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LOGICAL ANALYSIS OF EMOTIONS IN NATURAL LANGUAGE TEXTS

The study of emotional text analysis today is one of the most interesting and developing areas. The emotions presented in the text and their analysis are a special topic of our interest. In this article, we will explore the various modal judgments in logic, the emotional model and their connection with the analysis of emotions. We will offer interpretations of some simple modalities in connection with information technologies for analyzing emotions in texts. We will expand the logic of the possible worlds; our modalities will better explain and comprehend this logic of the perceived state of the environment. We are presenting the logical formulas for defining the most common modalities for analyzing emotions from text. Our work is a continuation of the work done on modalities with more flexibility and completeness. The paper discusses the logical properties of emotional modalities, the logic of emotional evaluations and the definition of various modalities for analyzing emotions. We propose six different definitions of modalities and use three theorems to prove our hypothesis. This methodology also sets the directions for future research on logical modalities for analyzing emotions from text.

Keywords: text analysis, natural language processing, emotional modalities, emotion analysis.

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Introduction

Emotional analysis has gained popularity in recent years. This is because a large amount of information relating to various kinds of emotional evaluations is freely available on the Internet online and offline. Using such an analysis, one can understand situations, causes, state of mind, for writing a specific text. This analysis can also be used to predict the future events that may occur based on public opinion and attitudes. This phenomenon has a huge impact on various applications such as product review summarization and the public opinion monitoring systems. There is a need and possibility for parallel and distributed computing use in the sphere of NLP (Natural Language Processing) [1]. The analysis of text corpus based on emotions can be used for summarizing the text [2]. The frequency with which we use different words changes all the time, and so often, a new lexical item is invented or another one ceases to be used [3]. Identification of the carriers of emotions is important for annotating the text corpus for emotion analysis (Wiebe et al., 2005 [4]). There are several methods and technologies used to analyze emotions expressed in texts. These methods are based on some models. The model as a whole describes a certain fragment of reality (an object, a phenomenon, a process and a situation). This abstract form contains the basic properties of the object being modeled. Important among these models are mathematical and logical models.

In mathematical logic, the model involves the interpretation of logical-mathematical systems. The study of such interpretations is performed in studies of logical semantics, as well as in the theory of models of mathematical logic, where the model is understood as an arbitrary set of elements with functions and predicates defined on it. The mathematical knowledge and its representation in mathematical formula is used for search and learning problems [5]. They are also used to identify relationships between different words and sentences in text. It is observed that in text, different patterns of emotions are expressed. These emotional patterns are used to express emotions and can be used to develop online educational systems for commercial purpose [6].

The measurement of sentence similarity is important for emotion analysis. It is more difficult to distinguish between precise and loose paraphrases than between loose paraphrases and non-paraphrases [7].

The largest source of data available on the Internet is in the form of reviews. These reviews may relate to products, social problems, economic problems, etc. Reviews are important for business owners, as they can make business decisions in accordance with the results of the analysis of users' opinions about their products and to identify the trends in stock markets [8, 9].

To build a model for measuring emotional response, it is necessary to analyze various characteristics of emotional reactions, such as intensity, duration, objectivity, influence on behavior and activity, sign (positive and negative emotions), etc. Emotions can be viewed as the attitude of a person at a given moment to something or someone.

Often a mathematical model is built based on the balance ratio for each of the components involved in the emergence and flow of emotions. In this concept, the particular features of emotions are not essential for analyzing the dynamics of their development, and the basic laws governing the movement of emotions come to the fore.

In 2018, M. Girlando et al. used the neighborhood semantics to obtain a labelled sequent calculus for Logic of Condition Beliefs. They argued that their calculus has strong proof-theoretic properties, in particular, admissibility of contraction and cut, and it provides a decision procedure for the logic [10].

Over the recent years, the main source of text for analyzing emotions has been social media, online blogs and other feedback mechanisms. The success of a campaign highly depends on how it is carried out in social networks. In 2015, B. Batrinca and Ph. C. Treleaven in their review observed the importance of social networks and people's opinion about the product for its sale [11]. In 2016, Vishal A. Kharde et al. studied complex methodologies used by twitter to analyze emotions in highly unstructured and heterogeneous tweets. In their opinion, a comprehensive analysis of emotions is very useful in managing society [12]. A similar idea was used on twitter data written in Indonesian Language. The idea was to remove the repeated characters and words so that the data was processed in accordance with the needs [13]. Jared Suttles and Nancy Ide in 2013 proposed a binary logical model for classification of emotional tweets. They used a set of eight basic bipolar emotions defined by Plutchik (Plutchik's wheel of emotions) which allowed the inherently multi-class problem of emotion classification as a binary problem for four opposing emotion pairs [14]. Laura A Janda and Valery D. Solovyev in 2014 defined a constructional profile as frequency distribution of words for Russian nouns denoting sadness and happiness based upon corpus data and analyzed it quantitatively [15].

