A SIX-DIMENSIONAL PARADIGM FOR GENERATING EMOTIONS IN VIRTUAL CHARACTERS

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ABSTRACT
The paper outlines an emotionally intelligent agent design for use in computer games. The agent is designed to provide users with a rationally unpredictable adversary or companion in virtual environments. An overview of the agent's emotional assessment mechanism are given followed by an assessment of the agent when used to model a computerized pet dog.

INTRODUCTION
Until recently, giving computers emotional abilities was the realm of science fiction (Stern 1999). However, much work is currently being performed by small groups of researchers around the world to enhance the field by giving computers affective capabilities. The motivation behind this work has been to allow computers to emulate areas of human behaviour, in order to increase information-processing efficiencies.

Research into the development of intelligent agents has long been established, however it has not been until recently that the realm of producing emotionally believable human-like artificial beings been explored. This evolution has been a natural extension of agent research and seeks to improve agent performances in simulating human elements in domains ranging from enterprise modelling to interactive fiction. One such domain that has mostly been ignored, but for a few dedicated researches, that would greatly benefit from this research is that of computer games and interactive fiction. The advent of the web and the profile change in computer consumers has generated a much larger potential gaming population. However, the bulk of games today still reflect the characteristic of initial developments and capturing the imaginations of new computer users is now a challenge. One such draw card will be the development and integration of intelligent, human-like artificial adversaries and companions to fire new fantasies and gaming challenges.

Chris Crawford, in his industry journal “Interactive Entertainment Design”, comments about the current state of the games industry as having reached “a state of moribund stasis”. We now see much of the PC consumer population being made up of non-gamers, whilst the vast majority of computer games coming out today are fundamentally the same as they were in the 1980s. These include products such as flight simulators, role-playing games, strategic war-games and puzzles. The major difference is that today’s games have been embellished with state of the art technologies in graphics, animation and sound. These new generations of PC purchasers were not interested in the games in the past (let alone computers) and neither are they now.

In order to create a virtual experience that suspends disbelief the user needs to be provided with a rich, deep and emotional interactive environment (Murray 1998). The user loses interest quickly in a world where they can only point and click or is presented with a limited number of plot development branches.

The distinction between current predictable mindless artificial life forms and what computer users really want to correlate with is the experience of interacting with something that is truly alive.
(Stern 1999). The key to creating such a virtual character may lie in emotions.

**AN EMOTIONALLY INTELLIGENT AGENT**

An intelligent agent is an entity that perceives its environment through sensors for the purpose of achieving prompt and sufficiently detailed orientation within the environment with reference to the relevant aspects of that environment on the basis of jointly explicit, relatively restricted, stereotyped, and insufficient information which through non-deterministic interaction, achieves high precision in behaving to act upon that environment for its own purpose.

For the computer gaming environment, intelligent agents mean the end of preprogrammed and predictable adversaries. They give game designers the means to create a truly dynamic and rich environment where the behaviours of the agents can be as reactive as the human players.

In an attempt to create a character that not only perceives and reacts to its environment but that can also be unpredictable in a believable way, the use of emotion as a motivational and behavioural generator have been examined through the development and experimentation of the Emotionally Motivated Artificial Intelligence (EMAI) architecture (Baillie et al 2002). The EMAI architecture allows us to examine emotional states and processes that affect human decision-making behaviour. Because of the complex nature of emotions and the plethora of application areas, this architecture has been designed to focus only on the modelling and synthesis of emotional states in relation to decision-making about the performance of behaviours. Keeping this in mind, this architecture implements a psychological basis for emotion generation that concentrates on motivation and the selection of behaviour.

The motivation to integrate emotions with an intelligent agent has been an attempt to model the way in which humans make emotional yet rational decisions that affect their behaviour. The EMAI architecture allows the create an agent whose behaviour is based on its emotional experiences. Situations that produce unpleasant emotional experiences cause the agent to avoid similar future situations and pleasant experiences have an opposite effect. Through its interaction with an environment the agent develops attitude values toward the elements within the environment. This allows very different personalities to evolve within the same agent put through different situations.

