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Recognizing emotions in text using ensemble of classifiers

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ABSTRACT

Emotions constitute a key factor in human nature and behavior. The most common way for people to express their opinions, thoughts and communicate with each other is via written text. In this paper, we present a sentiment analysis system for automatic recognition of emotions in text, using an ensemble of classifiers. The designed ensemble classifier schema is based on the notion of combining knowledge-based and statistical machine learning classification methods aiming to benefit from their merits and minimize their drawbacks. The ensemble schema is based on three classifiers; two are statistical (a Naïve Bayes and a Maximum Entropy learner) and the third one is a knowledge-based tool performing deep analysis of the natural language sentences. The knowledge-based tool analyzes the sentence's text structure and dependencies and implements a keyword-based approach, where the emotional state of a sentence is derived from the emotional affinity of the sentence's emotional parts. The ensemble classifier schema has been extensively evaluated on various forms of text such as, news headlines, articles and social media posts. The experimental results indicate quite satisfactory performance regarding the ability to recognize emotion presence in text and also to identify the polarity of the emotions.

1. Introduction

Human cognition and emotions are innate and very meaningful aspects of human nature. Research in Artificial Intelligence area tries to explore and get a better understanding of the mechanism underlying behavior aiming to give computer systems and applications the ability to recognize aspects of human nature, like emotions. Emotions constitute a key factor of human intelligence, which provides indicative characteristics of human behavior, colors the way of human communication and can play an important role in human computer interaction. The role of emotions was initially investigated by Picard, who introduced the concept of affective computing (Picard, 1997), indicating the importance of emotions in human computer interaction and drawing a direction for interdisciplinary research from areas, such as computer science, cognitive science and psychology. The aim of affective computing is to enable computers to recognize the emotional status and behavior of a human and bridge the gap between the emotional human and the computer by developing systems and applications that can analyze, recognize and adapt to the user's emotional states (Calvo and D'Mello, 2010).

Human emotions can be expressed through various media, such as speech, facial expressions, gestures and textual data. The most common way for people to communicate with other and with computer systems is via written text, which is the main communication mean and the backbone of the web and of social media. Over the last years the advent of the Web and the raising of social media have changed completely the way of human communication as they provide new means that connect people all over the globe with information, news and events in real time. Also, they have changed completely the role of the users; they have transformed them from simple passive information seekers and consumers to active producers (Kanavos et al., 2014). Every day, a vast amount of articles and text messages are posted in various sites, blogs, news portals, e-shops, social networks and forums. The vast amount of web textual content necessitates automated methods to analyze and extract knowledge from it (Anusha and Sandhya, 2015; Shaheen et al., 2014).

Analyzing web content and peoples' textual messages with the aim to specify their emotional status is a very interesting and challenging topic in the microblogging area (De Choudhury et al., 2012). The massive and continuous stream of textual data in the web can reflect the writers' feelings, opinions and thoughts about various phenomena ranging from political events across the globe to consumer products. It can convey people's emotional status and substantial information about their beliefs and attitudes (Qiu et al, 2012). The analysis of the textual data is necessary for deeper

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understanding a person's emotional status and behavior and in this line can provide very indicative factors regarding public attitude towards different events and topics and also can describe the emotional status of a community, a city or even a country. From a person-centric scope, analyzing the text messages of a specific person can provide very indicative factors of the person's emotional situation, his/her behavior and also provide deeper clues for determining his/her personality (Qiu et al., 2012). Furthermore, regarding news, articles and people comments, from a topic-center perspective, the analysis of the people comments on a specific topic can provide very meaningful information about the public stance, feelings and attitude towards various topics and events. In this line, emotion models can be employed to understand how people feel about a given entity such as a movie, a topic or a live event (Wang and Pal, 2015).

However, the development of systems and applications for automatically analyzing natural language with the aim to understand its sentimental content is a very hard process. Several studies have shown that analyzing and recognizing emotion in text documents is considered to be a very complex, NLP-complete problem and the interpretation varies depending on the context and the world knowledge (Shanahan et al., 2006). Also, it is pointed that sentiment analysis and emotion recognition approaches should move towards content, concept, and context-based analysis of natural language text and also support time efficient analysis techniques suitable for the special needs of the analysis of the vast web content and the big social data (Cambria et al., 2013). This work is a contribution towards this direction.

