Stuart, KDC.; Majewski, M. (2015). Intelligent opinion mining and sentiment analysis using artificial neural networks. Lecture Notes in Computer Science. 9492:103-110. doi:10.1007/978-3-319-26561-2_13.

Intelligent Opinion Mining and Sentiment Analysis using Artificial Neural Networks

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Abstract. The article formulates a rigorously developed concept of opinion mining and sentiment analysis using hybrid neural networks. This conceptual method for processing natural-language text enables a variety of analyses of the subjective content of texts. It is a methodology based on hybrid neural networks for detecting subjective content and potential opinions, as well as a method which allows us to classify different opinion type and sentiment score classes. Moreover, a general processing scheme, using neural networks, for sentiment and opinion analysis has been presented. Furthermore, a methodology which allows us to determine sentiment regression has been devised. The paper proposes a method for classification of the text being examined based on the amount of positive, neutral or negative opinion it contains. The research presented here offers the possibility of motivating and inspiring further development of the methods that have been elaborated in this paper.

Key words: computational linguistics, natural language processing, neural networks, opinion mining, sentiment analysis

1 Introduction

Intelligent opinion mining and sentiment analysis tasks concern the use of natural language processing, text analysis and computational linguistics to identify and extract subjective information in a selected set of texts. It involves the use of methods for predicting the orientation of subjective content in opinionated text documents, with various applications in many areas including opinion-oriented information-seeking systems for data mining, Web mining, and text mining.

Sentiment analysis analyzes people's opinions, sentiments, evaluations, appraisals, attitudes, and emotions towards entities such as products, services, organizations, individuals, issues, events, topics, and their attributes. Opinion mining represents a large problem space and includes many different tasks: opinion extraction, sentiment mining, subjectivity analysis, affect analysis, emotion analysis, review mining. Opinions may be direct or indirect (explicit/implicit) and comparative.

Sentiment analysis tries to measure subjectivity and opinion in text, usually by capturing speaker/writer evaluations (positive, negative or neutral) and the strength of these evaluations (the degree to which the word, phrase, sentence, or document in question is positive or negative). The task of automatically classifying the polarity (whether the expressed opinion is positive or negative) of texts (technically, large amounts of unstructured data) at the document, sentence, or feature/aspect level can be a challenging task. It is these kinds of linguistic subtleties that make automatic classification difficult and result in low accuracy rates (60%-70%) of automated systems when sentences express both negative and positive opinions and express implicit negativity. There is a need for better modeling of compositional sentiment [1]. And at the sentence level, this means more accurate calculation of the overall sentence sentiment of the sentiment-bearing words, the sentiment shifters, and the sentence structure.

Texts contain ideational and interpersonal meaning: facts and opinions. The construing of experience through interpersonal meaning is a very human act. Interpersonal meanings are often expressed in texts through opinions and points of view, which are given about a wide range of topics from commercial products to presidential speeches. What makes sentiment analysis difficult is how natural languages are used for communicative purposes. Words in natural languages are dynamic contributors to a process of meaning creation which is strongly affected by the context of use. Hence, a word is a dynamic variable whose value may change depending on the context in which it is used. Words enter into relationships with other words. These in turn form phrases/clauses that form sentences that form texts.

Sentiment analysis is the computational study of interpersonal meanings: the computational extraction of emotional expression in text. There are many advantages to be derived from information systems that are able to extract information about people's appraisal, opinion, sentiment about a product, individual, event, organization, or topic (for example, security reasons). Sentiment analysis is the task of finding people's opinions about specific entities in text, a technique to classify people's opinions. Research in sentiment analysis has focused mainly on two problems: detecting whether the text is subjective or objective, and determining whether the subjective text is positive or negative. An important concept in sentiment analysis is semantic orientation which refers to the sentiment polarity (positive or negative) and sentiment strength of words, phrases, or texts [2]. It is often the goal of sentiment analysis to find the semantic orientation of texts [3, 4].