For example, consider an agent in a role playing game. In the first run of the game, the agent may be assisted by the player, the agent therefore associates positive emotions with the player. This will cause the agent to act in a positive manner toward the player. In a second run of the game, the player may begin by shooting at the agent, the agent would then associate negative emotions with the player and could act aggressively toward the player for the duration of the game. The nature of the emotional mechanism within an EMAI agent, however, keeps an accumulative account to emotional experiences and therefore the player who initially shoots at the agent can gain back the agents trust through future pleasant interactions.

This is a simplistic example of the way in which emotions are used in an EMAI agent. The emotions used by the agent are not linear ranging from pleasant to unpleasant. Rather, they combine six orthodonal appraisal dimensions to create a six-dimensional emotional space used for calculating the agent’s emotional state. The emotional mechanisms used in the EMAI architecture make it possible for an EMAI agent to produce internal emotional states. These states are used to activate goals, develop plans to satisfy goals, make affective decisions about behaviour, develop attitudes and adapt to the environment.

**EMOTIONAL PLANNING**

An EMAI agent’s behaviour is determined by the plans it has scheduled. The agent’s schedule is based on a two-fold ordering process. The primary ordering of the plans is based on the agent’s goals. These goals are structured in a goal hierarchy (Baillie 2002). When a goal is activated or triggered an appropriate plan is added to the agent’s schedule. If a goal that has already been triggered is triggered again, the associated plan is given a priority rating. The more often a goal is triggered, the higher the agent’s priority to achieve that goal. Different plans will have different levels
of priority based on the number of times the associated goal has been triggered. The agent uses this priority to order the plans within the agent’s schedule.

This type of primary event scheduling also occurs in other affective agent architectures including Silas (Blumberg 1996), PETEEl (El-Nasr 1998) and EBC Framework (Velasquez 1998) where a priority is placed on a behaviour, based on the agent’s motivational state. However, this is where the similarity between the EMAI agent’s behaviour scheduling and other affective architectures ends. The agent is not only capable of deducing one plan to satisfy a goal, but it can also infer multiple and mutually exclusive plans that can satisfy just one goal.

Because each goal in the agent’s schedule may consist of one or more plans with the same priority, these plans need to be ordered in another way. The agent must further order the plans using an emotional sequence, from most desirable to least desirable\(^1\). The most desirable of plans are ones that, when executed, would produce emotions closest to the value of the internal register. Plans, that when executed, will produce the most desirable emotional state within the agent are ordered first and least desirable plans are placed last within each priority ordering of the schedule.

For example, if the agent has the goal [ATTACK PLAYER] triggered due to an enemy threat, the agent may deduce two plans [SHOOT PLAYER] and [PUNCH PLAYER]\(^2\). Assume in a previous attempt at satisfying the goal [ATTACK PLAYER] the agent selected the plan [SHOOT PLAYER] and that during the execution of this plan the weapon malfunctioned and hurt the agent. The agent would have associated unpleasant emotions toward the [SHOOT PLAYER] plan. As the agent will attempt to execute plans that are most pleasant, in attempting to satisfy the current goal, the agent will select [PUNCH PLAYER].

Not only does an EMAI agent associate emotions with plans, it also examines the elements involved with a plan and assigns individual emotional weightings to these elements. A plan and its associated elements is referred to as an event. When these elements arise in new events, the agent can use their emotional weightings to determine an overall weighting for that event.

