

Neural Machine Translation with Recurrent Networks*

Extended Abstract[†]

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ABSTRACT

In recent years, neural machine translation (NMT) has been a wide and open area to study Natural Language Processing. With increasing work, there is still much to do. NMT is an approach to machine translation that uses a large neural network. It departs from phrases-based statistical approaches that use separately engineered subcomponents. Neural machine translation (NMT) is not a drastic step beyond what has been traditionally done in statistical machine translation (SMT).

CCS CONCEPTS

• **Computer systems organization** → **Embedded systems**; *Redundancy*; Robotics; • **Networks** → Network reliability;

KEYWORDS

ACM proceedings, L^AT_EX, text tagging

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1 INTRODUCTION

This means the model does not have to explicitly store gigantic phrase tables and language models as in the case of standard MT; hence, NMT has a small memory footprint. Lastly, implementing NMT decoders is easy unlike the highly intricate decoders in standard MT.

2 NEURAL MACHINE TRANSLATIONS

NMT is an approach to machine translation that uses a large neural network. It departs from phrases-based statistical approaches that

use separately engineered subcomponents. Neural machine translation (NMT) is not a drastic step beyond what has been traditionally done in statistical machine translation (SMT). NMT starts emitting one target word a time as illustrated in. NMT is often a large neural network that is trained in an end-to-end fashion and has the ability to generalize well to very long word sequences.

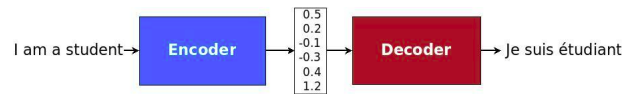


Figure 1: Encoder-decoder architecture

In this tutorial, we consider as examples a deep multi-layer RNN which is unidirectional and uses LSTM as a recurrent unit. We show an example of such a model in Figure 2. In this example, we build a model to translate a source sentence "I am a student" into a target sentence "Je suis étudiant". At a high level, the NMT model consists of two recurrent neural networks: the encoder RNN simply consumes the input source words without making any prediction; the decoder, on the other hand, processes the target sentence while predicting the next words.

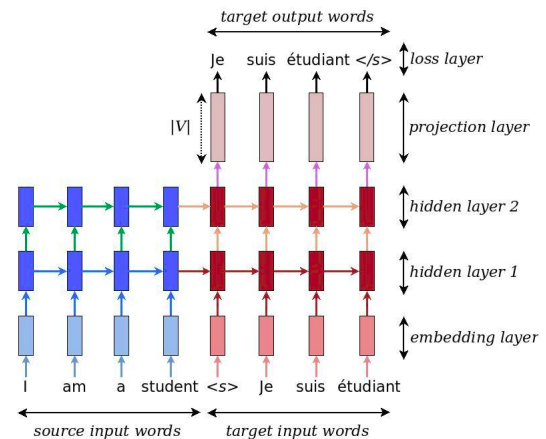


Figure 2: Neural machine translation

3 ATTENTION BASED MODELS

3.1 Global attention

We have already seen several typeface changes in this sample. You can indicate italicized words or phrases in your text with the

*Produces the permission block, and copyright information

[†]The full version of the author's guide is available as `acmart.pdf` document

[‡]Dr. Trovato insisted his name be first.

[§]The secretary disavows any knowledge of this author's actions.

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command `\textit`; emboldening with the command `\textbf` and typewriter-style (for instance, for computer code) with `\texttt`. But remember, you do not have to indicate typestyle changes when such changes are part of the *structural* elements of your article; for instance, the heading of this subsection will be in a sans serif¹ typeface, but that is handled by the document class file. Take care with the use of² the curly braces in typeface changes; they mark the beginning and end of the text that is to be in the different typeface.

You can use whatever symbols, accented characters, or non-English characters you need anywhere in your document; you can find a complete list of what is available in the *L^AT_EX User's Guide* [26].

3.2 Local attention

You may want to display math equations in three distinct styles: inline, numbered or non-numbered display. Each of the three are discussed in the next sections.

