

FOFE-based Deep Neural Networks for Entity Discovery and Linking

Nargiza Nosirova

Mingbin Xu, Nargiza Nosirova, Kelvin Jiang, Feng Wei and Hui Jiang

Lassonde School of Engineering, York University, Canada



2017 TAC Workshop

FOFE-based Deep Neural Networks for Entity Discovery and Linking

Overview

- What is FOFE?
- FOFE-based model for Entity Discovery
- Ensemble modeling for Entity Discovery
- Multi-task model for Entity Discovery
- FOFE-based model for Entity Linking
- Experiments
- Conclusion

What is FOFE?

Definition (Fixed-size Ordinally Forgetting Encoding)

- $S = w_1, w_2, \dots, w_n$ is a sequence of any discrete symbols;
- w_i is represented as \mathbf{e}_i in 1-hot representation;
- the encoding of a partial sequence up to the t -th word is recursively defined as:

$$\mathbf{z}_t = \begin{cases} \mathbf{e}_t, & \text{if } t = 1 \\ \alpha \cdot \mathbf{z}_{t-1} + \mathbf{e}_t, & \text{otherwise} \end{cases}$$

- $\alpha \in (0, 1)$ and $t \in \{\mathbb{Z} \mid 1 \leq x \leq n\}$

What is FOFE? (continued)

Example

- $A = [1, 0, 0]$
- $B = [0, 1, 0]$
- $C = [0, 0, 1]$
- $ABC = [\alpha^2, \alpha, 1]$

What is FOFE? (continued)

Any **variable length** sequence is **losslessly** encoded into a **fixed-size** vector.

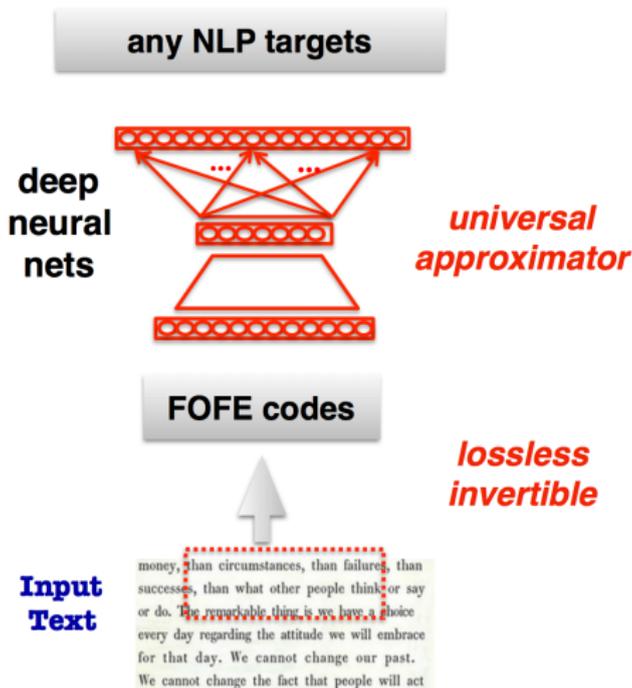
WORD	1-HOT
w_0	1000000
w_1	0100000
w_2	0010000
w_3	0001000
w_4	0000100
w_5	0000010
w_6	0000001

PARTIAL SEQUENCE	FOFE
w_6	$0, 0, 0, 0, 0, 0, 1$
w_6, w_4	$0, 0, 0, 0, 1, 0, \alpha$
w_6, w_4, w_5	$0, 0, 0, 0, \alpha, 1, \alpha^2$
w_6, w_4, w_5, w_0	$1, 0, 0, 0, \alpha^2, \alpha, \alpha^3$
w_6, w_4, w_5, w_0, w_5	$\alpha, 0, 0, 0, \alpha^3, 1 + \alpha^2, \alpha^4$
$w_6, w_4, w_5, w_0, w_5, w_4$	$\alpha^2, 0, 0, 0, 1 + \alpha^4, \alpha + \alpha^3, \alpha^5$

