Using Interval Type-2 Fuzzy Logic to Analyze Turkish Emotion Words

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***Abstract*—This paper describes a methodology that shows the feasibility of a fuzzy logic (FL) representation of Turkish emotion-related words. We analyzed 197 Turkish emotion words set through a web-based surveys that prompted users with emotional words and asked them to enter an interval valence, activation, and dominance emotion attributes using a double slider. Our previous experimental results indicated that there was a strong correlation between the emotions attributed to Turkish word roots and the Turkish sentences. In this paper, we extend our previous work and analyze Turkish emotion words by using an interval type-2 fuzzy logic.**

I. Introduction

Words play an important role in how we describe and understand emotions. Recently, the emotional content of language has become increasingly significant for applications. For example, the tasks of opinion mining and affective computing [1] are receiving a lot of attention in the fields of Natural Language Processing and Human Computer Interaction [2].

Words connote various meanings to different people, and some of them uncertain. Therefore, we need a fuzzy set model for a word. It has the capacity to capture their uncertainties [3], [4]. In spite of the progress of previous works [5] in the field, there has been relatively less progress in non-English languages. Unlike English, Turkish is an agglutinative language, which means that new words can be formed from existing words by a rich set of affixes [6]. In our previous study [7], we found that there was a strong correlation between the emotions attributed to word roots, which are the core forms of words, and the emotion of sentences when negations, derivations, and inflections are accounted for. In this paper, we extend our previous work and analyze Turkish emotion words by using interval type-2 fuzzy logic[8] approach.

Two approaches are usually used to define emotion. The classical approach is to use fixed number of emotion classes such as {negative, non-negative}, {neutral, sad, fear, happy, angry}, and {angry, non-angry} to describe emotion-related states. However, this approach fails to represent many types of emotions occur in real-life. The second approach is to use a multidimensional space where each point in the space represents one emotion. *Valence*, *activation*, and *dominance* are mostly used dimensions [9], [10]. Valence represents negative to positive axis, activation represents calm to excited axis and dominance represents weak to strong axis in the 3D space. However, both approaches fail to capture intra-user uncertainty, uncertainty a person has about the emotion word. To solve this problem, in [11], intervals were used instead of using fixed points for each emotion dimension. They showed that a reliable mapping can be made between a large vocabulary of emotional words and seven emotion categories using Interval Type-2 Fuzzy Logic. Also, in [12] Interval Type-2 Fuzzy Logic was used to translate Emotion Words From Spanish to English. In this paper, we followed a similar approach and built fuzzy models for Turkish emotion words from individual survey responses. In our study, the interval type type-2 fuzzy set is used as a FS model of a Turkish emotion word since it is described by its footprint of uncertainty (FOU). Consequently, it has capacity to seizure emotion word uncertainties. Two approaches have been used for accumulating data about a word from a group of subjects and then mapping that data into a FOU for that word: the person-membership function (MF) approach and the interval endpoints approach[8]. In the person-MF approach, a subject supplies its FOU for a Turkish emotion word on a prescribed(0-100), and this is implemented by a group of subjects. Each person FOU captures the intralevel of uncertainty the intralevel of uncertainty about a Turkish emotion word. All of the person FOUs are collected, which grabs the interlevel of uncertainty about the word across the group of subjects. These FOUs are shown and explained as figures in the results section. After all, an ITS FS model is adapted to the aggregated data. This paper is organized as follows: In the following section, the survey data and the concepts of Interval Type-2 Fuzzy Logic are described. The results and discussion are described in section 3. The conclusion follows in section 4.

II. Methodology

In this section we explained the data and described the concepts of Interval Type-2 Fuzzy Logic.

A. Data

The emotion words we chose came from the EMO20Q Project [13], which uses the emotion twenty questions game as a way to observe the human intuition about emotions. We translated 171 words from this project to Turkish and additionally added 26 synonyms.

