Collecting and evaluating speech recognition corpora for nine Southern Bantu languages

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Outline

- Introduction
- Background:
  - ASR corpus design
  - The Lwazi ASR corpus
- Computational analysis
  - Approach
  - Analysis of phoneme variability
- Conclusion

Introduction

- Information flow in developing countries
  - Availability of alternate information sources is low in developing countries
  - Telephone networks (cellular) are spreading rapidly
- Spoken dialog systems (SDSs)
  - Widespread belief that impact can be significant
  - Speech-based access can empower semi-literate people
- Applications of SDSs
  - Education (Speech-enabled learning)
  - Agriculture
  - Health care
  - Government services

Introduction

- To implement SDSs: ASR and TTS systems are needed
- Main linguistic resources needed for telephone-based ASR systems:
  - Electronic pronunciation dictionaries
  - Annotated audio corpora
  - Recognition grammars
- Challenges:
  - ASR only available for handful of African languages
  - Lack of linguistic resources for African languages
  - Lack of relevant audio for specific application (language used, profile of speakers, speaking style, etc.)

ASR audio corpus

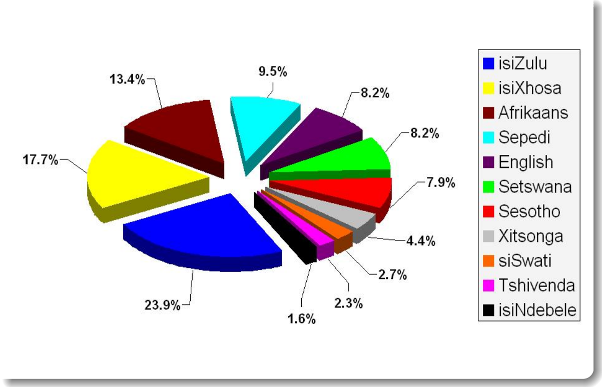
- Resource intensive process
- Factors that add to complexity:
  - Recordings of multiple speakers
  - Matching channel and style
  - Careful orthographic transcription
  - Markers required to indicate important events (eg. non-speech)
- Size of corpora:
  - Corpora of resource-scarce languages tend to be very small (1-10 hours of audio)
  - Contrasts with speech corpora used to build commercial systems (hundreds to thousands of hours)

Project Lwazi

- Three year (2006-2009) project commissioned by the South African Department of Arts and Culture
- Development of core speech technology resources and components (ASR, TTS, SDS, etc.)
- National pilot demonstrating potential impact of speech based systems in South Africa
- All 11 official languages of South Africa

Project Lwazi: Languages

- Distribution of home languages for South African population:
  - 9 Southern Bantu languages, 2 Germanic languages

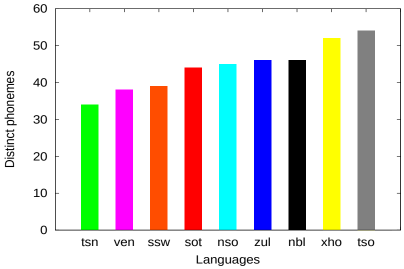


Project Lwazi

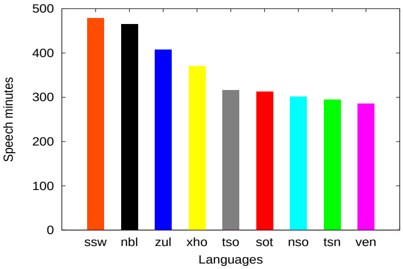
- ASR corpus:
  - Approximately 200 speakers per language
  - Speaker population selected to provide a balanced profile with regard to age, gender and type of telephone (cellphone/landline)
  - Read and elicited speech recorded over telephone channel
  - 30 Utterances/speaker:
    - 16 Randomly selected from phonetically balanced corpus
    - 14 Short words and phrases

Project Lwazi: Southern Bantu languages

Distinct phonemes per language



Speech minutes per language



Setswana	🟩
Tshivenda	🟪
siSwati	🟧
Sesotho	🟥
Sepedi	🟦
isiZulu	🟦
isiNdebele	⬛
isiXhosa	🟨
Xitsonga	⬜

- Amount of data within Lwazi ASR corpus

Computational analysis

- Goal:
  - Understand data requirements to develop a minimal system that is practically usable
  - Use as seed ASR system to collect additional resources
  - Implications of additional speakers and utterances
  - Develop tools:
    - Provide indication of data sufficiency
    - Potential for cross-language sharing

Computational analysis

- Approach:
  - Measure acoustic variance in terms of the separability between probability densities by modelling specific phonemes
  - Statistical measure provides an indication of the effect that additional training data will have on recognition accuracy
  - Utilise the same measure as indication of acoustic similarity across languages

Computational analysis

- Mainly focus on four languages here:
  - isiNdebele (nbl)
  - siSwati (ssw)
  - isiZulu (zul)
  - Tshivenda (ven)
- We report only on single-mixture context-independent models (similar trends observed for more complex models)
- Report on examples from several broad categories of phonemes (SAMPA) which occur most in target languages:
  - /a/ (vowels)
  - /m/ (nasals)
  - /b/ and /g/ (voiced plosives)
  - /s/ (unvoiced fricatives)