In our work, the focus is on the study of emotions expressed in written (printed) text, and the possibility of using the concepts of logical modalities to analyze these emotions. Modalities in logic express additional information about judgments about certain phenomena, to express the logical states of these judgments, regulatory, temporal and other characteristics of judgments. In the text, we often encounter a situation where the author expresses his/her judgment or emotions about the characteristics of an object, event, place, etc. Therefore, modal logic can be an important component for analyzing emotions.

§ 1. Related work on modal logic

Work on modal logic began in the second decade of the 20th century. However, the main work on modal logic at the level of propositional logic, proof procedures was introduced by C. I. Lewis, the founder of modern modal logic [16]. Then the main quantifiers of modal predicate logic were introduced by Ruth Barkan [17] and later refined by Georgette Ioup in 1977 [18].

From the very beginning, the problem of interpreting formulas combining modalities with quantifiers was acute. Carnap's interpretations did not satisfy other philosophical logicians, and Barkan's work was purely formal and did not address the question of interpretation at all. MacKinsie and Tarski in 1948 [19] associated modal logic systems with some algebraic models — for Boolean algebras with operators — with various axiom schemes corresponding to different algebraic conditions. Jonsson and Tarski in 1951 [20, 21] linked algebraic structures with structures consisting of the set X with the binary relation R. Saul Kripke and Andre Joyal in late 1959 [22] and then from 1962 onward [23–25] created relational and lattice semantics for non-classical logical systems. At first, they were conceived for modal logic, and then adapted to intuitionistic logic and other non-classical systems. The development of Kripke's semantics was a breakthrough in the theory of non-classical logics, since there had existed almost no theory of models for such logics before Kripke. Much closer to the Kripke approach was the approach of Jaakko Hintikki in 1963 [26], but compared to the approach of Kripke, Hintikka modeled the theoretical or semantic approach less clearly and purely. In 1984, Bull and Segerberg [27] used Kripke's axioms in the theory of higher recursion and the Kripke–Browser scheme in intuitionistic analysis. After that, several scientists worked on it such as Boolos, George in 1993 [28] with his work on provability logic, but they, as a rule, made some additions to Kripke's work.

After this, there was a delay nearly for a decade. Mostly the researchers were involved in using the work of Kripke using similar hypotheses. In 2009, W.A. Carnielli and C. Pizzi proposed a general completeness theorem for multimodal logics. However, the theorem sheds light on the interweaving between multimodalities and their algebraic trait. They argued that over the decades normally neglected subjects such as, for instance, the logic of contingency and the logic of propositional quantifiers, require more attention [29]. B. Lellman and D. Pattinson in 2012 presented unlabelled cut-free sequent calculi for Lewis' conditional logic VV and extensions, in both the languages with the entrenchment connective and the strong conditional [30]. In the same year, D. Tishkovsky, R. A. Schmidt, and M. Khodadadi developed an automatic theorem prover called Mettel. They developed a tableau prover generator for classic and non-classical logics, focusing on modal, description and intuitionistic logics. They use general principles for implementing theorem provers and techniques. It takes as input the specification of the syntax of a logic and a set of inference rules defining a deduction calculus for the logic [31].

In 2015, Alexander Lyaletski used Evidence Algorithm (EA) program and Search in First Order Logics to construct (sound and complete) quantifier-rule-free sequent calculi for classical and non-classical logics, including the intuitionistic and modal cases [32].

Jesse Allama et al. argued that premise selection is essential when using automated reasoning as a tool for large-theory formal proof development. They developed a learning-based premise by using a two-phase approach combining precise proof analysis with machine learning algorithms for premise selection [33].

In 2014, E. Orlandelli used sequent calculi to prove the deontic logics. He used the calculi that allows a systematic root-first proof search for formal derivations. He proposed that his hypothesis is sound and complete for deontic logics [34].

