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# Intelligent Agent System Simulation Using Fear Emotion

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***Abstract*****—**In this paper I have developed a system for evaluating the degree of fear emotion that the intelligent agent-based system may feel when it encounters to a persecuting event. In this paper I want to describe behaviors of emotional agents using human behavior in terms of the way their emotional states evolve over time.

I have implemented a fuzzy inference system using Java environment. As the inputs of this system, I have considered three parameters related on human fear emotion. The system outputs can be used in agent decision making process or choosing a person for team working systems by combination the intensity of fear to other emotion intensities.

***Keywords*****—**Emotion simulation, Fear, Fuzzy intelligent agent

## I. Introduction

INTELLIGENT agent-based systems are one of the oldest areas of research. Recently, researchers in computer science have acknowledged that models of emotions presented by psychologist are very useful to variety of computerized applications such as: personal assistance application, intelligent interfaces [24], intelligent tutoring systems, etc. Emotional intelligence is a different way of being smart. It includes knowing what your feelings are and using your feelings to make good decisions in life. It's being able to manage distressing moods well and control impulses [33]. Different projects are conducted in order to create an agent whose internal structure and behavior is inspired by ideas of emotions. There are many applications for emotional machines: education, health care, rescue, entertainment and other areas.

Reference [11] describes that "a number of leading psychological researchers in the study of human emotions, for example in [12], [13], appear to be reaching an agreement on what are the basic emotions: Fear, Anger, Disgust, Sadness and Happiness." Reference [8] describes that the "dimensional theory identifies six orthogonal planes by which to determine an emotional category, these being, pleasantness, responsibility, certainty, attention, effort and situational control (see reference [14] for explanation). Within this 6 dimensional space, Smith and Ellsworth have identified the approximate empirical location of 15 separate higher emotions; happiness, sadness, anger, boredom, challenge, hope, fear, interest, contempt, disgust, frustration, surprise, pride, shame and guilt. Emotions have been shown to have a significant influence on the decision-making process of human beings and thus, play an important role in intelligent behavior. There is psychological evidence that having emotions may help one to do reasoning and tasks for which rationality seems to be the only factor [22]. Emotionless agents are viewed as merely machines. If humans identify with and accept an agent as human instead machine-like, they may be more able to trust the agent and better able to communicate with it. The emotional aspect distinguishes a machine from an agent who believable, alive, and trustworthy [6]. Researchers have focused on the functions of emotion for computational models trying to describe some of behavioral responses to reinforcing signals, communications which transmit the internal states or social bonding between individuals, which could increase fitness in the context of evolution [23].

Reference [25], within the OZ project, creates an environment for simulating believable emotional and social agents; each agent has a set of goals trying to achieve. these agents are able to express emotions after evaluating the impact of an event on the agent's goals. A probabilistic model, based on Dynamic Decision Networks in [26] is used to recognize the emotional state of the user with educational games from possible causes of emotional arousal. Picard in [27] have been interested in recognizing eight emotions (neutral, anger, hate, grief, platonic love, romantic love, joy, and reverence) from a set of sensed physiological signals. Reference [28] have been found the optimal emotional state of the learner via the Emotional Intelligent Agent (EIA) which is used a set of roles defined from the results they found in their experiment, in which they tried to find a relationship between optimal emotional state (fear, anger, pride, joy and …) and personality (Extraversion, Lie, Neuroticism, Psychoticism).

Reference [37] intended to show how diverse strands of work in AI and cognitive science could be combined to create a fundamental theory of emotions and personality. Emotional-based system architecture together with an application of it for control and supervision purposes is presented in [3]. It mentions that findings on neuroscience studies have revealed that emotions, in fact, have an important role in what respects human reasoning and decision making [4, 5]. In [2], Pert

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states that from a neurological stand point, emotions act as a kind of filtering system for information processing within the brain. Reference [7] talks about the role of emotion in believable agents. He described that emotions of various intensities exist simultaneously. It also mentioned that many artificial intelligence researchers have long wished to build robots, and their cousins called agents that seem to think, feel, and live.

