Fast, Scalable Phrase-Based SMT Decoding

Anonymous ACL submission

Abstract

The utilization of statistical machine translation (SMT) has grown enormously over the last decade, many using open-source software developed by the NLP community. As commercial utilization has increased, there has been a pressing need that is optimized for their requirements. Specifically, faster phrase-based decoding, and more efficient utilization of modern multicore servers.

We present in this paper a re-assessment of the major components of phrase-based decoding and decoder implementation with particular emphasis on speed and scalability to multicore machines. The result is a drop-in replacement for the Moses decoder which is up to fifteen times faster and scales almost linearly with the number of cores. Furthermore, the decoder makes less search errors than the current Moses decoder.

1 Introduction

SMT has been one of the outstanding success story from the NLP community in the last decade. It has transition from a mostly research discipline to services such as Google Translate, Microsoft Translator Hub, as well as services and products built around offline products such as the open-source Moses toolkit. The latter has spawned a cottage industry encompassing a range of organizations and services from small language service providers that use SMT to reduce translation cost to large inter-govermental organizations such as the EU and the UN that provides high volume translation.

For high volume users, decoding is a largest and most critical part of the translation process which needs to be fast and efficient. However, it has been noticed that the Moses decoder, amongst others, is unable to efficiently use multiple CPU cores that are now common on modern servers (reviewed paper, github discussion). That is, the time taken to decode a test set does not substantial decrease when more cores are used, in fact, decoding time may increase when more cores are added. The issue will only become more noticeable as the commercial use of SMT grows and the number of cores in servers increases.

There have be speculation on the causes of the inefficiency as well as remedies. This paper is the first we know of that seeks to tackle this problem head on. We present an phrase-based decoder that is not only significantly faster than the Moses baseline for single-threaded operation, but is able to scale run multiple threads on multi-core machines with only a slightly loss in linear speed. Model scores and functionality are compatible with Moses to aid comparison and ease of transition for users. All source code will be made available under an open-source license.

1.1 Prior Work

There are a number of open-source SMT projects, most includes a decoder. The most well known is Moses, which supports phrase-based models, hierarchical phrase-based as well as various syntax-based models. Joshua also supports hiearchical and syntax models and has recently supported phrase-based models. Phrasal supports a number of variants of the phrase-based model. CDEC supports hierarchical and syntactic models.

A number of the decoders support multithreading whilst others use alternative methods such as Hadoop or external scripts to parallelize decoding. We shall investigate the efficiency of using parallelizing decoding using the multi-processor approach. None of the decoder focus on multithreads decoding.

(Recently reviewed) describes running multiple processes of the Moses decoder for increased speed.

Other prior work look to optimizing specific components of decoding. (Liang and Chiang) describes the cube-pruning and cube-growing algorithm for decoding which allows the tradeoff between speed and translation quality to the adjusted with a simgle parameter. (KenLM) and (DALM) describes fast, efficient datastructures for language models. (Zen) describes an implementation of a phrase-table for an SMT decoder that is loaded on demand, reducing the initial loading time and memory requirements. (CompactPT) extends this by compressing the on-disk phrase table and lexicalized re-ordering model resulting in impressive speed gains over previous work.

(mtplz) is perhaps closest in intent to this work. This takes a wholistic approach to decoding, describing a novel decoding algorithm which is fis focused on better decoding speed. It also describes a number of implementation details for faster decoding. However, the decoding algorithm is only able to incorporate one stateful feature function which precludes some of the useful decoding configurations which contains multiple stateful feature functions. It does not include a load-on-demand phrase table, therefore, cannot be used in a commercial environment where phrase-table has not be filtered with a know test set for any realistic size phrase-table. Neither did this paper analyze the scalability of their work to multicore servers.

The rest of the paper will be broken up into the following sections. Next, we will describe the phrase-based model and the major implementation components, with particular emphasis on decoding time shortcomings. We will then describe modifications to improve decoding speed and present results. We conclude in the last section discuss suggested improvements and future work.

2 Phrase-Based Model

The objective of decoding is to find the target translation with the maximum probability, given a source sentence. That is, for a source sentence s, the objective is to find a target translation $\hat{t}$ which has the highest conditional probability $p(t|s)$. Mathematically, this is written as:

$$\hat{t} = \arg\max_t p(t|s) \tag{1}$$

where the *arg max* function is the search. The log-linear model generalizes the noisy channel model to include more component models and weighting each model according to the contribution of each model to the total probability.

$$p(t|s) = \frac{1}{Z}\exp(\sum_m \lambda_m h_m(t,s)) \tag{2}$$

where λ_m is the weight, and h_m is the feature function, or 'score', for model m. Z is the partition function which can be ignored for optimization. The log-linear formulation in phrase-based SMT uses log probabilities as feature functions, in addition to features which do not have a probabilistic interpretation. Typical feature functions include the log transforms of the target language model probability $p(t)$, and translation model probabilities, $p_{TM}(t|s)$ and $p_{TM}(s|t)$, which we have suffixed with $_{TM}$ to avoid confusion with the overall model probability $p(t|s)$ and $p(s|t)$.

