Vocal Resonance as a Passive Biometric

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MOTIVATION

Body Area Networks:
- Devices continuously track health- and lifestyle- related conditions
- They discover, recognize each other and share secrets
- They can automatically identify the wearer

Goal: Automatically authenticate the wearable devices

BIOMETRICS

- *Universal*: Everybody possesses it
- *Unique*: It should be individually unique in a population
- *Permanent*: It remains invariant over a relevant time scale
- *Measurable*: It is captured by some sensor quantitatively
- *Unobtrusive*: We are able to unobtrusively measure it
- *Accurate*: Our authentication result is nearly-always correct

VOCAL RESONANCE

- Voice as heard through the vocalizer's body

HYPOTHESES

- Vocal resonance is a biometric (having all the properties above)
- Body voice and air voice are distinguishable

DATA COLLECTION

- 29 subjects: 18 male and 11 female
- 2 audios: *The Rainbow passage* and *The Wind in the Willows*
- 2 visits: a period of about 2 weeks between 2 data collection for each subject

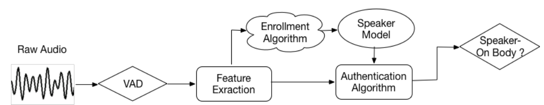
IMPLEMENTATION

- Raspberry Pi Zero W
  - 1 GHZ, single-core ARM CPU
  - 512 MB RAM
- External USB sound card
- Contact piezo microphone
- Remote Server for DNN algorithm

METRICS

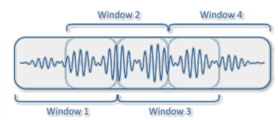
- Identification:
  - Precision: Fraction of audio samples that are identified correctly as the target user
- Verification:
  - Positive: correct user and body, Negative: otherwise
  - False Accept Rate: Fraction of negative cases where we accept
  - False Reject Rate: Fraction of positive cases where we reject
  - Balanced Accuracy: Balanced accuracy on positive and negative samples

SYSTEM PIPELINE



SIGNAL PROCESSING

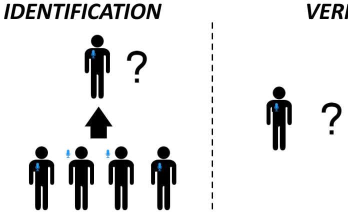
- Voice Activity Detector discards non-speech
- Extract features from sliding windows of audio signals
- Features include 26 MFCCs



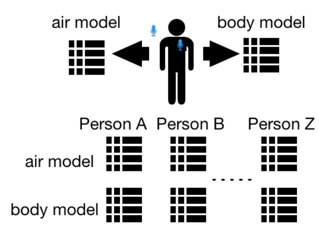
Windows are rectangles with margins
Overlaps are solid fills

AUTHENTICATION ALGORITHMS

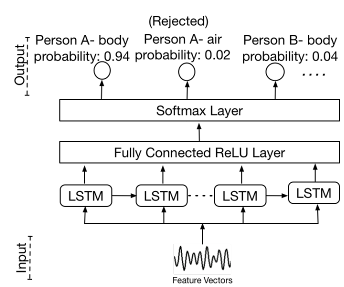
IDENTIFICATION / VERIFICATION



GMM



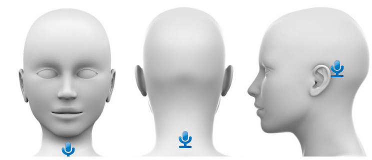
DNN



RESULTS

	GMM	DNN
Precision(identification)	**0.914**	0.817
BAC(verification)	**0.976**	0.929
FAR(verification)	0.047	**0.030**
FRR(verification)	**0.001**	0.030

DIFFERENT PLACEMENTS



	throat	neck	ear
Precision(identification)	**0.914**	0.895	0.913
BAC(verification)	**0.976**	0.957	**0.976**
FAR(verification)	**0.047**	0.0843	0.048
FRR(verification)	**0.001**	0.002	0.009

CONCLUSION

- We can use vocal resonance as a passive biometric, and it achieves high accuracy in terms of identification and verification problems
- We can even use the vocal resonance through neck/ear to authenticate a variety of wearable devices
- The DNN method requires a stable network connection to the remote server
- GMM works good for most of the occasions

FUTURE WORK

- Try vocal resonance through other parts of body, e.g., wrist, chest, even ankle

ACKNOWLEDGEMENTS

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