

# A.I. Techniques for Modelling Anger in Emotional Agents

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## ABSTRACT

The research presented here, attempts to review a range of techniques commonly categorized under the umbrella of artificial intelligence (A.I.) that could be applied when developing agents with emotions in a range of applications. The paper focuses on anger (and its related emotions), an emotion strongly linked with aggression which of course forms the basis of many computer games where killing or attacking other players or in-game agents is often central to the game's purpose. The paper begins with a psychology focused review of anger and its related emotions, before presenting techniques to encode some of these elements using Finite State Machines and Fuzzy Logic.

## 1 Introduction

Many modern computer games (and simulations) involve the user controlling a character on the screen that is sometimes referred to as an Avatar (especially when it represents their virtual self). This Avatar is moved through the virtual world using some form of interactive device such as a keyboard, joystick or mouse, completing tasks and/or interacting with objects and other characters that interest the user. Characters not controlled by a real human player are usually referred to by one of the following labels:

- If they provide information or non-combat interaction then they are often called **non player characters** (npc's), especially in multi user role playing games.
- In first person shooters the opponents are often called **bots** (*short for robots*).
- In many other games the opponents are often called **mobs** (short for monsters).

Because there will be continual reference to varieties of characters in numerous application areas, then any character (including non human) that is not controlled by the user will be referred to as agents. These agents are in essence controlled by software solutions, and currently there exists a wide range of techniques to alter their behaviour often referred to as A.I. by the developers. These techniques include chat systems that allow interaction between agents and users, path planning algorithms for traversing virtual worlds, and software solutions that alter an agent's behaviour to give them a seeming level of autonomy.

For the remainder of this paper *A.I.* refers to additions to an agent that make them behave more interactively and autonomously, and *emotions* as additions to agents that make them respond in a typical human way, including facial gestures of emotions, and behaviours that seem emotional to the user. A.I. techniques and emotion knowledge, are blended together to form the basis of the work presented here.

## 2 Finite State Machines

Finite state machines often abbreviated to FSM's, are commonly used when the developer needs to cycle through different agent's behaviour depending on an external stimulus such as (figure 1):

- an agent that can **patrol** when no threat is around
- **guard** when an enemy has been detected
- and **attack** when threatened

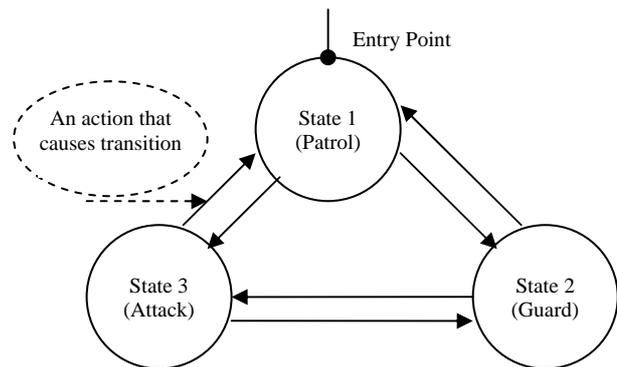


Figure 1 - a FSM for simple agent behaviour

The action that causes the transition can vary from a simple variable threshold, to a range of input conditions that can cause a state change. Important notes are that:

- only one state at any time can be active, therefore care needs to be taken to ensure that actions that cause transitions, do not cause activation for multiple states at once. If this is a possibility, then a priority system needs to be incorporated to ensure dominance of a particular state.
- it is customary to start in a particular state (entry point).
- the state diagram should include all possible changes to a particular state i.e. a finite number of possible states.

In a software solution each state could be represented by a series of Case statements as shown in figure 2.

```

Select Case
{
  Case 1: Patrol
  {
    // Patrol Behaviour
    Actions
  }
  Case 2: Attack
  {
    //Attack Player
    Actions
  }
  Case 3: Guard
  {
    //Guard Something
    Actions
  }
}
  
```

Figure 2 – Case Statements used to represent FSM's

Case statements can easily be substituted for “IF” “Then” “Else” statements to represent the FSM’s, though neither approach offers much scope for further expansion. For more scalable solutions a State Transition Table (Table 1) can be used in conjunction with one of several approaches including look up tables, databases or for the most versatile approaches using XML to represent the state transition information or state design patterns[Gamma et al 1995] to represent the data.

