Generic Affect Modeling: A Self Study

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1.0 Introduction

With advancing artificial intelligence (AI) researches and machine learning techniques, software agents and robots are becoming more commonplace. Two of the recent examples of software system designed to interact with people are Siri and WATSON. Siri, a virtual assistant software developed by Apple and released in 2011, is capable of understanding natural language input and responding to user commands. WATSON, a supercomputer developed by IBM, defeated humans in a much publicized show of Jeopardy. While these two technologies represent significant advances in the AI field, most people will consider neither Siri nor WATSON to be truly intelligent. On the other hand, most people will agree that a dog, or even a mouse, is intelligent. The defining difference is sentience: living organisms such as dog or mouse respond to its environment and displays emotions.

In order for robots and virtual agent to become integrated into everyday life, they must respond in a socially intelligent way and provide emotional cues to its human counterparts. Doing so would not only provide deeper and richer interactive experiences, but also allow humans to understand and anticipate virtual agent's behavior. To synthesize a believable and intelligent virtual agent requires more than traditional focus on problem solving in the AI field: a virtual agent must have sophisticated personality and emotive models. Without emotive responses, machines will remain machines.

There have been some notable efforts in addressing the lack of emotive feedback in both industries and academics, though most of them remain separate efforts. In the consumer space, Furby (1998) and Pleo (2007) are two notable attempts in robotics toys; focusing on building the social connections with its human counterparts, the toy robotics provides an illusion of evolution and emotional intelligence by changing its behavior as they interact with users and environments. Another example in the consumer space is Electronic Art's best-selling simulation game, The Sims; featuring an open-ended gameplay, player controls virtual agents that are driven by basic needs such as hunger, social interaction, etc. In the academic circles, Dr. Breazeal's Kismet and Cog are two research robots with advanced emotion and personality models that attempt to address the void (C. Breazeal, 2002).

This work report focuses on providing the missing social link by tackling the problem of generic affect modeling and simulation. The grand vision is to provide a general framework that is capable of simulating sentience of living organisms ranging from mouse to humans. Reasoning and problem solving are not the focus of this project; instead, the project focuses exclusively on researching and creating a model that can provide robots and software agents a "personality" capable of empathy to connect with its human counterparts emotionally.

As a first step in this direction, a survey of existing researches in the field will be conducted and a design of emotive model will be proposed and prototyped.

2.0 Literature Review

Computation modeling of human emotion has been studied extensively in academia, with most work focusing on the appraisal theory of emotion from psychology. The nascent field is referred to as affective computing, study of emotion detection, interpretation, and simulation. One fundamental work in the field is Ortony, Clore and Collin's emotion model in 1988, commonly referred to as the OCC model. Briefly, the OCC model attempts to develop a formal system to generically describe emotion by developing the concept of valence reactions focused on three aspects of emotional model: event (e), agent (a), and object (o). An event's outcome can be either desirable or not. An agent's reaction can be act of approval or disapproval. And an object can either be liked or disliked. Using this approach, emotion can then be described by functions that accept these three parameters; for instance, the emotion anger can be detected when f(e,a,o) exceeds a pre-set threshold (Ortony, Clore, Collin, 1998).

Building on theoretical emotion models such as OCC, numerous projects attempt to simulate emotion. For example, Egges' work tries to combine OCC model with the OCEAN personality model to build a framework for simulating emotion (A. Egges et al. 2003). Briefly, the OCEAN model of personality is a psychology theory that proposes human personality can be described via five factors: openness, conscientiousness, extraversion, agreeableness, and neuroticism, where each factor represents a particular aspect of personality.

Another interesting project is Bouricha's work focused on creating an empathetic agent. Building off belief-desire-intention theory, the work attempts to simulate empathy by interpreting human actions using its own computational model (H. Boukricha et al, 2007).

In addition to purely software simulation, there are also notable efforts focused on building robots with emotive expressions; Kismet, a robot built by Dr. Breazeal at MIT media lab, interprets emotion in a multi-dimensional space comprised of arousal, an indicator of how stimulating a signal is to the system, valence, an indicator of how desirable a signal is the to the system, and, finally, stance, an indicator of how approachable a percept is to the system (C. Breazeal, 2002). Fitting a robotic system with a computational emotive model not only greatly enhances the level of interactivity, but also holds the promise to take down the wall between coexistence between humans and robots.

3.0 Overview of the Model

The focus of this project is not on complex emotive expressions such as gestures or subtle language cues; rather, the scope of project, as a first prototype in examining the feasibility of a generic affect model, will be limited to interpreting a basic set of external events and interpreting those events via an internal model to generate a simple set of emotive output.

Capitalizing on the OCC and OCEAN model presented by Egges et al, this project will focus on creating an emotive model which takes in English words as inputs, interpret those keywords using of personality, experience, and current emotions to generate the final emotional response; the output of the emotive model is a three dimensional vectors modeled after Lövheim' cube of emotion with the three axis being amount of noradrenaline, dopamine, and serotonin, the three neurotransmitters that are thought to govern human's emotional process (Lövheim, 2012). An architecture diagram of the proposed model shown in figure 1.

