An Event-based Implementation of Emotional Agents

Mohammad Kazemifard, Nasser Ghasem-Aghaee
Department of Computer Engineering,
University of Isfahan, Isfahan, Iran
kazemifard@eng.ui.ac.ir
aghaee@eng.ui.ac.ir

Tuncer I. Ören
M&SNet: OC-MISS (Ottawa Center of the McLeod Institute of Sim. Sciences)
SITE, University of Ottawa
Ottawa, ON, Canada
oren@site.uottawa.ca

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Abstract

Emotions play a significant role in the process of decision making and render it much more complicated. Several models have already been discussed and introduced using emotions for the process of decision-making. Each model has its own merit. In this paper, a model of emotion is used in order to process the triggering events to possibly induce emotions and also to evaluate the emotions. An event-based implementation is presented. The model has the advantage of being implementable easily.

1. INTRODUCTION

Many early researchers in artificial intelligence field focused mainly on rational aspect of decision-making. However, emotions have an important role in human behavior. Since the decision-making process is essentially complex, incorporation of emotions requires more elaboration to the decision making process [Gratch 2000, Johns and Silverman 2001]. Believable agents require the emotional factors in their decision-making processes to display behavior analogous to humans. M.Minsky concluded that: "The question is not whether intelligent machines can have any emotions, but whether machines can be intelligent without any emotions" [Minsky, 1986]. According to this theory several models are represented [Poel et al., 2004]. Each of these models assesses a part of this process. The FLAME (Fuzzy Logic Adaptive Model of Emotions) model is a very good model among them [El-Nasr et al. 2000].

This article outlines the mapping of emotion-triggering events to emotions, updating the emotions and selection of behaviors. The purpose of this research is offering a model that in addition to cover throughout the emotional process can easily be implemented and utilizes its outputs in decision-making. In this article, Section 2 outlines a model for evaluating the emotions; Section 3 describes the structure of the suggested model. In Section 4 and 5, this suggested model is illustrated. Section 6 describes the simulation of this model and finally Section 7 presents the conclusion and future work.

2. EVALUATION OF EMOTIONS

At first, we need a model which is able to evaluate all of the conditions that the agent would be encountered with, for analyzing the emotions. There are a variety of models for emotions [Ortony and Turner, 1990]. The one developed by Ortony et al. (1988) represents a computational model for emotions [Bartneck, 2002]. This model is recognized as OCC (the abbreviation of their names) and indicates a standard model for analyzing emotions. This model denotes twenty two types of emotions. According to the type of the emotions, the structure of OCC model is partitioned to three branches. The first branch relates to the appraisal of the desirability or undesirability of events with respect to the agent's goals. The second branch relates to the appraisal of the approval of the actions of the agent(s) with respect to a set of standards for behavior. The third branch relates to the appraisal of the liking or disliking of objects with respect to the attitudes of the agent [Ortony et al., 1988]. In this research, only the first branch is considered.

3. SUGGESTED MODEL

The agents need three modules to process emotions. These modules serve to: evaluate the triggering events; update emotions, and select proper behavior. The overall diagram of this model is illustrated in figure 1.

