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End-to-End Dependency Parsing of Spoken French

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MOTIVATIONS

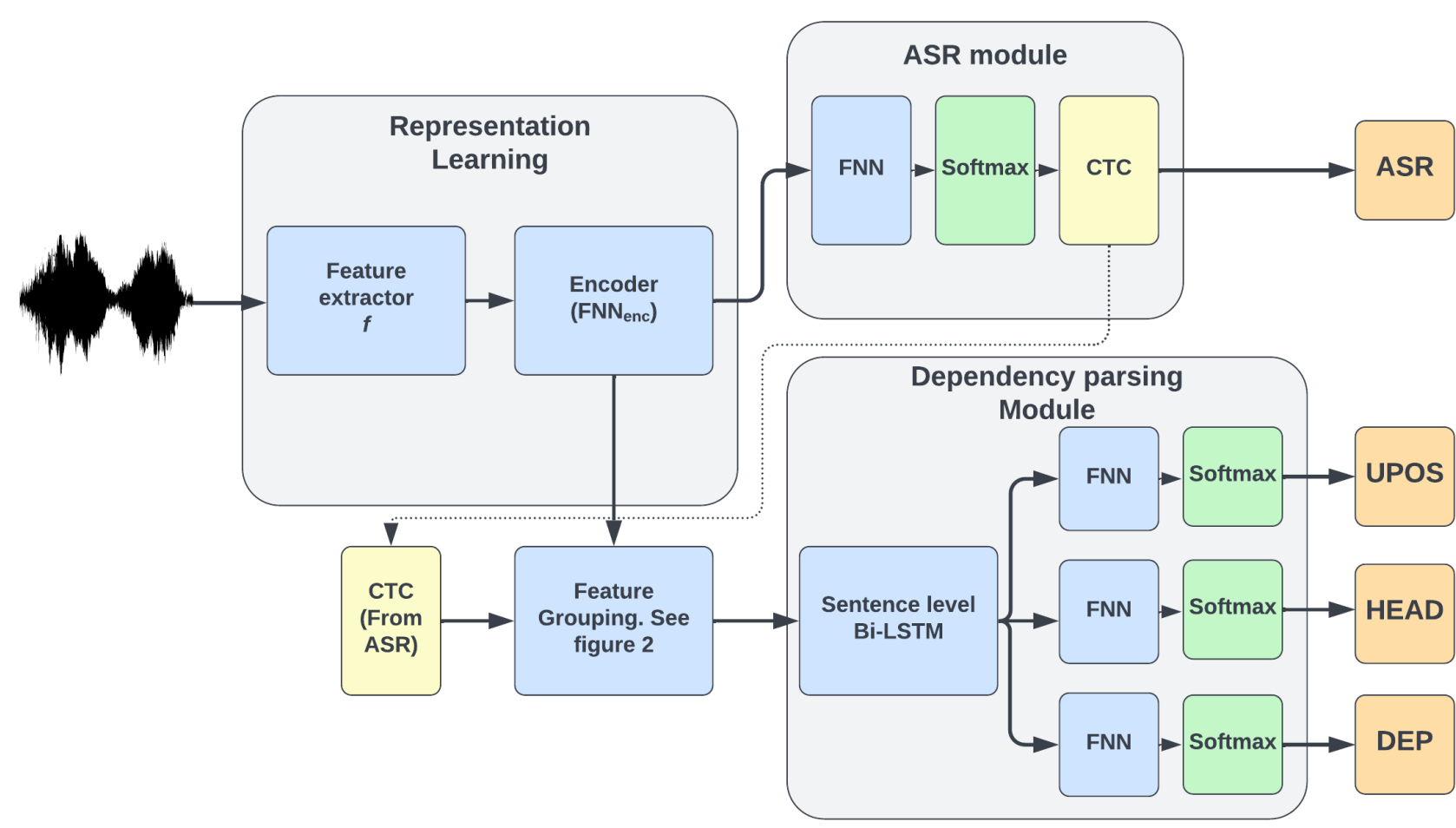
- Is it possible to do syntactic parsing with only the audio modality ?
- Using end-to-end to reduce propagation error.
- Use information (prosodic cues) present in speech to help parsing [4].