State	Action	Transition to State
Patrol	Enemy Sighted	Guard
Guard	Enemy in Melee Distance	Attack
Attack	Enemy Dead	Patrol

Table 1 – Sample State Transition Table

Examples of FSM’s being used in commercial computer games are widespread and include agent behaviour in Quake<sup>1</sup> and PacMan<sup>2</sup>

## 2.1 Emotions and FSM’s

Referring back to FSM’s and work previously conducted in understanding terminology related to emotions [Slater et al 2006], it seems that it is feasible to model some of the transitions associated with emotions such as “frustration to anger” using finite state machines. This approach would move one step closer to providing a more logical approach for facilitating the addition of emotions to software agents.

## 3 Anger

Anger is often categorized as a basic emotion [Ekman et al 2003] because of its often easily recognizable physical characteristics such as reddening of face and the tendency to move closer towards the trigger stimulus. Common beliefs as to why anger exists include a mechanism for dealing with threats (physically and to the ego), a tool for influencing the behaviour of others, and a way of controlling social situations by asserting a dominant position [Berkowitz 1993].

Because of its association with aggressive behaviour (although it does not always lead to such), and a broad range of published material, there is sufficient background information to allow the essential elements of a software model to be considered. This model could conceivably be applied to both agents in games and simulations where the aim is to create more human like characters, or anger’s close relations frustration and irritation that are essential focuses to consider when developing software interfaces.

Personality isn’t covered in detail in this work, but it is acknowledged that personality types may play a significant factor in the frequency and intensity of anger activation. For this work personality is used to describe prominent emotional-coping characteristics observed from individuals. These characteristics are usually categorised into personality type descriptions to help describe an individual’s general demeanour and behaviour.

### 3.1 Anger Stages

There is research to support the notion that anger is a broad title for one of eight possible categories as shown in figure 3 [Potter-Efron 2004]

2004], where the actual type of anger experienced, is dependant on the appraisal of the anger appraisal event.

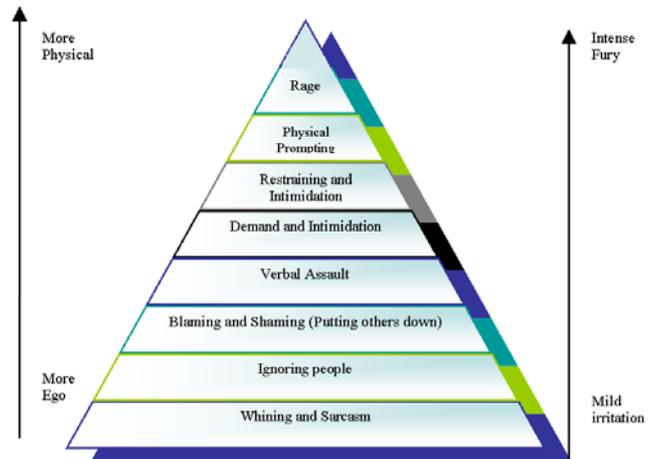


Figure 3 – Eight Levels of Anger [based on Potter-Efron model 2004]

Lower, less intense levels of anger, such as “Whining and Sarcasm” tend to focus more on attacking the stimuli’s ego, and as the anger escalates the ego attacks are combined with a more physical approach. Eventually a state of rage is entered which has a tendency to always be physical aggression [Ekman et al 2003]. There is a propensity for anger to become self fuelled, thus much of the behaviour associated with angry individuals is aimed at getting a verbal or physical response back. Any such response will invariably always escalate the anger; examples are physical prompting i.e. pushing someone.

### 3.2 Anger Focus

Anger is typically focused inwards at ourselves, at someone else, at an inanimate object, or an animal. In the context of computer games and simulations these could also include npc’s representing virtual characters. Action taken as a consequence of anger activation can be controlled if the individual realises they are angry and is prepared to hold back the outward expression typically called anger management [APA 2008].

### 3.3 Anger Habituation

It is a widely supported concept that individuals have different trigger thresholds for emotions, and as with all emotions, anger can become habituated. This habituation means that the individual can be in an ongoing angry state without becoming conscious of it [Potter-Efron 2004], i.e. angry behaviour and affective states seem normal to the individual. This habituation may be because the trigger threshold for anger is low.

### 3.4 Anger Duration

Typically emotions only last a very short time, therefore any affective state following the activation of anger is something other than anger itself, possibly a mood. Anger decays slowly if its cause is not resolved, which means that anger triggers stay elevated (though it slowly decays) until it’s fully cooled down, this is in line with the fact that people who have experienced an angry event are more easily angered for a time afterwards.