3.2.1 Input-feeding Approach. A formula that appears in the running text is called an inline or in-text formula. It is produced by the **math** environment, which can be invoked with the usual `\begin . . . \end` construction or with the short form `$. . . $`. You can use any of the symbols and structures, from α to ω , available in L^AT_EX [26]; this section will simply show a few examples of in-text equations in context. Notice how this equation: $\lim_{n \rightarrow \infty} x = 0$, set here in in-line math style, looks slightly different when set in display style. (See next section).

3.2.2 Display Equations. A numbered display equation—one set off by vertical space from the text and centered horizontally—is produced by the **equation** environment. An unnumbered display equation is produced by the **displaymath** environment.

Again, in either environment, you can use any of the symbols and structures available in L^AT_EX; this section will just give a couple of examples of display equations in context. First, consider the equation, shown as an inline equation above:

$$\lim_{n \rightarrow \infty} x = 0 \quad (1)$$

Notice how it is formatted somewhat differently in the **displaymath** environment. Now, we'll enter an unnumbered equation:

$$\sum_{i=0}^{\infty} x + 1$$

and follow it with another numbered equation:

$$\sum_{i=0}^{\infty} x_i = \int_0^{\pi+2} f \quad (2)$$

just to demonstrate L^AT_EX's able handling of numbering.

3.3 Input-feeding approach

Citations to articles [6–8, 19], conference proceedings [8] or maybe books [26, 34] listed in the Bibliography section of your article will occur throughout the text of your article. You should use BibTeX to automatically produce this bibliography; you simply need to insert one of several citation commands with a key of the item cited in the

¹Another footnote here. Let's make this a rather long one to see how it looks.

²Another footnote.

Table 1: Frequency of Special Characters

Non-English or Math	Frequency	Comments
Ø	1 in 1,000	For Swedish names
π	1 in 5	Common in math
\$	4 in 5	Used in business
Ψ_1^2	1 in 40,000	Unexplained usage

proper location in the `.tex` file [26]. The key is a short reference you invent to uniquely identify each work; in this sample document, the key is the first author's surname and a word from the title. This identifying key is included with each item in the `.bib` file for your article.

The details of the construction of the `.bib` file are beyond the scope of this sample document, but more information can be found in the *Author's Guide*, and exhaustive details in the *L^AT_EX User's Guide* by Lamport [26].

This article shows only the plainest form of the citation command, using `\cite`.

Some examples. A paginated journal article [2], an enumerated journal article [11], a reference to an entire issue [10], a monograph (whole book) [25], a monograph/whole book in a series (see 2a in spec. document) [18], a divisible-book such as an anthology or compilation [13] followed by the same example, however we only output the series if the volume number is given [14] (so Editor00a's series should NOT be present since it has no vol. no.), a chapter in a divisible book [37], a chapter in a divisible book in a series [12], a multi-volume work as book [24], an article in a proceedings (of a conference, symposium, workshop for example) (paginated proceedings article) [4], a proceedings article with all possible elements [36], an example of an enumerated proceedings article [16], an informally published work [17], a doctoral dissertation [9], a master's thesis: [5], an online document / world wide web resource [1, 30, 38], a video game (Case 1) [29] and (Case 2) [28] and [27] and (Case 3) a patent [35], work accepted for publication [31], 'YYYYY'-test for prolific author [32] and [33]. Other cites might contain 'duplicate' DOI and URLs (some SIAM articles) [23]. Boris / Barbara Beeton: multi-volume works as books [21] and [20].

A couple of citations with DOIs: [22, 23].

Online citations: [38–40].

3.4 bal bla

Because tables cannot be split across pages, the best placement for them is typically the top of the page nearest their initial cite. To ensure this proper "floating" placement of tables, use the environment **table** to enclose the table's contents and the table caption. The contents of the table itself must go in the **tabular** environment, to be aligned properly in rows and columns, with the desired horizontal and vertical rules. Again, detailed instructions on **tabular** material are found in the *L^AT_EX User's Guide*.

Immediately following this sentence is the point at which Table 1 is included in the input file; compare the placement of the table here with the table in the printed output of this document.

To set a wider table, which takes up the whole width of the page's live area, use the environment **table*** to enclose the table's contents



Figure 3: A sample black and white graphic.



Figure 4: A sample black and white graphic that has been resized with the includegraphics command.

and the table caption. As with a single-column table, this wide table will “float” to a location deemed more desirable. Immediately following this sentence is the point at which Table 2 is included in the input file; again, it is instructive to compare the placement of the table here with the table in the printed output of this document.