**EMOTIONAL ASSOCIATIONS**

An event is represented in the agent’s knowledge base as a conceptual graph (Sowa 1984) in the form dictated by the Theory of Reasoned Action (Petty and Cacioppo 1996). This theory defines a behavioural event as having four elements; action, object, time and context. A generic event is represented by the conceptual graph shown in Figure 1 where an event is defined as *some entity performing an action on some other entity at some time and in some context.*

![Figure 1. A Conceptual Graph Representation of an Event](image)

This can also be represented in linear form as:

\[
\text{[ACTION]} - \text{(OBJ)} \rightarrow [\text{ENTITY}] \\
\text{(AGNT)} \rightarrow [\text{ENTITY}] \\
\text{(TIM)} \rightarrow [\text{TIME}] \\
\text{(CON)} \rightarrow [\text{CONTEXT}]
\]

---

\(^1\) An internal register determines what constitutes a desirable plan.

\(^2\) These plans are associated with a goal in the agent's knowledge base.
This graph provides the agent with precise knowledge about how, when, where and with what an action should occur to execute the associated event. Thus an event can be re-defined as Expression 1:

$$E = \{a, o, c, t\}$$

(1)

where $a$ is the action that relates to the event, $o$ is the object involved or affected by $a$, $c$ is the context or condition where $a$ is taking place or being performed and $t$ is the temporal component of $a$. Each of these elements may vary along a dimension of explicitness. At the most exact level of identifying the event, an EMAI agent will intend to perform a specific action, with or towards a certain object, in a particular context or situation at an exact point in time.

Continuing with the [ATTACK PLAYER] example from the previous section, the graph for [SHOOT PLAYER] might be:

[SHOOT] -
- (OBJ) -> [PHASAR PISTOL]
- (AGNT) -> [PLAYER]
- (TIM) -> [TIME: Now]
- (CON) -> [IN THE CAVE]

and the graph for [PUNCH PLAYER] might be:

[PUNCH] -
- (OBJ) -> [FIST]
- (AGNT) -> [PLAYER]
- (TIM) -> [TIME: Now]
- (CON) -> [IN THE CAVE]

To determine the emotion associated with each event the agent combines the emotions associated with each entity. This is calculated using appraisal dimensions.

Smith and Ellsworth's experimentation and analysis outlined in (Smith and Ellsworth 1985), identifies six orthogonal appraisal dimensions: *pleasantness, anticipated effort, certainty, attentional activity, responsibility and control*, across 15 emotions: *happiness, sadness, anger, boredom, challenge, hope, fear, interest, contempt, disgust, frustration, surprise, pride, shame and guilt*.

Figure 2 displays two of the orthogonal dimensions (pleasantness and control) and where the 15 emotional states are positioned with respect to them. The empirical values for the positions of the pure emotions comes from Smith and Ellsworth’s original study (Smith and Ellsworth 1985).

For each element $e$, in an event $E$, the emotional state, $\Omega_e$ is defined as Expression 2:

$$\Omega_e = \{P_e, E_e, C_e, A_e, R_e, O_e\}$$

(2)

Based on the outcome of event $E$, the agent will assign a weighting $w$, to the emotional state of each of the elements, $e$. This weighting describes how much influence the element has over the outcome of the event. As the weighting of an element and resulting emotional state with respect to an event are dynamic, the time, $t$, at which the emotional state is being calculated must also be taken into consideration. Therefore, the emotional state resulting from an event $E$, written as $\Omega_{E,t}$ is calculated as Expression 3:

$$\Omega_{E,t} = \sum_{e=1}^{n} W_{e,t} \Omega_{e,t}$$

(3)

---

3 A full explanation and calculation of the appraisal dimensions can be found in Baillie 2002.
where \( n \) is the number of elements associated to event \( E \), and

\[
0 \leq w_i \leq 1 \quad \text{and} \quad \sum_{i=1}^{n} w_i = 1
\]

Once an event has been completed, each of the elements involved in the event have their emotional states updated with respect to the change in the emotional state of the agent (or the agent’s mood) evoked by the outcome of the event, \( \Omega_{O,t+1} \).