This research presents a rigorously developed concept of opinion mining and sentiment analysis shown in Fig. 1. The concept consists of a general processing scheme, using artificial intelligence methods and techniques, for opinion analysis and classification. It also contains a conceptual method for processing natural-language text [5]. The aim of the concept is to enable a variety of analyses of the subjective content of texts. The system contains the following subsystems: natural language dataset preprocessing subsystem, intelligent opinion mining

subsystem for detecting subjective content in opinionated texts, intelligent sentiment analysis for detecting positive or negative opinions.

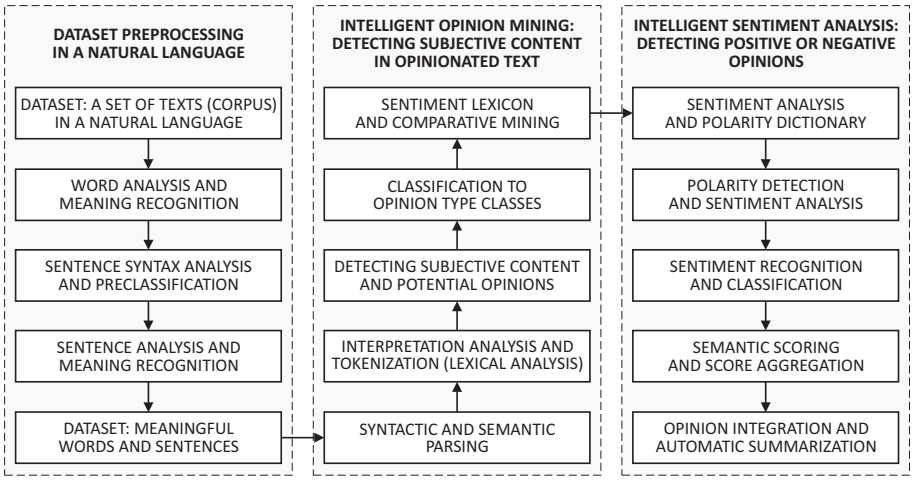

Fig. 1. Proposed concept of opinion mining and sentiment analysis

2 The State of the Art

Sentiment analysis has been investigated mainly at the following levels: document level, sentence level, and feature/aspect level [1].

The task at the document level is to classify whether a whole opinion document expresses a positive or negative sentiment. This task is commonly known as document-level sentiment classification. This level of analysis assumes that each document expresses opinions on a single entity. Therefore, it is not applicable to documents which evaluate or compare multiple entities.

The task at sentence level determines whether each sentence expresses a positive, negative, or neutral opinion. Neutral usually means no opinion. This level of analysis is closely related to subjectivity classification [2, 3], which distinguishes sentences (called objective sentences) that express factual information from sentences (called subjective sentences) that express subjective views and opinions.

Both document level and sentence level analyses do not discover what exactly people like and do not like. Aspect level performs finer-grained analysis. Aspect level was earlier called feature level (feature-based opinion mining and summarization). Instead of looking at language constructs (documents, paragraphs, sentences, clauses or phrases), aspect level directly looks at the opinion itself. It is based on the idea that an opinion consists of a sentiment (positive or

negative) and a target (of opinion). An opinion without its target being identified is of limited use. Realizing the importance of opinion targets also helps to understand the sentiment analysis problem better. In many applications, opinion targets are described by entities and their different aspects. Therefore, the goal of this level of analysis is to discover sentiments on entities and their aspects. Based on this level of analysis, a structured summary of opinions about entities and their aspects can be produced, which turns unstructured text to structured data and can be used for all kinds of qualitative and quantitative analyses. Both document level and sentence level classifications are already highly challenging. The aspect-level is even more difficult. It consists of several sub-problems [4].

3 Description of the System

This research proposes an intelligent system for opinion mining and sentiment analysis presented in Fig. 2. The system consists of a processing scheme, using artificial hybrid neural networks, for natural language processing, opinion mining, sentiment analysis and classification. It uses a method for processing natural-language texts [5–7]. The aim of the system is to enable a variety of analyses of the text and its subjective content.

