A study on spoofing attack in state-of-the-art speaker verification: the telephone speech case

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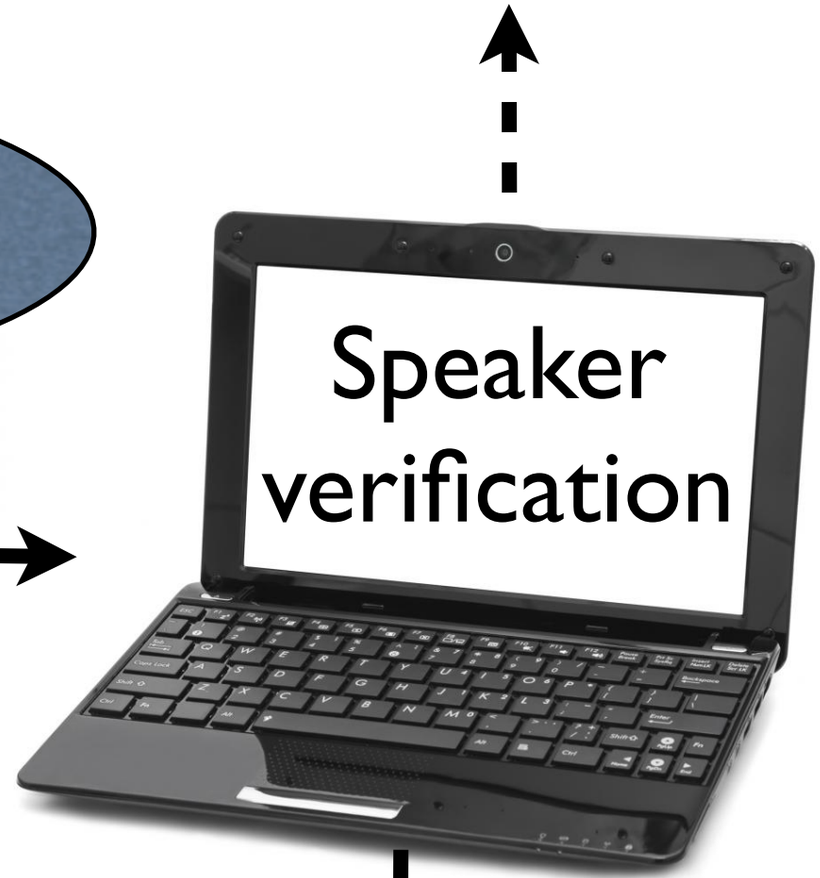
Outline

- Introduction of speaker verification
- Spoofing attack
- Motivation
- Anti-spoofing techniques
- Experiments and results
- Conclusions and future work

Speaker verification

I am Obama, verify me!



Not Obama!

Spoofing attack in speaker verification

Voice conversion techniques can break a speaker verification system!

Motivation

- To prevent spoofing attack to speaker verification systems, we need to develop a technique to detect synthesized/converted speech

