Development of an Emotion-Oriented Computing System for Text Analytics

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Abstract–*Text Analytics is an interdisciplinary field which draws on data mining, machine learning, information extraction, statistics and computational linguistics.This paper deals with the development of an IntelligentAgent that exhibits the concept of emotional intelligence and which can be used for Text Analytics. Text Analytics is the most recent name given to Natural Language Understanding, Data and Text Mining. The architecture used is a Neuro-Fuzzy system which is a fuzzy system that uses a learning algorithm derived from or inspired by neural network theory to determine its parameters (fuzzy sets and fuzzy rules) by processing data samples. The input to the system is a real life event which is tokenized and the tokens are compared to a pre-defined database of emotional keywords. Based on the matching, the tokens are processed by the neuro-fuzzy controller and the corresponding emotion underlying the event is generated.The system can be used to analyze the text content in emails, blogs, tweets, forums and other forms of textual communication.*

Keywords—Intelligent Agent, Neural Networks, Fuzzy Logic, Neuro-Fuzzy System, Pattern Matching, Linguistic variables, Membership Function.

I. INTRODUCTION

Exploratory experiments can be performed to articulate nature of specific behavior of a human being using artificial automata or computer simulated models. Human beings have two minds, one that thinks (rational mind) and one that feels (emotional mind). These two fundamentally different ways of knowing interact to construct our mental life. This results in two different kinds of intelligence i.e., rational and emotional.

If our aim in AI is to build systems that behave like human beings then it is necessary that we incorporate elements of both rational and emotional intelligence into the system. The agent function for an artificial agent will be implemented by an agent program, running on agent architecture.

Emotions are complex, multifaceted phenomena. Emotion is the language of a person's internal state of being, normally based in or tied to their internal (physical) and external (social) sensory feeling. Artificial agents can be endowed with emotions so that they can be used as a test bed for theories of emotions, providing a synthetic approach that is complementary to the analytical study of natural systems.

Agents are entities capable of autonomous goal-oriented behavior in some environment. An intelligent agent is a device that interacts with its environment in flexible, goal-directed ways, recognizing important states of the environment and acting to achieve desired results. They canhave one or more attributes such as Autonomous, Adaptive, Communicative, Collaborative, Personal and Mobile. Research in the domain of emotion has found that intelligence and emotion are linked. *Emotional Agent* has an emotional state which gets altered by stimuli from environment or internal elements. Emotional state steers the decision process. An emotional agent can be implemented by developing a computational approach.

Emotional intelligence represents an ability to validly reason with emotions and to use emotions to enhance thought. Neurologists have made progress in demonstrating that emotion is as, or more, important than reason in the process of making decisions and deciding actions. The significance of these findings should not be overlooked in a world that is increasingly reliant on computers to accommodate to user needs. Emotional Intelligence involves the following concepts:

- Managing Emotions
- Understanding Emotions
- Facilitating Thought
- Perceiving Emotions

Neural networks are designed to operate in numeric frameworks. They deal with problem space variables that are numerically quantifiable, or that are measurable. However, much of the information available in the real world cannot be measured. In order to exploit such vast repositories of information while developing models of real world processes, one needs a mechanism to embed linguistic information into neural network operational environments. Fuzzy set theory provides precisely this modeling platform.

Fuzzy logic provides a high level framework for approximate reasoning that can appropriately handle both the uncertainty and imprecision in linguistic semantics, model expert heuristics, and provide requisite high level organizing principles.Fuzzy logic and neural networks are complementary technologies. They work at different levels of abstraction and individually provide rich functionality, which when brought together in a cohesive fashion provide us with “intelligent” systems. Neural networks provide self-organizing framework for low level representation of information with on-line adaptation capabilities.

Text Analytics is the discovery of new, previously unknown information, by automatically extracting information from different written resources.It is an extension of data mining, that tries to find textual patterns from large non-structured sources. Text mining is similar to data mining except that data mining tools are designed to handle structured data from databases whereas text analytics can handle unstructured or semi-structured data like mails, newspaper articles, HTML files etc.

Neuro-Fuzzy system is a fuzzy system that uses a learning algorithm derived from or inspired by neural network theory to determine its parameters (fuzzy sets and fuzzy rules) by processing data samples.

