Integrating Grammar-Based Language Models into Domain-Specific ASR Systems

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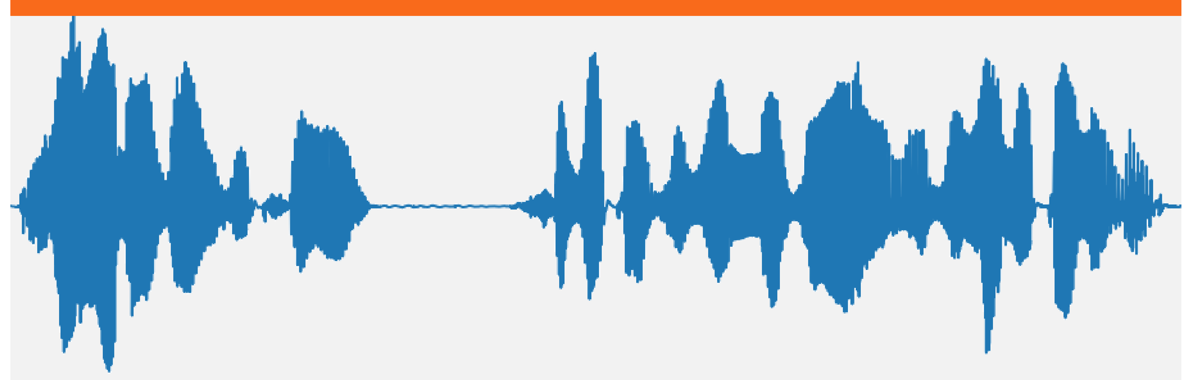
Introduction and motivation



- **Language Models (LMs)** represent a vital component in the design of **ASR technologies**.
- **Domain-specific** ASR applications often require:

An efficient control of the outputs generated by the ASR system

- One possible solution is to rely on:

Probabilistic approaches ⇒
- ✓ **Generalizability**
- ✕ **Short memory span**
- ✕ **High-quality data not always available**

- Meaning that **more efficient modeling techniques** are needed.

Proposed solution

Implementing grammar-based LMs

✓ Large scope of constraints between words	✓ Parsing efficiency	✕ Lack of software to feed them into ASR toolkits

</> Development of **kaldi-grammar-compiler**

An OpenFST-based extension that transforms:

Regulus Lite (RL) grammars
- Finite-state-based.
- User-friendly syntax.

⇒ **Binary Finite State Transducers (FSTs)**
Readable LM format by Kaldi.

Kaldi – Speech Processing Toolkit
- Finite state framework for training and decoding algorithms.
- Highly usable and modifiable.

Methodology

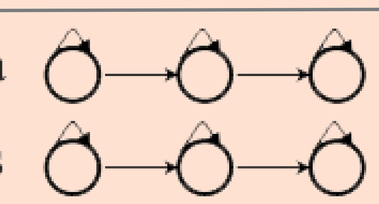
I. System overview

KEY POINTS	BENEFITS
Online (real-time) decoding	Better transcription accuracy compared to offline recognizers
Chain-based HMM-DNN models	Faster training and decoding

II. ASR architecture

Speech signal

Acoustic modeling (HC)



- Training set: **755 hours of French speech**, based on **Common Voice Dataset 7.0**.
- **Time Delay Neural Network** architecture (TDNN).
- MFCC features + speaker adaptation.

Lexicon modeling (L)

Grapheme-to-phone mapping based on:
- BDLEX French phonetical database.
- LIA_PHON automatic phonetizer.

WORD	PRON
vous	v u
avez	a v e
mal	m a l

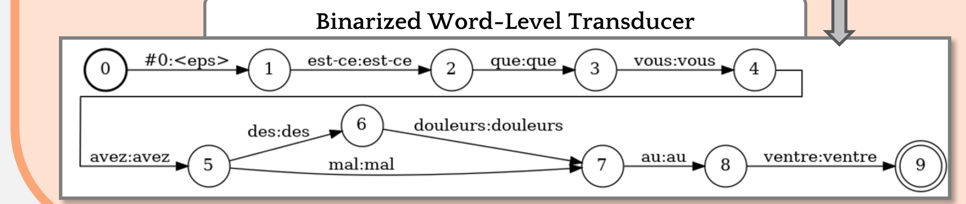
Grammar-based language modeling (G)

RL Fixed grammars

```
Utterance
Source est-ce que vous
avez ( des douleurs |
mal ) au ventre ?
EndUtterance
```

⇒ kaldi-grammar-compiler

Binarized Word-Level Transducer



Speech-to-text decoder (HCLG)

Est-ce que vous avez mal au ventre ?

Evaluation and results

I. Dedicated corpora for evaluation

	Description	Language	Speakers	Gender	Duration	Utterances	Words
MeDiCo – *Medical Discourse Corpus*	• Artificial spoken dataset. • Obtained via data collection campaign. • Including utterances related to **medical consultations**.	FR	14	9F, 5M	0h 41mn	713	≲6k
HomeAutomation	• **Voice command-based** spoken corpus. • Collected in realistic smart-home conditions.	FR	23	9F, 14M	1h 38mn	3114	≲10k

Results/Corpus	MeDiCo	HomeAutomation
Recognized words	5292 / 5598	9058 / 9639
Insertions	58	87
Deletions	34	295
Substitutions	214	199
WER (%)	5.47	6.03

II. Speech recognition results

- **Two different Kaldi ASR engines** were built.
- Both integrated a **fixed grammar** as **LM** in their **decoding graph (HCLG)**.
- Transcription accuracy was calculated in terms of **Word Error Rate (WER)**.

Summary and conclusions

Key points:

- **Introduced** an **extension** for **easily integrating fixed regular grammars** as **LMs** into **Kaldi**.
- Achieved **satisfactory results** in the experiments performed:
  - Both **MeDiCo** and **HomeAutomation** return a **significantly low WER** (5.47% and 6,03%, respectively).

This shows that **grammar-based ASR systems** obtain a **competitive** performance when applied in **constrained domain-specific applications**.

Further work

Some questions still need to be explored:

- Explore how to **leverage grammar knowledge**, so as to **specialize a neural-based LM**.
- **Generalize the input grammar format**, so as to:
  - Extend the applicability of our designed tool beyond the Regulus Lite syntax.

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References

- **Horndasch, A. *et al.*** (2016): How to Add Word Classes to the Kaldi Speech Recognition Toolkit. In *Text, Speech, and Dialogue.*
- **Povey, D. *et al.*** (2011): The Kaldi Speech Recognition Toolkit. *IEEE Workshop on Automatic Speech Recognition and Understanding.*
- **Rayner, M. *et al.*** (2018): Handling Ellipsis in a Spoken Medical Phraselator. In *Statistical Language and Speech Processing.*

This QR code links to the GitHub repository where we made available the **kaldi-grammar-compiler** extension. Some working examples are also provided.

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