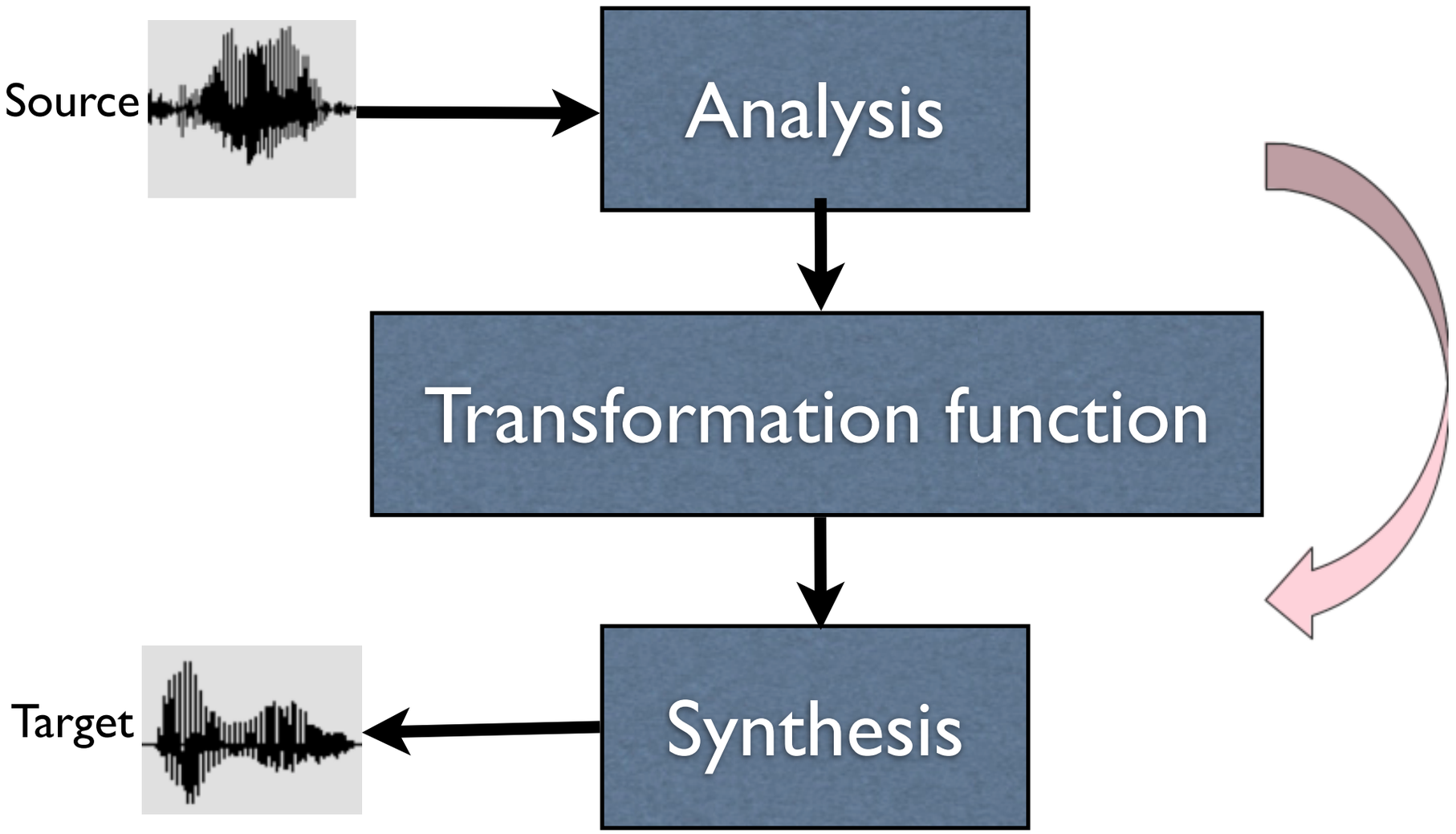
- Phase information was not given much attentions in speaker verification studies, but phase artifacts in synthesized speech is an informative cue

  - Zhizheng Wu, Eng Siong Chng, Haizhou Li, "*Detecting Converted Speech and Natural Speech for anti-Spoofing Attack in Speaker Recognition*", Interspeech 2012.

  - Tomi Kinnunen, Zhizheng Wu, Kong Aik Lee, Filip Sedlak, Eng Siong Chng, Haizhou Li, "*Vulnerability of Speaker Verification Systems Against Voice Conversion Spoofing Attacks: the Case of Telephone Speech*", ICASSP 2012.