To measure the word-level emotion characteristics, we conducted a survey[1] of approximately 40 people who were presented with 197 emotion words (Table 1) and asked the subjects to rate these on valence, activation, and dominance scales. The emotional rating scales for this survey included that two points are used for the scale, one to present the lower bound of a range of possible values and the other for the upper bound, which allows for measurement of intra-subject uncertainty. Also, the survey's scales ranged from 0 to 100.

The survey consisted of four sessions per subject wherein each subject was presented with thirty-five words chosen randomly from the set of 197 words. This resulted in each of the 197 words being rated approximately 30 times. Then, with using an interval approach, user data is gathered that related to each emotion word with intervals on three scales of emotional characteristics, valence, activation, and dominance, and assessed interval type-2 fuzzy membership functions for each scale.

TABLE I
ENGLISH EMOTION WORDS AND TURKISH TRANSLATIONS

English	Turkish
Enthusiasm	Şevk
Terrible	Berbat
Courage	Cesaret
Mad	Çılgın
Tired	Yorgun
Calm	Sakin
Hopeful	Ümitli
Interested	İlgili
Surprised	Şaşkn
Boredom	Sıkıntı
Sadness	Üzüntü
Expectation	Beklenti
Worried	Endişeli
Lucky	Şanslı
Happy	Mutlu
Amusement	Eğlence
Assiduous	Gayretli
Confidence	İtimat
Willing	İstekli
Mercy	Merhamet
Patient	Sabırlı
Love	Sevgi
Joyful	Sevinçli
Admiration	Hayran
Fear	Korku
Frustration	Hüsran
Arrogant	Kibirli
Depression	Depresyon
Nervous	Sinirli
Pleasure	Memnuniyet
Sympathy	Sempati
Proud	Gururlu
Restful	Huzurlu
Excited	Heyecanlı
Heroism	Kahramanlık
Honorable	Onurlu

B. Interval Type-2 Fuzzy Logic

Practitioners of fuzzy logic will be accustomed to generalizing traditional sets related to fuzzy logic (a.k.a., "crisp" or "type-0" logic). The initial insight of fuzzy logic was to generalize the notion of membership to a continuous range of [0, 1], which is entitled the membership grade to indicate its gradient nature. This is called as a type-1 fuzzy set. Type-2 fuzzy logic further broadens the generalization by identifying a membership functions value to be a distribution in [0,1], which captures uncertainty in the membership function's value[14].

We used interval type-2 fuzzy sets in this paper since they propose the theoretical benefits of full type-2 fuzzy sets. In addition, they can be implemented easily. In the place of a distribution, an interval is utilized to model the uncertainty about the membership grade. This interval is called as two type-1 fuzzy sets, an upper membership function, which defines an interval's high point, and a lower membership function, which represents an interval's low point. When these functions correspond, the type-2 fuzzy set abridges to a type-1 fuzzy set[15], [16]. The region between these set is commonly recognized as the membership function's footprint of uncertainty. We understand that there is more uncertainty about membership grade if the discrepancy between the upper and the lower membership function is wide.

The method for calculating interval type-2 membership functions from the type of survey represented above is widely known as the interval approach was first described and clarified in [17], [18]. This approach is implemented by taking the strengths of two foregoing approaches such as the interval endpoints approach [19], [20] and the person membership function approach.

In our study, we use the Interval Approach (IA)[18]. Interval end-point data for a word, collected from a group of subjects, to map each subjects data into type-1 person membership function (MF) is used by this approach. Then, it uses the aggregation of all subject's person MFs as embedded MFs in an interval type-2 fuzzy set.

The IA approach consists of two fundamental parts: the data part and the fuzzy set part. First, in the data part the data is preprocessed to remove outliers and to calculate statistics of the accumulated data by the data part. Next, the fuzzy set part utilizes the data statistics and instances remaining after pre-processing to create and initiate person MFs and selects whether they are interior or shoulder functions. In conclusion, fuzzy set part builds a mathematical model for the given word for which end-point data was collected. The plot of the interval type-2 membership functions were made using the python code in the cwwfl(Computing with Words using Fuzzy Logic) project which focuses on computing with words using fuzzy sets, especially interval type-2 fuzzy sets[21]. We show these examples of this type of membership functions in the result section.