In 2015, Lellmann and Pimentel introduced the nested sequent calculi to prove the theory of classical modal of logics. The nested sequent calculi are a useful generalization of ordinary sequent calculi, where sequents are allowed to occur within sequents. They applied Nested sequent calculi employed in the area of (multi)-modal logic to obtain analytic and modular proof systems for these logics [35].

§ 2. Modalities of judgment

Modality is directly or indirectly expressed in the judgment of additional information about the logical or actual status of judgments, regulatory, evaluative, temporal, and other characteristics. Modal logic is formal logic, primarily developed in the 1960s, which extends the classical propositional and predicate logic with the inclusion of operators expressing modality. A modal word that expresses a modality qualifies a statement. For example, the statement: "John is happy" can be qualified as "John is usually happy", in which case the term "usually" functions as a modal. The most important and widespread are such types of modality as alethic, deontic, epistemic, axiological.

1. Alethic modality expressed in judgment in terms of the necessity and possibility or possibility and impossibility of information expressed in logical form. Such an acceptance of judgments is determined either by structural or logical characteristics of the judgments themselves, or by their correlation with the state of affairs in reality.

2. Electoral modality is a judgment of a reliable fact, for example, "In Europe, educational institutions are actually being reformed". In such judgments, only the fact is mentioned, a different modality is not expressed.

3. Problem modality is a judgment of the possibility of something, for example, “Schools can be reformed”.

4. Apodeictic modality is a judgment about the need for something, for example, “It is necessary to reform the education system”.

5. Deontic modality refers only to the activities of people, moral and legal norms of their behavior in society. It is expressed through words such as “authorized”, “prohibited”, “mandatory”, etc. Depending on the nature of the norms, the deontic modality has the following varieties:

– judgments about the presence (or absence) of any right. They are formed with the words “allowed”, “prohibited”, “right” etc.

– judgments about the presence or absence of any obligations. They are formulated with the words “must”, “if”, etc.

6. Epistemic modality characterizes the degree of reliability of knowledge. This is expressed in the information about the judgment, the reasons for acceptance and the degree of its validity. Acceptance of a statement depends on many subjective and objective, internal and external factors. The most important of them are logical and extralogical (which expresses knowledge and faith). They are expressed by the words “proved”, “unprovable”, “refuted”, etc. There are two versions of this modality:

– judgments based on faith, for example, “I believe in a better future”.

– knowledge based judgments, for example, “According to witnesses, she did not participate in the crime”.

7. Axiological modality expresses the attitude of a person to such values as material and spiritual values. It includes words such as “good”, “bad” and so on. As an example, one can cite the judgment: “An indifferent attitude to public rights leads to a loss of the values of society”.

§ 3. Our contribution

In this paper, based on the research of other authors, we used the Kripke concept to offer our model of logical analysis of emotional evaluations. The purpose of this work is to expand the scope of modal logic to the analysis of the logic of emotions expressed in the texts. Our work and methodology are described in detail in the following sections.

Methodology

Let there be some set of “situations” and some set of propositional letters. From these letters and the usual logical connectives, one can construct ordinary propositional formulas using conventional rules. The truth of the propositional letter depends on the situation. The following describes the means for introducing into the language of propositional logic some single-valued modalities with a meaning described in the spirit of the Kripke models. Let $Force$ be the forcing relation between situations and formulas, where

$$Force(x, C)$$

means that, in the situation x, the formula C is true. The forcing relation on propositional letters will define the forcing relation on all formulas. For ordinary logical connectives, this is done in a standard way. How this is done for formulas containing modalities is described below.

The following describes the relationship between the situations in the spirit of the Kripke model for modal logic.

Let $Good$ be a positive evaluation relation:

$$Good(x, y)$$

means that the situation y is considered good from the perspective of the situation x.

Let Bad be a negative evaluation relation:

$$Bad(x, y)$$

means that the situation y is considered bad from the perspective of the situation x.

For the convenience of further generalization (and the use of our formulas in computer technology), we use the following notation for classical logical quantifiers:

$\forall x\, C(x)$ means that the formula $C(x)$ is true for all values of the variable x from the subject domain;

$\exists x\, C(x)$ means that the formula $C(x)$ is true for at least one value of the variable x from the subject domain.

Further, as a subject area, we consider a number of situations that a subject can get into (at least, he thinks or feels that he can get into them).