The system comprises of three different layers **:**

1. Fuzzification Layer: Here each neuron represents an input membership function of the antecedent of a fuzzy rule.
2. Fuzzy Inference Layer : In this layer, fuzzy rules are fired and the value at the end of each rule represents the initial weight of the rule, and will be adjusted to its appropriate level at the end of the training.
3. Defuzzification Layer : Here each neuron represents a consequent proposition and its membership function can be implemented by combining sigmoid functions and linear functions.

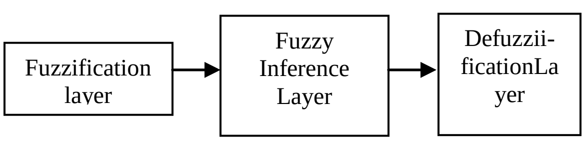

Fig 1 : Neuro Fuzzy System

II. PREVIOUS WORK

The concept of Text Analytics has been around for years as it helps organizations harness their data and use it to identify new opportunities. FLAME − Fuzzy Logic Adaptive Model of Emotions [4] was modeled to produce emotions and to simulate the emotional intelligence process. FLAME was built using fuzzy rules to explore the capability of fuzzy logic in modeling the emotional process. Psychology, Neurology, Philosophy and Cognitive Science have been concerned with modeling the mind and its behavior for many years. Among the neurological models, LeDoux published his book, The Emotional Brain, to explore the emotional process in the brain [7]. More recently, D. Goleman explained the idea of emotional intelligence and its importance in [5]. While in the psychology field, D. Price and J. Barrell developed a mathematical model that described emotions in terms of desires and expectations [11]. Pain was modeled by R. Schumacher and M. Velden [14] and again by S. Tayrer’s book [18]. A description of models of emotions from early 1960’s until the 1980’s was presented by R. Pfeifer [10]. However, since the psychology of emotions was not yet complete at the time, it was not easy to find a computational model that describes the whole emotional concept.

Initially, an effort was made by Masuyma to formulate the human emotions into a set of rules [8]. An attempt was made by S. Sugano and T. Ogata [17] to simulate the human mind through an electrically wired robot. A prototype of the decision making process was developed by Inoue [6], they used neural networks to simulate behavior. The topic of emotion was regarded as a very challenging topic, since it was hard to fully understand how we feel and why we do feel that way. Part of the reason for the so-called “mystery of emotions” is due to the fact that most of our emotions occur at the subconscious level [7]. Searching for a better solution, researchers on agent’s technology began working on emotions. J. Bates is building a believable agent (OZ project) [1, 2, 12] using the model described in The Structure of Emotions by Ortony, Clore and Collins [9]. The OZ project at the Carnegie Mellon School of Computer Science is developing technology for high quality interactive fiction and virtual realities. They developed “Em”, an implemented model of emotion for use in these agents. “Em” is based on the theoretical, cognition based emotion model of Ortony, Collins and Clore [9]and has shown promise of being a flexible model of emotion.

The MIT lab is also producing an emotional multi-agent project.The model only describes basic emotions and innate reactions.

A distributed architecture for a system simulating the emotional state of an agent acting in a virtual environment was presented by Aard-Jan van Kesteren, Rieks op den Akker, Mannes Poel, Anton Nijholt [3]. The system is an implementation of an event appraisal model of emotional behavior and uses neural networks to learn how the emotional state should be influenced by the occurrence of environmental and internal stimuli.

III. MODEL OF THE SYSTEM

A. Architecture

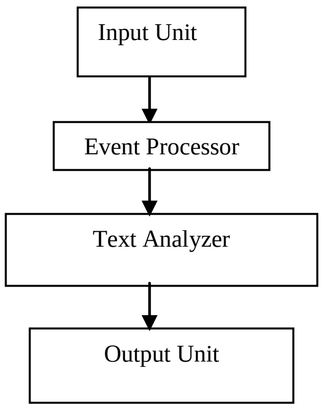

Fig 2 : Functional Diagram of the System

The system comprises of the following units :

1) Input Unit .
2) Event Processor.
3) Text Analyzer (Neuro-Fuzzy system) with the following five layers :
   - The input layer
   - The input Fuzzy layer
   - The conjunction layer
   - The output fuzzy layer
   - The output layer
4) Output Unit.

B. Methodology

Step 1 **:** The input to the system is an external event which is a string representing the real world event. The string is accepted, processed and divided into tokens by the Input Unit.

Step 2 : The Event Processor parses the tokens of the string and compares them to a corpus of emotional keywords and a lexicon of the English language database. The comparison is done using the Knuth-Morris-Pratt pattern matching algorithm. The matched tokens are converted into corresponding linguistic variables and fed to the emotional state calculator which is a neuro-fuzzy system.

