Software Project NLP with NNs

Proto-Word Reconstruction with RNNs

Project Sketch

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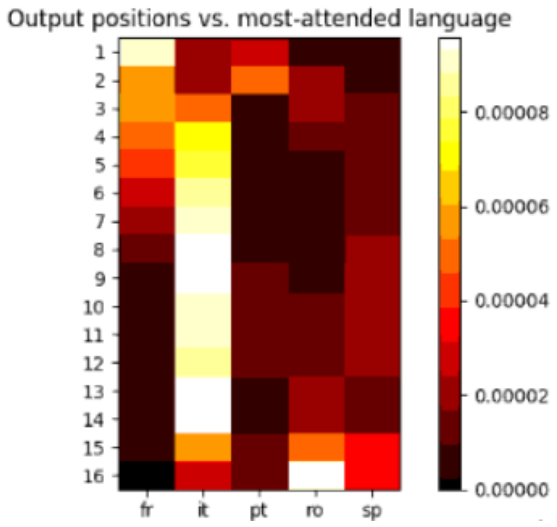
Goal of the Project

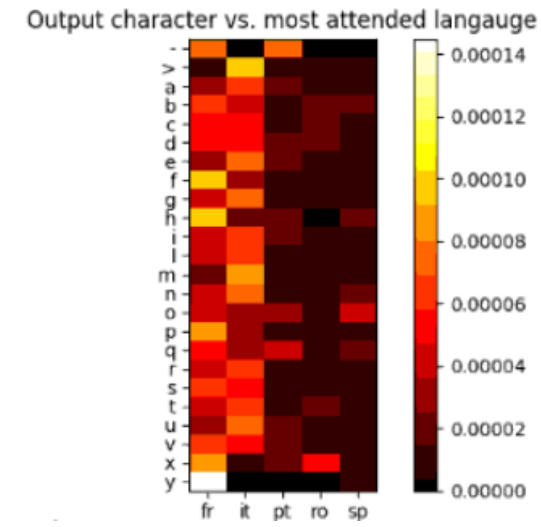
- Provide a tool to automatically reconstruct proto-words for a given sample of cognate sets
- Initial hypothesis if not much is known about the family
- Allow for integration of linguistic knowledge
  - Alignment between cognate loci in different languages
  - Exclude word parts assumed to be innovations (e. g. spanish *nos-otros* from latin *no:s*)
- Examine the influence of input representations on model performance

Baseline

Start from Meloni et al. (2019):

- Romance dataset (not publicly availabe)
- Character-based encoder-decoder architecture with Bahdanau attention
- Characters encoded as 100-bit vectors (localist representation)
- Output one character of the reconstructed word per timestep
- Evaluate impact of individual languages on reconstruction:





Model

Idea:

- Use distributed feature encodings to represent characters, not embeddings
- Use the stem of the Latin word as the proto-form, since nominative inflection is seldom preserved in modern Romance
- Start with ASJP (easily available) transcriptions (Brown et al. (2008)), later switch to IPA (richer annotation).
- Pairwise alignments of sequence chunks (following Ciobanu and Dinu (2018))

Latin acc. sing *corticem* 'bark' → ASJP {kortike}										
	1	2	3	4	5	6	7	8	9	10
latin	-	k	o	-	r	t	i	k	-	e
italian	-	k	o	-	r	t	e	t	C	a
spanish	-	k	o	-	r	t	e	8	-	a
french	e	k	o	-	r	-	-	-	-	-
romanian	s	k	o	a	r	-	-	c	-	3

Model, feature encoding

ASJP consonant feature encodings																
segment	voiced	labial	dental	alveolar	palatal	velar	uvular	glottal	stop	fricative	affricate	nasal	click	approximant	lateral	rhotic
p	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
b	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
f	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
v	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
m	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
8	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
4	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
t	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
d	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
s	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
z	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
c	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
n	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
S	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Z	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
C	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
j	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
T	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
k	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
g	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
x	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
N	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
q	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
G	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
X	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
7	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
h	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
l	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
L	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
w	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0
y	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
r	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
!	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

ASJP vowel features							
segment	high	mid	low	front	central	back	rounded
i	1	0	0	1	0	0	1
e	0	1	0	1	0	0	1
E	0	0	1	1	0	0	1
3	1	1	0	0	0	1	0
a	0	0	1	0	1	0	0
u	1	0	0	0	0	1	1
o	0	1	1	0	0	1	1

Model, continued

Input:

- One column represents the input at a single timestep:

$$I_{T=t_1} = (-, -, -, e, s)$$
$$I_{T=t_2} = (k, k, k, k, k)$$
$$\dots$$
$$I_{T=t_{10}} = (e, a, a, -, 3)$$

- Attention: Meloni et al. (2019) attend on different languages in the cognate set.
  In our case it depends on how whe present the data to the model: Either (as in the paper) perform a pass through the model to reconstruct a single character (each $I_{T=t_i}$ a sequence of inputs), or
- Use the matrix/vector $I_{T=t_i}$ at a single time step, and perform only one pass

Model, limitations

But: The direct precursor of italian *corteccia*, spanish *corteza* etc. is the latin adjective *corticeus, -a, -um*

- We expect the model to reconstruct an a-stem noun instead of a consononat stem cortex, cortices
- Spurious sounds (french *e-*, romanian *s-*) should be dropped
- Ambiguous sounds may not indicate a clear rule (latin *-k-* vs. rom. *-c-* vs. spanish *-θ-*)

Milestones

Minimal:

- Reconstruction with ASJP encodings, small Swadesh list as data
- Then switch to IPA encodings [1]
- Try different language family (initial guess on unseen data)
- Examinate the influence of differrent (or absent) alignments on model performance

Great to have:

- Use larger dataset (Ciobanu shared her dataset)
- Ensure compatibility with the LingPy [2] WordList [3] class

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[1] Plan to use epitran: https://github.com/dmort27/epitran

[2] http://lingpy.org/

[3] http://lingpy.org/reference/lingpy.basic.html#lingpy.basic.wordlist.Wordlist

References

Brown, C. H., Holman, E. W., Wichmann, S., and Velupillai, V. (2008). Automated classification of the world's languages: a description of the method and preliminary results. *Language Typology and Universals*, 61(4):285–308.

Ciobanu, A. M. and Dinu, L. P. (2018). Ab Initio: Automatic Latin Proto-word Reconstruction. In *Proceedings of the 27th International Conference on Computational Linguistics*, pages 1604–1614, Santa Fe, New Mexico, USA. Association for Computational Linguistics.

Meloni, C., Ravfogel, S., and Goldberg, Y. (2019). Ab Antiquo: Proto-language Reconstruction with RNNs. arXiv: 1908.02477.