1) Introduction

Regional Frisian language
- Regional official language of the Netherlands
- Most spoken in the province of Fryslân
- Approximately half a million speakers
- Most speakers are bilingual due to the extensive influence of Dutch
  - Code-switching is common practice in daily conversations
- Member of West Germanic language family
  - Closely related with English and Dutch

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• Linguistically well-researched, however few speech and language technology applications are available
  - Frisian speech synthesizer, Google Translate...
  - Omrop Fryslân
    - Regional public broadcaster with a radio station and a TV channel both broadcasting in Frisian

3) Basic Frisian ASR system

• Challenges
  - Low resources available
  - Code-switching nature of Frisian
  - Complex vowel system
    - FAME! Database is created
    - Fryslân Academys text corpus
    - Omrop Fryslân news articles
  - Frisian Wikipedia
  - Transcriptions of training speech
  - Fluency Frisian Lexicon
  - Elex Dutch Lexicon

4) FAME! Frisian Radio Broadcast Database

• Preparation
  - Manually annotating the radio broadcasts from Omrop Fryslân
  - Collaboration with Fryslân Akademys
  - Annotations include orthographic transcription, speaker ids, spoken language, code-switching details, dialect info
    - A modified annotation protocol has been created

• Some statistics
  - 18.5 hours of radio broadcasts annotated in total
    - Longitudinal data: recordings from 1966 to 2015
    - More than 500 speakers, 309 with known identity
    - 21 speakers appear at least 3 times
  - 3939 code-switching cases:
    - 2896 cases: Frisian speaker switches to Dutch
    - 95 cases: Dutch speaker switches to Frisian
    - 848 cases: Speakers use a mixed-word that is neither Frisian nor Dutch

6) Initial Recognition Experiments

• Speech data from Frisian speakers
  - FAME! Database is divided into three parts
    - Training set: 8h 20m
    - Development set: 1h
    - Test set: 1h
  - Acoustic models (AM)
    - KALDI speech recognition toolkit is used
    - GMM-HMM and subspace GMM (SGMM) are trained on LDA-MLLT features
    - Speaker adapted training (SAT): FMLLR-adapted features
  - Language models (LM)
    - 3-gram interpolated modified Kneser-Ney
    - Omrop Fryslân Lexicon
      - Bilingual lexicon contains ~150k words
      - Various phonetic alphabets are compared:
        - mono: cons. + monoph.
        - tfl: mono + fall dipth.
        - ris: mono + rise dipth.
        - dph: mono + all dipth.
        - triph: mono + all triph.

7) Results (I) – Phonetic Alphabet

<table>
<thead>
<tr>
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<th>GMM</th>
<th>SGMM</th>
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<td>mono</td>
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- Word error rates (WER) in % on the development set -

- The choice of the phonetic alphabet has a minor effect on the recognition accuracy
  - Inferior performance of ditri is explained by the limited amount of training data
  - In the following experiments, mono is adopted

9) Conclusion

• Initial recognition results are promising for an accurate spoken document retrieval system
• Future work: Investigating deep architectures and recognition schemes with flexibleness for code-switching ASR