (aff_{t+1} and int_{t+1}) are the sum of the values for these variables before the interaction (aff_t and int_t) and values associated with the interaction ($aff_{interaction}$ and $int_{interaction}$). The user chooses a conversation option for interaction, which is assigned values for both affinity and intimacy. As a consequence, despite initial both these variables' initial values being equal to 0, they may assume negative values. Regarding relationship evolution, we modeled each stage according to the aforementioned concepts of *Affinity* and *Intimacy*, following the Social Penetration Theory [1] and the underlying stage definition [25]. Each stage of a relationship has an associated numerical threshold value both for *Affinity* and *Intimacy*. Taking into account Social Penetration Theory's four states, the relationship is on a stage i ($i \in \{1, 2, 3\}$) if the current *Affinity* value (aff) is higher than or equal to the threshold associated with the current stage ($affT_i$) and lower than the threshold for the next stage ($affT_{i+1}$). It should also be verified that the present *Intimacy* value (int) is higher or equal than the current stage's intimacy threshold ($intT_i$) and lower than the threshold for the next stage ($intT_{i+1}$). Since there are no stages beyond stage 4, we have created a special condition for this level, so that stage computation does only take into account the current stage's thresholds ($affT_i$ and $intT_i$). Relationship stage modeling is then used for social regulation. It is actually the main basis for action decision. In fact, our computational model for a socially regulated agent follows Social Penetration Theory's [1] principles associated with each relationship stage when making decisions on which actions to perform. For instance, it is not until the second stage that the model allows the agent to perform disclosure.

On the other hand, on the first and second stages, the agent often displays a polite smile. Regarding physical closeness representation, there are three different proximity frames. The agent's visual representation on the first stage consists of its full body, while at the second stage we can see a closer representation, where it is depicted approximately from its waist up. Regarding further stages, the agent's face is zoomed in, representing increased proximity.

The ways in which people perceive and react are affected by personality. Even though certain particular behaviors may change over time, personality itself remains almost constant over one's lifetime [2]. The Five Factor Model of personality traits [10] has been generally accepted [26]. It represents a taxonomy that captures individual psychological traits and describes the human personality as consisting of five traits: openness to experience, conscientiousness, extraversion, agreeableness and neuroticism. We relied on this model to build both the agent's and the user's personality model. A numerical value is assigned to each trait, following a 5-point scale, ranging from 1 (lowest) to 5 (highest). When creating the personality model for a conversational agent that aims at building an evolving relationship with the user, we have defined high scores for all the traits except *Neuroticism*. User personality is taken into account when performing agent decision making. At the beginning of each interaction, since there is no *a priori* available information on the user's personality, all personality traits are assigned an initial score of 3 points out of the aforementioned 5-point scale. As conversation takes place, the user's personality model is iteratively updated. Each option selected by the user to verbally interact with the agent is assigned a tuple of personality traits' values (o, c, e, a, n), ranging from 1 to 5 points, corresponding to the intensity of the traits that are expressed in that interaction. For instance, if the user selected an option where she replied to the user *You are welcome. I'll always be here for you.*, corresponding to a strong agreeableness (while it does not contribute to other factors), the interaction resulting tuple would be $(3, 3, 3, 5, 3)$, with a resulting score of 5 for agreeableness and a 3-point score for all other traits. Personality is updated regarding both these values and the assumptions from the previous model.The previous trait value T_t is weighted with the interaction trait value T_{int}, regarding the relationship stage S. The deeper the relationship is, the less impact a single interaction has upon it, as stated by Altman and Taylor [1].

Our model consists of five main modules: **(i) User Personality Evaluation** takes the user's chosen verbal interaction as input and updates the user personality model regarding the current interaction. It takes into account the valence of the answer regarding all personality traits, as well as resulting affinity and intimacy scores; **(ii) Empathic Appraisal** while also taking the user written interaction as input, this module creates a set of candidate user emotions (happiness, sadness, fear, disgust, surprise, anger, strong happiness and neutral state) that may be associated with the interaction option that has been selected; **(iii) Social Evaluation** as aforementioned, regulates the development of relationships. This module is central, since it regulated merged information from both the user personality model and the set of candidate user emotions

to infer the current user emotion. It does so by assigning probability functions to candidate emotions, regarding numerical values of each personality trait, and then choosing the best candidate; **(iv) Agent Emotion Evaluation** processes the current agent's emotion regarding the current relationship status and user emotion, taking into account the agent's personality model; and **(v) Action Decision** makes a decision on which actions to perform, both verbally and visually, taking into account both the current relationship status and both the user's and agent's current state of emotions. However, actions are not limited to written verbal expression. Actually, regarding the fundamentally social and emotional characteristics of relationships [5] and the fact that people respond to social cues from a computer in a similar way to other people's, even if unconsciously [20], we created a model enables the agent to visually represent affect. Since facial expressions are a powerful way to convey emotion [18], we modeled the *six basic expressions* [12]: *happiness*, *sadness*, *surprise*, *anger*, *disgust*, *fear*, as well as the neutral expression and an expression of strong happiness. Furthermore, since the representation of proximity increases the closeness felt by the user [16] [3], our model supports the three aforementioned conversational frames, that are directly related to the relationship's current status of intimacy.