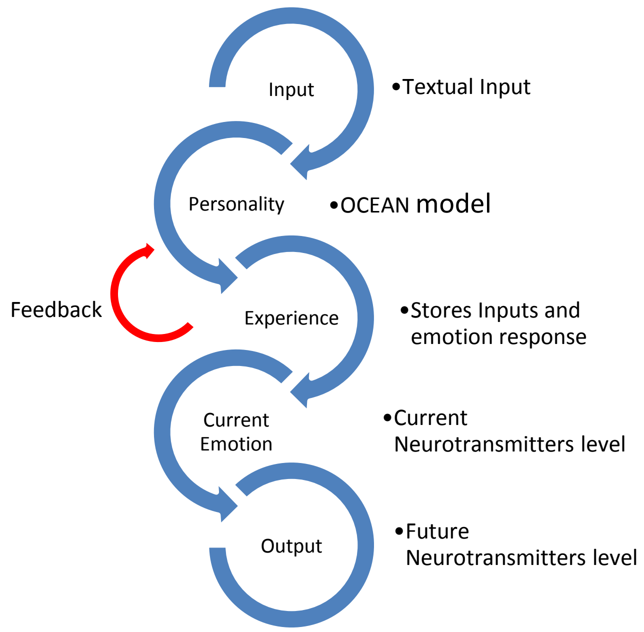

Figure 1: Emotive Model

3.1 Input to the Model

The inputs to the proposed emotive models will be the primary interaction point. While a fully featured robotic system will have numerous sensors that capture optical, acoustic signals, etc., to keep the prototype manageable, the model in this work report will accept only text as inputs. Specifically, the model will accept, not unlike a traditional UNIX command, a text input in the following format:

Actor, Receiver, Action

Actor is the entity doing the action and receiver is the entity receiving the action. An example would be as follows:

Bob, Plants, Watered

As the above example demonstrates, action would be a simple verb describing the action. In order to interpret the input, a precompiled database of words with typical response value is prepared. The input would be searched against this database and take those response values as inputs into the filter component of the model discussed below.

3.2 Personality

As a major component of the emotive model, personality directly influences the mood and how external events are interpreted. Personality model employed here is the OCEAN model due to its wide applicability (Costa, McCrae, 1992). Each of the five traits is specified by a real number ranging from 0 to 1 to describe the character. In addition to these five traits in the OCEAN model, the personality model also has a list of preferences of the virtual agent. The preference list is a simple list of entities tagged with the emotional response it tends to elicit from an initialized agent. This is a dynamic list that is updated as the model evaluates more inputs. How these personality qualities will affect the neurotransmitter output is will be discussed further in the implementation and testing section of the report.

Rather than remaining static once set, the architecture proposed allows these personality traits to be changed by experiences' memory unit when the influence weight exceeds a pre-set threshold; each personality traits are modified according to the following logic:

```
if influence weight for trait > 1.0:
    personality trait += influence weight - 1.0
else if influence weight for trait < 0:
    personality trait += influence weight
```

A more detailed explanation for influence weights and memory unit are discussed in the section below.

3.3 Experience

Experience is the central database that stores previous inputs and the associated emotive model output. This tuple is referred to as a memory unit. Each memory unit has an influence weight associated with it to simulate forgetting and oversaturation. The influence factor ranges from -1 to +1, with zero being the neutral point and having no effect on future output. When a new event occurs, the event is assigned an influence weight. This computation is model-specific as no person experience the same event in the same way and requires tuning. The influence weight's magnitude decreases exponentially when an event recurs excessively; this is to simulate the natural tendency observed in humans that repeated events lose its effect over time. As time passes, the influence weight's magnitude also decays exponentially to zero to help the virtual model "forget". The experience filter's primary objective is to help ensure the virtual agent act consistently; for example, one would expect one person who likes chocolates to continue to like chocolates unless some drastic events occurred that reversed the tendency. Because of its highly individualistic nature, effect on the neurotransmitter for this filter must be hand-crafted.

3.4 Current Emotion

Because a believable character does not change its emotion or behavior instantaneously, any future emotive output is a combination of current emotion of the virtual agent with the new emotive response. This ensures the virtual model acts consistently and also introduces a damper effect to prevent wild swings in the virtual agent's response. Moreover, gradual updates also simulate the effect of time on the agent. The update rule is simply adding the deltas between the current neurotransmitters level and the new neurotransmitters level in a fixed number of steps.

3.5 Output of the Model

The final output of the model is the tuple consisted of three neurotransmitters: noradrenaline, dopamine, and serotonin. This is based on Lövheim's hypothesis that emotion is regulated by neurotransmitters and wide gamut of basic emotions can be described by these three substances. This model is chosen primarily for its ability to describe the basic eight emotions described by Tomkins's affect theory using only three dimensions (H., Lövheim H, 2012). The sample classifications of emotional output for different level of neurotransmitters are shown in figure 2 below.

