Integrating Semantic information into Factored Neural Network Language Models

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Abstract

Neural network and translation models have recently shown great potentials in improving the performance of language modeling in phrase-based machine translation. Recurrent language models with different word factors, in particular, were a great success due to their ability to incorporate additional knowledge into the model. At the same time, great achievements have been attained in latent concept learning in the area of text mining. In this work, we combined both ideas to integrate global semantic information extracted from large independent knowledge bases into neural network language models. To do this, we propose two novel approaches: one on the word and one on the sentence level. The new resulting models are especially helpful for morphologically rich languages without the need to expand the training corpus but also in solving lexical ambiguities. This approach of integrating global context information is not restricted to language modeling but can also be easily applied to any model that profits from context, e.g. neural network machine translation. Using this model has improved translation quality of a state-of-the-art phrase-based translation system by ... BLEU points. We performed experiments on two language pairs.

1. Introduction

Neural network and translation models have recently shown great potentials in improving the performance of language modeling in phrase-based machine translation. Recurrent language models with different word factors, in particular, were a great success due to their ability to incorporate additional knowledge into the model. In the past, mainly restricted to syntactic or clustered word class information on the word level. At the same time, great achievements have been attained in topic modeling and latent concept learning in the area of text mining. In this work, we combined both ideas to use global context extracted from large independent knowledge bases as an additional input into the neural network model. This is especially helpful for languages with little training data, great morphology and lexical ambiguities. Using this model has improved translation quality of a state-of-the-art phrase-based translation system by ... BLEU points. This approach of integrating additional semantic information is not restricted to language modeling but can also be easily applied to any model that profits from context, e.g. neural network machine translation. We performed experiments on two language pairs.

2. Page layout and style

Authors should should observe the following rules for page layout. A highly recommended way to meet these requirements is to use a predefined template and check details against the corresponding example file.

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The first page should have the paper title, author(s), and affiliation(s) centered on the page across both columns. The remainder of the text must be in the two-column format, staying within the indicated image area.

2.1.1. Paper Title

The paper title must be in boldface. All non-function words must be capitalized, and all other words in the title must be lower case. The paper title is centered across the top of the two columns on the first page as indicated above.

2.1.2. Authors' Name(s)

The authors' name(s) and affiliation(s) appear centered below the paper title. If space permits, include a mailing address here. The templates indicate the area where the title and author information should go. These items need not be confined to the number of lines indicated; papers with multiple authors and affiliations may require two or more lines. Note that the submission version of technical papers *should be anonymized for review*.

2.1.3. Abstract

Each paper must contain an abstract that appears at the beginning of the paper.

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- Top margin 25 mm (except first page 30 mm to title top).
- Text height (without headers and footers) is maximum 235 mm.
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Section headings are centered in boldface with the first word capitalized and the rest of the heading in lower case. Subheadings appear like major headings, except they start at the left margin in the column. Sub-sub-headings appear like subheadings, except they are in italics and not boldface. See the examples given in this file. No more than 3 levels of headings should be used.

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Times or Times Roman font is used for the main text. Recommended font size is 9 points which is also the minimum allowed size. Other font types may be used if needed for special purposes. While making the final PostScript file, remember to include all fonts!

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2.4. Figures

All figures must be centered on the column (or page, if the figure spans both columns). Figure captions should follow each figure and have the format given in Fig. 1.

Figures should preferably be line drawings. If they contain gray levels or colors, they should be checked to print well on a high-quality non-color laser printer.

2.5. Tables

An example of a table is shown as Table 1. Somewhat different styles are allowed according to the type and purpose of the table. The caption text may be above or below the table.

Table 1: *This is an example of a table.*

ratio	decibels
1/1	0
2/1	≈ 6
3.16	10
10/1	20
1/10	-20

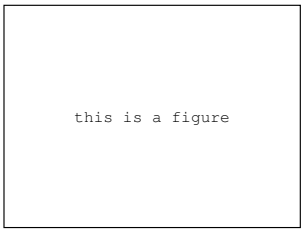

Figure 1: *Schematic diagram of speech production.*

2.6. Equations

Equations should be placed on separate lines and numbered. Examples of equations are given below. Particularly,

$$x(t) = s(f_\omega(t)) \tag{1}$$

where $f_\omega(t)$ is a special warping function

$$f_\omega(t) = \frac{1}{2\pi j} \oint_C \frac{\nu^{-1k} d\nu}{(1-\beta\nu^{-1})(\nu^{-1}-\beta)} \tag{2}$$

A residue theorem states that

$$\oint_C F(z)dz = 2\pi j \sum_k Res[F(z), p_k] \tag{3}$$

Applying (3) to (1), it is straightforward to see that

$$1 + 1 = \pi \tag{4}$$

Make sure to use `\eqref` when refering to equation numbers. Finally we have proven the secret theorem of all speech sciences (see equation (3) above). No more math is needed to show how useful the result is!

2.7. Hyperlinks

Hyperlinks can be included in your paper. Moreover, be aware that the paper submission procedure includes the option of specifying a hyperlink for additional information. This hyperlink will be included in the CD-ROM. Particularly pay attention to the possibility, from this single hyperlink, to have further links to information such as other related documents, sound or multimedia.

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3. Experiments

Please make sure to give all the necessary details regarding your experimental setting so as to ensure that your results could be reproduced by other teams.

4. Conclusions

This paper has described a novel approach for doing wonderful stuff such as ...

5. Acknowledgements

The IWSLT 2015 organizing committee would like to thank the organizing committees of INTERSPEECH 2004 for their help and for kindly providing the template files.

6. References

[1] Smith, J. O. and Abel, J. S., "Bark and ERB Bilinear Transforms", IEEE Trans. Speech and Audio Proc., 7(6):697–708, 1999.

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[3] Rudnicky, A. I., Polifroni, Thayer, E. H., and Brennan, R. A. "Interactive problem solving with speech", J. Acoust. Soc. Amer., Vol. 84, 1988, p S213(A).