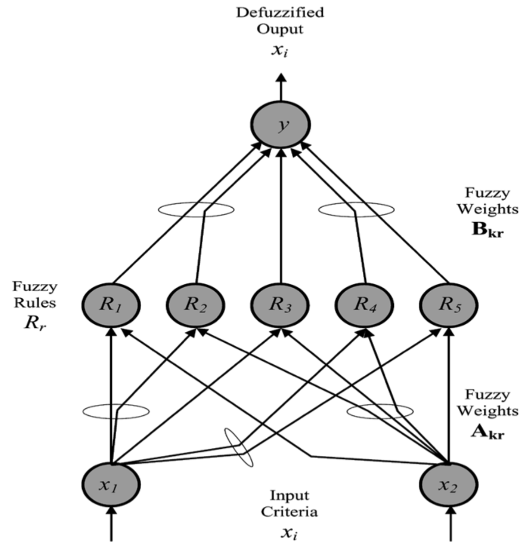

Fig 3:Schematic of the neurofuzzy system used to perform fuzzy function approximation (adapted from Nauck and Krause[17])

Step 3 **:** In the text analyzer the activation level of an input unit is the value of a certain input variable in the given instance. The input value is passed onto fuzzy set units, which then translate the value into a degree of membership as the activation level of a fuzzy set unit. The conjunction unit will take the minimum of the inputs (degrees of membership) it receives from the input fuzzy set units below. Now, the output fuzzy set unit will collect information from one or more conjunction units (each corresponding to a fuzzy rule). An output fuzzy unit takes the maximum of its inputs.Then the output unit generates the final result by integrating the information from the output fuzzy set units.

The activation function used in each layer is as follows :

1. The input layer : no activation function.
2. The input fuzzy layer : the sigmoid function.
3. The conjunction layer : the min function.
4. The output fuzzy layer: the max function.
5. The output layer: no activation function.

Consider a single node from each layer .Let us denote f as the transfer function (which is a weighted sum in a normal neural network), a as theactivation function, x^k_p as the inputs to the node, w^k_p astheinput weights and y^k_iasthe outputs of the node, where $k=1...5$, p and i are the total number of the input and output variables respectively. The process of each node can be described as follows:

- Layer 1: The input layer consists of the input nodes and directly transmits the input linguistic variables to the next layer. The link weight, w^1_i, at the layer one is unity.

$$f = x_i^1 a$$

- Layer 2: Each node in the input fuzzy layer acts as a membership function and represents the terms of the respective linguistic variables. The fuzzy membership function i.e., the activation function (sigmoid function) is ,

  $f = 1 / (1- e^{-NET})$

  Where $NET = XW = x_1w_1 + x_2w_2 + \ldots..+x_nw_n$

- Layer 3: The conjunction layer is a fuzzy rule layer where each node represents one fuzzy rule. The links in this layer are used to perform antecedent matching fuzzy logic rules and also the fuzzy *AND* operation. The link weight, w^3_i, at the third layer is also equal to unity.The conjunction operationin fuzzy logic is represented using the "min" function.

$f = min (x_1^3, x_2^3, \ldots. x_p^3) a$

- Layer 4: The output fuzzy layer has nodes where each node acts as a membership function for consequents. The links to this layer define consequences of the rule nodes. The links in the third and fourth layer, in association, function as a fuzzy inference engine. The links in the layer should perform the fuzzy *OR* operation to integrate the fired rules which have the same consequence. The disjunction operation in fuzzy logic is represented using the "max" function.

$f = max (e_1^3, e_2^3, \ldots. e_p^3) a$

- Layer 5 : The output layer has output nodes which transmit the generated output. The link weight, w^4_i, at the fourth layer is also equal to unity. This layer is an output linguistic layer.

The network can learn by adjusting weights. Training strategy used is Back propagation . Initially the weights are initialized to a small random no. Then the pairs (x^P, t^P) of the training set are applied in some order. For each value of x , calculate the actual output y and find the square error as

$$E_P = ½ (y^P - t^P)^2$$

Using E_P , the weights in the network are updated according to the backpropagation algorithm. The cumulative cycle error is calculated as

$$E = ½ \sum(y^P - t^P)^2 p = 1 \text{ to } n$$

At the end of each cycle, in which each sample in the training set is applied once, the cumulative error is compared with the largest acceptable error E_{MAX} . When $E <= E_{MAX}$, a solution is obtained which means that the network represents the desired membership function. When $E > E_{MAX}$, a new cycle is initiated. The algorithm is terminated when a solution is obtained or the no.of cycles exceeds the limit.