4 Evaluation

We have implemented an agent that is built upon our model, which interacts through written dialogue and expresses both facial expressions and physical proximity. The agent takes the initiative of interacting by prompting the user with a simple phrase. The user then chooses a verbal response out of a list of verbal interactions. The agent reasons upon this answer by updating both the user's model of personality and the relationship's stage and it then infers the user's current emotional state. Finally, it generates a response that is expressed in both a verbal and visual way, to which the user again responds, continuing the interaction cycle.

We created two test conditions. The first consisted of the interaction with an embodied virtual agent that implemented a version of our model without the social regulation component being active. On the second test condition, the user interacted with a visually similar agent where our model was fully integrated. As stated, the objective of this research was to study the impact of our model in the development and regulation of a user-agent relationship. In particular, we intended to study three particular interaction aspects: believability, engagement and fun. To do so, we designed a questionnaire to be filled in at the end of each user test. Along with a small number of profiling questions, and given that friendship is a particularly relevant type of social relationship, we used some questions from an adapted version of the McGill Friendship Questionnaire [23] to infer engagement and fun. In order to study believability, we also created a set of questions comparing user-agent conversation to interaction with other human beings. The resulting questionnaire was subject to validation with 5 users before performing further tests. At the evaluation stage, we started tests by

briefly presenting the agent to each test subject, while verbally and visually explaining how to interact. Afterwards, we allowed users to freely interact for ten minutes. Participants were then asked to fill in the questionnaire. We had a total of 30 participants, 15 for each test condition. All subjects were university students, 11 (36.67%) of whom were female and 19 (63.33%) male. Furthermore, 24 (80%) subjects were aged between 18 and 25, while the remaining 6 (20%) belonged to the age group between 26 and 35 years old. Regarding the three model evaluation aspects we have taken into account (believability, engagement and fun), all measured aspects display general higher values when comparing both test conditions. Average believability increased from 3.04 ($\overline{x} = 3.04$, $\sigma = 0.56$) to 3.82 ($\overline{x} = 3.82$, $\sigma = 0.55$), while engagement from 3.73 ($\overline{x} = 3.73$, $\sigma = 0.47$) to 4.49 ($\overline{x} = 4.49$, $\sigma = 0.53$) and fun from 3.38 ($\overline{x} = 3.38$, $\sigma = 0.47$) to 4.11 ($\overline{x} = 4.11$, $\sigma = 0.50$). Looking more closely at the results, a Shapiro-Wilk test showed evidence against normality, suggesting the adequateness of a Kruskall-Wallis test. We were able to conclude that social regulation does in fact have a great impact on either believability, engagement or fun. In particular, when concerning believability, the model version with social regulation (Mdn = 3.67) differs significantly from the model without this feature (Mdn = 3.00) ($U = 187.50$, $p < 0.05$, $z = -3.09$). As for engagement, social regulation also seems to have a great impact, since the version that displays this feature (Mdn = 4.67) is significantly different from the one who does not (Mdn = 3.67) ($U = 189.00$, $p < 0.05$, $z = -3.15$). Regarding fun, there is a significant difference between the condition where social regulation is taken into account (Mdn = 4.00) and the scenario one where this feature is not active (Mdn = 3.33) ($U = 190.00, p < 0.05$, $z = -3.19$). This corroborates the previous general conclusions confirming that the social regulation component of our model has a great impact in all aspects we have taken into account, which validates our hypothesis that social regulation plays an important role on user-agent interaction.

5 Conclusions and Future Work

The popularity of conversational virtual agents has increased over the years. The exploration of emotion is such agents, besides improving user-agent relationships, increases believability. However, when regarding the nature of social relationships, we must take into account several particularities, such as gradual development over time. We have created a model that regulates the evolution of relationships, articulating the Social Penetration Theory [1] with the Five Factor personality model [10], allowing a user-agent relationship to naturally unfold. We have performed user tests with an agent implementation of our model, which have shown promising results, ascertaining that our model increases believability, while engaging users in a positive, engaging and fun interaction experience. One very interesting aspect to take into account in the future would be to implement memory mechanisms to further enhance interaction over time, since we already provide social mechanisms that will potentially keep users engaged in interaction for a longer period of time. Such a research study would also provide us with the means to adapt our model to more human-like, longer-term interactions.

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