In this paper, we present an ensemble classifier system for sentiment analysis of textual data. The ensemble schema seek to effectively integrate different types of learners and classification methods aiming to overcome the drawbacks of each one and benefit from each ones advantages and in this line, improve the overall performance of the sentiment classification. The system is based on three main learners, two statistical learners and a knowledge based classifier tool, ensembled on a majority voting approach. The statistical learners are a naïve Bayes learner and maximum entropy leaner, which are trained on ISEAR (International Survey on Emotion Antecedents and Reaction) (Scherer and Wallbott, 1994) and Affective Text (Strapparava and Mihalcea, 2007) datasets. The knowledge-based tool analyzes sentence's structure using tools such as Stanford parser (de Marneffe et al., 2006) to specify word dependencies and uses WordNet Affect (Strapparava and Valitutti, 2004), lexical resources to spot words known to convey emotions. Then, it specifies each emotional word's strength and determines the sentence's emotional status based on the sentence's dependency graph in an approach where the overall sentence emotional state is derived by the emotional affinity of the sentence's emotional parts. The ensemble classifier system performs sentiment analysis on sentence level and so, a new text is initially split in sentences and each sentence is forwarded to the ensemble classifier schema, where features are extracted, represented as bag-of-words, and then handled by the statistical classifiers. The ensemble classifier determines whether the sentence is emotional or neutral and, in case it is emotional, determines the underlying emotional polarity.

The rest of the paper is structured as follows. Section 2 presents background topics on textual emotion recognition and ensemble classifiers. Section 3 presents related work. Section 4 presents the ensemble classifier system, describes its architecture and analyzes its functionality. Section 5 presents the evaluation study conducted and analyzes its performance results. Finally, Section 6 concludes the work presented in this paper and draws directions for future work.

2. Background topics

2.1. Emotion models

What is and what defines an emotion is a philosophical question that remains open for more than a century. In general, emotion is considered to be a strong feeling deriving from one's circumstances, mood or relationships with others (Oxford Dictionary, 2008). The way that emotions are represented is a basic aspect of an emotion recognition system (Reisenzein et al., 2013). The most popular models for representing emotions are the categorical and the dimensional models. The categorical model assumes that there is a finite number of basic and discrete emotions, where each one is serving a particular purpose. On the other hand, the dimensional model follows a different way and represents emotions in a dimensional approach. In this approach, dimensional model assumes that an emotional space is created and each emotion lies in this space.

A very popular and widely used categorical model is the Ekman emotion model (Ekman, 1999), which specifies six basic human emotions: anger, disgust, fear, happiness, sadness, surprise. These emotions are characterized as universal, as they are expressed in the same way across different cultures and eras. Ekman's emotion model has been used in several research studies and in various systems that are used to recognize emotional state from textual data and facial expressions. Another model that is also adopted in many studies on human emotion recognition is the Ortony–Clore–Collins (OOC) emotional model (Ortony et al., 1988). OOC model specifies 22 emotion categories based on human emotional reactions to various situations and it is mainly designed to model human emotions in general. Also it has been established as the standard model for emotion synthesis and is mainly utilized in systems that reason about emotions or incorporate emotions in artificial characters. Parrot's model (Parrott, 2001), constitutes of a group of six basic emotions, which are: love, joy, surprise, anger, sadness and fear, and also created a tree structure of emotions consisting of three levels. The first level of this classification model consists of the aforementioned six basic emotions and each level refines the granularity of the previous level, making abstract emotions more concrete. Parrot's model identifies over 100 emotions, conceptualized in a tree structured list and is considered to be the most nuanced classification of emotions.

Plutchik's model of emotions (Plutchik, 2001) is a dimensional model which offers an integrative theory based on evolutionary principles and defines eight basic bipolar emotions. These eight emotions are organized into four bipolar sets: joy vs. sadness, anger vs. fear, trust vs. disgust, and surprise vs. anticipation. Each emotion can be further divided into three degrees, for example, serenity is a lesser degree of joy and ecstasy is a more intense degree of joy. Also, the eight basic emotions can be combined to form feelings. For example, joy and trust can be combined to form love. Russell (1980) proposed the circumplex model of emotions, where emotions are represented in a two-dimensional circular space. The one dimension of the space is used to represent the emotion's polarity and the other dimension the emotion's activation. The polarity dimension characterizes an emotion as positive or negative, whereas the activation characterizes an emotion as activated or deactivated.

In our work, the ensemble classifier system utilizes the Ekman's basic emotions and the two dimensional model of Russell, characterizing basic emotions in terms of polarity as either positive or negative. The Ekman emotion model was adopted since it is the basic model for recognition of emotional content not only in facial, but also in textual data (see Related Works section), and also is can be scaffold by available lexical resources. Also, Russell's scale is used in order to quantitatively describe emotions and, in this