

Semantic understanding of natural language text using distant supervision

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1 Motivation

The beauty of natural language lies in the fact that it allows us to express the same thought in very different ways. But this makes it hard for machines to **deal with** natural languages since machines are good at memorizing data but pretty bad at generalizing from them. For e.g. a human can easily identify that the two sentences “The boy wants the girl to believe him” and “The boy has a desire to be believed by the girl” mean the same but it is difficult for a machine to do so. What can help machines in this case is if they can work with a kind of representation that abstracts away from various syntactic idiosyncrasies and captures the very meaning of the sentence. Such semantic level of understanding of text is becoming more and more necessary as the field of natural language processing (NLP) tries to solve problems that are closer to natural language understanding. **Machines** learn from examples and hence need annotated data to train on. However, **manually** **annotating** data with semantic information is expensive and time-consuming since it requires a linguistic expert in the loop. **The availability** of rich knowledge bases in recent times has given rise to an indirect way of gathering training data called distant supervision (Mintz et al., 2009). In this technique, instead of annotating a sentence with information, **given an information** stored in the database, we gather sentences that may contain evidence for that information.

My research work focuses on how we can use distant supervision **technique** for solving problems that require deeper semantic understanding of text. In subsequent sections I will discuss some of my work that fall under this category and also discuss how these ideas are relevant to ~~some of~~ the work at Adobe Research.

2 Zero pronoun resolution

I first came to appreciate the usefulness of distant supervision in my work on zero pronoun resolution for Chinese (Rao et al., 2015),. Chinese being a “pro-drop” language tends to drop pronouns when they are implicit from the context. This phenomena is more apparent in a dialogue setting since the speakers tend to refer to each other a lot. The corresponding task of resolving the dropped pronouns to one of the speakers (or to an outside entity in case of third person pronoun) is called zero pronoun resolution. In our work we developed a novel sequential model that explicitly tracked the conversation focus in a dialogue and used that to resolve the zero pronouns. To train our model, we needed annotated data and it was expensive to have humans annotate data for us. **English** unlike Chinese is not a pro-drop language and mentions pronouns explicitly. Also there is huge amount of readily available Chinese-English parallel corpora. ~~So in our work we developed a method to automatically annotate the training data using the pronouns in the English translation of the Chinese sentence, allowing us to have a large amount of data to train on.~~ This kind of a distant supervision, ~~even though noisy, turned out to be very useful for our task and~~ gave significant improvements over purely supervised approaches.

3 Relation extraction

Given a text, identifying who did what to whom has been an **important task** in NLP. This problem becomes even more challenging when the text expresses multiple hierarchical relations in a complex manner. For e.g. consider the following sentence from biomedical literature - “ This LPA-induced rapid phosphorylation of radixin/moesin was significantly suppressed in the presence of C3 toxin, a potent inhibitor of Rho”. As humans we can identify the various complex relationships in

It would help to make the reading smoother here. Eg. you could say something like so we decided to use distance sup. using readily avail. Chi-Eng parallel data. Also, "English, unlike Chinese, is not.." would look better?

I think that "turned out" makes it sound like it worked by chance

you might have to elaborate on this...not sure. maybe ask somebody else

would be a good idea to use something more formal than "deal with"

I would make the reading smoother here. Something like "Most of these NLP systems learn..."

might be a good idea to put this in a new para (not sure)

given a piece of information?"

techniques

I would put an opening sentence here.

You might want to give an example here/explain a little more. Ask Hal/Phillip if they feel the same way

This sentence hints that humans do not work with any such structures in mind? Just saying

this text but for a machine to do so, it needs a deeper semantic representation of the text. Abstract Meaning Representation (AMR) (Banarescu et al., 2013) in one such semantic representation that tries to capture the overall meaning of the sentence in the form of a graph structure. Figure 1 shows the AMR corresponding to the previously mentioned sentence. Identifying the right relations is much easier for a machine now given the

AMR structure as opposed to when it was given just the original sentence. During summer 2015, I worked with Dr. Daniel Marcu and Dr. Kevin Knight at ISI on developing methods for relation extraction from biomedical text using AMR. Existing supervised methods for relation extraction gave a low recall on this task. We hypothesized that the key reason for this was the low amount of training data. Biomedical domain has a rich source of knowledge bases that contain information about protein-protein interactions. Additionally, it also has millions of research papers published over the years that talk about such protein interactions. We made use of these resources to gather a large amount of additional training data using the distant supervision technique. It has been shown that training data gathered using distant supervision can be noisy sometimes (Takamatsu et al., 2012). Hence, we made use of some path heuristic in the AMR of the sentence to label them more cleverly. This work lead to a system with high recall of 0.75 (F1 0.49) over a baseline recall of 0.23 (F1 0.32). Currently I am working on building deep neural network that can further exploit the AMR graph structure.

