

Recommendation Systems for Movies with Sentiment Analysis using Neural Networks

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Abstract

In this research paper we apply the methodology outlined in the Google Research paper "Wide and Deep Learning for Recommender Systems" to predict user ratings of movies. Unlike the Google Wide and Deep model based on only categorical features, our approach utilizes user sentiment analysis by incorporating text-based movie reviews to enhance model prediction accuracy.

1. Introduction

Our approach is unique in that unlike the Google Wide and Deep model based on only categorical features, our approach incorporates text-based movie reviews to enhance the our model's prediction accuracy. Our initial milestone recreated the Google model similarly using only categorical features but with our data. This will serve as a baseline for model comparison and evaluation. Going forward, we will add in text based reviews in our model then experiment with convolutional and recurrent neural network architectures to learn the sentiment of reviews with the goal of more accurately predicting movie ratings.

Source Code:: Wide & Deep Learning for Movie Recommendation Systems

1.1. Related Work

The literature on recommendation systems is deep and until recently has traditionally focused on well-known matrix factorization algorithms, such as collaborative filtering, as popularized by Netflix and Spotify [Lee, et. al., 2012]. The benefits of collaborative filtering is that it is relatively easy to implement and computationally efficient given most similarity measure i.e. cosine similarity is matrix multiplication. Conversely, the draw backs in real-world applications have significant implications: namely CF suffers from the "cold-start" problem in that it requires user ratings to make predictions. For instance, for new users without prior history it's hard to predict ratings/recommendations

thus models have poor generalization [Balakrishnan, Dixit, 2016]

Recent research has focused on using Deep Learning, specifically convolutional and recurrent neural networks to help solve the generalization problem. Specifically, we will be focusing on expanding the Google Wide and Deep model thus our primary reference will be the original [Cheng, Koc, et. al. 2016] paper. Google provided a very basic tutorial outlining the general TensorFlow implementation of a generic Wide and Deep model. According to our knowledge no specific source code referencing the paper is open-source, however there are a few similar code-bases which we will reference open-source examples. Additional related papers that we referenced for constructing the Deep portion of our network include DeepFM [Guo, Tang, et. al. 2017] which similar to us, combine a matrix factorization with a CNN architecture; and DeepCoNN [Zheng, Noroozi, Yu, 2017] which uses parallel CNN architectures to predict ratings from users text reviews.

1.2. Problem Formulation

Prior to deep learning, standard approaches for recommendation systems (*RecSys*) used collaborative filtering which relies on decomposing users, items (i.e. movies), and ratings into latent feature matrices. Then the weights of these matrices are used to predict a rating a user would give for an item.

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difficult to do well when the paper contains many figures and equations, and, when done, looks ugly. Just use fractional references (e.g. this line is 095.5), although in most cases one would expect that the approximate location will be adequate.

1.3. Methodology

Design

Architecture

Please number all of your sections and displayed equations. It is important for readers to be able to refer to any particular equation. Just because you didn't refer to it in the text doesn't mean some future reader might not need to refer to it. It is cumbersome to have to use circumlocutions like "the equation second from the top of page 3 column 1". (Note that the ruler will not be present in the final copy, so is not an alternative to equation numbers). All authors will benefit from reading Mermin's description of how to write mathematics: <http://www.pamitc.org/documents/mermin.pdf>.

1.4. Preliminary Results

Many authors misunderstand the concept of anonymizing for blind review. Blind review does not mean that one must remove citations to one's own work—in fact it is often impossible to review a paper unless the previous citations are known and available.

Blind review means that you do not use the words "my" or "our" when citing previous work. That is all. (But see below for techreports.)

Saying "this builds on the work of Lucy Smith [1]" does not say that you are Lucy Smith; it says that you are building on her work. If you are Smith and Jones, do not say "as we show in [7]", say "as Smith and Jones show in [7]" and at the end of the paper, include reference 7 as you would any other cited work.

An example of a bad paper just asking to be rejected:

An analysis of the frobnicatable foo filter.

In this paper we present a performance analysis of our previous paper [1], and show it to be inferior to all previously known methods. Why the previous paper was accepted without this analysis is beyond me.

[1] Removed for blind review

An example of an acceptable paper:

An analysis of the frobnicatable foo filter.

In this paper we present a performance analysis of the paper of Smith *et al.* [1], and show it to be inferior to all previously known methods. Why the

previous paper was accepted without this analysis is beyond me.

[1] Smith, L and Jones, C. "The frobnicatable foo filter, a fundamental contribution to human knowledge". Nature 381(12), 1-213.

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You can handle this paper like any other. Don't write "We show how to improve our previous work [Anonymous, 1968]. This time we tested the algorithm on a lunar lander [name of lander removed for blind review]". That would be silly, and would immediately identify the authors. Instead write the following:

We describe a system for zero-g frobnication. This system is new because it handles the following cases: A, B. Previous systems [Zeus *et al.* 1968] didn't handle case B properly. Ours handles it by including a foo term in the bar integral.

...

The proposed system was integrated with the Apollo lunar lander, and went all the way to the moon, don't you know. It displayed the following behaviours which show how well we solved cases A and B: ...

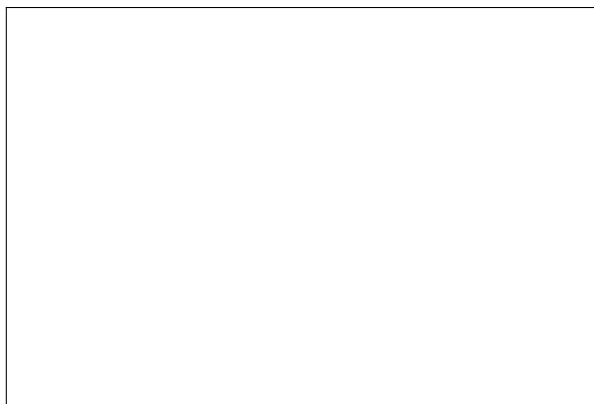


Figure 1. Example of caption. It is set in Roman so that mathematics (always set in Roman: $B \sin A = A \sin B$) may be included without an ugly clash.