III. RESULTS AND DISCUSSION

Emotion words can be very complicated. Even though they are comprehensible, they are not easily explicit. According to this situation, it can make the range of the membership function smaller if it is prone to abate the FOU. Example membership functions (MF's) for some words from 197 Emotion

[1] http://sail.usc.edu/~kazemzad/fuzzyEmotionEvaluation/turkish/turkish_experiment1.cgi

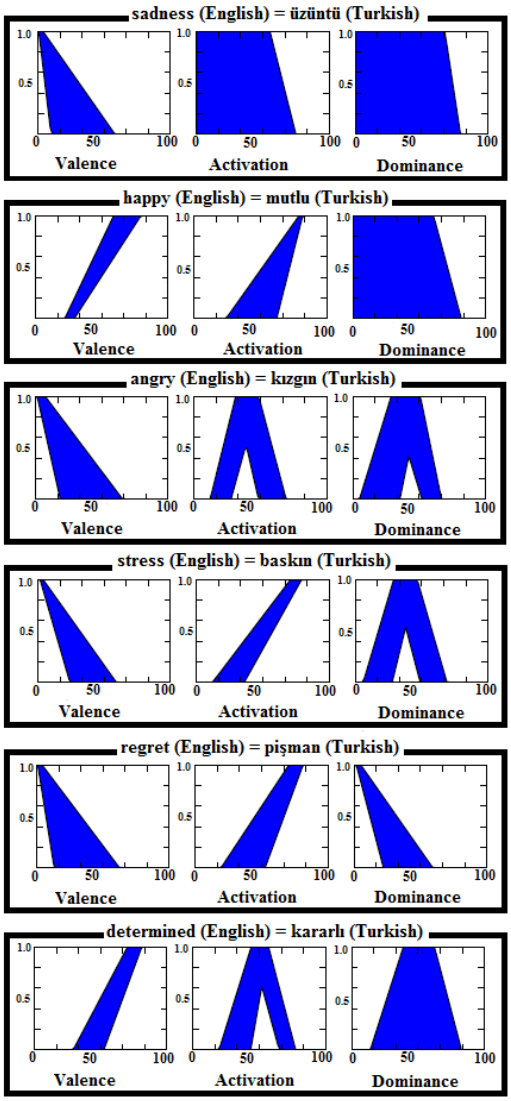

Fig. 1. Membership functions of the Turkish emotion words for dimensions valence, activation, and dominance.

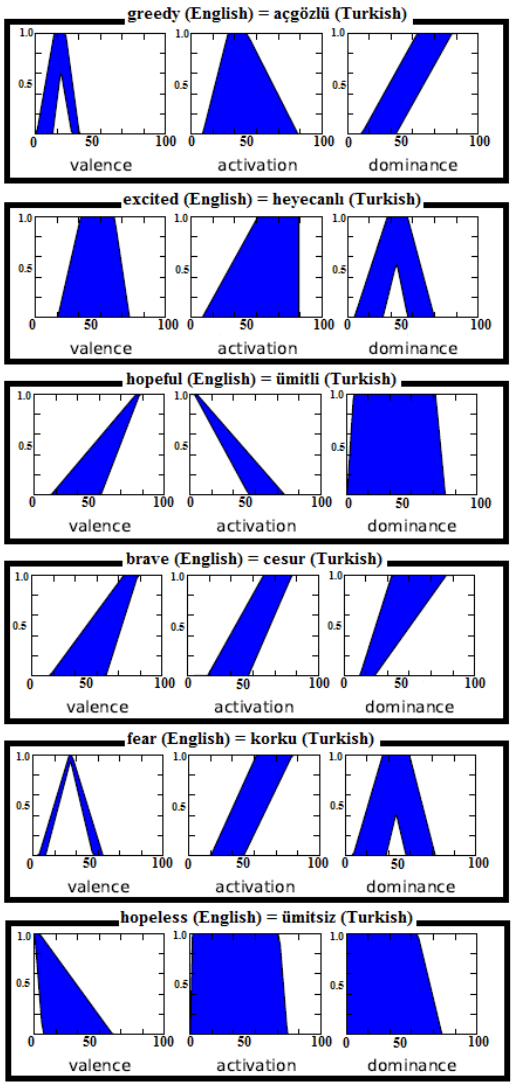

Fig. 2. Cont. Membership functions of the Turkish emotion words for dimensions valence, activation, and dominance.