ARCHITECTURE WAV2TREE

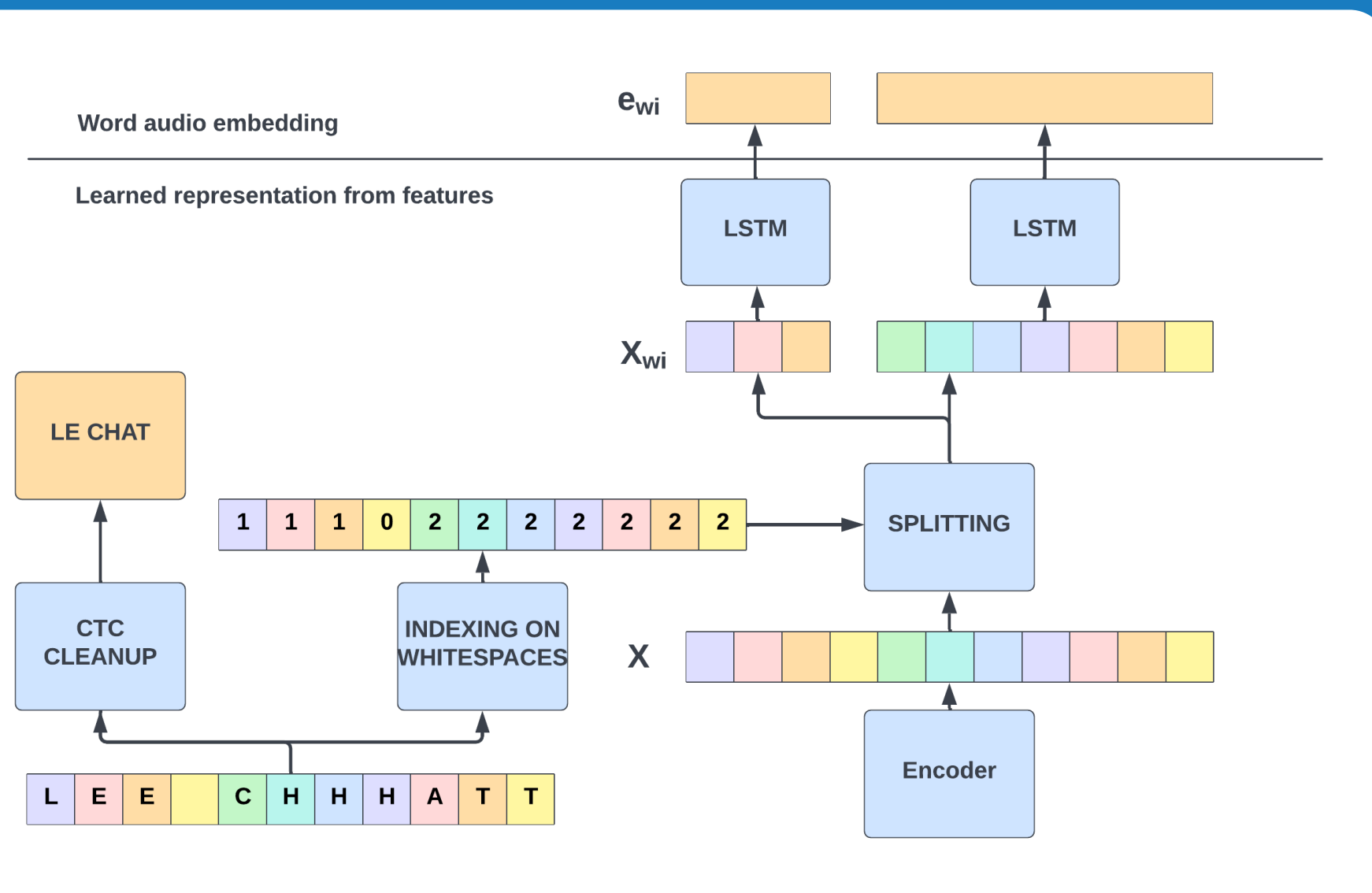
3 modules : Representation learning, ASR and syntactic parsing.

- Feature extractor : MFCC, wav2vec[1], etc. . .
- Compute “word audio embedding” by using the CTC whitespace prediction
- Can use any generic parsing method in the dependency parsing module. We use Dep2Label[5] which reduce the parsing problem to 3 sequence labeling ones. (UPOS, HEAD, DEP)

Global wav2tree architecture



Transforming signal representation into word audio embedding



TRAINING AND ORACLE

- Dependency parsing relies on the segmentation of the signal from the ASR module.
- What to do if the segmentation is wrong during training?