\( \Omega_{O,t+1} \) represents the emotional state of the agent after an event has occurred where \( O \) stands for the outcome emotion and \( t+1 \) is the time at which the event ended.

A change in the emotional state of the agent occurs when the values for each of the appraisal dimensions (P, E, C, A, R, O) are updated during and after an event. While each of six appraisal values of an individual element involved in the event influence how these values are changed for the agent’s emotional state, the final emotional state cannot be determined before the event occurs. The agent can only speculate. For example, an event the agent believes will make the agent happy may fail during execution, may take longer to complete than initially thought or may require extra effort. These factors would change the values of the appraisal dimensions independently of any influence over these values by the elements of an event or the event itself. The resulting emotional state in this example may be sad rather than the expected happy. Therefore, \( \Omega_{O,t+1} \) cannot be calculated by combining the appraisal dimensions of the elements of an event, but can only be determined after the event has been executed. Only then can an analysis of the appraisal dimensions take place. This would include values from the appraisal dimensions of the elements in the event and also takes into consideration changes in the agent’s physical and mental states. The new emotional state of the agent is used to update the values of the appraisal dimensions for each of the event elements. The agent attributes a change in its emotional state to be the result of the event and therefore, updates the emotional state of the event and its elements accordingly.

The change in the emotional state of an event is calculated using Expression 4:

\[
\Delta_{\Omega} = \Omega_{E,t+1} - \Omega_{E,t}
\]  

After this has been calculated the emotional states for each element in the event set can be updated as Expression 5:

\[
\Omega_{e,t+1} = \Omega_{e,t} + w_{e,t+1} \Delta_{\Omega}
\]  

Instead of the element taking on the final emotional state of the event, the previous emotional state of the element is taken into account along with the effect the element had in the resulting emotional state for the event. If the event’s resulting emotional state is the same as its initial state and \( w_{e,t} = w_{e,t+1} \) then the emotional state for the element will not change.

For example, assume an event \( E \) with two elements A and B. At the beginning of the event, elements A and B both have emotional states of happiness\(^4\), that is:

\[
\Omega_{A,t} = [-146, -33, -46, 15, 9, -21] \\
\Omega_{B,t} = [-146, -33, -46, 15, 9, -21]
\]

and weightings of 0.2 and 0.8 respectively, thus:

\[
w_{A,t} = 0.2 \\
w_{B,t} = 0.8
\]

This would result in the emotional state for the event before execution as:

\[
\Omega_{E,t} = w_{A,t} \Omega_{A,t} + w_{B,t} \Omega_{B,t} \\
= 0.2 \times [-146, -33, -46, 15, 9, -21] + \\
0.8 \times [-146, -33, -46, 15, 9, -21] \\
= [-146, -33, -46, 15, 9, -21]
\]

\(^4\) Values used here are indicative of the values obtained from Smith and Ellsworth's study.
In other words, a happy event. Assuming that after the event has occurred, the outcome results in an emotional state of happiness and A and B are still weighted the same then both A and B can be updated using Expression 5 as shown below.

\[ \Omega_{A,t+1} = \Omega_{A,t} + W_{A,t+1}(\Omega_{O,t+1} - \Omega_{E,t}) \]
\[ = ([-146, -33, -46,15, 9, -21] + \\
0.2([-146, -33, -46,15, 9, -21] \\
- [-146, -33, -46,15, 9, -21]) \\
= [-146, -33, -46,15, 9, -21] \]

\[ \Omega_{B,t+1} = \Omega_{B,t} + W_{B,t+1}(\Omega_{O,t+1} - \Omega_{E,t}) \]
\[ = ([-146, -33, -46,15, 9, -21] + \\
0.8([-146, -33, -46,15, 9, -21] \\
- [-146, -33, -46,15, 9, -21]) \\
= [-146, -33, -46,15, 9, -21] \]

When the same event’s emotional state needs to be calculated in the future it will again be evaluated, using Expression 8, to be happy. However, if the final emotional state of the event changes from its initial state, the emotional states for the elements will change.