It is strongly recommended to use the package booktabs [15] and follow its main principles of typography with respect to tables:

- (1) Never, ever use vertical rules.
- (2) Never use double rules.

It is also a good idea not to overuse horizontal rules.

3.5 Figures

Like tables, figures cannot be split across pages; the best placement for them is typically the top or the bottom of the page nearest their initial cite. To ensure this proper “floating” placement of figures, use the environment **figure** to enclose the figure and its caption.

This sample document contains examples of .eps files to be displayable with L^AT_EX. If you work with pdfL^AT_EX, use files in the .pdf format. Note that most modern T_EX systems will convert .eps to .pdf for you on the fly. More details on each of these are found in the *Author's Guide*.

As was the case with tables, you may want a figure that spans two columns. To do this, and still to ensure proper “floating” placement of tables, use the environment **figure*** to enclose the figure and its caption. And don’t forget to end the environment with **figure***, not **figure**!

3.6 Theorem-like Constructs

Other common constructs that may occur in your article are the forms for logical constructs like theorems, axioms, corollaries and proofs. ACM uses two types of these constructs: theorem-like and definition-like.

Here is a theorem:

THEOREM 3.1. *Let f be continuous on $[a, b]$. If G is an antiderivative for f on $[a, b]$, then*

$$\int_a^b f(t) dt = G(b) - G(a).$$

Here is a definition:

Definition 3.2. If z is irrational, then by e^z we mean the unique number that has logarithm z :

$$\log e^z = z.$$

The pre-defined theorem-like constructs are **theorem**, **conjecture**, **proposition**, **lemma** and **corollary**. The pre-defined definition-like constructs are **example** and **definition**. You can add your own constructs using the *amsthm* interface [3]. The styles used in the `\theoremstyle` command are **acmplain** and **acmdefinition**.

Another construct is **proof**, for example,

PROOF. Suppose on the contrary there exists a real number L such that

$$\lim_{x \rightarrow \infty} \frac{f(x)}{g(x)} = L.$$

Then

$$l = \lim_{x \rightarrow c} f(x) = \lim_{x \rightarrow c} \left[gx \cdot \frac{f(x)}{q(x)} \right] = \lim_{x \rightarrow c} g(x) \cdot \lim_{x \rightarrow c} \frac{f(x)}{q(x)} = 0 \cdot L = 0,$$

which contradicts our assumption that $l \neq 0$.

4 EXPERIMENTS

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4.1 Training Details

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4.2 English-Spanish Results

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4.3 Spanish-English Results

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5 ANALYSIS

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5.1 Learning curves

5.2 Effects of Translations Long Sentences

5.3 Choices of attentional Architectures

5.4 Alignment Quality

5.5 Sample Translations

6 CONCLUSIONS

This paragraph will end the body of this sample document. Remember that you might still have Acknowledgments or Appendices; brief samples of these follow. There is still the Bibliography to deal

Table 2: Some Typical Commands

Command	A Number	Comments
<code>\author</code>	100	Author
<code>\table</code>	300	For tables
<code>\table*</code>	400	For wider tables

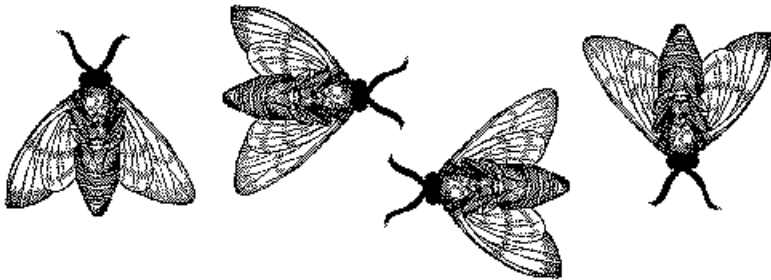


Figure 5: A sample black and white graphic that needs to span two columns of text.

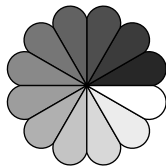


Figure 6: A sample black and white graphic that has been resized with the `includegraphics` command.

with; and we will make a disclaimer about that here: with the exception of the reference to the \LaTeX book, the citations in this paper are to articles which have nothing to do with the present subject and are used as examples only.

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