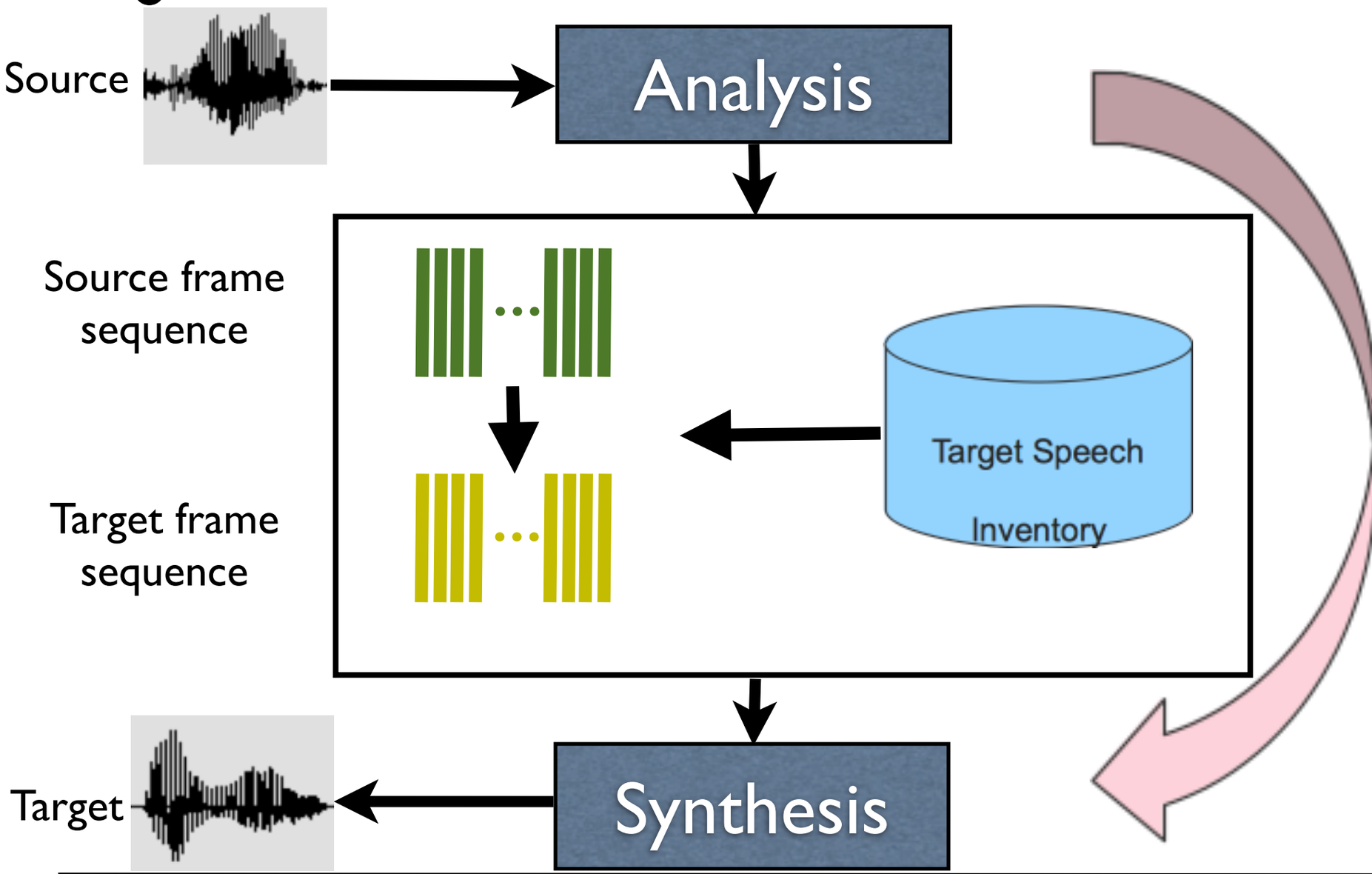
Overview of voice conversion (1/4)

- **GMM-based voice conversion**



Overview of voice conversion (2/4)