Reference [9] has built a 2-layer feed-forward connectionist model that recognizes six basic emotions (happiness, surprise, sadness, anger, fear, and disgust) from static face images. Another example of this type of work is the Facial Expression Analysis Tool (FEAT) and Facial Action Composing Environment (FACE), developed at the University of Geneva [10]. In this paper, in section 2, we have defined the concept of fear and its related parameters. How to consider fear emotion as a fuzzy concept have been presented in section 3. Next in section 4, the designed and implemented fuzzy system, fuzzy sets, and fuzzy rules have been described. At last, the paper has been concluded in section 5.

## II. Description of Fear and Related Parameters

Each emotional behavior can be described by the different states of physiological changes, feelings, expressive behavior and inclinations to act. Fear is a feeling of agitation and anxiety caused by the presence or imminence of danger.

It is also a feeling of disquiet or apprehension and Extreme Reverence or awe, as toward a supreme power. Fear is defined by the Merriam-Webster Collegiate Dictionary as an unpleasant often strong emotion caused by anticipation or awareness of danger [31]. Fear can also be defined as an actual emotional response that can impel changes in attitude or behavior intentions [32]. Fear is much more than simply a reaction in your head. It's an automatic adrenaline rush to prepare us for fight or flight. Your whole body responds to fear, especially your heart. This involves nerve and chemical signals that fire instant messages, a peanut-sized structure deep within the brain, to the heart, lungs, and other organs of the body whenever we sense fear or strong emotions [11].

Without a proper fear motivation, animals would not be Capable of taking the proper safeguards to avoid harm to themselves or others from simple and routine actions, such as walking around a ledge or crossing a busy street. However, the phrase ‘frozen with fear’ is far more than a simple metaphor. Animals are often so torn between a desire to fight or flight, that they are incapable of doing either. Of first concern in designing an intelligent multi agent system based of fear emotion is to try to get the benefits of such a strong protection mechanism without incurring the risk that it will generally make the agent’s actions less beneficial. The value of Fear must lie over the so-called self-perception threshold. After the information passes the self-perception threshold, the perceived fear will be transferred to Cognition, which will hand it on to the self model [29].

In this paper we try to model fear emotion for intelligent Fuzzy agent. To begin modeling this agent computationally, it is first necessary to model how emotions are triggered.

As has been reported in [15], [16], [17], [18] and [29], when the people evaluate the persecuting events of their life; the most common reasons of factors that can cause fear in humans are the sudden degree of problem, the possibility of reaction to problem and uncertainty degree of problem. These relations are as follow:

-The sudden degree of problem: when an individual encounters to the problem which suddenly disturb his objects and expectance, he may feel fear. The degree of fear is related to the sudden degree of that problem. As more sudden degree, more fear.

-The possibility of reaction to problem: When he knows that he can do a good and necessary reaction to the problem, the degree of fear will be lower.

-Uncertainty degree of problem: When the problem is definite, the degree of fear is lower because the individual knows what he must do and he can imagine the condition clearly for himself.

## III. Fuzzy fear Concepts

The borders of emotion concept are fuzzy [19]. Fear concept is not well characterized from the classical perspective. In this paper, I have described the relation between the mentioned three reasons of fear emotion and the fear degree that a human may feels, and simulate an emotional fuzzy intelligent agent via some fuzzy rules. I designed 27 fuzzy rules in which the degree of three reasons of fear are considered as inputs (or antecedents) and the degree of captured fear emotion is considered as output (or conclusion). For this system I have considered three fuzzy sets for fear (annoyance, jealousy and fury)and three reasons which cause fear. Each of them have been described as three fuzzy concepts with three fuzzy sets (low, medium and high). In the following section, I have presented a survey on fuzzy logic, designed fuzzy sets and fuzzy rules.

## IV. Designed Fuzzy System

Fuzzy logic has proved to be particularly useful in expert systems and other artificial intelligence applications [20]. It was introduced as a means to model the uncertainty of natural language. Fuzzy logic is a set of Boolean logic that has been extended to handle the concept of partial truth-false values between "completely true" and "completely false".

Fuzzy systems are an alternative to traditional notions of set membership and logic that has its origins in ancient Greek philosophy, and applications at the leading edge of Artificial Intelligence.