As you can see, the above text follows standard scientific convention, reads better than the first version, and does not explicitly name you as the authors. A reviewer might think it likely that the new paper was written by Zeus *et al.*, but cannot make any decision based on that guess. He or she would have to be sure that no other authors could have been contracted to solve problem B.

FAQ

Q: Are acknowledgements OK?

A: No. Leave them for the final copy.

Q: How do I cite my results reported in open challenges?

A: To conform with the double blind review policy, you can report results of other challenge participants together with your results in your paper. For your results, however, you should not identify yourself and should not mention your participation in the challenge. Instead present your results referring to the method proposed in your paper and draw conclusions based on the experimental comparison to other results.

1.5. Miscellaneous

Compare the following:

$\$conf_a\$$ $conf_a$
 $\$\mathit{conf}_a\$$ $conf_a$

See The T_EXbook, p165.

The space after *e.g.*, meaning “for example”, should not be a sentence-ending space. So *e.g.* is correct, *e.g.* is not. The provided `\eg` macro takes care of this.

When citing a multi-author paper, you may save space by using “et alia”, shortened to “*et al.*” (not “*et. al.*” as “*et*” is a complete word.) However, use it only when there are three or more authors. Thus, the following is correct: “Frobination has been trendy lately. It was introduced

by Alpher [?], and subsequently developed by Alpher and Fotheringham-Smythe [?], and Alpher *et al.* [?].”

This is incorrect: “... subsequently developed by Alpher *et al.* [?] ...” because reference [?] has just two authors. If you use the `\etal` macro provided, then you need not worry about double periods when used at the end of a sentence as in Alpher *et al.*

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All text must be in a two-column format. The total allowable width of the text area is $6\frac{7}{8}$ inches (17.5 cm) wide by $8\frac{7}{8}$ inches (22.54 cm) high. Columns are to be $3\frac{1}{4}$ inches (8.25 cm) wide, with a $\frac{5}{16}$ inch (0.8 cm) space between them. The main title (on the first page) should begin 1.0 inch (2.54 cm) from the top edge of the page. The second and following pages should begin 1.0 inch (2.54 cm) from the top edge. On all pages, the bottom margin should be 1-1/8 inches (2.86 cm) from the bottom edge of the page for 8.5 × 11-inch paper; for A4 paper, approximately 1-5/8 inches (4.13 cm) from the bottom edge of the page.

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All printed material, including text, illustrations, and charts, must be kept within a print area 6-7/8 inches (17.5 cm) wide by 8-7/8 inches (22.54 cm) high. Page numbers should be in footer with page numbers, centered and .75 inches from the bottom of the page and make it start at the correct page number rather than the 4321 in the example. To do this fine the line (around line 23)

```
%\ifcvprfinal\pagestyle{empty}\fi
\setcounter{page}{4321}
```

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Make sure the first page is numbered by commenting out the first page being empty on line 46

```
%\thispagestyle{empty}
```

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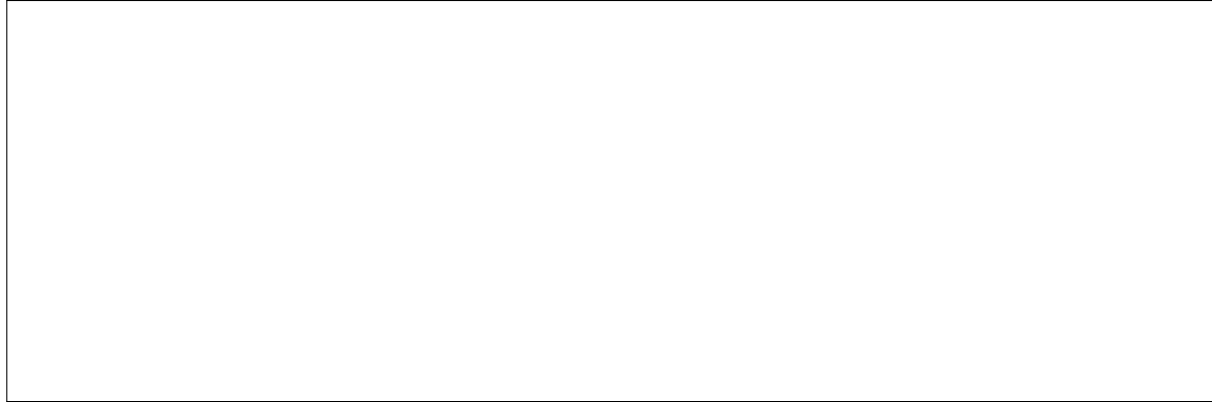


Figure 2. Example of a short caption, which should be centered.

AUTHOR NAME(s) and AFFILIATION(s) are to be centered beneath the title and printed in Times 12-point, non-boldface type. This information is to be followed by two blank lines.

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MAIN TEXT. Type main text in 10-point Times, single-spaced. Do NOT use double-spacing. All paragraphs should be indented 1 pica (approx. 1/6 inch or 0.422 cm). Make sure your text is fully justified—that is, flush left and flush right. Please do not place any additional blank lines between paragraphs.

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Method	Frobnability
Theirs	Frumpy
Yours	Frobbly
Ours	Makes one's heart Frob

Table 1. Results. Ours is better.

bottom of the column on the page on which it is referenced. Use Times 8-point type, single-spaced.

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\includegraphics[width=0.8\linewidth]  
    {myfile.eps}
```

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