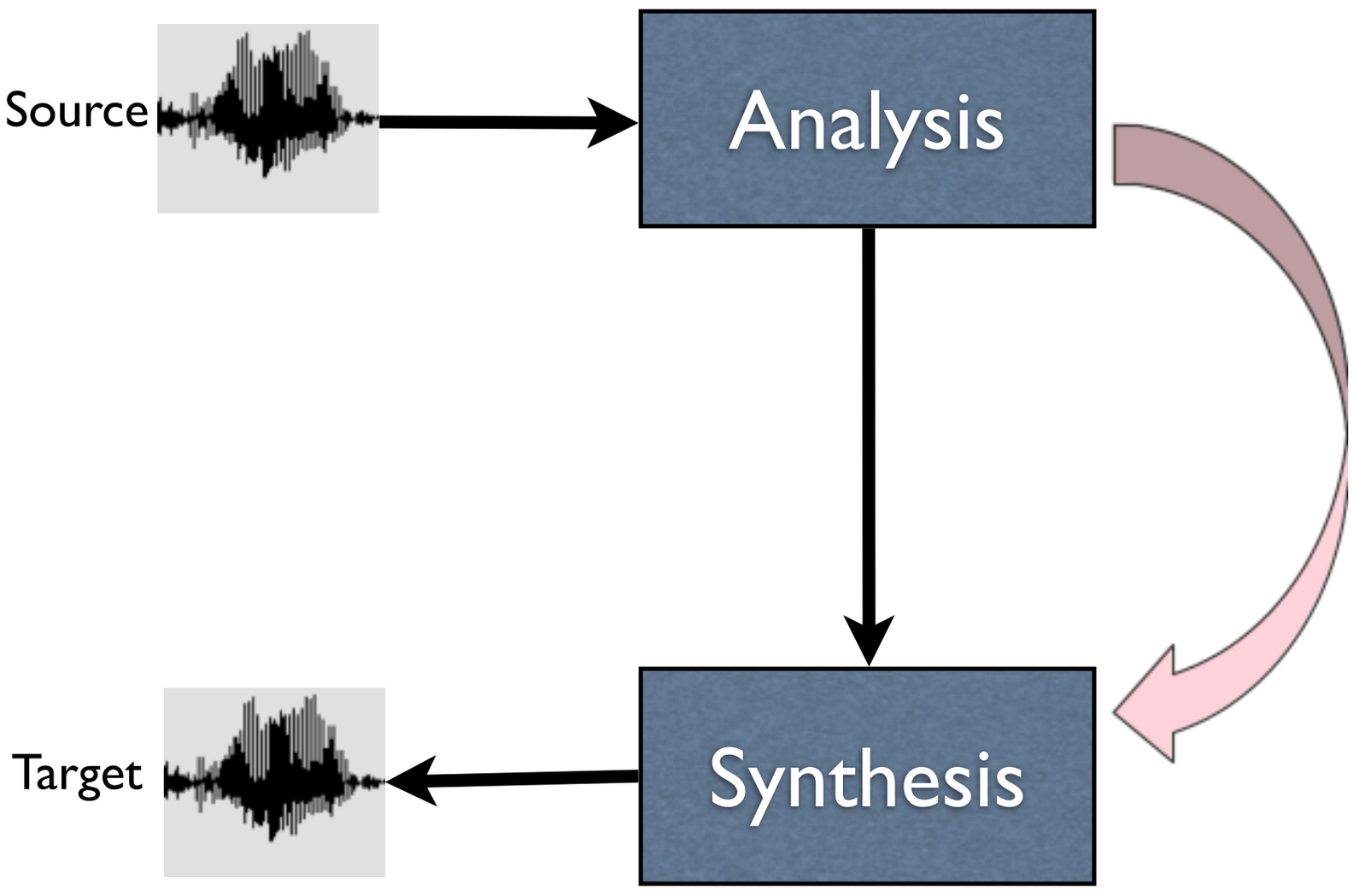
- **Unit-selection based voice conversion**



Phase artifacts created between analysis and synthesis

Overview of voice conversion (3/4)

