An Improved Phase Coding Audio Steganography Algorithm

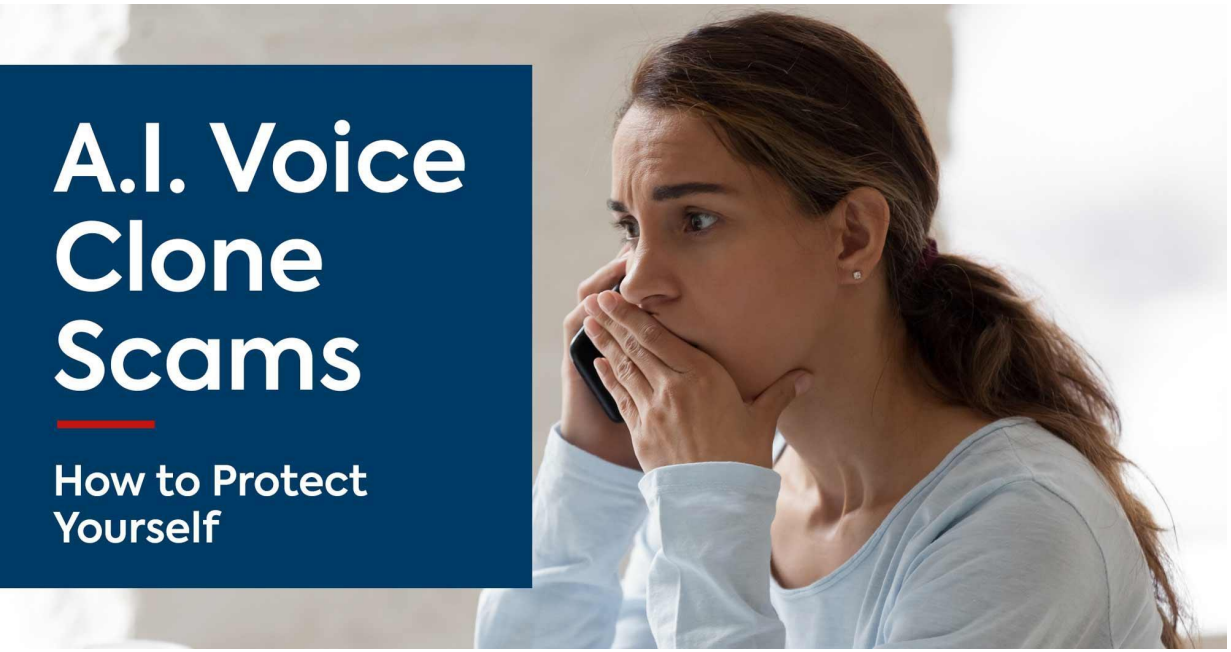
Guang Yang

Nov 2024 at 28th CISSE

guangyang19@berkeley.edu

https://www.linkedin.com/in/guangyang19/

Berkeley
UNIVERSITY OF CALIFORNIA



Bank Robbers Steal $35 Million by Deepfaking Boss's Voice
-- 2021

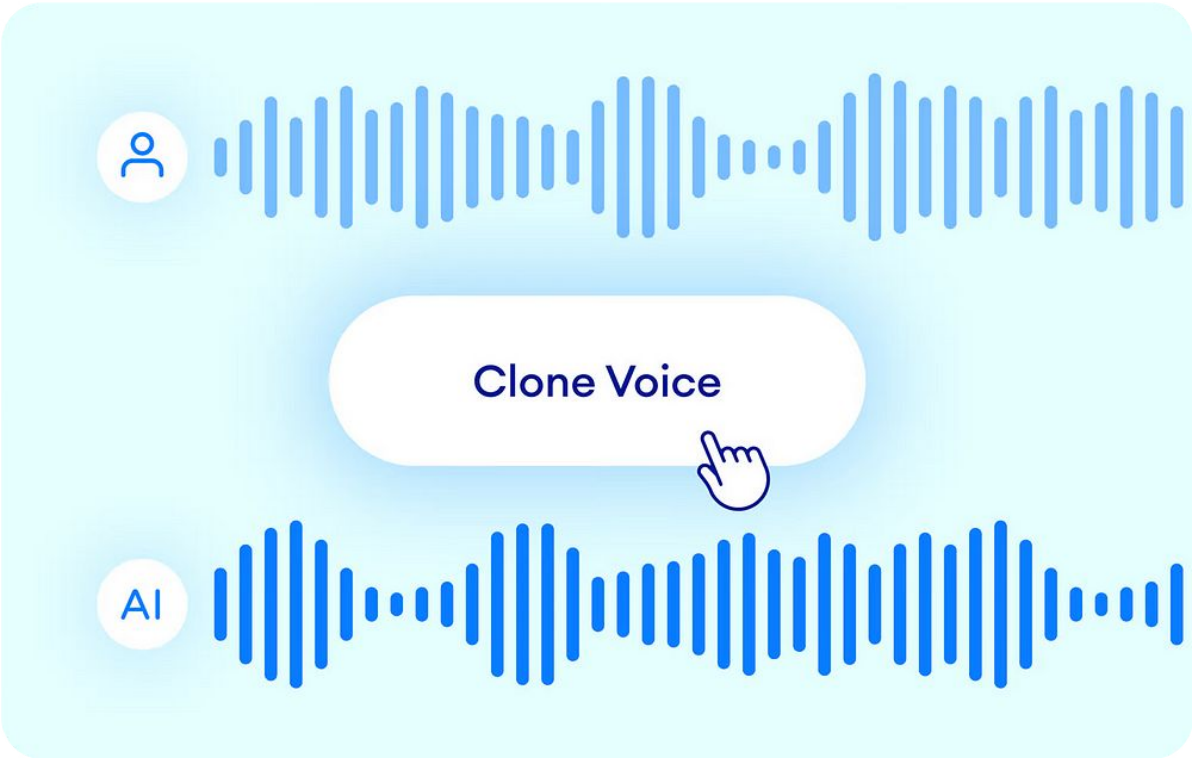
Finance worker pays out $25 million after video call with deepfake CFO
-- 2024

