

## Feature exploration for almost zero-resource ASR-free keyword spotting using a multilingual bottleneck extractor and correspondence autoencoders

Raghav Menon<sup>1</sup>, Herman Kamper<sup>1</sup>, Ewald van der Westhuizen<sup>1</sup>, John Quinn<sup>2</sup>, Thomas Niesler<sup>1</sup> <sup>1</sup>Stellenbosch University, South Africa; <sup>2</sup>UN Global Pulse, Kampala, Uganda; <sup>2</sup>University of Edinburgh, UK



## Summary

- 1. Features for dynamic time warping (DTW) in an almost zero-resource setting for a keyword spotting (KWS) application are compared.
- 3. The objective is to identify acoustic features that provide acceptable KWS performance in such environments.
- 5. Multilingual bottleneck features (BNFs) from well-resourced out-of-domain languages and correspondence autoencoder (CAE) features are evaluated.
- 7. BNFs as input to the CAE result in notable (>11%) performance improvements over MFCCs for two evaluated languages, English and Luganda.
- 2. The keyword spotting systems aid the United Nations (UN) humanitarian relief efforts in parts of Africa with severely under-resourced languages.
- 4. A small, independently compiled set of isolated keywords is the only supervised resource.
- 6. BNFs and CAE features achieve modest (>2%) performance improvements over baseline MFCCs.
- 8. Integrating BNFs with the CAE allows both large out-of-domain and sparse indomain resources to be exploited for improved ASR-free keyword spotting.

## Radio browsing system

### **Neural network feature extraction**



- Live audio from phone-in radio talk shows is processed and monitored for keywords.
- Current ASR-based radio browsing systems require large annotated speech resources.
- **Dynamic time-warping** (DTW) keyword spotting systems:
  - are word template-based;
  - can perform in an almost zero-resource setting.

#### Autoencoder

- The same feature frame is used at the input and output of the network.
- Hence no annotations or labels required for training.



#### **Correspondence autoencoder**

- Two different instances of a word aligned by DTW.
- Alignments used to train CAE.
- Factors not common to keyword pairs (speaker; gender; channel) are suppressed, while common factors (word identity) are enhanced.





# Feature extraction and evaluation

- extractors Various feature are evaluated. (AE) • Autoencoder and correspondence autoencoder (CAE)
  - extractors are trained on unla**belled** training data.



#### **Data sets**

- Search data from radio talk show speech.
  - Training data is unlabelled.
  - Only evaluation sets are labelled.

| Set   | English |              | Luganda |              |
|-------|---------|--------------|---------|--------------|
| 001   | #utts   | duration (h) | #utts   | duration (h) |
| Train | 5231    | 7.94         | 6052    | 5.57         |
| Dev   | 2740    | 5.37         | 1 786   | 2.04         |
| Test  | 5005    | 10.33        | 1 420   | 1.99         |
| Total | 12976   | 23.64        | 9258    | 9.60         |



#### Multilingual bottleneck feature extractor

• Ten languages from the GlobalPhone corpus are used at the output of the network.



|              | , i           |                    |
|--------------|---------------|--------------------|
| CAE with BNF | $\rightarrow$ | CAE <sub>BNE</sub> |

| Keywords templates are the only labelled in- |
|--|
| domain data and are used to train the KWS.   |

| # keywords | # speakers                    | # utterances                          |
|------------|-------------------------------|---------------------------------------|
| 40         | 24                            | 1 1 6 0                               |
| 18         | 16                            | 603                                   |
|            | <b># keywords</b><br>40<br>18 | # keywords # speakers   40 24   18 16 |

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- AUC: Area under the receiver operating characteristic curve.
- P@10: Precision at 10 is the proportion of correct keyword detections among the top 10 hits.
- P@N: Precision at N is the proportion of correct keyword detections among the top N hits.
- In terms of AUC:

 $CAE_{BNF} > BNF > CAE_{MFCC} > MFCC$ 

 Multilingual feature extraction and target language fine-tuning are complimentary.

#### Conclusion

- Keyword templates are the only labelled data.
- Extractor and feature combinations can lead to improved KWS performance.
- CAE<sub>BNF</sub> yielded the best performance among the evaluated feature types.
- CAE<sub>BNF</sub> extractor uses labelled data in wellresourced out-of-domain languages to leverage extremely sparse in-domain data.
- CAE<sub>MFCC</sub> yields comparable performance in the absence of a multilingual BNF extractor.
- Future work includes integrating this model into a larger keyword spotting framework and expanding it to include more under-resourced languages.