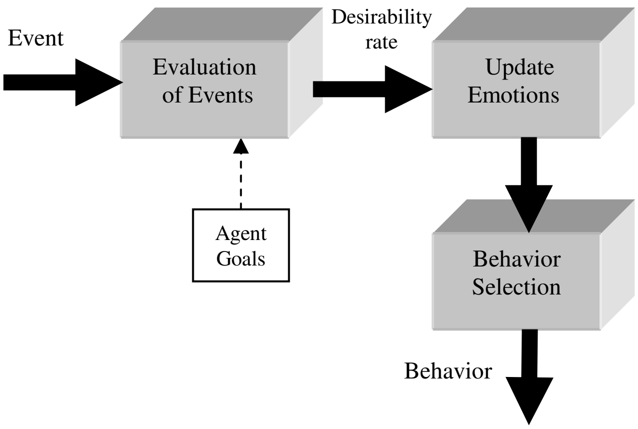

Figure 1: The emotional model

"Evaluation of events" module processes the triggering input events according to the goals of agent and then specifies the emotion and its degree of its desirability. Using FLAME model [El-Nasr et al., 2000], a new method will introduce the evaluation of the events in this module. Then the "Update emotions" module specifies the current emotion and its intensity. Afterward, the "Behavior selection" module will produce the proper behavior, based on the intensity of the emotion. In this article, we will concentrate on the "Evaluation of events" module and "Update emotions" module.

4. EVALUATION OF EVENTS

A complete evaluation of events, require the following points:

1. Each agent has a number of goals which may have different importance as indicated in weighting factors.
2. The degree of impact of input event on agent goal(s)
3. The degree of desirability to be determined by using points 1 and 2.

The FLAME model represents the importance of goals by fuzzy variable *Importance*, the degree of event impact on goals by fuzzy variable *Impact* and the degree of desirability by fuzzy variable *Desirability*. The fuzzy sets are as follows:

Impact ={HighlyPositive, SlightlyPositive, NoImpact, SlightlyNegative, HighlyNegative}
Importance ={NotImportant, SlightlyImportant, Extremely Important}
Desirability={HighlyUndesired, SlightlyUndesired, Neutral, SlightlyDesired, HighlyDesired}

The degree of desirability is determined by the following fuzzy rule:

IF		Impact(G_1,E) is A_1
	AND	Impact(G_2,E) is A_2
		…
	AND	Impact(G_k,E) is A_k
	AND	Importance(G_1) is B_1
	AND	Importance(G_2) is B_2
		…
	AND	Importance(G_k) is B_k
THEN		Desirability(E) is C

Where k is the number of goals involved. A_i, B_j, and C are represented as fuzzy sets, as described above. This rule reads as follows: if the goal, G_1, is affected by event E to the extent A_1 and goal G_2 is affected by event E to the extent A_2, etc., and the importance of the goal, G_1, is B_1 and the importance of goal, G_2, is B_2, etc., then the desirability of event E will be C.

For example, if agent goal is "prevent starvation" and input event is "food dish taken away", then the desirability rate of this event would be [El-Nasr et al., 2000]:

IF Impact (prevent starvation, food disk taken away) is HighlyNegative
AND Importance (prevent starvation) is ExtremelyImportant

THEN Desirability (food dish taken away) is HighlyUndesired

Evaluation of events in this way entails the following problems:

1. Fuzzy deduction engine is needed
2. If the domain has large number of goals and events, then a large number of fuzzy rules are needed.

For solving this problem, the following method is represented. In this method, the goals are showing like a vector named G: (Eq.1)

$$G = \begin{pmatrix} g_1 \\ g_2 \\ \cdots \\ g_n \end{pmatrix} \forall i \in [1,n] : g_i \in [0,1] \qquad (1)$$

Where g_i is the importance of each goal. Also in using an *Impact* matrix, for showing the impact of events on goals, each element of the matrix is the impact degree of events on goals; and m is the number of events: (Eq.2)

$$Impact(m*n) = \begin{pmatrix} \alpha_{11} & \alpha_{12} & \dots & \alpha_{1n} \\ \alpha_{21} & \alpha_{22} & \dots & \alpha_{2n} \\ \dots & \dots & \dots & \dots \\ \alpha_{m1} & \alpha_{m2} & \dots & \alpha_{mn} \end{pmatrix} \quad (2)$$

$$\forall i \in [1,m]; j \in [1,n] : \alpha_{ij} \in [-1,1]$$

The desirability of each event can be computed by using the following formula: (Eq.3)

$$Desirability(e_i) = \frac{\sum_{j=1}^{n} \alpha_{ij} g_j}{\sum_{j=1}^{n} g_j} \quad (3)$$

$$\forall j \in [1,n] and \forall i \in [1,m], Desirability(e_i) \in [-1,1]$$

Note that, we consider two states success and unsuccessful for each event.
Now an example illustrates this suggested model which was also solved by FLAME model. Suppose that the agent has two goals "is alive" and "prevent starvation".