Table: Vocab of size 7

Table: Partial encoding of $w_6, w_4, w_5, w_0, w_5, w_4$

Universal Framework for NLP



FOFE-based model for Entity Discovery

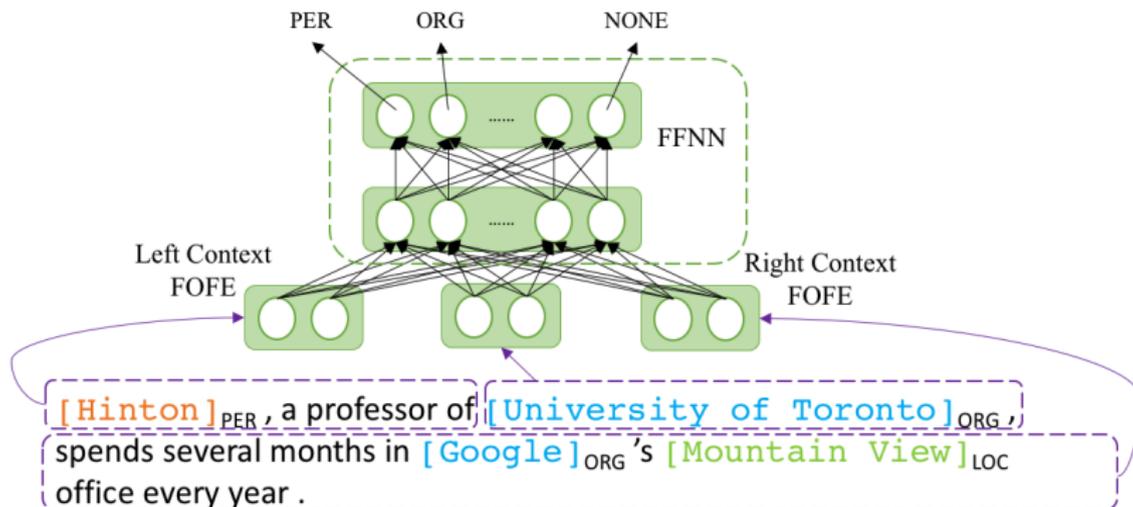


Figure: Illustration of the local detection approach for Entity Discovery using FOFE codes as input and FFNN as model.

FOFE-based Model for Entity Discovery (continued)

Features used:

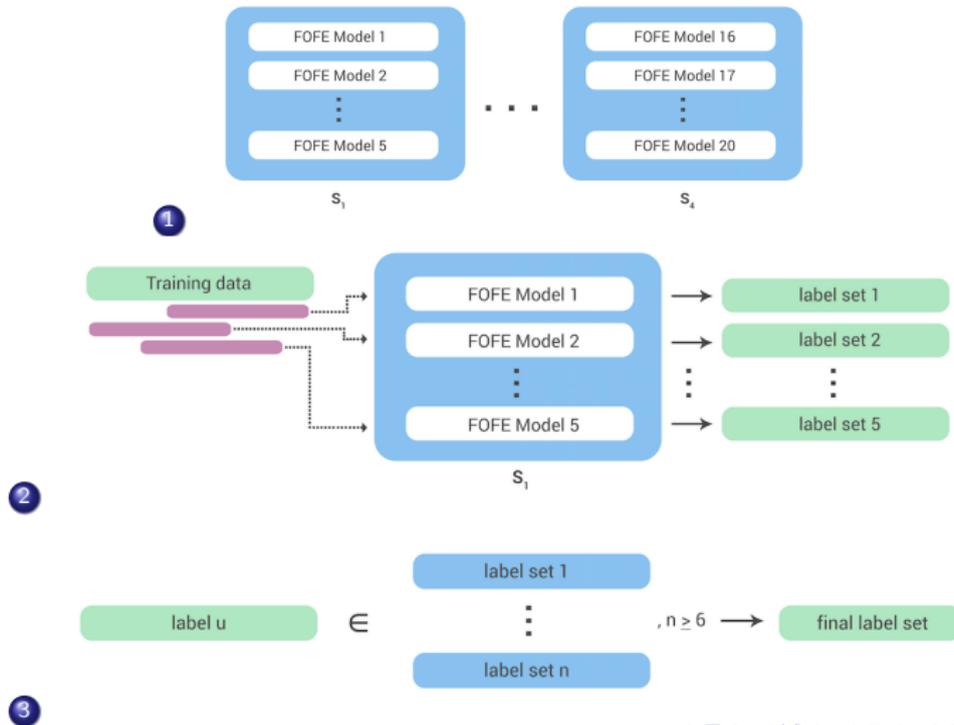
Word-level:

- BOW vector of the fragment
- FOFE codes of the left/right contexts

Character-level:

- FOFE code of the fragment
- Char CNN

Ensemble Modeling



Multi-task Model for Entity Discovery using FOFE

Multi-task Learning:

Concurrently learning a task alongside related (auxiliary) tasks by using a shared representation.

- Word and character level features are also FOFE based.
- Make use of different datasets, each treated as separate tasks.