<sup>1</sup> <http://ai-depot.com/FiniteStateMachines/FSM-Framework.html>

<sup>2</sup> <http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/9096/28869/01299397.pdf?temp=x>

### 3.5 Anger Triggers

An examination of much of the research that has been conducted into the causes of anger shows a varied and diverse range, as such only a selection of common triggers are highlighted in table 2:

CATEGORY	CAUSE OF ANGER	NOTES
Goals Violated	Blaming an object for a failed goal.	Depending on anger threshold and importance of goal, any anger response possible.
	Blaming self for a failed goal.	Possible to redirect anger outwards or feel disappointment, thus internalizing anger.
	Blaming someone else for a failed goal.	Depends if it was deliberate, if so likely to be more verbal, if deliberate then any anger response possible.
Physical Danger	Threat of physical harm and object can be overcome.	Any response possible dependant on personality type and severity of threat.
	Someone wishing you dead.	Likely to <i>Verbal Assault</i> or above.
	Being attacked and threat can be overcome.	Restraining and Intimidation and above depending on threat level.
	Being assaulted and threat can be overcome including being knocked over or pushed accidentally. Including accidental physical harm.	Any response possible based on personality type.
	Threats that can not be easily overcome and are not persistent.	May lead to redirected anger at an "easier" target.
Memory Related	Remembering angry moments, things that make you angry.	Any response possible.
Ego Threats	Seeing one of your social standards being violated.	Any response possible.
	Observing actions that conflict with your moral values.	
	Ideas and knowledge that are trusted, being challenged.	
	Being removed from decision processes affecting self.	
	Social disclusion Being ignored.	
	Social rejection.	
	Being sneered at. Being made fun of. Someone calling you names. Someone making faces at you and rolling eyes.	
	Being put down Someone acting superior. Telling people how to run their lives.	
	Being insulted.	
	Someone criticizing you.	
Other Emotion Triggered	Anger from frustration.	Any response possible.
	Anger from annoyance.	Any response possible.
	Anger from irritation.	Any response possible.
	Anger from shyness Anger from shame	Anger can become self directed.
	Anger from being surprised by someone who you do not like.	Any response possible.

Table 2 – Typical Anger Triggers

Where Ego in this instance incorporates Freud's description of Id, Ego and Superego [Mischel 1971].

### 4 Anger Transitions

#### 4.1 Annoyance to Anger

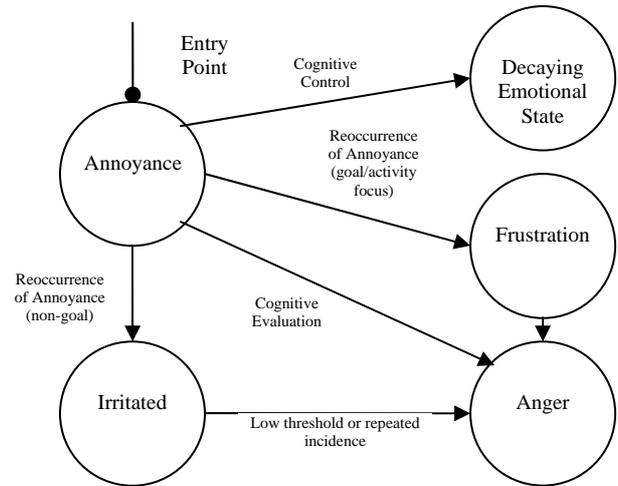


Figure 4 – Annoyance Transitions

Annoyance is less intense than anger, and can involve trigger actions that are not deliberate by others, and probably the first time the incident has happened. Whereas annoyance can be internalized and rationalized, anger is more likely to result in action against the source of the problem [Power et al 2003]. Repeated incidences of annoyance can lead to other states such as irritation and frustration.

#### 4.2 Frustration to Anger Transition

Frustration is usually caused by goals (actions) being thwarted or interfered with by an external entity [Ekman et al 2003]. The transition to anger is usually more likely if the act was deliberate (from the individual's point of view). Reoccurrence of the frustrating incidence usually increases the frustration level until it transitions into anger. Research in the area of frustration and anger is often based on the *Frustration-Aggression Hypothesis* [Dollard et al 1939], which suggests that frustration invariably leads to aggressive behaviour if not resolved. This can be both physical and verbal aggression and it should be noted that there are exceptions to this, where an individual has learned to control frustration [Fromm 1973].

