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Abhijit Mishra

Learning Cognitive Features from Gaze Data for Sentiment and Sarcasm Classification using Convolutional Neural Network

Abhijit Mishra[†], **Kuntal Dey**[†], **Pushpak Bhattacharyya**[⋆]
[†]IBM Research, India
[⋆]Indian Institute of Technology Bombay, India
[†]{abhijimi, kuntadey}@in.ibm.com
[⋆]pb@cse.iitb.ac.in

Abstract

Cognitive NLP systems- *i.e.*, NLP systems that make use of behavioral data - augment traditional text-based features with cognitive features extracted from eye-movement patterns, EEG signals, brain-imaging *etc.*. Such extraction of features is typically manual. We contend that manual extraction of features may not be the best way to tackle text subtleties that characteristically prevail in complex classification tasks like *sentiment analysis* and *sarcasm detection*, and that even the extraction and choice of features should be delegated to the learning system. We introduce a framework to automatically extract cognitive features from the *eye-movement / gaze* data of human readers reading the text and use them as features along with textual features for the tasks of sentiment polarity and sarcasm detection. Our proposed framework is based on Convolutional Neural Network (CNN). The CNN *learns* features from both gaze and text and uses them to classify the input text. We test our technique on published sentiment and sarcasm labeled datasets, enriched with gaze information, to show that using a combination of automatically learned text and gaze features often yields better classification performance over (i) CNN based systems that rely on text input alone and (ii) existing systems that rely on handcrafted gaze and textual features.

1 Introduction

Detection of sentiment and sarcasm in user-generated short reviews is of primary importance for social media analysis, recommendation and dialog systems. Traditional sentiment analyzers and sarcasm detectors face challenges that arise at *lexical*, *syntactic*, *semantic* and *pragmatic* levels (Liu and Zhang, 2012; Mishra et al., 2016c). Feature-based systems (Akkaya et al., 2009; Sharma and Bhattacharyya, 2013; Poria et al., 2014) can aptly handle lexical and syntactic challenges (*e.g.* learning that the word *deadly* conveys a strong positive sentiment in opinions such as *Shane Warne is a deadly bowler*, as opposed to *The high altitude Himalayan roads have deadly turns*). It is, however, extremely difficult to tackle subtleties at semantic and pragmatic levels. For example, the sentence *I really love my job. I work 40 hours a week to be this poor.* requires an NLP system to be able to understand that the opinion holder has not expressed a positive sentiment towards her / his job. In the absence of explicit clues in the text, it is difficult for automatic systems to arrive at a correct classification decision, as they often lack external knowledge about various aspects of the text being classified.

Mishra et al. (2016b) and Mishra et al. (2016c) show that NLP systems based on cognitive data (or simply, *Cognitive NLP* systems) , that leverage eye-movement information obtained from human readers, can tackle the semantic and pragmatic challenges better. The hypothesis here is that human gaze activities are related to the cognitive processes in the brain that combine the "external knowledge" that the reader possesses with textual clues that she / he perceives. While incorporating behavioral information obtained from gaze-data in NLP systems is intriguing and quite plausible, especially due to the availability of low cost eye-tracking machinery (Wood and Bulling, 2014; Yamamoto et al., 2013), few methods exist for text classification, and they rely on handcrafted features extracted from gaze data (Mishra et al., 2016b,c). These systems have limited capabilities due to two reasons: (a) Manually designed gaze based features may not adequately

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