For example, imagine the same event is to occur again. This time the elements A and B are weighted initially as before (0.2 and 0.8 respectively) but after the event the emotional state is sad and the weightings of A and B are now 0.4 and 0.6, respectively. Given the new emotional state of E and the weighting of A and B after the event, the new emotional states for A and B can be calculated as:

\[ \Omega_{A,t+1} = \Omega_{A,t} + W_{A,t+1}(\Omega_{O,t+1} - \Omega_{E,t}) \]
\[ = ([-146, -33, -46,15, 9, -21] + \\
0.4([-75, -14,0, -21, -36,151] - \\
[-146, -33, -46,15, 9, -21]) \\
= [-75, -14,0, -21, -36,151] - \\
[-146, -33, -46,15, 9, -21]) \\
= [-146, -33, -46,15, 9, -21] + \\
[93.2, 7.6, -18.4, -14.4, -18,68.8] \\
= [-58.8,-25.4,64.4,6,-9,47.8] \]

\[ \Omega_{B,t+1} = \Omega_{B,t} + W_{B,t+1}(\Omega_{O,t+1} - \Omega_{E,t}) \]
\[ = ([-146, -33, -46,15, 9, -21] + \\
0.6([-75, -14,0, -21, -36,151] - \\
[-146, -33, -46,15, 9, -21]) \\
= [-146, -33, -46,15, 9, -21] + \\
[139.8,114.4,-27.6,-21.6,-27,108.2] \\
= [-6.2,-21.6,-73.6,-6.6,-18,82.2] \]

Essentially, this moves the emotional point for each of the elements closer to the final emotional state for the event by using the weightings to add a portion of the vector from E_t to E_{t+1} onto the emotional states for A and B.

Once the agent has calculated the emotional points for each of the events and in turn each element involved in an event, the agent can use this emotional point in its affective decision-making process.

**EVALUATION OF AN EMAI AGENT**

The primary use of the EMAI architectures has been in the development of believable artificial characters, either human or animal-like for virtual reality and computer games. In this domain, the agent should produce performances that create a suspension of disbelief for the user. To create this illusion the agent should be able to simulate emotion, motivation, and personality (Pisanich and Prevost 1996).
The evaluation of the EMAI architecture was conducted using 18 volunteer evaluators who were asked to contribute between one and one and a half hours of their time for the evaluation of the software. The evaluators included nine members of the public and 9 first year university students. An introductory verbal explanation and walk-through of the EMAI agent interface (shown in Figure 3) was presented to each participant.

The evaluators were given an instruction sheet that outlined the user interface and explained the function of each of the buttons, textboxes and gauges that appeared on the interface. Once each participant was clear on how the interface functioned, they were asked to begin the simulation of the pet dog Fido. The evaluators were given a set of five walk-through exercises to perform with the agent. This ensured that each participant had a similar interactive experience with Fido. While running the simulation the evaluators were asked to fill out the questionnaire to evaluate different aspects of the agent, including how the agent set goals, produced emotions and behaved. The simulation produced a narrative as it ran. Stop and Start buttons on the user interface allowed the participant to stop the simulation and read back over the narrative before answering any of the questions.

In brief, the Fido agent will play, eat or sleep. In association with its actions are items in its environment. For example, Fido could choose to play by chewing on a shoe. In keeping with the Theory of Reasoned Action, [CHEW] is the action and the object is [SHOE]. At any time during the simulation the user could tell the agent whether or not they thought its actions were good or bad. The agent would then associate unpleasant emotions with the elements of the event being performed when the bad button was pressed and pleasant emotions with the elements when the good button was pressed. In the exercises, the evaluators were asked to train Fido's behaviour using the good and bad buttons.