The proposed system contains many specialized modules and it is divided into the following subsystems: a subsystem analyzing natural-language texts [8, 9] - for the purpose of sentiment analysis - in search of dictionary words and meaningful sentences, and a subsystem for intelligent sentiment analysis for detecting positive or negative opinions. In this system, artificial intelligence methods [10, 11] allow interpretation of a natural language, resulting in the detection of potential subjective contents, analyses of opinions and sentiments in examined texts, as well as classification of opinion type classes. The system is equipped with several adaptive intelligent layers for word analysis and recognition, sentence syntax analysis, sentence segment analysis, sentence recognition, syntactic parsing, semantic parsing, interpretation analysis [12, 13], sentence tokenization, polarity detection and classification, sentiment analysis and classification.

This research also proposes a methodology based on hybrid neural networks for detecting subjective content and potential opinions, which is presented in Fig. 3. It involves intelligent opinion mining (detecting subjective content in examined text). It also contains a method allowing to classify to opinion type and sentiment score classes. The hybrid neural network consists of a modified probabilistic neural network [14] combined with a single layer classifier. The inputs of the network comprise binary images of potential opinion samplers. The consecutive bits represent evaluative words (the words which have the greatest impact on sentiment scores) which were scored on a scale of intensity in an appropriate manner. The output provides the detection of potential opinions and the classification of opinion type classes. Fig. 3 shows the hybrid neural network architecture (A) and its details: (Fig. 3B) neural classifier, (Fig. 3C) neuron of the pattern layer, (Fig. 3D) neuron of the output layer.

The method uses modified hybrid multilayer probabilistic neural networks to recognize the opinion type and find its score. The network is a pattern classifier. It uses learning files containing patterns of possible opinion type classes. The network allows for detection of any potential combination of a subjective content with similar meanings but different lexico-grammatical patterns. It becomes an effective tool for solving classification problems of subjective content text structures, where the objective is to assign cases of opinions to one of a number of discrete opinion type classes. It offers a way to interpret the network's structure in the form of a probabilistic density function. The overall results also include text characteristics, statistical analysis, checking opinion occurrences, and validating sentiments.