3 BLAH BLAH

The following instructions are directed to authors of papers submitted to and accepted for publication in the ACL 2016 proceedings. All authors are required to adhere to these specifications. Authors are required to provide a Portable Document Format (PDF) version of their papers. The proceedings will be printed on A4 paper. Authors from countries where access to word-processing systems is limited should contact the publication chairs as soon as possible. Grayscale readability of all figures and graphics will be encouraged for all accepted papers (Section 4.8).

Submitted and camera-ready formatting is similar, however, the submitted paper should have:

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3. Page numbers
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4 General Instructions

Manuscripts must be in two-column format. Exceptions to the two-column format include the title, as well as the authors' names and complete addresses (only in the final version, not in the version submitted for review), which must be centered at the top of the first page (see the guidelines in Subsection 4.4), and any full-width figures or tables. Type single-spaced. Do not number the pages in the camera-ready version. Start all pages directly under the top margin. See the guidelines later regarding formatting the first page.

The maximum length of a manuscript is eight (8) pages for the main conference, printed single-sided, plus two (2) pages for references (see Section 5 for additional information on the maximum number of pages).

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4.2 Electronically-available resources

ACL provides this description in LaTeX2e (`acl2016.tex`) and PDF format (`acl2016.pdf`), along with the LaTeX2e style file used to format it (`acl2016.sty`) and an ACL bibliography style (`acl2016.bst`) and example bibliography (`acl2016.bib`). These files are all available at `acl2016.org/index.php?article_id=9`. We strongly recommend the use of these style files, which have been appropriately tailored for the ACL 2016 proceedings.

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```

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{\o}	ø	{\H o}	ő
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Table 1: Example commands for accented characters, to be used in, e.g., BibTeX names.

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Center the title, author name(s) and affiliation(s) across both columns (or, in the case of initial submission, space for the names). Do not use footnotes for affiliations. Use the two-column format only when you begin the abstract.

Title: Place the title centered at the top of the first page, in a 15 point bold font. (For a complete guide to font sizes and styles, see Table 2.) Long titles should be typed on two lines without a blank line intervening. Approximately, put the title at 1in from the top of the page, followed by a blank line, then the author name(s), and the affiliation(s) on the following line. Do not use only initials for given names (middle initials are allowed). Do not format surnames in all capitals (e.g., "Mitchell," not "MITCHELL"). The affiliation should contain the author's complete address, and if possible, an electronic mail address. Leave about 0.75in between the affiliation and the body of the first page.

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Headings: Type and label section and subsection headings in the style shown on the present document. Use numbered sections (Arabic numerals) in order to facilitate cross references. Number subsections with the section number and the subsection number separated by a dot, in Arabic numerals.

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References: We recommend including references in a separate `.bib` file, and include an example file in this release (`naalhlt2016.bib`). Some commands for names with accents are provided for convenience in Table 1. References stored in the separate `.bib` file are inserted into the document using the following commands:

```
\bibliography{acl2016}
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```

References should appear under the heading **References** at the end of the document, but before any Appendices, unless the appendices contain references. Arrange the references alphabetically by first author, rather than by order of occurrence in the text. Provide as complete a reference as possible, using a consistent format, such as the one for *Computational Linguistics* or the one in the *Publication Manual of the American Psychological Association* (American Psychological Association, 1983). Authors' full names rather than initials are preferred. You may use **standard** ab-

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author affiliation	12 pt	
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document text	11 pt	
abstract text	10 pt	
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caption label	9 pt	bold
bibliography	10 pt	
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Table 2: Font guide.

breviations for conferences[1] and journals[2].

Appendices: Appendices, if any, directly follow the text and the references (but see above). Letter them in sequence and provide an informative title: **Appendix A. Title of Appendix**.

Acknowledgment sections should go as a last (unnumbered) section immediately before the references.

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Footnotes: Put footnotes at the bottom of the page. They may be numbered or referred to by asterisks or other symbols.[3] Footnotes should be separated from the text by a line.[4] Footnotes should be in 9 point font.

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Illustrations: Place figures, tables, and photographs in the paper near where they are first discussed, rather than at the end, if possible. Wide illustrations may run across both columns and should be placed at the top of a page. Color illustrations are discouraged, unless you have verified that they will be understandable when printed in black ink.

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[1] https://en.wikipedia.org/wiki/List_of_computer_science_conference_acronyms

[2] http://www.abbreviations.com/jas.php

[3] This is how a footnote should appear.

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As the reviewing will be blind, the paper must not include the authors' names and affiliations. Furthermore, self-references that reveal the author's identity, e.g., "We previously showed (Smith, 1991) ..." must be avoided. Instead, use citations such as "Smith previously showed (Smith, 1991) ..." Papers that do not conform to these requirements will be rejected without review. In addition, please do not post your submissions on the web until after the review process is complete (in special cases this is permitted: see the multiple submission policy below).

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7 Multiple Submission Policy

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Acknowledgments

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