§ 4. Logic of Emotional Assessment

Next, we determine the most natural from our point of view "logic of emotional evaluations". This, of course, narrows the set of emotional subjects under consideration, since there are also subjects with emotional evaluations that do not agree with the logic described below. Our hypothesis is that the set of subjects with emotional evaluations, the logic of which is consistent with that described below, is large enough for it to make sense to consider it.

4.1. Definition of modalities

1. Definition of Modality

$$Must(Good)C$$

means that it is desirable that the condition C be met:

$$Force(t, Must(Good)C) \Longleftrightarrow \forall x(Good(t,x) \Rightarrow Force(x,C)).$$

2. Definition of Modality

$$Must(Bad)C$$

means that it is better the condition C not to be met:

$$Force(t, Must(Bad)C) \Longleftrightarrow \forall x(Bad(t,x) \Rightarrow Force(x,C)).$$

3. Definition of Modality

$$Should(Good)C$$

means that it is good, if the condition C is met:

$$Force(t, Should(Good)C) \Longleftrightarrow \forall x(Force(x,C) \Rightarrow Good(t,x)).$$

4. Definition of Modality

$$Should(Bad)C$$

means that it is bad if the condition C be met:

$$Force(t, Should(Bad)C) \Longleftrightarrow \forall x(Force(x,C) \Rightarrow Bad(t,x)).$$

5. Definition of Modality

$$Can(Good)C$$

means that the condition C may be good:

$$Force(t, Can(Good)C) \Longleftrightarrow \exists x(Good(t,x) \& Force(x,C)).$$

6. Definition of Modality

$$Can(Bad)C$$

means that the condition C may be bad:

$$Force(t, Can(Bad)C) \Longleftrightarrow \exists x(Bad(t, x)\&Force(x, C)).$$

In the next sections, we describe some evaluation modalities defined through the relationships introduced.

4.2. Logical properties of Emotional modalities

Properties of the modality "it is good". Here for brevity $Must(R)$, $Can(R)$ and $Should(R)$ will be denoted by $[R]$, $\langle R\rangle$ and $\{R\}$ respectively. If the relationship R is fixed, then we will use the corresponding notation: $[\ ]$, $\langle\ \rangle$ and $\{\ \}$. In particular, with a positive emotional evaluation R formula $\{\ \}A$ means: "A it is good".

Note that for the modality $[\ ]$ the following Kripke axiom holds:

$$[\ ](A \Rightarrow B) \implies ([\ ]A \Rightarrow [\ ]B).$$

The modality $\{\ \}$ has a stronger property:

$$\{\ \}(A \Rightarrow B) \implies \{\ \}B.$$

Now let's establish the connections between modalities and negation:

$$\neg([R]A) \iff \langle R\rangle \neg(A), \qquad \neg(\{R\}A) \iff \langle\neg(R)\rangle A,$$

where the relation $\neg(R)$ is the negation of the relation R on a given set of situations. That is, if it is not true that A is good, then A may be bad. The last property can be formulated as the following theorem.

Theorem 1. *For any set of situations U and any binary relation R defined on it, the following formula holds for all A in all situations:*

$$\neg(\{R\}A) \iff \langle\neg(R)\rangle A.$$

P r o o f. It is not difficult to carry out the proof of this theorem by translating the indicated formula in accordance with the definitions of modalities into the language of predicate logic and proving the validity of the resulting formula. We accept that the evaluations of the subject are such that the operator *Force* for ordinary propositional ligaments is determined elementwise. For example, the formula is fulfilled:

$$Force(t, (A \Leftrightarrow B)) \iff (Force(t, A) \Leftrightarrow Force(t, B)).$$

Therefore, we need to prove that in any situation t the following formula is fulfilled:

$$\neg(Force(t, \{R\}A)) \Longleftrightarrow Force(t, \langle\neg(\ R)\rangle A),$$

which, according to the definition of the operator $Force$ for the modalities $\{\ \}$ and $\langle\ \rangle$, is equivalent to the formula

$$\neg(\forall x(Force(x, A) \Rightarrow R(t, x))) \Longleftrightarrow \exists x(\neg(R(t, x))\&Force(x, A)).$$

The introduction of the negation in this formula inward by the usual logical rules gives the formula

$$\exists x(Force(x, A)\&\neg(R(t, x))) \Longleftrightarrow \exists x(\neg(R(t, x))\&Force(x, A)),$$

which is obviously a tautology, that completes the proof. □

Other logical properties of emotional modalities

Corollary 1. *For any set of situations U and any binary relation R defined on it, the following formula holds for all A in all situations:*

$$\{R\}A \Longleftrightarrow \neg(\langle\neg(R)\rangle A).$$

The proof lies in adding negations on both sides of the equivalence operator in the formulation of Theorem 1.