- An analysis-synthesis pass-through without transformation



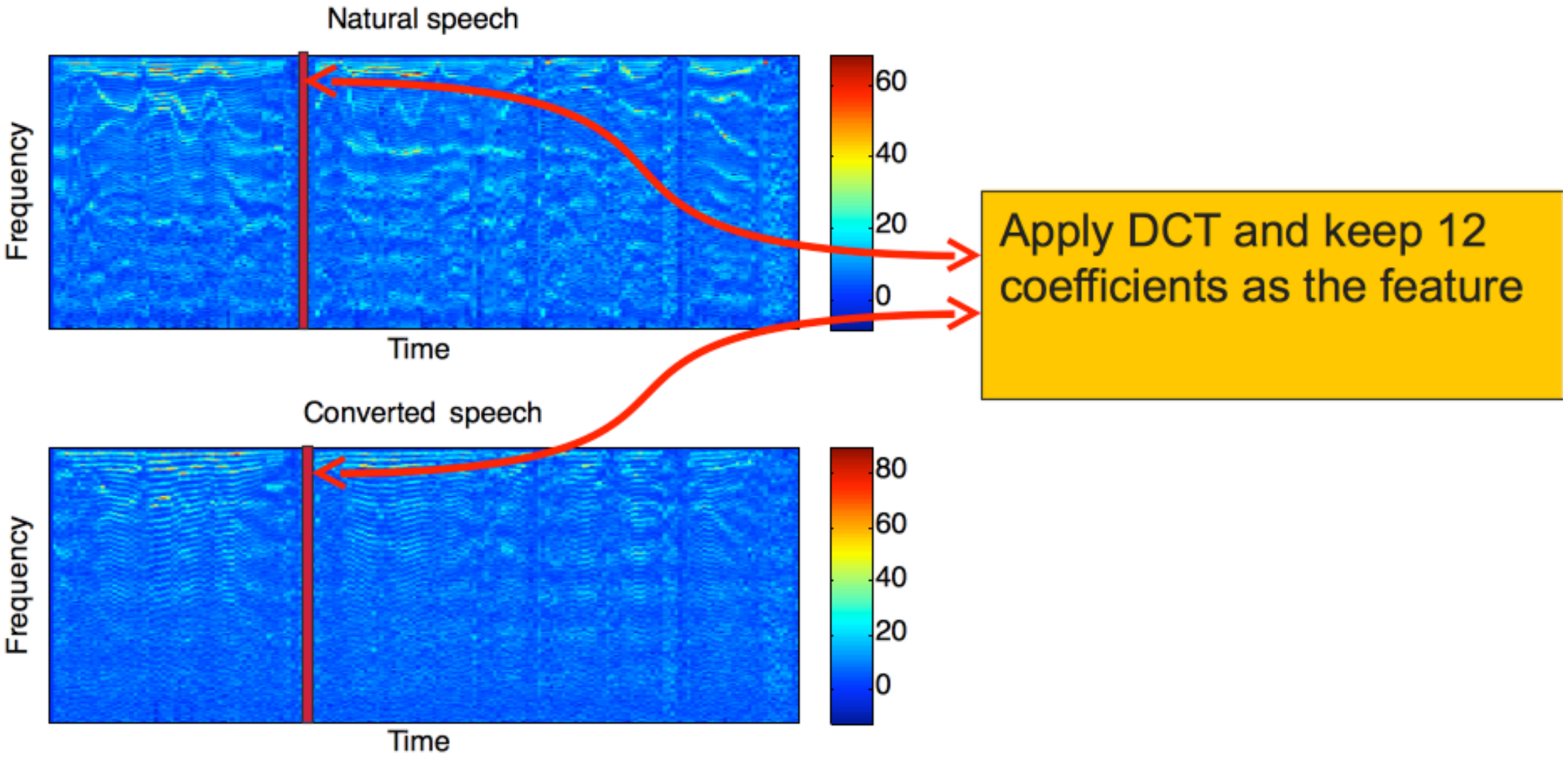
Phase artifacts created between analysis and synthesis

Overview of voice conversion (4/4)

- The three voice conversion systems all adopt analysis-synthesis module.
  - Use analysis module to extract features
  - Use synthesis filter to reconstruct speech signal from features
  - Hence, we can use the pass-through speech as training data for the synthetic speech detector

Anti-spoofing attack in speaker verification(1/3)

- **Feature for detection: modified group delay phase**



Anti-spoofing attack in speaker verification(2/3)

- **GMM-based detector**
  - **The decision is made based on the log-likelihood threshold**

$$\Lambda(C) = \log p(C|\lambda_{converted}) - \log p(C|\lambda_{natural})$$

  - **C is the feature vector sequence of a testing speech**
  - **$\lambda_{converted}$ is the GMM model for converted speech**
  - **$\lambda_{natural}$ is the GMM model for natural speech**
  - **512 Gaussian components are employed in this study**