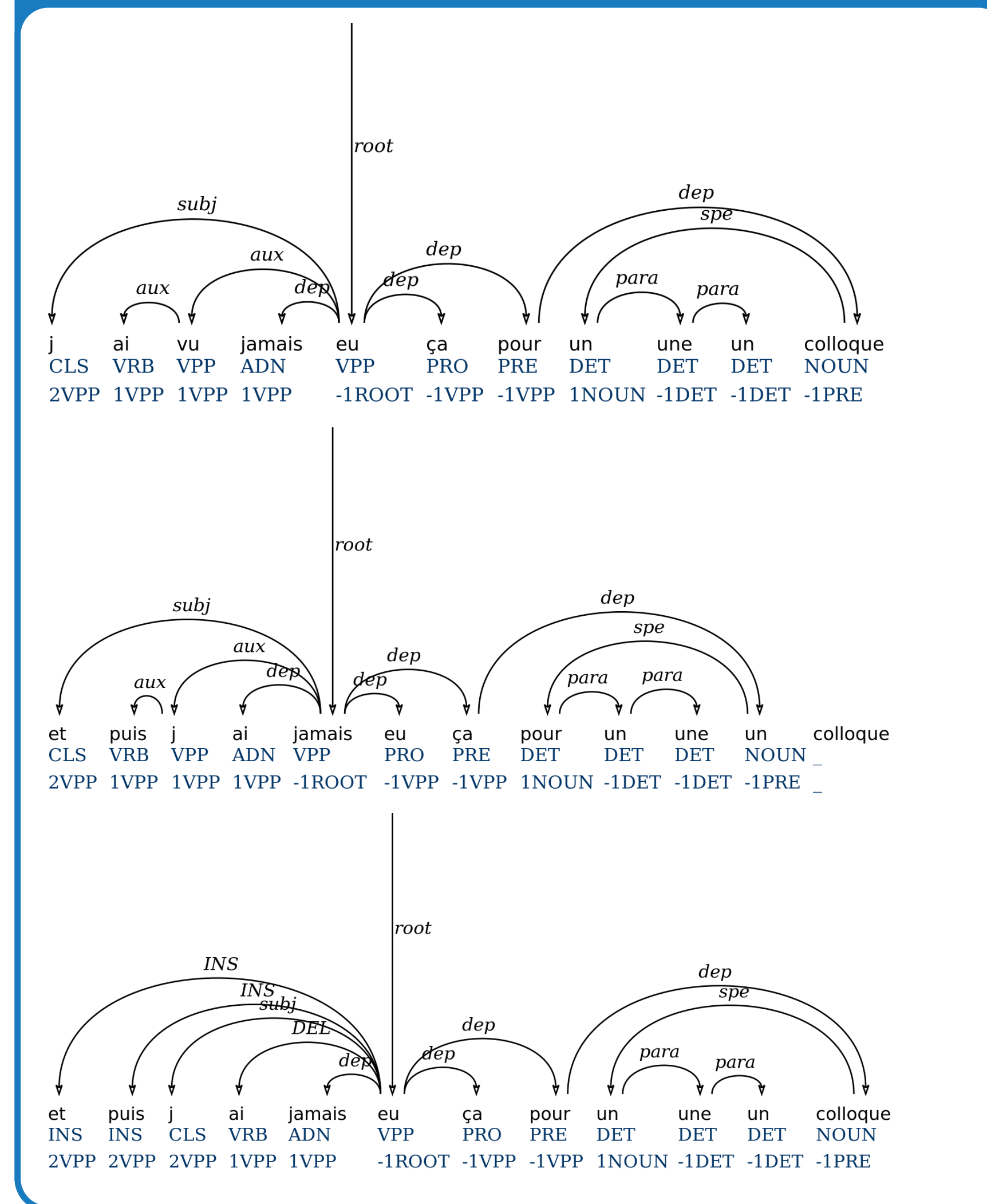
Creation of an oracle :

- Use the gold data and the noisy ASR segmentation to compute the best possible tree
- Allow the model to train on adapted coherent dependency tree
- Heuristics to deal with missing and added token
- Relies on alignment tool

References

- [1] Alexei Baevski et al. “wav2vec 2.0: A framework for self-supervised learning of speech representations”.
- [2] Christophe Benzitoun et al. “Le projet ORFÉO: un corpus d’étude pour le français contemporain”.
- [3] Solène Evain et al. “LeBenchmark: A Reproducible Framework for Assessing Self-Supervised Representation Learning from Speech”.
- [4] Patti J Price et al. “The use of prosody in syntactic disambiguation”.
- [5] Michalina Strzyz et al. “Viable Dependency Parsing as Sequence Labeling”.

Illustration of the oracle process



ORFÉO AND EXPERIMENTAL PROTOCOL

- Evaluation of the model on CEFC-Orféo treebank [2].
- Composed of multiple subcorpora with different speech characteristics.

Pipeline baseline :

- Baseline is composed of one ASR module and one dep2Label module.
- The dep2Label module uses Flaubert-large embeddings in the pipeline.
- Experiments with and without oracle.