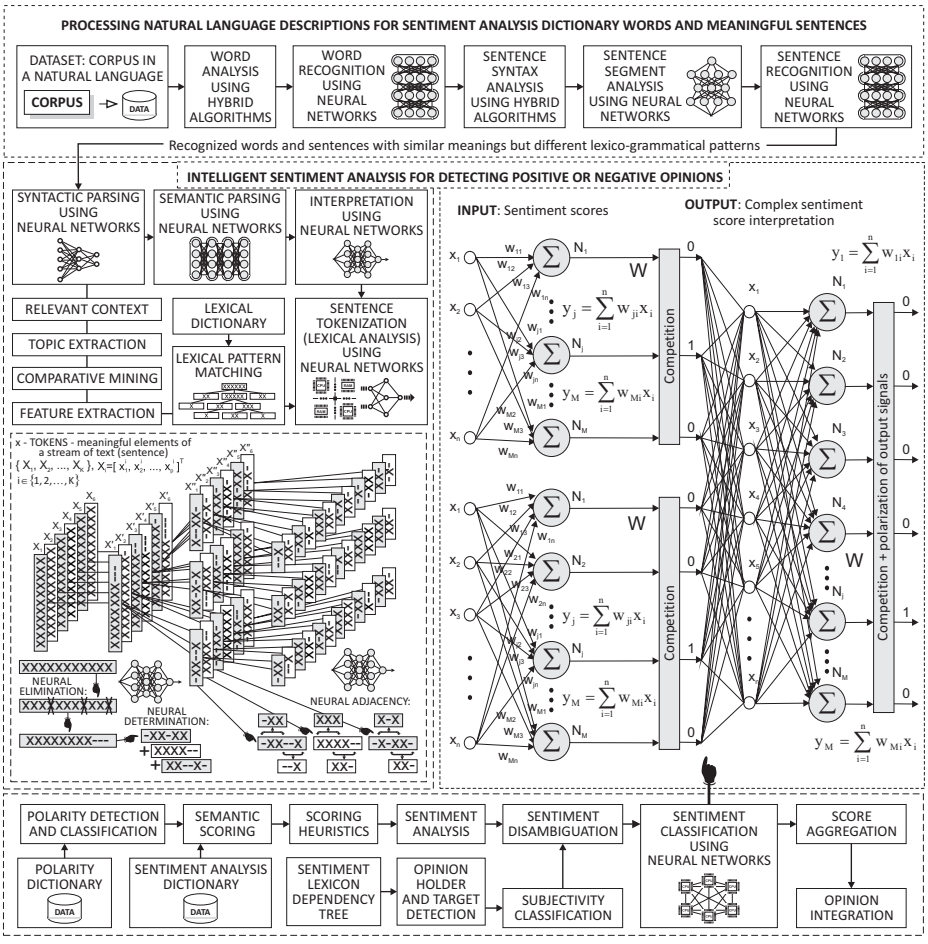

Fig. 2. Proposed intelligent system for opinion mining and sentiment analysis

The presented system also consists of a methodology based on a regression neural network [15] allowing to determine sentiment regression (Fig. 4A). Inputs of the network comprise sentiment scores (vectors) for each utterance. The network's output produces sentiment regressions. The sentiment analysis is modeled with a linear combination of sentiment scores to produce an opinion approximation. Another method based on a Hamming neural network proposes a classification process of the examined text depending on the amount of positive, neutral or negative opinion it contains (Fig. 4B). The inputs of the network comprise

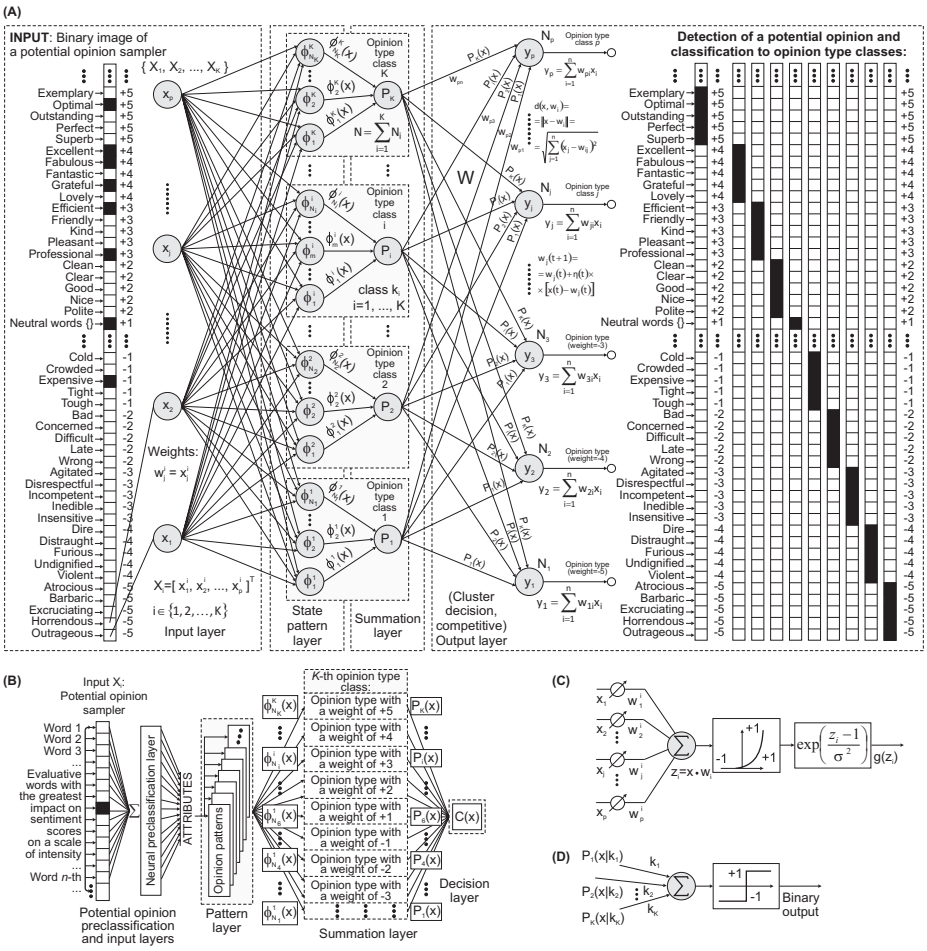

Fig. 3. Proposed hybrid neural networks for intelligent opinion mining (detecting subjective content in examined text): (A) neural network architecture for detection of a potential opinion in a text and its classification of opinion type classes, (B) neural classifier, (C) neuron of the pattern layer, (D) neuron of the output layer

binary sentiment score images representing sentiment tone intensity. The outputs provide binary images of the recognized sentiment/opinion classes. Because of the binary input signals, the Hamming neural network [5] is chosen for the recognition of normalized sentiment scores and sentiment tone intensities, which directly realizes the one-nearest-neighbour classification rule.

