DEEP SENTIMENT ANALYSIS ON TUMBLR

Anonymous authors
Paper under double-blind review

ABSTRACT

We propose a novel approach to Sentiment Analysis using Deep Neural Networks combining Visual Recognition and Natural Language Processing. Our approach leverages Tumblr posts containing images and text to predict the emotional state of users. Deep convolutional layers extract relevant features from images and high-dimensional word embedding followed by a recurrent layer process the textual information in order to infer the emotion conveyed by a given Tumblr post. We demonstrate that our network architecture, named Deep Sentiment, learns meaningful relations between visual data and language as it vastly outperforms models using a single modality. We then show that Deep Sentiment can also be adapted to generate images and text representative of an emotion.

1 INTRODUCTION

Sentiment analysis has been an active area of research in the past few years, especially on the readily available Twitter data, e.g. Bollen et al. (2011) who investigated the impact of collective mood states on stock market or Flaxman & Kassam (2016) who analysed day-of-week population well-being.

Contrary to Twitter, Tumblr posts are not limited to 140 characters, allowing more expressiveness, and are not focused on the textual content but on the visual content. A Tumblr post will almost always be an image with some text accompanying the latter. Pictures have become prevalent on social media and characterising them could enable the understanding of billions of users.

We propose a novel method to uncover the emotional state of an individual posting on social media. The ground truth emotion will be extracted from the tags, considered as the 'self-reported' emotion of the user. Our model incorporates both text and image and we aim to 'read' them to be able to understand the emotional content they imply about the user. Concretely, the Deep Sentiment model associates the features learned by the two modalities as follows:

- We fine-tune a pre-trained Deep Convolutional Neural Network, named Inception (Szegedy et al., 2015), to our specific task of emotion inferring.
- We project the text in a rich high-dimensional space with a word representation learned by Word2Vec (Mikolov et al., 2013). The word vectors then go through a Recurrent Neural Network which preserves the word order and captures the semantics of human language.
- A fully-connected layer combines the information in the two modalities and a final softmax output layer gives the probability distribution of the emotional state of the user.

We will also see that Deep Sentiment can be rearranged to generate Tumblr posts expressing one of the learned emotion.

2 CITATIONS, FIGURES, TABLES, REFERENCES

These instructions apply to everyone, regardless of the formatter being used.

2.1 CITATIONS WITHIN THE TEXT

Citations within the text should be based on the `natbib` package and include the authors' last names and year (with the "et al." construct for more than two authors). When the authors or the

publication are included in the sentence, the citation should not be in parenthesis (as in "See Hinton et al. (2006) for more information."). Otherwise, the citation should be in parenthesis (as in "Deep learning shows promise to make progress towards AI (Bengio & LeCun, 2007).").

The corresponding references are to be listed in alphabetical order of authors, in the REFERENCES section. As to the format of the references themselves, any style is acceptable as long as it is used consistently.

2.2 FOOTNOTES

Indicate footnotes with a number[1] in the text. Place the footnotes at the bottom of the page on which they appear. Precede the footnote with a horizontal rule of 2 inches (12 picas).[2]

2.3 FIGURES

All artwork must be neat, clean, and legible. Lines should be dark enough for purposes of reproduction; art work should not be hand-drawn. The figure number and caption always appear after the figure. Place one line space before the figure caption, and one line space after the figure. The figure caption is lower case (except for first word and proper nouns); figures are numbered consecutively.

Make sure the figure caption does not get separated from the figure. Leave sufficient space to avoid splitting the figure and figure caption.

You may use color figures. However, it is best for the figure captions and the paper body to make sense if the paper is printed either in black/white or in color.

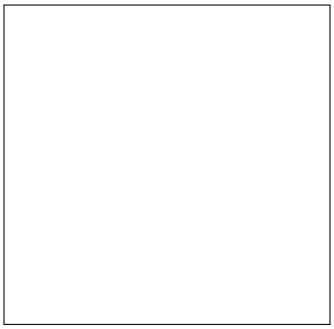

Figure 1: Sample figure caption.

2.4 TABLES

All tables must be centered, neat, clean and legible. Do not use hand-drawn tables. The table number and title always appear before the table. See Table 1.

Place one line space before the table title, one line space after the table title, and one line space after the table. The table title must be lower case (except for first word and proper nouns); tables are numbered consecutively.

ACKNOWLEDGMENTS

Use unnumbered third level headings for the acknowledgments. All acknowledgments, including those to funding agencies, go at the end of the paper.

[1] Sample of the first footnote

[2] Sample of the second footnote

Table 1: Sample table title

PART	DESCRIPTION
Dendrite	Input terminal
Axon	Output terminal
Soma	Cell body (contains cell nucleus)

REFERENCES

Yoshua Bengio and Yann LeCun. Scaling learning algorithms towards AI. In *Large Scale Kernel Machines*. MIT Press, 2007.

Johan Bollen, Huina Mao, and Xiao-Jun Zeng. Twitter mood predicts the stock market. *Journal of Computational Science*, 2:1–8, 2011.

Seth Flaxman and Karim Kassam. On #agony and #ecstasy: Potential and pitfalls of linguistic sentiment analysis. In preparation, 2016.

Geoffrey E. Hinton, Simon Osindero, and Yee Whye Teh. A fast learning algorithm for deep belief nets. *Neural Computation*, 18:1527–1554, 2006.

Tomas Mikolov, Kai Chen, Greg Corrado, and Jeffrey Dean. Efficient estimation of word representations in vector space. In *ICLR*, 2013.

Christian Szegedy, Wei Liu, Yangqing Jia, Pierre Sermanet, Scott Reed, Dragomir Anguelov, Dumitru Erhan, Vincent Vanhoucke, and Andrew Rabinovich. Going deeper with convolutions. In *CVPR*, 2015.