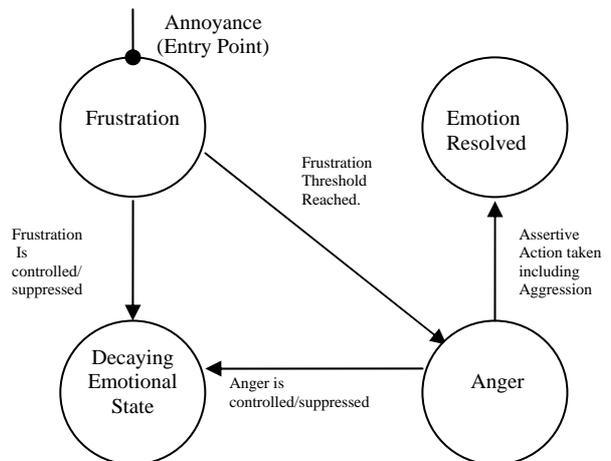


Figure 5 – Frustration to Anger Transition

## Notes on Modelling Frustration

Because of the subjective nature of frustration and little available information on modelling its implementation in software agents, the following are typical considerations:

- Entry into a state of a frustration requires an event as mentioned above.
- The event should not always result in a state change into frustration, and thus a trigger level needs to be assigned, that depending on computing resources could be as simplistic as a percentage value that is then evaluated using a random number. Alternatively more complex solutions can involve assigning a threshold value with a corresponding evaluation function that can evaluate a possible state change.
- Frustration could be assigned an intensity level to dictate behaviour whilst in the frustration state.
- Frustration is synonymous with the reoccurrence of an event, therefore single events may be better categorised as annoyance.
- Care needs to be taken to differentiate whether an angry response is more appropriate.
- Frustration can decay over time if the individual is pre-occupied or can control the frustration. i.e. “saying to self I will not get annoyed”, “cooling off” etc. This decay should be timed carefully as it is possible that any incidence during the cooling off period could transition to immediate anger.
- Some personality types get easily frustrated, these individuals have a tendency to have a lower activation level for frustration, and thus tend to be angrier people. Or alternatively angry people could be individuals who are easily frustrated when doing things in their lives (they place a higher value on activity completion than others).
- Frustration could be categorized as repeated annoyance (i.e. something not deliberate by cause of stimulus)

### 4.3 Irritation to Anger

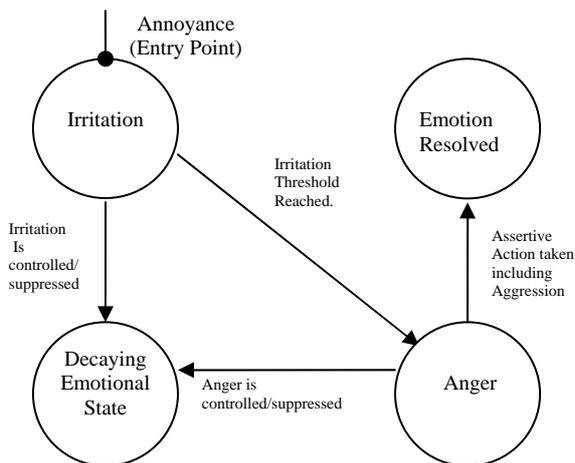


Figure 6 – Irritation to Anger Transition

Irritation is a similar state to frustration but encompasses reoccurrences other than goal directed including accidental happenings.

### 4.4 Grief to Anger

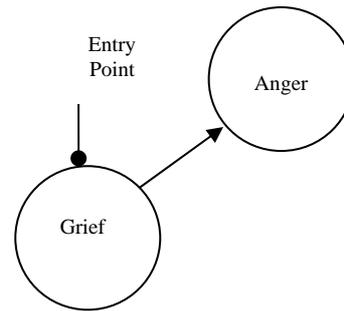


Figure 7 – Grief to Anger Transition

Grief is a variant of sadness, where individuals do not resolve sadness immediately after a loss, but retain the unresolved feelings which emerge later. Typically grief tends to be about the loss of a loved/respected figure in someone’s life. [Power et al 2003]. This late emergence of sadness (grief) can lead to anger at the loss of future shared experiences.

## 5 Anger Experienced With Other Emotions

It is widely accepted that some individuals feel happiest when they are in an angry state thus they may seemingly experience a variant of happiness and anger at the same time. This hypothesis is one possible explanation; another hypothesis is that the anger state for these individuals leads to happiness. Either approach could conceivably also apply to individuals who feel sadness or other emotions after becoming angry.

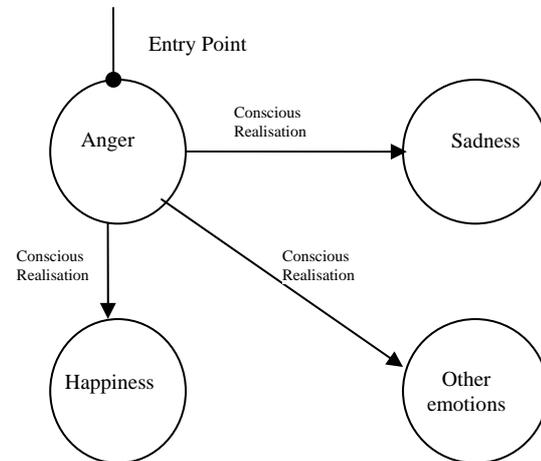


Figure 8 – Post Anger Emotion Transitions.