The procedure mentioned above was repeated for a second model of the agent. This second model, without the participant’s knowledge, simulated the same pet dog Fido, but this time with random goal setting, random emotion generation and random behaviours. This provided a benchmark for the Fido model that used the EMAI architecture. If a participant had not experienced this type of interaction with a computer character before, their initial response to the EMAI model could have been positive to the extent that it biased their judgment and responses on the questionnaire. By including a Fido character with random emotions and behaviours it provided a calibration point for the data collected from the survey about the EMAI model. Due to the random model’s randomised behaviours, it was expected that some of the time the agent would act in a manner that the evaluators think is appropriate and other times it would not. Half of the evaluators began their evaluations with the EMAI model. This was followed by an evaluation of the random model. The other half of evaluators began their evaluations with the random model and continued afterwards with the EMAI model. The evaluators were not aware which model was which. Evaluators completed the entire evaluation questionnaire with one agent model before beginning again with the other.
**RESULTS AND DISCUSSION**

Due to space considerations only key results relating to the agent’s emotional behaviour will be presented in this section.

The emotional mechanism is closely tied to the outward behaviours of the agents. Evaluators had to rely on the outward behaviour of the agent to evaluate the agent’s emotion forming abilities. Of course, this is always the case with computer character interaction as the user is not aware of the internal mechanisms driving the character. Although motivation, learning and emotions were evaluated separately from behaviour, the results obtained for the agent’s capacities were essentially the evaluator’s evaluation of the agent’s behaviour. For this reason, several questions about the agent’s behaviours were also asked (see Table 1).

Although evaluators were asked questions relating to intelligence, motivation, goals and emotions, the evaluation of these categories relied on how the evaluators viewed the outward behaviour of the agents. In the debriefing the evaluators were asked to rate the agent’s behaviours on two scales, one for reasonableness and one for predictability. The evaluators thought the EMAI model produced behaviours that were significantly more reasonable and predictable than the random model. It is ideal that the EMAI model was rated highly for both reasonableness and predictability as the architecture was designed with these characteristics in mind.

However, while these results seem in favour of the EMAI model, the evaluators also needed to be asked if they thought the models met their expectations of computer generated characters. The EMAI model may be able to produce reasonable and predictable behaviours but if these characteristics are not expected in a computer generated character then the architecture may need to be modified when used for this purpose.

Evaluators were given the opportunity in the evaluation to comment freely on their expectations of the models. Typical comments received about the EMAI model included:

*He responded well to positive and negative reinforcement, acting in a logical fashion with enough randomness of behaviour to discover and evolve new ways of interacting with his world.*

and

*Sometimes he can be a bit predictable but overall yes. He is motivated by his goals and urges and will try different approaches if he does not get them.*

Throughout the evaluation the evaluators were asked to answer questions about the reasonableness of the agent’s emotional states and how they thought these emotions were affecting

<table>
<thead>
<tr>
<th>Question</th>
<th>EMAI Yes</th>
<th>Random Yes</th>
<th>$\chi^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think that Fido set’s goals?</td>
<td>78%</td>
<td>11%</td>
<td>16.20</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>Did Fido ever perform actions that were not related to his WANTS?</td>
<td>44%</td>
<td>78%</td>
<td>4.21</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Do you think that Fido can formulate ways in which to satisfy his goals?</td>
<td>83%</td>
<td>11%</td>
<td>18.84</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>Do you think that Fido tries other plans of action when one fails?</td>
<td>89%</td>
<td>33%</td>
<td>7.20</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Do you think that Fido shows the ability to form attitudes?</td>
<td>89%</td>
<td>7%</td>
<td>25.08</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>Do you think that Fido uses his attitudes to make decisions?</td>
<td>89%</td>
<td>11%</td>
<td>21.78</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>Do you think that Fido shows the ability to form emotions?</td>
<td>100%</td>
<td>28%</td>
<td>20.35</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>Do you think that Fido’s emotions influence his behaviour?</td>
<td>100%</td>
<td>60%</td>
<td>7.89</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>Another definition of intelligence is the ability to adapt to certain environmental changes. Do you think that Fido has this form of intelligence?</td>
<td>94%</td>
<td>22%</td>
<td>13.31</td>
<td>&lt;0.0005</td>
</tr>
</tbody>
</table>

