Towards automatic validation of pronunciation variants for speech recognition and synthesis

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Problematic

Speech synthesis and recognition have become important challenges for the future. They allow us to use voice commands on devices, but also to transcribe speech into text.

Objective: validation of word pronunciation variants by → alignment rules, inconclusive results, research of grapheme-to-phoneme conversion models to improve word prediction performance.

English pronunciation corpus

CMUdict - 134 304 words with their phonetic transcription (ARPABET symbols):

```
CATEGORIZE      K AE1 T AH0 G ER0 AY2 Z
CATEGORIZED     K AE1 T AH0 G ER0 AY2 Z D
CATEGORIZES     K AE1 T AH0 G ER0 AY2 Z IH0 Z
CATEGORIZING    K AE1 T AH0 G ER0 AY2 Z IH0 NG
CATEGORY        K AE1 T AH0 G AO2 R IY0
CATELLI         K AH0 T EH1 L IY0
CATENA          K AH0 T IY1 N AH0
CATER           K EY1 T ER0
CATERED         K EY1 T ER0 D
CATERER         K EY1 T ER0 ER0
```

0 : no stress - 1 : primary stress - 2 : secondary stress

French pronunciation corpus

BDLex - 337 550 words with their phonetic transcription (in SAMPA):

Right side		Upside down	
ballottement	b a l O/ t @ m a~	tnemettollab	a~ m @ t O/ l a b
ballottements	b a l O/ t @ m a~	stnemettollab	a~ m @ t O/ l a b
balsa	b a l z a	aslab	a z l a b
balsas	b a l z a	saslab	a z l a b
bambochade	b a~ b O/ S a d	edahcobmab	d a S O/ b a~ b
bambochades	b a~ b O/ S a d	sedahcobmab	d a S O/ b a~ b
bambocheur	b a~ b O/ S 9 R	ruehcobmab	R 9 S O/ b a~ b
bambocheurs	b a~ b O/ S 9 R	sruehcobmab	R 9 S O/ b a~ b
bambocheuse	b a~ b O/ S 2 z	esuehcobmab	z 2 S O/ b a~ b
bambocheuses	b a~ b O/ S 2 z	sesuehcobmab	z 2 S O/ b a~ b

Processing of the corpus

Train 70%	Development 15%	Test 15%

For the English lexicon, *test* (with stress) and *test bis* (without stress)

For the French lexicon, each file in right side and upside down versions.

For the models of the **neural network** approach and the **statistical** approach, we evaluate the prediction performances of the files with 2 scores:
WER = *Word Error Rate*, the error rate per word and **PER** = *Phoneme Error Rate*, the error rate per phoneme.

Alignment rule approach

Alignment of graphemes and phonemes using predefined rules. If insufficient, add new rules:

um → o~ columbarium → k O/ l o~ b a R j O m
z → ts breitschwanz → b R a j t S v a t s
ue → ju fuel → f j u l

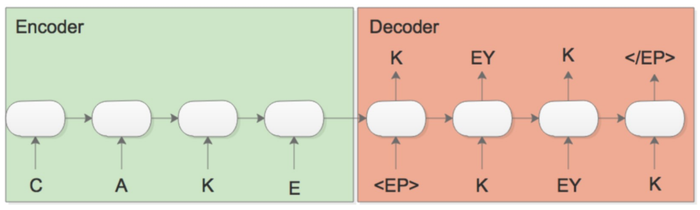
Résultats

Do not detect mispronunciations
→ even if incorrect predictions, alignment possible:

abstinent a b s t i n

Neural network approach

It is given a sequence of letters as input and the network provides a sequence of phonemes as output.



Software : OpenNMT

- Free software for neural networks;
- Use of a YAML configuration file (where to find the files needed for training).

Statistical approach

Statistical method for predicting a phoneme from a sequence of letters.

"mixing" [mɪksɪŋ] = m [m] | i [ɪ] | x [ks] | i [ɪ] | n [ŋ] | g —

Software : Sequitur

- Each element is linked to a sequence of letters and a sequence of phonemes, sequences that allow the reconstruction of the word with its pronunciation → Sequence Joined;
- Based on a grapheme-phoneme alignment.

English and French lexicon results

English Lexicon

Modele	PER	WER
With consideration of stress	10.93%	41.58%
Without taking stress into consideration	8.71%	36.86%

French Lexicon

Modele	PER	WER
OpenNMT right side	0.59%	3.05%
OpenNMT upside down	0.76%	4.24%
Sequitur right side	0.53%	3.15%
Sequitur upside dow	0.50%	2.92%

Models combination results (French lexicon)

Combination of the models

Number of identical predictions among the models	Number of predictions out of 51612	Proportion of configurations of a total in percent
4	48 165	93.32%
3-1	2098	4.06%
2-2	917	1.78%
2-1-1	424	0.82%
1-1-1-1	8	0.02%

Examples:

3 - 1	: a b l y t j o~	a b l y s j o~	a b l y s j o~	a b l y s j o~
2 - 1 - 1	: a~ m 9 l	a m 9 l	a~ m 2 l	a~ m 2 l

Conclusion

- Rules not sufficient to validate pronunciation variants;
- Neural network and statistical models perform well, slightly better when combined: (**PER** : 0.47% and **WER** : 2.75%).