## 6 Pathological Anger Transitions

Though there is evidence and agreement that many anger transitions affect a wide range of individuals in a similar way, some individuals have developed non standard emotional responses and behaviour these are labelled as pathological emotions, examples include depression and anxiety.

## 6.1 Unresolved Anger

Anger that is not resolved or expressed can turn inwards to become depression (depression can also be activated more commonly by other emotions such as sadness and grief).

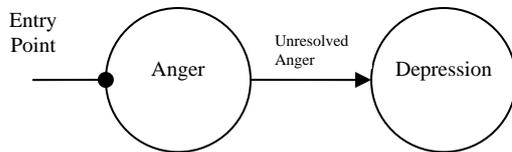


Figure 9 – Unresolved Anger Transitions.

For modelling it is:

- Unresolved anger.
- Directed at self.
- Tends to be stronger anger such as rage.

## 6.2 Difficulty Expressing Anger

Passive Aggressive Behaviour (Pathological Condition) – Getting at people indirectly/continual cynical or hostile behaviour, continually putting people down. This type of behaviour is common in people who have not learned to express their anger [APA 2008].

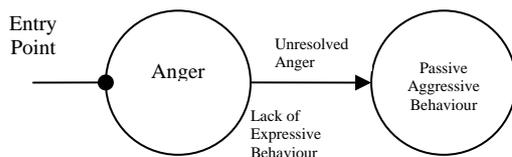


Figure 10 –Passive Aggressive Behaviour Transition.

## 7 Related Emotions: Envy to Hatred Transition

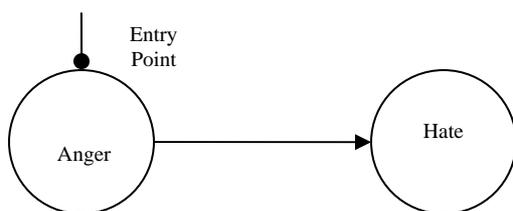


Figure 11 –Hatred Related Transitions

Hate is categorized in this paper as repeated activations of anger when:

- The individual appraises that the stimulus deliberately did something repeatedly that made them angry.
- Feelings of hatred can build over extended periods to provide a transition into contempt and disgust.

## 8 Anger and Memory

During anger, and its related states, there is a general consensus that memories of anger related events are more common and frequent [Gelman et al 2002]. This recall of memory is shared by other emotional states and is indicative that memories of events are in essence hard wired with an emotional significance.

## 9 Aggression

Aggression is defined as behaviour that causes harm either psychologically or physically to the victim. This aggression is widely recognized as either being hostile or instrumental:

- Hostile aggression is the category of offensive aggression that is directed towards another. This form of aggression is motivated cognitively without an immediate threat, and is often as a consequence of impulsive anger such as anger resulting from frustration [Dollard et al 1939].
- Instrumental aggression is a form of self-preservation aggression that is directed at immediate threats i.e. self defence. This form of aggression may require more calculated actions in order to remove an imminent threat and as such is often classified as a controlled form of aggression.

## 10 Fuzzy Logic

Traditionally it is common in software solutions, to include threshold values for certain variables so that for example

```
IF x = 10 THEN
{
  Do Something
}
```

Or alternatively include ranges such as

```
IF x>0 AND x<50 THEN
{
  Do something
}
Else
IF x>=50 AND x < 100 THEN
{
  Do something else
}
```

This style of programming and concrete boundaries (referred to a Crisp Sets [Buckland 2005]) is a well established method of organizing ranges of variables, and works well for many applications. When attempting to model emotional behaviour, a method is required to be able to represent emotional language i.e.

- I am feeling a little unhappy.
- I am really sad, but a little bit angry as well.

For these situations a more linguistic style of representation is needed and this is addressed by the use of Fuzzy Logic.

For this work, it is not the intention to delve into detail about the origin and use of fuzzy logic as much has already been written [Buckland 2005], instead applications to emotional significance of stimuli will be used to demonstrate the usage of Fuzzy Logic.