4 Future work

Syntactic representations like constituent parse trees and dependency parse trees have been successfully used for solving many problems in NLP for a long time now. But equivalent semantic representations like AMR have been less explored. One of the main reasons for this is the lack of automatic parsers that can accurately parse sentences into such semantic representations. Recently there has been a lot of work on AMR parsing (Flanigan et al., 2014), (Pust et al., 2015), etc. But the accuracy of these parsers is much lower than those we get for syntactic parsers (e.g. dependency parsers). One of the main reasons for this is the paucity of annotated data. Semantic annotation requires much deeper linguistic expertise than

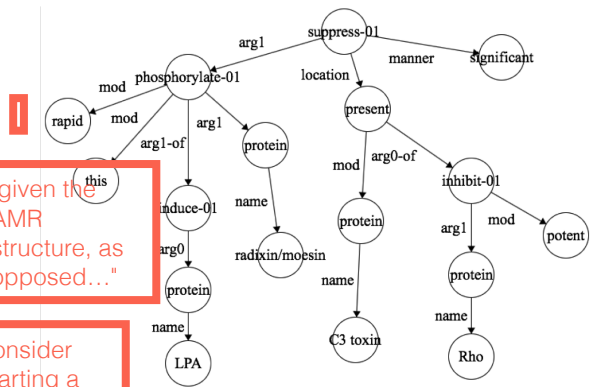


Figure 1: AMR for sentence "This LPA-induced rapid phosphorylation of radixin/moesin was significantly suppressed in the presence of C3 toxin, a potent inhibitor of Rho"

any kind of syntactic annotation and hence is time consuming and expensive. One might go as far as saying that huge amounts of semantically annotated data might never be available for machine learning models to efficiently learn from. But humans do not need such huge amounts of data to efficiently parse a sentence for its meaning. They can generalize much better. How do they do that? There has been a lot of work in linguistics to show that humans make use of context and common sense knowledge while parsing a sentence for its meaning. Can machines do something similar? Wikipedia, DBpedia, OpenCyc, Freebase, etc. are some examples of knowledge bases that machines can make use of. We have already seen the potential of distant supervision to solve semantically challenging tasks and so in future I plan to explore how we can leverage the information stored in such knowledge bases to improve semantic parsing using distant supervision techniques.

5 Applications to Adobe

I believe that my current expertise in semantics puts me in a good position to contribute to the ongoing research in text analytics at Adobe. In recent times the combination of vision and natural language processing has been successfully used for solving many interesting problems. One specific project at Adobe that caught my interest was: Editing images with natural language (Laput et al., 2013). Interpreting user commands can be challenging when they go from simple ones like "make it bright" to more challenging ones like "the image needs to be bright" or "the image is too bright"

in --> is

the AMR str is very complex. It might help the reader if you tell them what nodes/path to look at (by using colors/boxes etc). Eg the subtree at present tells that presence of C3, a protein, inhibits another protein Rho

I wouldn't use "some", "cleverly". Kind of makes your work sound hacky

"made use of"

"building a deep"

I think you are not sending the right message here. Just because some parsing has been useful should not be a reason why people should start using AMR. They should be used because they provide a glimpse of the semantic meaning etc. etc. However, state-of-the-art systems aren't 'good enough'...

long sentence

"recent times, the combination of methods in vision.... Challenging" used twice?

Not sure if I get why they are 'completely' different?

which need better semantic interpretations to understand that the action required in the two cases are completely different. Making use of semantic representation to parse the phrases can ease the task of interpretation and help provide a platform where users can express themselves more naturally. Contextualized advertising system based on text is another area that can benefit from deeper semantics. Recommending truly relevant ads to the user requires an understanding of the text that is deeper than just a keyword match.

You might want to have a final 'concluding' line.

References

- Laura Banarescu, Claire Bonial, Shu Cai, Madalina Georgescu, Kira Griffitt, Ulf Hermjakob, Kevin Knight, Philipp Koehn, Martha Palmer, and Nathan Schneider. 2013. Abstract meaning representation for sembanking.
- Jeffrey Flanigan, Sam Thomson, Jaime Carbonell, Chris Dyer, and Noah A. Smith. 2014. A discriminative graph-based parser for the abstract meaning representation. In *Proceedings of the 52nd Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 1426–1436, Baltimore, Maryland, June. Association for Computational Linguistics.
- Gierad P Laput, Mira Dontcheva, Gregg Wilensky, Walter Chang, Aseem Agarwala, Jason Linder, and Eytan Adar. 2013. Pixeltone: a multimodal interface for image editing. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2185–2194. ACM.
- Mike Mintz, Steven Bills, Rion Snow, and Dan Jurafsky. 2009. Distant supervision for relation extraction without labeled data. In *Proceedings of the Joint Conference of the 47th Annual Meeting of the ACL and the 4th International Joint Conference on Natural Language Processing of the AFNLP: Volume 2-Volume 2*, pages 1003–1011. Association for Computational Linguistics.
- Michael Pust, Ulf Hermjakob, Kevin Knight, Daniel Marcu, and Jonathan May. 2015. Using syntax-based machine translation to parse english into abstract meaning representation. *arXiv preprint arXiv:1504.06665*.
- Sudha Rao, Allyson Ettinger, Hal Daumé III, and Philip Resnik. 2015. Dialogue focus tracking for zero pronoun resolution. In *Proceedings of the 2015 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies*, pages 494–503, Denver, Colorado, May–June. Association for Computational Linguistics.
- Shingo Takamatsu, Issei Sato, and Hiroshi Nakagawa. 2012. Reducing wrong labels in distant supervision for relation extraction. In *Proceedings of the 50th Annual Meeting of the Association for Computational Linguistics: Long Papers-Volume 1*, pages 721–729. Association for Computational Linguistics.