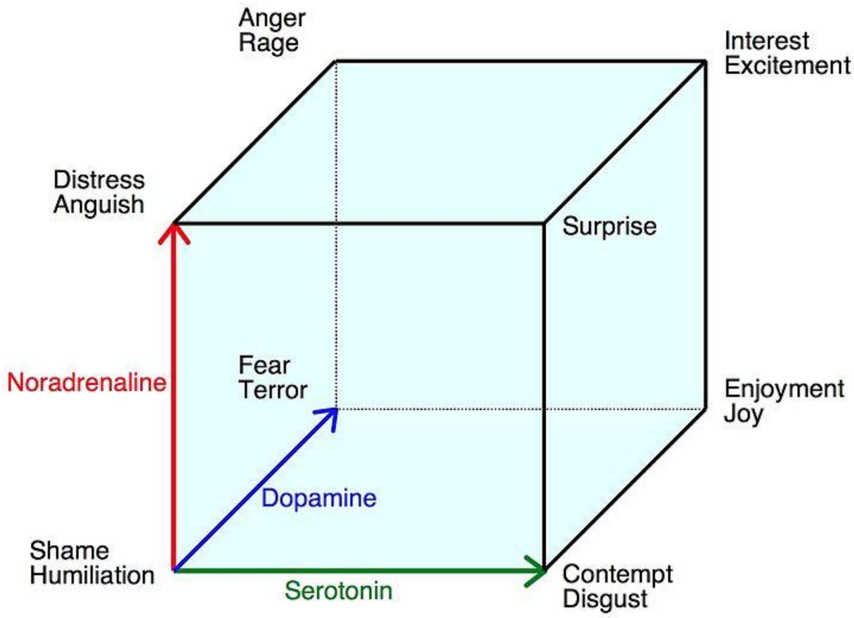

Figure 2: Lövheim Cube of Emotion

4.0 Implementation

The model is implemented in the programming language Python and divided into three distinct parts: input interpretation engine, core emotion model components (personality, experience, current emotion), and evaluation engine.

The input interpretation is the part that translates the textual input into a numerical signal that the core emotion model components evaluate. Consisting of personality, experience, and current emotion discussed in section 3, the core emotion model components are responsible for interpreting those inputs and generating the emotive response output. Evaluation engine, on the other hand, is responsible for modeling the cognition aspect of human's mind: it allows for knowledge expansion and absorption; the engine evaluates similarity between inputs by utilizing natural language toolkit (NLTK), a popular library used for natural language processing for Python, to expand a virtual agent's preferences by searching for synonyms and antonyms.

Before the model can be used, it must be initialized with the five personality traits described in OCEAN along with a basic set of preferences. For testing the created model, a virtual character that has a phobia for bugs and friendly personality is instantiated as follows.

```
#Openness,Conscientiousness,Extraversion,Agreeableness,Neuroticism
0.2,0.1,0.5,0.7,0.8

#preferences, serotonin dopamine noradrenaline
sweet, 0.7 0.7 0.7
bugs, 0.12 0.652 0.34
```

The first line of numbers specifies the traits of the OCEAN model followed by a list preferences with emotional response encoded as the level of the three neurotransmitters in Lövheim three dimensional emotive spaces. The preference list can be updated by the evaluation engine. For example, when the given agent, initialized to be fond of sweets, eats a chocolate, the evaluation engine would identify chocolate as a type of sweet and assign a similar neurotransmitter values for the entity chocolate.

In the current implementation, these evaluations are largely static and have to be manually programmed into the evaluation engine.

5.0 Conclusion

While the model's design is based on existing theoretical researches, the implemented model behaved largely statically as originally initialized because the lack of dynamism in the evaluation engine. However, the emotive model was able to successfully interpret basic actions that involved two parties and a single verb and modeled key aspect of emotion influencers such as personality, past experiences, and current emotion. Furthermore, the simplistic nature of the model makes it an ideal entry point for students and professionals alike who are interested in the affect modeling and do not know where to start. Overall, the model served as a useful prototype for future iterations and improvements but lacked the dynamics and spontaneity of human emotive responses.

6.0 Recommendation and Future Work

The emotive model presented in this work report is simplistic in nature but architecturally extensible. For instance, to increase the believability of the system, a drive filter can be added to the emotive model. The drive filter would simulate basic needs of such as hunger, sleepiness, hygiene, etc. and define how those needs affect emotive output for new inputs.

To increase usability of the emotive model, the model's evaluation engine has to be dynamic by incorporating learning. This will research integration with existing machine learning and data mining techniques and will require further researches.

An important component missing from this emotive model is the interpretation of final emotive output according to context. For example, positive emotive output in the context of a person may be interpreted as love but if the associated context for the positive emotive response for an event such as earning a Bachelor degree, the emotive output may be interpreted as pride. The model proposed and developed in this work report lacks this component but the decoupled nature of the architecture allows easy extension.

Final but perhaps the most important improvement for the model would be augmenting the input the model can interpret. As presented, the model takes an artificial text input that does not reflect the natural language input accepted by technology like Siri. It would be important to augment the emotive model with natural language understanding capability to ensure more natural interaction.

7.0 References

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