## 10.1 Fuzzy Logic and Emotional Appraisal

When a stimulus is detected, the individual needs to perform two kinds of appraisal, the first is a fast appraisal of threats which can quickly prepare the individual for a fight or flight response, called in psychology the low road [Le Doux 1998]. The other appraisal mechanism the high road [Le Doux 1998], is a more complex appraisal which identifies:

- 1) The emotional significance of an object i.e. if we like or dislike something.
- 2) Whether something is useful to us for a current goal or action.
- 3) The threat level of the object to our mental and physical well being.

It is suggested that object identifiers are stored with three variables representing each of the appraisal stages shown above so that they can be combined together to form a final assessment of the situation as shown in figure 12, 13 and 14.

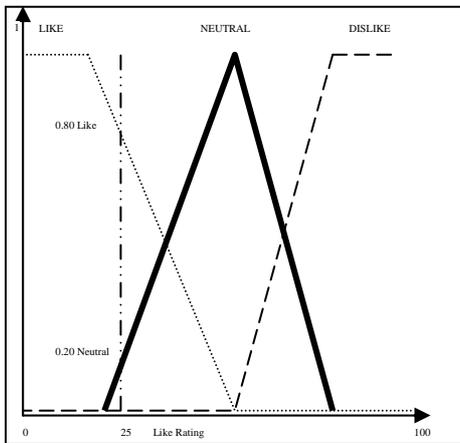


Figure 12 – Fuzzy Logic Emotional Appraisal for Liking.

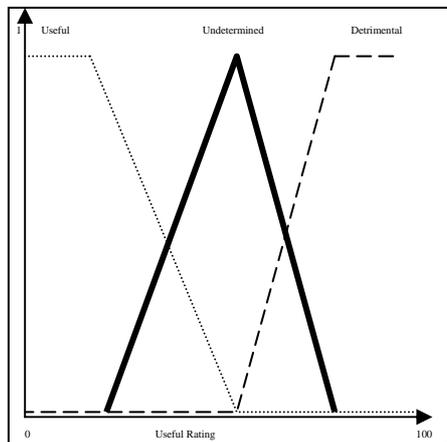


Figure 13 – Fuzzy Logic Emotional Appraisal for Useful.

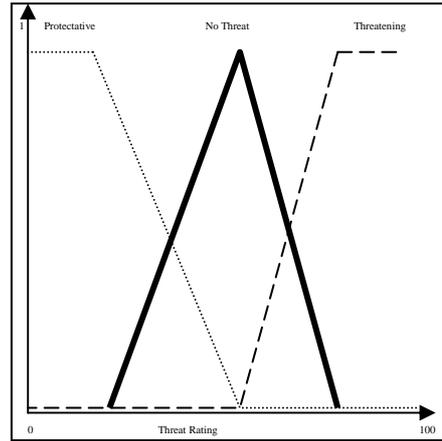


Figure 14 – Fuzzy Logic Emotional Appraisal for Threat.

As can be seen from the graphs, there are several areas that require explanation in order to understand how the graphs should be interpreted and used.

### 10.1.1 Activation levels

Each aspect to be represented such as *Like*, *Neutral* and *Dislike* (figure 12) requires the activation levels to be set by the developer. Referring to figure 12, if an agent has a *Like* rating of between 0 and 20 associated with a particular stimulus, then there is no doubt that the agent likes it. Alternatively if the stimulus has a like rating of 80 or above, then the agent dislikes it. For these examples the activation levels can be easily changed to reflect differing personality types such that, if dislike was set to 40 as shown in figure 15, then it is feasible that it is describing a personality that is not easily pleased.

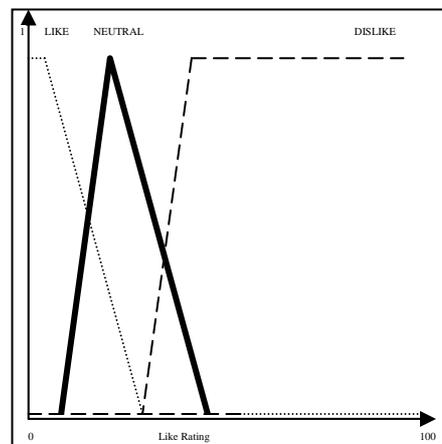


Figure 15 – Negative personality type graph for liking.

### 10.1.2 Mixed Feelings

It has been shown that at certain levels, *Like* and *Dislike* are clearly associated with specific stimulus, but what is certainly not clear is *Like* ratings between 20 and 80 where there is a blend of “Like & Neutral” and “Dislike and Neutral”. For this range, textual descriptions can be applied to describe the level of *Likeness* such that:

$$\text{Like}_{(\text{Agent X})} = F_{(\text{Like})} 25 = 0.80$$

$$\text{Neutral}_{(\text{Agent X})} = F_{(\text{Neutral})} 25 = 0.20$$

This could correspond to:

*I pretty much like Agent X when they are around, but I have some neutral feelings about their ability to help me.*

This textual description can be mapped to the *Like* rating as the developer chooses, as long as the logical text is applied consistently to all agents.