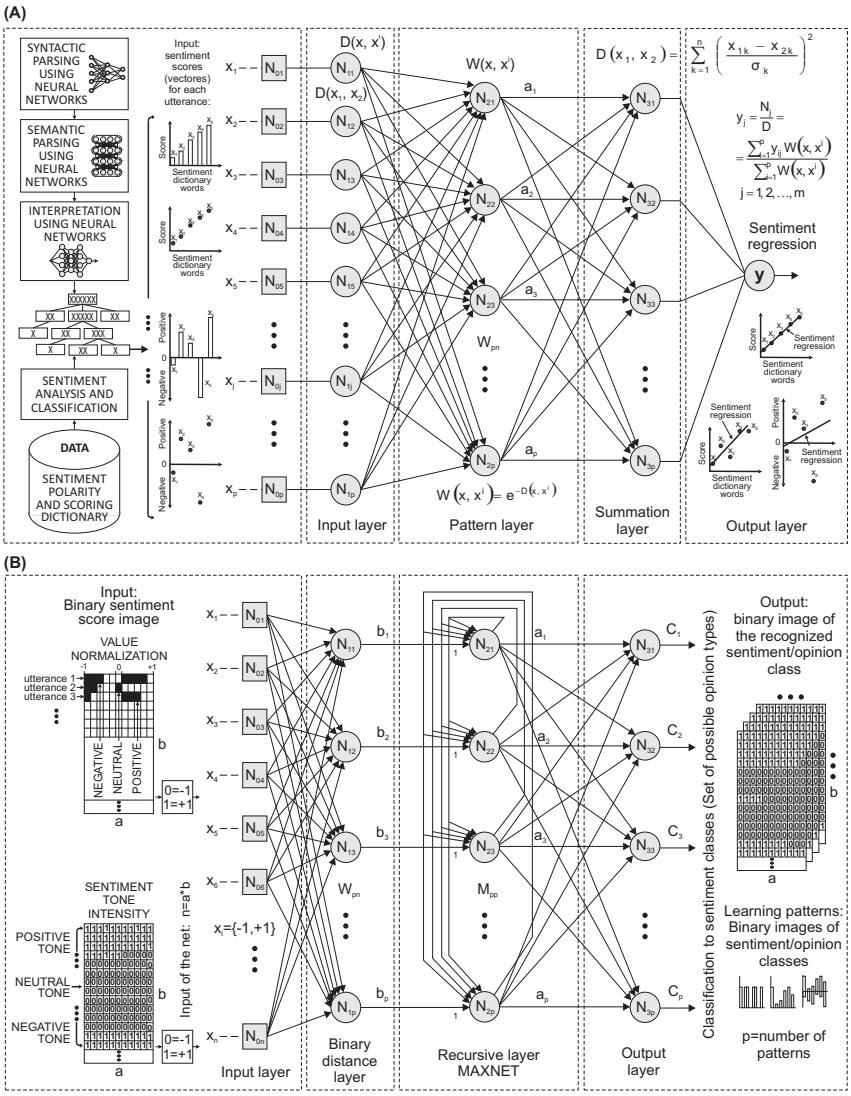

Fig. 4. Proposed neural networks for sentiment and opinion analysis: (A) methodology based on a regression neural network for determining sentiment regressions, (B) method based on a Hamming neural network for recognition of sentiment/opinion classes.

4 Conclusions and Perspectives

In the past few years, opinion mining and sentiment analysis has attracted a great deal of attention from both academia and industry due to many challenging research problems and a wide range of applications. The research presented in this article has proposed a concept of intelligent opinion mining and sentiment analysis which enables a variety of analyses of the subjective content of texts. Methods based on the proposed concepts can be extended in order to provide an even greater number of possible experimental applications.

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