$$G = \begin{pmatrix} g_{\text{is alive}} \\ g_{\text{prevent starvation}} \end{pmatrix} = \begin{pmatrix} 1 \\ 0.7 \end{pmatrix}$$

And the events are:

$$events = \begin{pmatrix} \textit{food} \text{ dish taken away} \\ \textit{water} \text{ dish taken away} \\ \textit{food} \text{ dish taken} \end{pmatrix} \qquad \text{Impact} = \begin{pmatrix} -0.8 & -1 \\ -1 & -0.1 \\ 0.8 & 1 \end{pmatrix}$$

For instance, first row of *Impact* matrix, i.e. (-0.8,-1), shows that the impact degree of "food dish taken away" on goal "is alive" is -0.8 and on goal "prevent starvation" is -1. Now the desirability degree of event "food dish taken away" is given as follow:

$$Desirability(food\ dish\ taken\ away) = \frac{-0.8*1+(-1)*(0.7)}{1+0.7} = \frac{-1.5}{1.7} = -0.88$$

By stating it with fuzzy logic, it would be the same *highly undesired*. Therefore, we can gain the following vector for desirability rate, by using the above formula (Eq. 3):

$$desirability = \begin{pmatrix} -0.88 \\ -0.51 \\ 0.88 \end{pmatrix}$$

The proposed method has the following advantages:

1. Does not need a deduction engine.
2. The desirability degree can be computed by using a straightforward mathematical presentation.
3. Simple implementation for agents with large number of goals and events.

5. UPDATE THE INTENSITY OF EMOTIONS

After specifying the desirability degree with "evaluating of events" module, the intensity of emotions is updated with respect to this degree. Here, two OCC classes, namely *prospect-base* and *well-being* are used; they generate the emotions relevant to events. The impacts of triggering events on the types of emotions are shown in Table 1. By using the following overall rule, emotions can be updated. For instance, emotion *Joy* has:

$$\begin{aligned} &If \quad P_{joy} > T_{joy} \quad Then \quad I_{joy} = P_{joy} - T_{joy} \\ &Else \quad I_{joy} = 0 \end{aligned}$$

In this rule, P_{joy} is the potential of emotion *joy* based on desirability degree of input event, T_{joy} is the appearance threshold of emotion *joy* and I_{joy} is the intensity of *joy* [Adamatti et al., 2001].

Table 1: The impact of triggering events on the types of emotions

	Desirable event	Undesirable event
Occurrence of	*Joy*	*Distress, Anger*
Waiting for	*Hope*	*Fear*

		In hope state	In fear state
Expected event	**Occurs**	*Satisfaction*	*Fear -confirmation*
	Does not occur	*Disappointment*	*Relief*

5.1. Computing the Potential Value

Some rules for computing the potential value of any emotion are given in the sequel; where *D (e, t)* is the desirability of event *'e'* at time'*t*':

Joy	: If D(e,t)>0	Then	P_{joy}	=D(e,t)
Distress	: If D(e,t)<0	Then	$P_{distress}$	=|D(e,t)|
Hope	: If D(e,t)>0	Then	P_{hope}	=D(e,t) *likelihood(e)
Fear	: If D(e,t)<0	Then	P_{fear}	=|D(e,t)*likelihood(e)|

In these rules, P_{hope} and P_{fear} are the result of the production of desirability rate and their event probabilities. The emotions *satisfaction, disappointment, fear-confirm* and *relief* are generated as follows:

If	believe(e,t_2)	Then	$P_{satisfaction}$	$=P_{hope}(t)$
If	disbelieve(e,t_2)	Then	$P_{disappointment}$	$=P_{hope}(t)$
If	believe(e,t_2)	Then	$P_{fear\text{-}confirm}$	$=P_{fear}(t)$
If	disbelieve(e,t_2)	Then	P_{relief}	$=P_{fear}(t)$

Where *believe(e, t2)* indicates the event occurrence which is expected to be happened at time $t_2>t$. Note that the two parameters *effort* and *realization* which are the effort rate of agent to get the goal and realization degree of that goal, respectively, are effective in computing the four last emotions, but computing of these parameters is outside the scope of this article.

6. SIMULATION

Here, the model is simulated by using two character *mouse* and *cat*. "The world is a two-dimensional 10*10 square grid where cats, mice and foods are randomly placed. Mice have to look for food and run away of the attack of the cats. The cats look for mice, kill them and eat them. The initial number of mice, cats and food are 20, 5 and 15, respectively. Cats and mice have initial strength of 20 points. Mice as well as cats can move four directions (up, down, right, and left), and at each movement they lose one point. Mice do not reproduce and they earn a score for each food that they eat (5 points). Cats earn a score for each mouse that they kill and eat (10 points). Mice perceive cats in two grid positions regarding to each available direction. The simulation finishes when all mice are killed" [Adamatti et al., 2001]. (See also Figure 2).

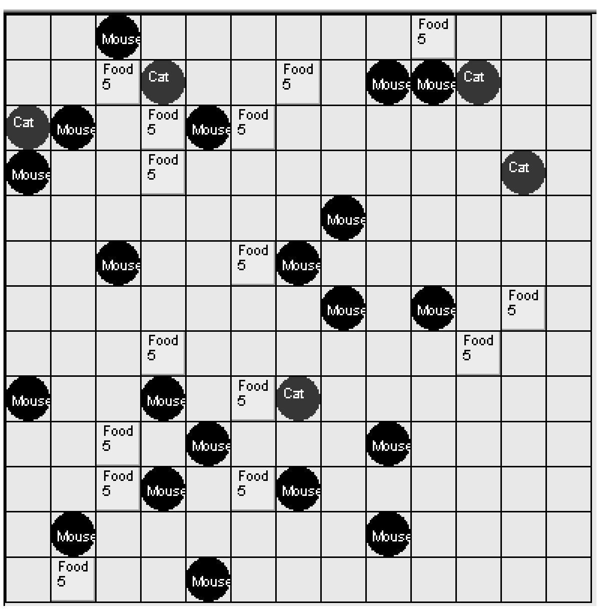

Figure 2: Simulation environment

In this simulation, the *mice* have only two emotions *hope* and *fear*. When a *mouse* feels a *cat* on its adjacency, has emotion '*fear*', otherwise has emotion '*hope*'. The intensity of emotion '*fear*' will determine with regard to number and distance of *cats*. When a *mouse* feels *fear*, it tries to runaway from *cat* and when feel *hope*, looking for *food*. We do the simulation for random motions, FLAME model and suggested model. The results have shown that the issues of our model are similar to FLAME model. Hence, a simple event-based computation scheme leads to equivalent results obtained by fuzzy logic.

7. CONCLUSIONS

In this research, a new emotional model in believable agents has been introduced. Also a new computational method is offered which is based upon the evaluation of events. With respect to the agent goals, the mathematical rules are used to mapping the impact of events on emotional states. This method benefits of the adaptability with different environments; and can be utilized as a separate module in intelligent applications and its outputs use for selection of proper behavior.

In our future work, we aim to perform experiments on more complex situations and to handle the *personality*, *motivational* and *mood* state for computations. Moreover, in this article we focused on only use emotions of two classes of OCC model. We aim to try to use the other emotions of this model in our computations. Also the impact of two parameters *effort* and *realization* will be assessed in computations.

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