Theorem 2. *For any set of situations U and any binary relation R defined on it, the following formula holds for all A in all situations:*

$$\{R\}A \vee \{R\}B \Longrightarrow \{R\}(A\&B).$$

P r o o f. We need to prove the formula

$$Force(t, (\{R\}A \vee \{R\}B) \Longrightarrow \{R\}(A\&B)),$$

which, by definition of $Force$, means the formula

$$Force(t, \{R\}A) \vee Force(t, \{R\}B)) \Longrightarrow Force(t, \{R\}(A\&B)),$$

i.e., formulas

$$\forall x(Force(x, A) \Rightarrow R(t, x)) \Longrightarrow \forall x(Force(x, A)\&Force(x, B) \Rightarrow R(t, x)),$$
$$\forall x(Force(x, B) \Rightarrow R(t, x)) \Longrightarrow \forall x(Force(x, A)\&Force(x, B) \Rightarrow R(t, x)).$$

It is not difficult to see that these are tautologies, which completes the proof. □

Theorem 3. *For any set of situations U and any binary relation R defined on it, the following formula holds for all A in all situations:*

$$\{R\}A \,\&\, \{R\}B \Longleftrightarrow \{R\}(A \vee B)$$

P r o o f. We need to prove the formula

$$Force(t, (\{R\}A \,\&\, \{R\}B) \Longleftrightarrow \{R\}(A \vee B)),$$

which, by definition of $Force$, means the formula

$$Force(t, \{R\}A) \,\&\, Force(t, \{R\}B)) \Longleftrightarrow Force(t, \{R\}(A \vee B)).$$

This means the formula

$$\forall x(Force(x, A) \Rightarrow R(t, x)) \,\&\, \forall x(Force(x, B) \Rightarrow R(t, x)) \Leftrightarrow \forall x(Force(x, A) \vee Force(x, B) \Rightarrow R(t, x)).$$

It is not difficult to see that this is tautology, which completes the proof. □

Corollary 2. *For any set of situations U and any binary relation R defined on it, the following formula holds for all A in all situations:*

$$\{R\}(A \Rightarrow B) \Longleftrightarrow \{R\}B \,\&\, \{R\}\neg(A)$$

i.e., assertion “A implies B is good” is equivalent to the assertion that, firstly, B is good, and secondly, the negation of A is good.

P r o o f. Replace the formula $(A \Rightarrow B)$ with the equivalent formula $(\neg(A) \vee B)$ and use the theorem 3. □

Let us give an example of a logical conclusion for a transitive negative estimate: if the formula (“the transitivity of a negative estimate”)

$$\langle\neg(R)\rangle\, \langle\neg(R)\rangle\, A \Rightarrow \langle\neg(R)\rangle$$

is satisfied then the following equivalence chain is fulfilled:

$$\neg(\{R\}\neg(\{R\}A)) \Longleftrightarrow \langle\neg(R)\rangle\, \langle\neg(R)\rangle\, A \Rightarrow \langle\neg(R)\rangle\, A \Longleftrightarrow \neg(\{R\}A).$$

That is, in this case, if it is not good, that A is not good, then condition A itself is not good.

§ 5. Discussion & Conclusion

It is not always possible to describe the assessment of the situation in terms of the quantifiers mentioned above: $\forall$ and $\exists$. It is not always possible to manage with the three assessments of the situation implied here: $Good$, Bad, and $Neither$. In the more general case, a relative assessment of the situation is not one of these three values, but is an element of some partially ordered set, in general. Although sometimes this set, has the smallest and largest elements: "worst of all" and "best of all".

For our purposes, both the sets of minimum and maximum elements are sufficient: "there is no worse place" and "there is no place better". In addition, for the logical analysis of the estimates, some of these elements may remain unknown. Naturally, the relative assessments of some situations may not be comparable. For example, one situation may be considered better than another one in one aspect and worse in another aspect. Further, the value of the comparative assessment of the situation x with respect to the situation y will be usually denoted by

$$e(x, y).$$

The value of the function e belongs to some pre-selected partially ordered set of estimates. Let it be some set E with the order relation "<" ("worse").