The notion central to fuzzy systems is that truth values (in Fuzzy logic) or membership values (in fuzzy sets) are indicated by a value on the range [0.0, 1.0], with 0.0 representing absolute Falseness and 1.0 representing absolute Truth [20, 36]. Fuzzy systems, including fuzzy logic and fuzzy set theory, provide a rich and meaningful addition to standard logic. The mathematics generated by these theories is consistent, and fuzzy logic may be a generalization of classic logic [35]. The applications which may be generated from or adapted to fuzzy logic are wide-ranging, and provide the opportunity for modeling of conditions which are inherently imprecisely defined, despite the concerns of classical logicians. Many systems may be modeled, simulated, and even replicated with the help of fuzzy systems, not the least of which is human reasoning itself [36].

In this paper, via designed fuzzy sets and fuzzy rules, a fuzzy system for calculating the intensity of fear emotion, using the related parameters on fear, as inputs is designed and implemented and then its output has been used as the input of second phase for calculating the resulted emotional state of agent, after catching this degree of fear.

### A. Fuzzy Sets

A fuzzy subset F of a set S can be defined as a set of Ordered pairs, each with the first element from S, and the second element from the interval [0, 1], with exactly one ordered pair present for each element of S. This defines a mapping between elements of the set S and values in the interval [0, 1]. The value "zero" is used to represent complete non-membership, the value "one" is used to represent complete membership, and values in between are used to represent intermediate degrees of membership. The set S is referred to as the universe of discourse for the fuzzy subset F. The mapping is described as a function, the membership function of F. The degree of truth for the statement of "x is in F" is determined by finding the ordered pair whose first element is x. This degree is the second element of the ordered pair [20]. Based on the works reported in [15] , [16] , [17], [18] and [29] , in the first step for describing the level of each reason of fear emotion, I considered three fuzzy sets (low, medium and high) and in the second step, for the level of captured fear emotion I designed three fuzzy sets (annoyance, jealousy and fury).

"Zero" is assigned for the lowest degree of each emotion's Membership and "one" for the highest degree that a person may show. Figure 1 is shown the membership functions of fuzzy sets for fear emotion.

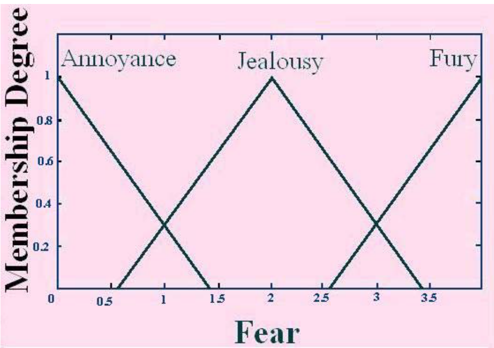


Fig. 1 Designed fuzzy Sets for Fear

### B. Fuzzy Rules

Due to psychology literature [15] , [16] , [17], [18] and [29] and the described fuzzy sets in previous section, fuzzy rules are given for calculation of fear emotion degree. In this article, after fuzzy inference and defuzzification, the degree of the agent's fear emotion is determined by the implementation of designed rules.

The relationship between fear reasons and degree of resultant fear for an intelligent agent is shown in Table 1. To save space only some sample rules are given.

### C. Fuzzy Concept Implementation

In this step, Fuzzy Set class, Fuzzy rule class and Fuzzy rule base class must be implemented. First Fuzzy set class is implemented and is used in fuzzy rule class. Result of this step is used in fuzzy rule base class and then a fuzzy rule base is created for each cluster of rules.

**Fuzzy set class (FuzzySet.java):**

A fuzzy set can be defined, using the coordinates of the node, and the number of these nodes. These values are used as the attributes of fuzzy set class. We can measure the membership degree of each value by evoking the "MembershipDegree" method of this class.

**Fuzzy Rule class (FuzzyRule.java):**

This class uses fuzzy set class. By definition of a fuzzy rule object, it is possible to insert antecedent and conclusion parts to each rule by evoking "AddAntecedent" and "AddConclusion" methods of this class. The antecedent and conclusion are two attributes of this class. The method of "TestRuleMatch" is used for verification whether the rule is fired or not. This method assigns "True" or "False" to the "fire rule" attribute of this class. If the antecedent of rule is complex, the AND operator will be applied between the parts of antecedent. For calculation the degree of "fire rule" (DOF), the "minimum" technique [21] is applied.

After calculation of DOF (via "TestRuleMatch" method), we can calculate the output fuzzy set by evoking "GetOutputSet" method. This method, evaluates the fuzzy relation between antecedent and conclusion of each rule, using "Larsen Product" technique [21] and then calculates the node coordinates of output fuzzy set.