Analysis of phoneme variability

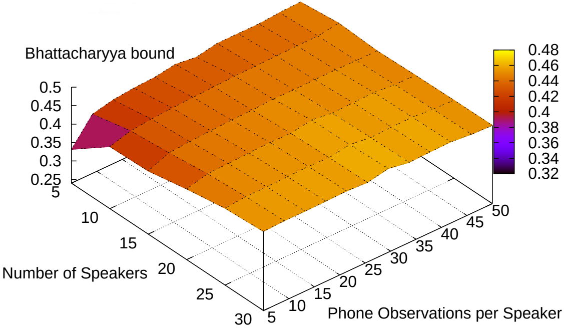


Figure: Speaker-and-utterance three-dimensional plot for the siSwati nasal /m/

Number of phoneme utterances

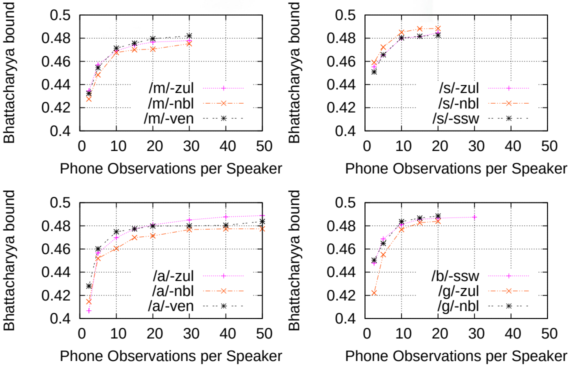


Figure: Effect of number of phoneme utterances per speaker on similarity measure for different phoneme groups using data from 30 speakers

Number of speakers

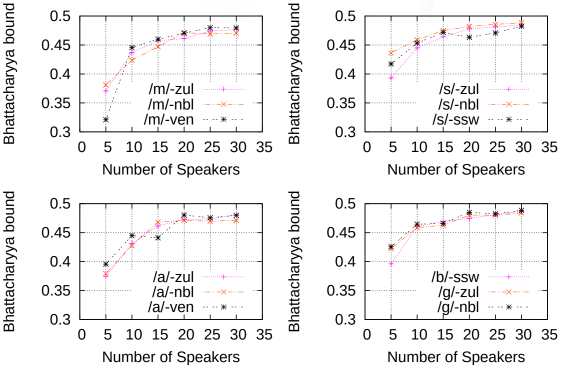
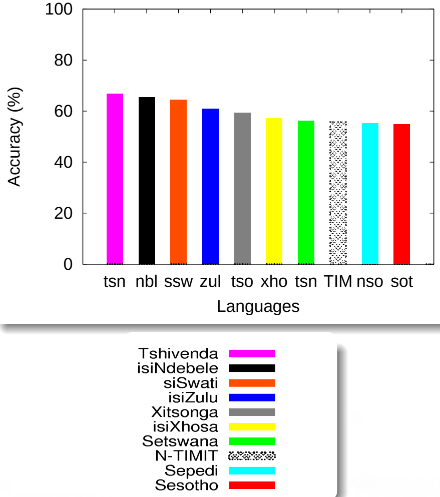


Figure: Effect of number of speakers on similarity measure for different phoneme groups using 20 utterances per speaker

Initial ASR Accuracy

Accuracy of phoneme recognisers



- Developed initial ASR systems for all of the Bantu languages
- Test sets: 30 speakers per language
- ASR system is *phoneme recogniser*, with flat language model
- A rough benchmark of acceptable phoneme accuracy: N-TIMIT

Impact of data reduction

- Division factor of 8:
  - Approximately 20 training speakers
  - Correlate well with the stable phoneme similarity values

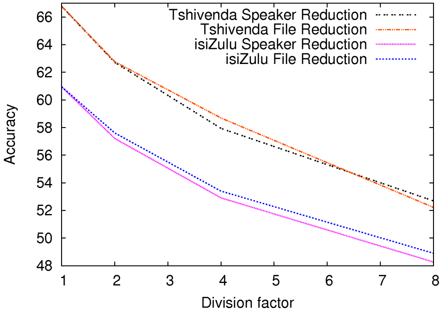


Figure: Reducing the number of speakers has (approximately) the same effect as reducing the amount of speech per speaker

Distances between phonemes

- Based upon proven stability of our phoneme models:
    - Phoneme similarity between phonemes across languages

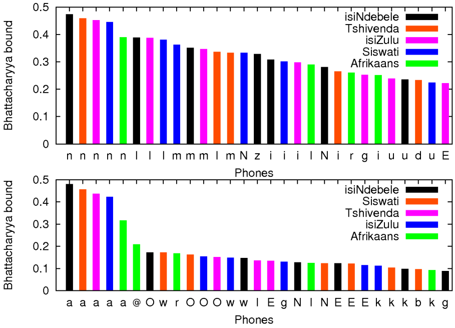


Figure: Effective distances for isiNdebele phonemes /a/ and /n/ and their closest matches.

Conclusion

- New method to determine data sufficiency
- Confirmed that different phoneme classes have different data requirements
- Our results suggest that similar phoneme accuracies may be achievable by using more speech from fewer speakers
- Based upon proven model stability we performed successful measurements of distances between phonemes of different languages

Conclusion

- Project Lwazi website:
  - http://www.meraka.org.za/lwazi
  - More info
  - Download corpora (ASR, TTS)
  - Download tools
  - Contact details