An estimated quantifier is any operator Q used to formulate the formulas

$$Q(x)(f(x), C(x)),$$

where f is a function defined on situations with values in a set of estimates. This formula reads as follows: "Statement $C(x)$ has a general estimate of Q for the particular estimates of $f(x)$ for values of the variable x". The operator Q maps the evaluation function f and the logical function C to a logical value. For example, if we want the formula

$$Q(x)(e(t, x), Force(x, C))$$

to mean the following: "In the situation t, it is desirable that condition C be fulfilled", it is sufficient to define the function e by the equality

$$e(t, x) = (Good(t, x) - Bad(t, y))$$

(where the false value is 0, the true value is 1) and the following definition of operator Q was fulfilled:

$$Q(x)(f(x), C(x)) \Longleftrightarrow \forall x((f(x) = 1) \Longrightarrow C(x)).$$

Similarly, one can do for the other modalities discussed above.

One can define a quantifier Q so that the formula

$$Q(x)(f(x), C(x))$$

will be interpreted as a statement that the sum of the estimates of $f(x)$ for x such that the condition $C(x)$ is fulfilled exceeds a certain predetermined threshold of "desirability" r. In this case, the set of estimates must be at least a commutative partially ordered monoid (to avoid problems with the summation and comparison of results):

$$Q(x)(f(x), C(x)) \Longleftrightarrow Sum(i, U, C(i), f(i)) > r,$$

where U is the set of all situations, $Sum(i, U, C(i), f(i))$ is the sum of the values of $f(i)$ in the considered monoid of estimates for all values of the index i from the set U for which the condition $C(i)$ is fulfilled; and the relation ">" is a partial order on this monoid. For such the definition of the quantifier, the statement

$$Q(x)(e(t, x), Force(x, C)),$$

where e gives estimates from the monoid under consideration, means that, in situation t, the statement C is "on average desirable" (or "most likely, desirable").

Of course, the assumption made here that the subject summarizes the assessments of different situations is idealization and simplification. In fact, Q may be much more complicated, and the nature of the possible actions of operators Q is for further study.

§ 6. Future research direction

In the future, possible operators of evaluative quantifiers can be studied, which may reflect possible statements. Here, only so-called extensional estimates are investigated, i.e., the estimates depending on the situations represented by the subject. It should also examine the intensional assessments, i.e., the assessments that statements forms themselves produce. Often they depend not only on the logical form of the statement, but also on the syntactic form in the natural language under consideration. The following remark is related to this.

In fact, when studying emotional analysis of texts, we are concerned with the following three types of meaning and three types of syntax of these texts.

The first kind of meaning is a superficial "search meaning", which, for example, is considered in the vector analysis of text semantics by search engines. To extract such a superficial meaning, it is possible not to delve deeply into the syntax of sentences; it is enough to analyze which combinations contain different words.

The second kind of meaning is ontological meaning. He talks about the properties and relationships of the elements of the subject area to which the text in question belongs. To identify the ontological meaning, it is necessary to use the traditional syntactic analysis of the text and its deeper processing. Ideally, a full identification of ontological meaning should lead to exact formulas of complex logical-subject languages. This a very difficult task.

The third kind of meaning is the little-studied emotional meaning of the text, which speaks of the emotions and emotional evaluations, associated with the text. In theory, an analysis of the syntax of emotions in the text should be connected with the emotional meaning. The latter is an important not yet fully resolved problem.

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Логический анализ эмоций в текстах на естественном языке

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Изучение эмоционального анализа текста — сегодня одно из самых интересных и развивающихся направлений. Эмоции, представленные в тексте, и их анализ — это особая тема нашего интереса. В этой статье изучаются различные модальные суждения в логике в связи с анализом эмоций и построением модели эмоций, пригодной для логического анализа с использованием модальных связок. Предлагаются интерпретации некоторых простых модальностей в связи с информационными технологиями для анализа эмоций в текстах. Расширяется понятие логики возможных миров так, чтобы охватить логический анализ эмоциональных оценок. Предлагаемые модальности объясняют эмоциональные оценки с позиции логики воспринимаемого состояния окружающей среды. В работе рассматриваются логические свойства эмоциональных модальностей, логика эмоциональных оценок и определение различных модальностей для анализа эмоций. Данная методология предназначена для будущего использования логических модальностей при исследованиях, направленных на анализ эмоций, выраженных в текстах на естественном языке.

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