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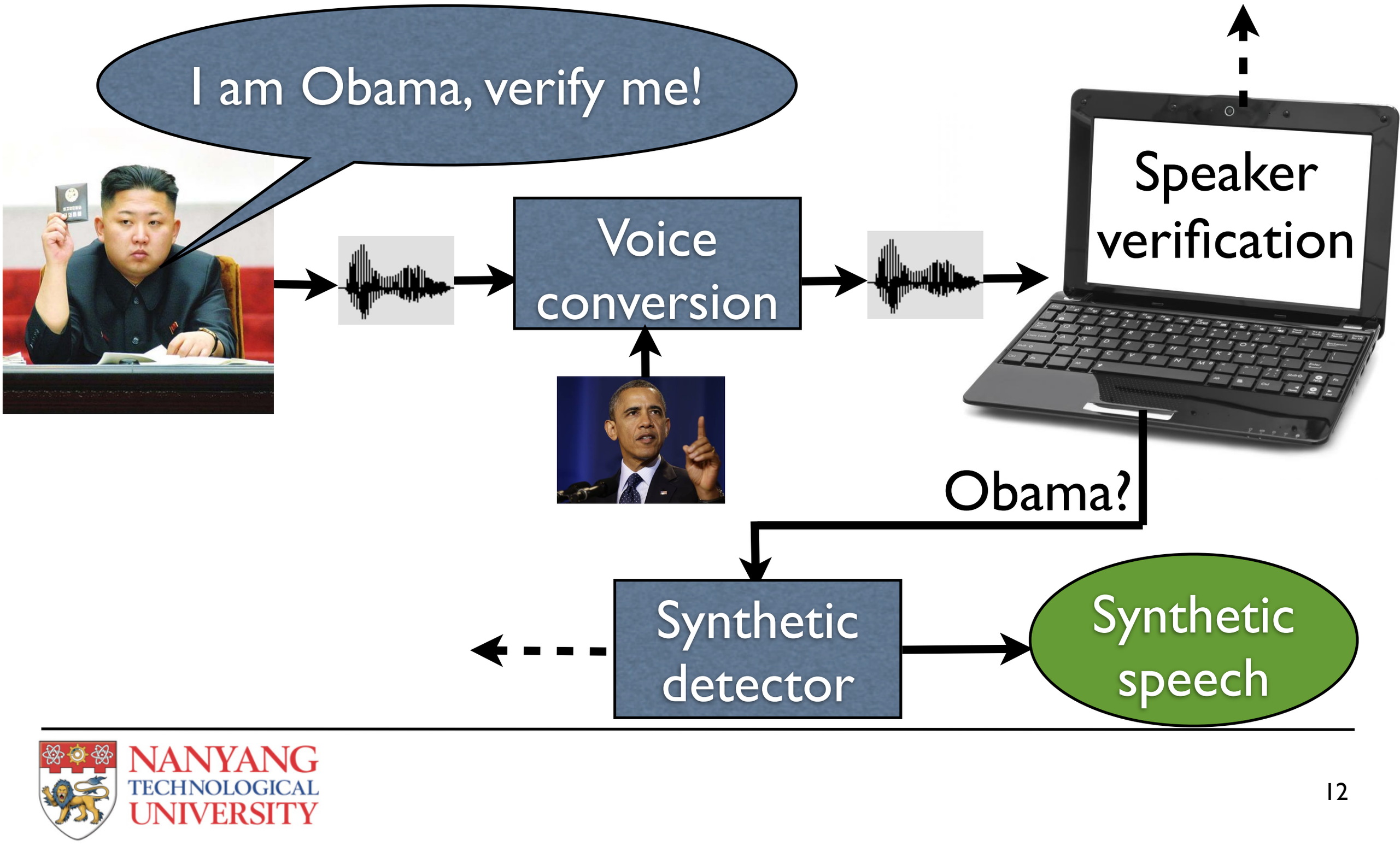
Anti-spoofing attack in speaker verification(3/3)



Experimental setups (1/3)

- **Original Dataset**
  - **subset of NIST 2006 SRE core task**

	Female	Male	Total
Unique speakers	298	206	504
Genuine trials	2, 349	1, 629	3, 978
Impostor trials	1, 636	1, 146	2, 782

  - **The duration of each conversation is about 5 minutes**

Experimental setups (2/3)

- **Spoofing dataset**
  - **Converted the 2, 782 impostor samples to the target speakers (the claimed identities)**
  - **Use *3conv4w* and *8conv4w* training sections for voice conversion function training**
  - **SPTK: http://sp-tk.sourceforge.net/ is used for analysis-synthesis**
    - **Analysis: Mel-cepstral analysis**
    - **Synthesis: MLSA filter**

Experimental setups (3/3)

- **Speaker verification systems**
  - **GMM Joint factor analysis (GMM-JFA) system**
    - **Models the intersession and speaker variability in the GMM supervector space**
  - **Probabilistic linear discriminant analysis system**
    - **PLDA system is similar as JFA system, but use i-vector as the basis for factor analysis**

Experimental results

- Performance of speaker verification systems with/without anti-spoofing attack
  - Equal error rate (EER)
    - The lower of EER, the better performance

Voice conversion	EER(%)			
	Without anti-spoofing		With anti-spoofing	
	GMM-JFA	PLDA	GMM-JFA	PLDA
Baseline (No conversion)	3.24	2.99	3.13	2.88
GMM conversion	17.36	19.29	0.0	0.0
Unit-selection conversion	32.54	41.25	1.64	1.71

Conclusions and future work

- **Conclusions**
  - **Voice conversion techniques present a threat to state-of-the-art speaker verification systems**
  - **Phase features are useful for detecting the synthetic speech from natural speech**
- **Future work:**
  - **Investigate vocoder independent features**
  - **Investigate temporal features for synthetic speech detection**