**Fuzzy Rule Base class (FuzzyRuleBase.java):**

By creating an instance of this class, it is possible to define a cluster of rules, and fuzzificate, inference and defuzzificate on the rules and finally calculate the output results.

Some important attributes of this class are an array of fuzzy rules, the number of fuzzy rules and the number of fired fuzzy rules after inference.

We can add the predefined fuzzy rules to a fuzzy rule base, by evoking the method of "Add Rule." The "fuzzification" method fuzzificates the input value of the rule base. The method of "Inference" of the rule base catches the fuzzificated values and then obtains the DOF of each rule by evoking "TestRuleMatch" method of that rule. If DOF is higher than zero, the rule will be considered as a fired rule. The method of "defuzzification" can be used for calculation of final result. For this purpose, this method applies the "center of area" technique [21].

TABLE I

SOME DESIGNED FUZZY RULES FOR AN INTELLIGENT AGENT

| If | Sudden | And | Possibility of | And | Uncertainty | Then | Degree of |
|---|---|---|---|---|---|---|---|

| | degree of problem is | | reaction to problem is | | degree of problem is | | Fear is |
|---|---|---|---|---|---|---|---|
| | High | | High | | Low | | annoyance |
| | Low | | Low | | Low | | annoyance |
| | Low | | Medium | | Low | | annoyance |
| | High | | Low | | Low | | jealousy |
| | Medium | | Low | | medium | | jealousy |
| | High | | Low | | High | | fury |
| | High | | Medium | | Medium | | fury |

## V. THE MODEL IMPLEMENTATION

In this paper I implemented software for an intelligent emotional agent in Java environment. As shown in Figure 2, the class diagram in which each class contains class name at the top, attributes at the middle, and methods at the bottom is designed.

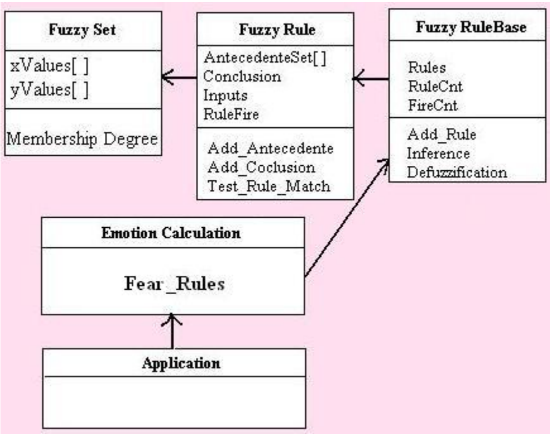


Fig. 2 Class diagram of my designed software

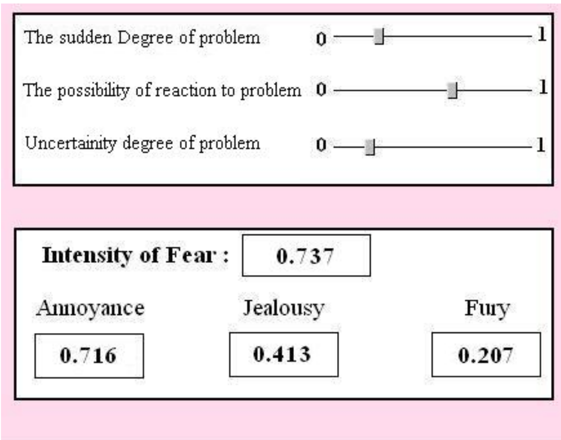


Fig. 3 Calculated fear emotion intensity

Emotion calculation component uses the degrees of fear parameters which are set by user to calculate fear intensity of agent by using the implemented fuzzy rules as the result.

These outputs can be used in agent decision making process by creating a function that combines this fear intensity to other Emotion intensities and applies them for choosing a proper action from some available actions. The outputs in Figures 3 shows calculated fear emotion intensity.

## VI. CONCLUSION

In this paper an emotional intelligent system has been described to provide an estimate of fear emotion for an agent using a set of designed fuzzy rules.

I obtained degree of fear emotion from a set of emotion parameters which have been used in the development of a fuzzy rule base system for the automatic analysis of effective input parameters for estimating fear emotion intensity.

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