VOICE LIVENESS DETECTION FOR SPEAKER VERIFICATION BASED ON A TANDEM SINGLE/DOUBLE-CHANNEL POP NOISE DETECTOR

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1. Introduction

Spoofing attacks against ASV systems

- ASV performance is seriously degraded.
- Main types of spoofing attacks:
  Replay, Speech synthesis, Voice conversion
- Some anti-spoofing techniques have been reported.

A fundamental solution against the spoofing attacks is required.

Voice liveness detection (VLD) framework [Shiota; '15]

- Identification of liveness information in input samples
- High performance for detecting spoofinging attacks

Pop noise detector

- Capture pop noise as liveness evidence
- Single- and double-channel approaches were reported

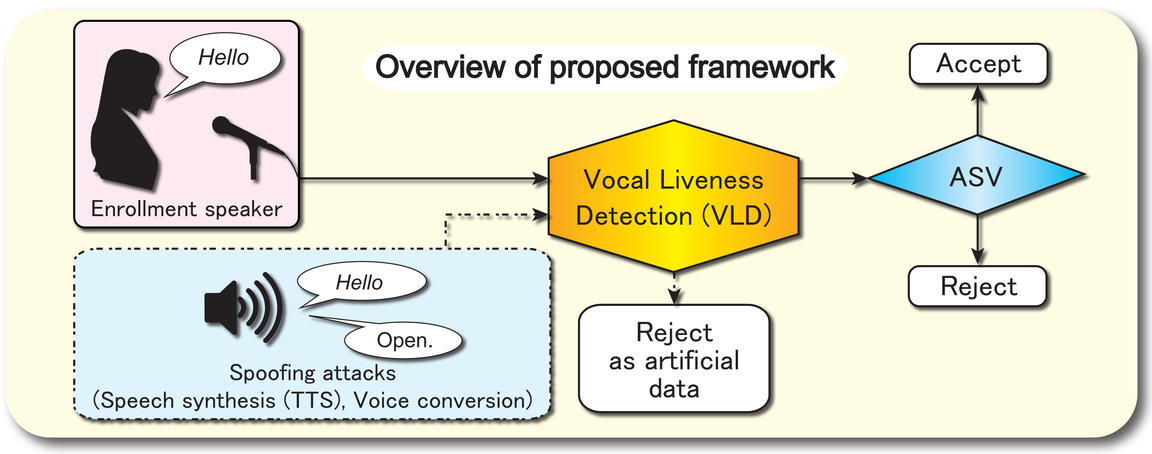
Tandem approach leads to improve the VLD performance

2. Voice Liveness Detection (VLD)

Concept of VLD framework

- Spoofing attacks are played via loudspeakers
- Distinguish input data produced by a live human from input data played via loudspeakers.

Protect against all types of spoofing attacks



What is the liveness evidence in a speech waveform?

- Voice made by airflow, and it transform to an acoustical signal via a microphone
- Pop noise phenomena: a sort of perceived plosive burst only living human caused pop noise.

Pop noise detection leads to reduce the vulnerability of ASV

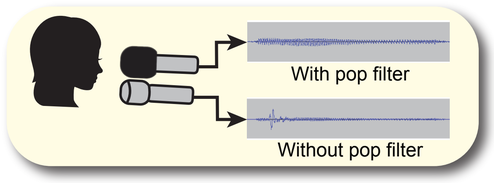
3. Pop noise detection algorithms

Low-frequency-based single channel algorithm

- Pop noise appears as high energy regions at low freqency
  - Sudden irregular modulations of strong energy
  - focus under 1000Hz
- A min/max energy variation and velocity ensure there will be a relative increment/drop in the pop noise energy.