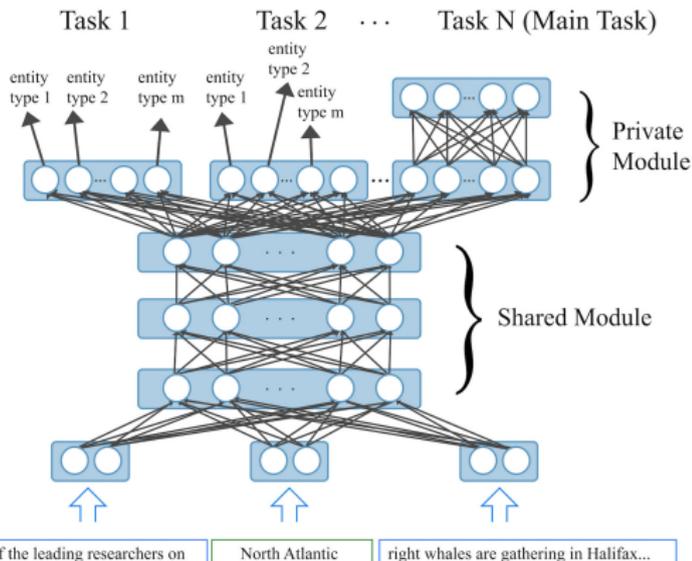
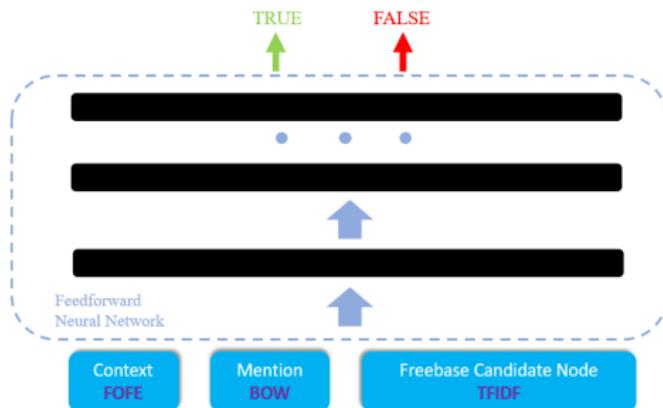


Figure: Illustration of the multi-task FFNN approach for Entity Discovery.

FOFE-based Entity Linking

- 1 Rule-based candidate generation
 - Generated based on knowledge bases (KB), such as Freebase, Wikipedia
 - Outputs a candidate list (Freebase nodes)
- 2 Neural Network based probability ranking
 - Candidate with the highest probability is chosen as the final linking result

FOFE-based Entity Linking (continued)



Features used:

- FOFE codes of left/right context.
- BOW of mention.
- Mention's candidates KB description as BOW normalized by tf-idf.

Figure: Illustration of our FOFE-based Entity Linking system using FFNNs.

Results: Datasets

- **FOFE-based Entity Discovery and Entity Linking models**
 - *Training data*: KBP 2015 (train & eval), KBP 2016 (eval), and iFLYTEK's in-house dataset.
- **Multitask FOFE-based model**
 - Main task: KBP 2017 EDL task
 - Auxiliary tasks:
 - *English*: CoNLL-2003, OntoNotes 5.0
 - *Spanish & Chinese*: DEFT Light ERE dataset

Ensemble Modeling Results

LANG	single model			model ensemble		
	P	R	F_1	P	R	F_1
ENG	0.801	0.745	0.772	0.808	0.774	0.791
CMN	0.775	0.660	0.713	0.793	0.726	0.758
SPA	0.856	0.715	0.779	0.839	0.773	0.805
ALL	-	-	-	0.817	0.747	0.781

Table: Entity Discovery (ED) performance of model ensemble in the KBP 2017 trilingual EDL evaluation.

Multi-task Learning Results

LANG	Single-task model			Multi-task model		
	P	R	F_1	P	R	F_1
ENG	0.866	0.706	0.778	0.878	0.705	0.782
CMN	0.795	0.635	0.707	0.789	0.665	0.722
SPA	0.919	0.631	0.748	0.844	0.738	0.787
ALL	-	-	-	0.830	0.698	0.758

Table: Entity Discovery (ED) performance for multi-task learning in the KBP 2017 trilingual EDL evaluation.

Entity Linking Results

LANG	baseline1		baseline2		FOFE-EL	
	NERLC	CEAFmC	NERLC	CEAFmC	NERLC	CEAFmC
ENG	0.646	0.630	0.572	0.615	0.648	0.631
CMN	0.617	0.650	0.579	0.615	0.641	0.674
SPA	0.569	0.568	0.538	0.547	0.577	0.576
ALL	0.611	0.607	0.565	0.586	0.624	0.620

Table: Performance on the KBP2017 EDL evaluation of our three entity linking systems. (*NERLC* denotes for *strong_typed_all_match* and *CEAFmC* for *typed_mention_ceaf*)

Conclusion

A local detection approach to Entity Discovery and MD by applying FFNN on top of FOFE

An extended multi-task approach to Entity Discovery using FOFE

No feature engineering and No external knowledge

Strong results on the KBP 2017 EDL track

THANK YOU!
(Q&A)