### 10.2 Combining Fuzzy Outputs

The three graphs shown for stimulus *Liking*, *Useful* and *Threat* can be used in conjunction with each other to provide a partial stimulus appraisal of anger i.e.

*If Stimuli Liked AND Stimuli Useful for a Goal AND Stimuli poses no Threat then Low Anger response.*

The possible combinations can be tabled for ease of reference thus:

Liking	Useful (undecided not shown)	Threat	Response
Like	Yes	Beneficial	Not Annoying
Like	Undecided	Beneficial	
Like	No	Beneficial	
Like	Yes	Undetermined	
Like	Undecided	Undetermined	
Like	No	Undetermined	
Like	Yes	Threat	
Like	Undecided	Threat	
Like	No	Threat	
Neutral	Yes	Beneficial	
Neutral	Undecided	Beneficial	
Neutral	No	Beneficial	
Neutral	Yes	Undetermined	
Neutral	Undecided	Undetermined	
Neutral	No	Undetermined	
Neutral	Yes	Threat	
Neutral	Undecided	Threat	
Neutral	No	Threat	
Dislike	Yes	Beneficial	
Dislike	Undecided	Beneficial	
Dislike	No	Beneficial	
Dislike	Yes	Undetermined	
Dislike	Undecided	Undetermined	
Dislike	No	Undetermined	
Dislike	Yes	Threat	
Dislike	Undecided	Threat	
Dislike	No	Threat	

Table 3 – Partial Stimulus Appraisal

The rules can be adjusted, rewritten or changed, and are purely one interpretation that can be mapped to an additional Fuzzy Graph as shown in figure 16.

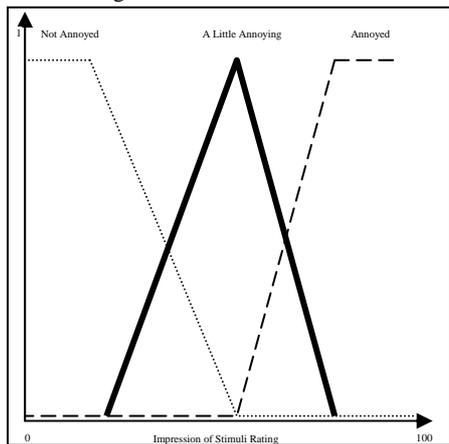


Figure 16 – Partial Anger Appraisal

These results could then feed into other parts of the appraisal mechanism in order to evaluate the stimulus's anger significance. Typically, other defuzzification techniques could be used dependant on the application, and the novel approach shown above is only one possible solution.

### 10.3 Additional Anger Dependencies

1. If the Agent has anger emotion related to an *Object*, *Other Agent* or *Avatar* and detects them, then they may become angry.
2. If the agent is, or is becoming angry and the anger is caused by something it has angry feelings about, then a higher level of anger is likely.
3. If another agent or Avatar is approaching, showing signs of anger and the agent also has anger or disgust related to them then they will become increasingly angry.

### 10.4 Combining Anger Appraisals

The output from table 3 can be combined with the additional Anger dependencies to create a final fuzzy chart as shown in Table 4.

Annoyance	Anger at Stimuli	Stimuli is showing signs of anger	Anger Response
<b>Lower importance</b>	<b>Greater importance</b>	<b>Lower Importance</b>	No Anger
Not Annoying	No	No	
Not Annoying	No	Maybe	
Not Annoying	No	They Look Angry	
Could Be Annoying	No	No	
Could Be Annoying	No	Maybe	
Could Be Annoying	No	They Look Angry	
Annoying	No	No	
Annoying	No	Maybe	
Annoying	No	They Look Angry	
Not Annoying	Some	No	Angrier
Not Annoying	Some	Maybe	
Not Annoying	Some	They Look Angry	
Could Be Annoying	Some	No	
Could Be Annoying	Some	Maybe	
Could Be Annoying	Some	They Look Angry	
Annoying	Some	No	
Annoying	Some	Maybe	
Annoying	Some	They Look Angry	
Not Annoying	A Lot of Anger	No	
Not Annoying	A Lot of Anger	Maybe	Rage
Not Annoying	A Lot of Anger	They Look Angry	
Could Be Annoying	A Lot of Anger	No	
Could Be Annoying	A Lot of Anger	Maybe	
Could Be Annoying	A Lot of Anger	They Look Angry	
Annoying	A Lot of Anger	No	
Annoying	A Lot of Anger	Maybe	
Annoying	A Lot of Anger	They Look Angry	

Table 4 – Final Anger Appraisal

Additionally if agent is already angry, then it can be presumed that the anger level is increased. This anger value can then be compared to the tiered anger responses shown in figure 17, to arrive at the final anger appraisal.