Step 4 : The Output Unit generates the result of the system which is an emotional state in response to the input external event.

IV. IMPLEMENTATION

The emotional keywords parsed by the event processor are considered and their emotional values are computed as :

Emoval = weight + f(freq) + h(conc-dep)

Where weight is taken from the corpus of emotional keywords ,freq is the frequency of occurrence and conc-dep is the conceptual dependency with respect to the context of the statement.

Based on the numerical values computed, the linguistic values are generated using the membership function. In the membership graph, the emotional values are on the X-Axis (0 to 50) and the membership values are on the Y-Axis (0 to 1)

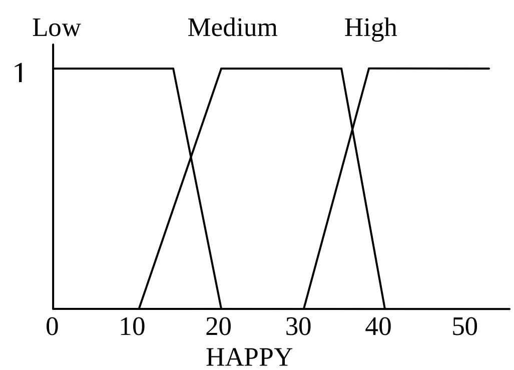

Fig 4 : The membership graph for the emotion Happy

The emotional keywords fall under six categories represented by the corresponding input linguistic variables :
V = { Happy, Sad, Fear, Anger, Surprise, Disgust}
where V1 = Happy , V2= Sad ………V6 = Disgust
Each linguistic variable has three linguistic terms , i.e.,
L = { High, Medium, Low }
where L1 = High, L2 = Medium and L3 = Low.
The output linguistic variable is denoted as E which can take any one of the six emotions considered as the linguistic terms. All emotions except "Neutral" are qualified by the linguistic hedges { fairly, very, extremely } i.e.,

E11=fairly happy, E12 = very happy, E13 = extremely happy

Rule Base for the Fuzzy Inference system :

R1 : If V is V1 and L is L1 then E is E11.

R2 : If V is V1 and L is L2 then E is E12.

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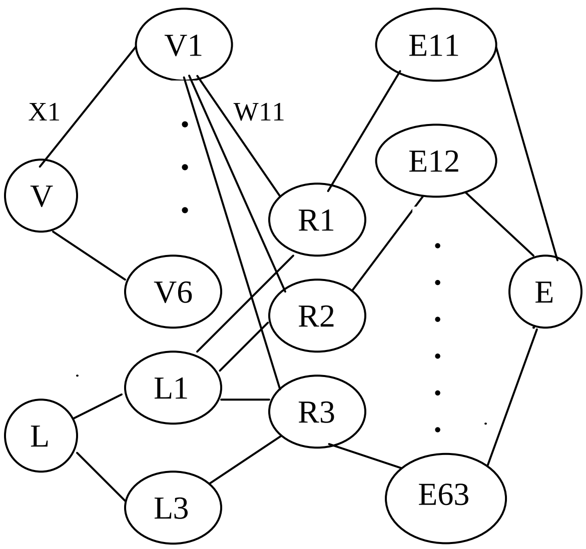
R18 :If V is V6 and L is L3 the E is E63.



Layer1Layer2Layer3Layer4Layer5

Fig 5 : Text Analyzer

The above model can be programmed in a programming language and implemented on a computer. The system can be embedded into a computer system with due enhancements and modifications, which could possibly give it the potential of emotional intelligence. Such a system can be used to analyse the emotions behind textual information of mails and other documents or as an inference engine for other language processing systems. Text Analytics is considered as the next step in Big Data Analysis.

CONCLUSION

In this paper we have suggested an approach to enable a computer to process real life events and detect the emotion associated with the event, which is eventually used for analyzing text.The AI major thrust is to develop computer function normally associated with human intelligence. Emotion is fundamental to human experience, influencing cognition, perception, and everyday tasks such as learning, communication, and even rational decision-making. However, technologists have largely ignored emotion. Machines of the future would need it to survive, interact with other machines and humans, learn, adapt to circumstances. Text analytics is gaining importance in many industries from marketing to finance as the analysis of text helps decision makers to understand market dynamics and predict trends and manage risks.

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