Words in figure 1 and 2 show the membership functions that were calculated from the survey data. In these figures indicate that graph had general tendency to make the membership function steeper and more peripheral if emotion words are accordant with real meaning. In addition to this, graph had general tendency to make the membership function less steep and more central if emotion words have ambiguous and undetermined meaning. Besides, graph had general tendency to shift the membership function to the opposite side of at least one of the scales if emotion words do not conform with real meaning.

For figure 1, in the valence dimension for “baskı (stress)”,we can see that it is quite narrow and indicates low value. In the activation dimension, it indicates high activation value. However, in the dominance, it is quite broad and also has a large footprint of uncertainty. It means that in the dominance dimension for “baskı (stress)” has no clear in meaning of the word. Finally, this word carries meaning that is well determined by valence and activation dimension, but is not well determined by dominance dimension.

For figure 1, in the valence dimension for “kızgın (angry)”, we can see that it is quite narrow, left slanting and indicates low value. However, in the activation and dominance, it is quite broad and also has a large footprint of uncertainty. It means that this word has vague meaning. Finally, this word carries meaning that is well determined by valence dimension, but is not well determined by activation and dominance dimension.

For figure 1, we can see that this word “pişman (regret)” carries the meaning that is well determined by all three dimensions for “pişman (regret)”. Actually, in the real life, this word “pişman (regret)” can be thought of as having a negative valence, high activation and low dominance.

For figure 1, word “mutlu (happy)” is seen that is well

determined by valence and activation. However, dominance is broad, not clear and different. Although word "mutlu (happy)" is generally expected to have high dominance value, it is quite broad. It indicates that emotion words sometimes mean various things to different people. According to a sense-based emotion theory, it might make distinctions between emotion words. For example; this word "mutlu (happy)" maybe means that someone is happy about something good that happened to a friend, in other words, "glad" or means that someone is happy about something bad that happened to an enemy, put differently, "malicious" [22].

These words "cesur (brave)" and "ümitli (hopeful)" are well determined by valence and activation for figure 2, but "ümitli (hopeful)" is wide with regard to have more or less hope. Both figure 1 and figure 2 show that dominance has been difficult for annotators of the surveys to understand. Maybe this problem can be solved by giving better instructions during the survey. In figure 2, word "ümitsiz (hopeless)" is well determined by valence, but is undetermined by activation and dominance because maybe annotators felt strong or weak sensations during the survey. Moreover, in figure 2, the word "açgözlü (greedy)" is very well shaped by valence and dominance dimensions. Valence and dominance values are in accord with the real meaning, that is, this word means excessively or inordinately desirous of wealth, profit, etc.

IV. Conclusions

Emotion words play a major role in how we describe and understand emotions. In this paper, we presented an experiment that used interval type-2 fuzzy logic from 197 Turkish emotion words. Our method featured a survey that prompted users with Turkish emotion words, which refer to emotions. Each emotion word was rated by users with intervals on valence, activation and dominance dimensions' data is collected by user. It is essential to collect data about how people describe or know emotion words naturally because the aim of this research is to make communication easier about chosen specific emotion words between human and computer.

We plan to confirm the results of this paper by experiments on the survey and the natural language corpora, which will be analyzed in more detail to consider implementing Interval Approach for sentence-level. In addition, for both sentence and word level, we will calculate fuzzy similarity metrics between fuzzy membership functions that can be used to project the related distances for visualization using multidimensional scaling. Besides, we also plan to examine the inter- and intra-subject variability, and create a vocabulary of the most specific emotion words since it should be large enough so that a human will feel comfortable in interacting with a computer. The critical question we will try to answer in future study is: Is the fuzzy logic approach useful to represent emotion words correlated with sentences including these emotion words? The answer to this question will lead us to focus on this aspect.

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