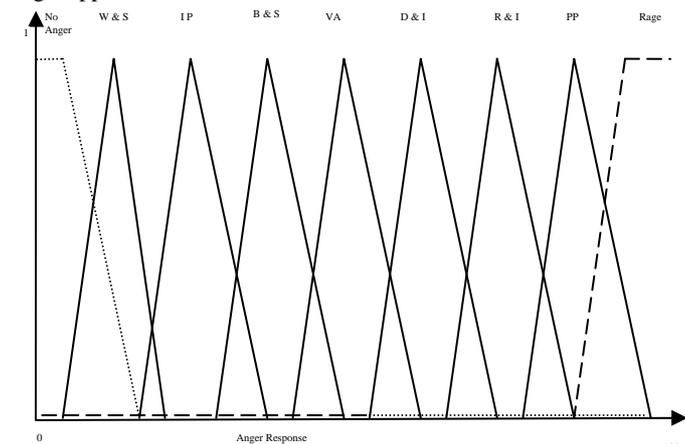


Figure 17 – Final Emotional response (Abbreviations from Figure 3)

## 11 Anger Behaviour

Anger is usually classified under the category of basic emotions [Ekman et al 2003], because of its easily recognizable signs such as:

- Tendency to move toward the stimulus.
- Reddening of face.

- Facial changes according to Ekman's basic emotion model [Ekman et al 2003].
- Verbal or physical action from table 2.

## 12 Asking an Agent How They Feel

Throughout this work, the use of finite state machines and fuzzy logic have been used to model aspects of anger. These transitions and states can be implemented in software using a variety of software techniques, and tested to ensure correct operation. This testing would allow clearly defined behaviours based on certain trigger stimulus to be compared to expected results and validate the software implementation prior to end user use. One advantage of the fuzzy approach shown within this document is that it is feasible to actually add a new dimension to validation via agent emotion querying. I.e. asking the agent how they feel. This could then be used by end users to compare the agents' behaviour against an expected psychology baseline of behaviour given similar real world situations.

This can be achieved by combining the information from the fuzzy graphs so that:

User – "How do you feel about Robert?"

Bot – "I Like Robert, he doesn't annoy me."

### **Bot response from:**

*Text parse sentence*

*Word "feeling" preceded a known stimuli type therefore check data store for liking, useful, threat and response (From Table 3 – row 1).*

If bot has no information on Robert then

Bot – "Sorry I don't know Robert."

## 13 Angry Chat Bots

Presently, one application area of emotional agents is in the development of more human chat bot's. Chat bot's are agents (not necessarily human in appearance) who can provide interaction through text or speech with users.



Figure 18 – Daden chat bot in Second Life.

The chat bots can be thought of as more advanced NPC's in games, that rather than clicking on one of several predefined responses, allows the user to type or talk the answer's or questions. In e-commerce solutions, the chat bots can provide information to user's when they visit a virtual corporate location such as the chat bot's developed by Daden Ltd<sup>3</sup> (as shown in figure 18) in Second Life. These chat bots can be asked questions and at present provide a predefined response and little in the way of emotionally responsive behaviour. Part of this work is to enhance the chat bot's developed

by Daden in order to give them an added dimension in user interaction through the addition of emotional characteristics.

## Conclusion

The research presented here attempts to offer an overview of the anger emotion. The work breaks the anger emotion into three areas,

- 1) Detection and appraisal of stimulus to give a corresponding anger emotion.
- 2) Decision on which one of the eight anger levels is activated, or if a related anger emotion is activated instead.
- 3) Behavioural aspects of anger.

The work shows how the usage of finite state machines and fuzzy logic can reduce the complexities of the emotion in order for it to be more easily integrated into software solutions.

At present this work, which is part of a larger architecture E-AI [Slater et al 2008] has been applied to social agents within Quake III and currently within chat bots within Second Life, other application areas could include e-Drama and web avatars.

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Stuart Slater is a principal lecturer in the school of IT & Computing at the University of Wolverhampton. His current research involves the development of an 'agent emotion architecture' for use with commercial games, simulations and the web.

<sup>3</sup> <http://www.daden.co.uk>