Table 1. Comparisons between the EMAI and Random agents
the agents’ behaviour. Some initial questions asked the evaluators to rate the agents’ emotional states with respect to agent’s current behaviour and the evaluators’ interaction. The EMAI model rated favourably on both these aspects. With respect to the agent’s emotional states and current behaviours, the mean responses obtained for the EMAI model show the emotion producing mechanisms present in the EMAI architecture are working to produce a computer character that is capable of producing quite reasonable emotional states from an onlookers point of view (see Table 2).

<table>
<thead>
<tr>
<th>Question</th>
<th>EMAI</th>
<th>Random</th>
<th>t (P=.&lt;.0005)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Int</td>
<td>Mean</td>
</tr>
<tr>
<td>Do you think that the actions that Fido performs throughout the simulation meet your expectations of a computerised character?</td>
<td>5.83</td>
<td>0.015</td>
<td>3.56</td>
</tr>
<tr>
<td>Do you think the emotions produced by Fido seem reasonable?</td>
<td>6.06</td>
<td>0.015</td>
<td>2.39</td>
</tr>
<tr>
<td>During your interaction with Fido did you find that Fido produced actions that you thought were outrageous or out of the ordinary?</td>
<td>2.16</td>
<td>0.019</td>
<td>4.61</td>
</tr>
</tbody>
</table>

Table 2. Evaluations of the agents' emotions.

The random model, while not rated as totally unreasonable, was expected to produce mediocre results. Due to the nature of the randomness of the emotions produced there was always a possibility the agent, by coincidence, would meet the evaluators’ expectations.

**CONCLUSIONS AND FURTHER WORK**

Having completed an evaluation of the EMAI architecture in the form of a simple pet dog and a comparison of its performance against a randomly programmed model, an issue has arisen that questions the depth of architecture needed to create a suspension of disbelief. During the evaluation, the random modelled pet dog performed in a manner that was acceptable to the evaluator. While the EMAI model did outperform the random model, the depth of the EMAI architecture may have implemented more mechanisms than necessary in order to fool the user.

Stern in (Hirsh 1998) identifies some key characteristics for the successful creation of a computerised character. He suggests they need to

- act like humans – to use natural language, reason and discuss events;
- have knowledge about their world and memories of personal history; and
- exhibit emotions and personalities that fuel their motivations and desires.

Stern also explains one important key point in the development of a life-like computerised character. All they need to do is make the user believe they are real. The characters do not have to be internally alive, just perceived as such. This approach is called user-perception-based development.

This research could lead to the development of a computer character generation engine. Similar to a games engine, this would allow novice programmers and applications developers easy access to building computerised gaming characters with the EMAI architecture without having a depth of knowledge that spans conceptual graph theory, cognitive appraisal theories of emotion and goal setting and planning. Rather an ideal front-end could be written that makes the internal workings of an EMAI agent invisible to the developer. This way creative designers could put more energy into the development of the personality and background of the character rather than be concerned with artificial intelligence concepts.

This type of application would require extensive research into the psychology of human-computer interaction, what the user believes they are perceiving when interacting with a computer generated character and the tools needed by games developers and interactive fiction writers.

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Dr Penny Baillie-de Byl is a lecturer at the University of Southern Queensland in Australia where she teaches Computer Graphics and Multimedia Programming. She has been working in the domain of affective computing since 1996. She has a number of internationally published papers in the area of emotionally intelligent agents and has presented at conferences both in Europe and Australia. Her second research interest is in the area of online assessment authoring tools for learning management systems.