Subtraction-based detection with double channel

- Two microphone are used.
- Capture the whole freqency components of the pop noise



- Assuming only one signal includes pop noise, it is estimated by subtracting the ordinary speech component as follows:

$$D(b,\omega) = F_p(b,\omega) - C(\omega)F_x(b,\omega)$$

Non-Filtered speech / Filtered speech

$F(b,\omega)$: STFT
b : Time frame
ω : Angular frequency

- An estimate of $C(\omega)$ to minimize $\sum_{b,\omega}|D(b,\omega)|^2$ can be represented as $C(\omega) = \frac{\sum_b F_p(b,\omega)F_x(b,\omega)^*}{\sum_b |F_x(b,\omega)|^2}$. (* complex conjugate)
- Amplitude of inverse STFT for $D(b,\omega)$ is used for estimating boundaries of the pop noise.

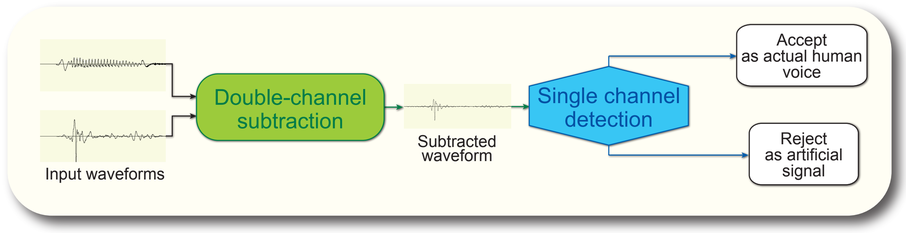
4.Tandem single/double-channel popnoise detection algorithm

Benefits and drawbacks of the conventional algorithms

- Single-channel algorithm
  - Performance was depended on speakers and microphones
  - Difficult to distinguish played pop noise from real pop noise
- Double-channel algorithm
  - Amplitude-base decision can characterize presence of the pop noise more precisely
  - Performance is lower than the single algorithm

Tandem algorithm

- First step: double channel subtraction used to obtain subtracted waveform
- Second step: single channel detection

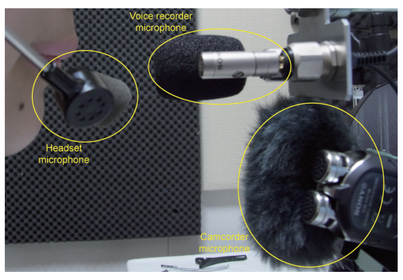


Subtracted waveform has irregular modulations precisely and it help to improve the single-channel detection

5. Experiments

Experimental conditions

- Database including pop noise is recorded with three kinds of microphones
  - Compatible microphone with camcorder (CAMCORDER)
  - Microphone with a voice recorder (VOICE)
  - Microphone with a headset (HEADSET)
- 17 female Japanese speaker
- 100 sentences for each speaker
- 48kHz sampling
- Training data: 70 sentences per speaker
- Test data: 30 sentences per speaker
- Spoofing data: 30 sentences estimated by HTS adaptation technique



Experimental results

1.Pop noise detection performance

- Judge an input signal comes from a actual human or a loudspeaker.

Tab. 1, EER (FAR=FRR) of VLD algorithms with some microphone

		Input	
		Human	Spoof
Judge	Human	Correct	FAR
	Spoof	FRR	Correct

- Tandem method can capture pop noise as liveness evidence
- Pop noise phenomenon depends on the microphone type

Tab. 2, EER of the VLD algorithms

Microphone	Single	Double	Tandem
VOICE	36.06%	45.52%	26.61%
CAMCORDER	4.73%	29.11%	0.95%
HEADSET	3.95%	5.88%	2.35%

2.Combine VLD module and ASV system (VLD+ASV)

- Judge an input signal comes from a live human or a loudspeaker, and judge the input signal is a enrollment speaker or not.

Fig 1, EER of the ASV + VLD

- ASV performance is degraded by spoofing attacks
- Tandem approach obtains high performance

6. Future work

- Conducting trials using a larer database
- Simple pop noise detection can be broken by wind or spoof breath. Thus, considering phoneme information in pop noise periods.
- Evaluate the replayed pop noise samples via each pop noise detection algorithms.