RESULTS

| Corpus | Wav2Tree | | | | Pipeline | | | | Pipeline + oracle | | | | |
|----------------|----------|-------------|-------------|-------------|---------------------------|---------------------|------|------|-------------------|--------------------------|-------------|-------------|------|
| | Input | SIGNAL | | | Train : Gold - Test : ASR | WER | UPOS | UAS | LAS | Train : ASR - Test : ASR | WER | UPOS | UAS |
| Pre-trained | | Wav2vec2[3] | | | | Wav2vec2 + flauBERT | | | | Wav2vec2 + flauBERT | | | |
| Parameters | | 350M+33M | | | | 350M+373M+32M | | | | 350M+373M+32M | | | |
| | | WER | UPOS | UAS | LAS | WER | UPOS | UAS | LAS | WER | UPOS | UAS | LAS |
| Cfpb | | 36.7 | 77.6 | 73.4 | 68.8 | 35.0 | 76.6 | 71.8 | 67.5 | 35.0 | 78.0 | 73.0 | 68.5 |
| Cfpp | | 40.6 | 71.8 | 66.6 | 61.8 | 40.4 | 69.9 | 64.8 | 60.2 | 40.4 | 70.7 | 65.0 | 60.4 |
| Clapi | | 62.3 | 58.8 | 54.4 | 47.6 | 62.0 | 56.4 | 53.5 | 46.7 | 61.9 | 57.4 | 53.75 | 47.0 |
| Coralrom | | 26.0 | 83.9 | 77.8 | 74.5 | 25.4 | 82.0 | 75.3 | 71.8 | 25.4 | 83.0 | 75.9 | 72.4 |
| Crfp | | 30.9 | 81.7 | 75.9 | 72.2 | 30.0 | 80.3 | 74.0 | 70.4 | 30.0 | 81.3 | 74.8 | 71.1 |
| Fleuron | | 39.9 | 71.9 | 65.3 | 60.5 | 38.9 | 71.0 | 65.1 | 61.3 | 38.9 | 72.1 | 66.0 | 61.1 |
| Oral-Narrative | | 12.3 | 93.2 | 87.9 | 85.7 | 11.4 | 92.1 | 86.1 | 83.4 | 11.4 | 93.0 | 86.6 | 84.2 |
| Ofrom | | 22.1 | 85.2 | 79.3 | 75.9 | 21.3 | 84.2 | 77.9 | 74.7 | 21.3 | 85.1 | 78.4 | 75.1 |
| Reunions | | 46.9 | 67.7 | 61.8 | 56.3 | 45.8 | 65.5 | 60.3 | 55.1 | 45.8 | 66.7 | 60.8 | 55.6 |
| Tcof | | 38.9 | 74.3 | 67.4 | 62.7 | 38.3 | 72.3 | 65.4 | 60.8 | 38.2 | 73.2 | 65.6 | 61.0 |
| Tufs | | 37.6 | 75.2 | 69.6 | 65.1 | 36.9 | 73.5 | 67.8 | 63.5 | 36.9 | 74.6 | 68.7 | 64.1 |
| Valibel | | 26.1 | 82.8 | 76.9 | 73.2 | 25.4 | 81.3 | 75.4 | 71.7 | 25.4 | 82.2 | 75.7 | 71.8 |
| Orféo full | | 35.0 | 77.4 | 71.7 | 67.5 | 34.0 | 75.8 | 70.0 | 65.8 | 34.0 | 76.7 | 70.5 | 66.2 |

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CONCLUSION

- Using only the audio modality for the syntactic parsing is feasible
- Our model outperforms traditional baseline approaches without using pre-trained language model embedding such as Flaubert.
- Our architecture is heavily customisable and can be used for any task needing word level embedding such as NER, parsing, MWE recognition. . .

future work:

- multimodality text embedding + audio embedding
- Adding language model to improve WER and thus, signal representation segmentation

Composition of Orféo

| Corpus | Type | Train size | Test size |
|----------------|---------------|-----------------|---------------|
| Cfpb | spontaneous | 3030 (2.2h) | 362 (0.3h) |
| Cfpp | spontaneous | 25500 (19.1h) | 3232 (2.4h) |
| Clapi | spontaneous | 7682 (5.3h) | 967 (0.7h) |
| Coralrom | spontaneous | 10889 (9.6h) | 1376 (1.2h) |
| Crfp | spontaneous | 17357 (15.3h) | 2259 (2.0h) |
| Fleuron | spontaneous | 1779 (1.4h) | 217 (0.2h) |
| Oral-Narrative | prepared/read | 8388 (7.3h) | 1050 (1h) |
| Ofrom | spontaneous | 11665 (9.3h) | 1476 (1.2h) |
| Reunions | spontaneous | 10067 (8.0h) | 1245 (1h) |
| Tcof | spontaneous | 16063 (11.6h) | 1997 (1.5h) |
| Tufs | spontaneous | 35990 (24.3h) | 4525 (3.0h) |
| Valibel | mixed | 21095 (17.5h) | 2753 (2.3h) |
| Total | mixed | 169505 (130.9h) | 21459 (16.8h) |

WER: Word Error Rate • **UPOS**: Universal Part of Speech • **UAS**: Unlabeled attachment score • **LAS**: labeled attachment score