AI scam nearly cheats mom of $50,000 by cloning daughter's voice
-- 2024 (Last week, LA)

The bank says 'millions' of people could be targeted by AI voice-cloning scams
CNN -2024

Berkeley
UNIVERSITY OF CALIFORNIA

OpenSource AI Voice Cloning Technologies



Real-Time Voice Cloning

OpenVoice

Mimic 3

coqui-ai

VITS

BERTS **… more**

AI voice models and their variants are rapidly increasing and becoming more and more realistic.

developing detection algorithms to counter the security risks of voice cloning is becoming increasingly complex.

Steganography

A more direct approach is to add an anti-counterfeit code to audio using steganography, as long as the algorithm stays hidden.

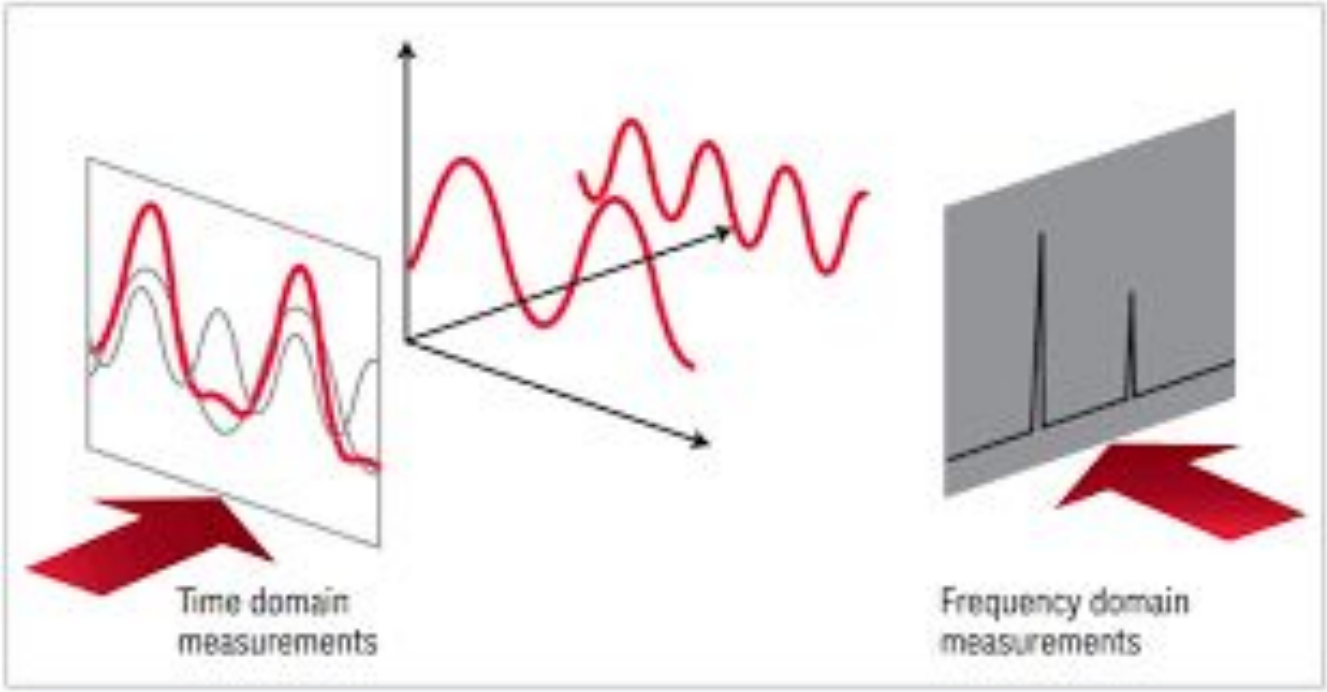
Key Points

- Minimize impact on voice quality
- Verify data integrity
- Resist detection.

What is Audio ?

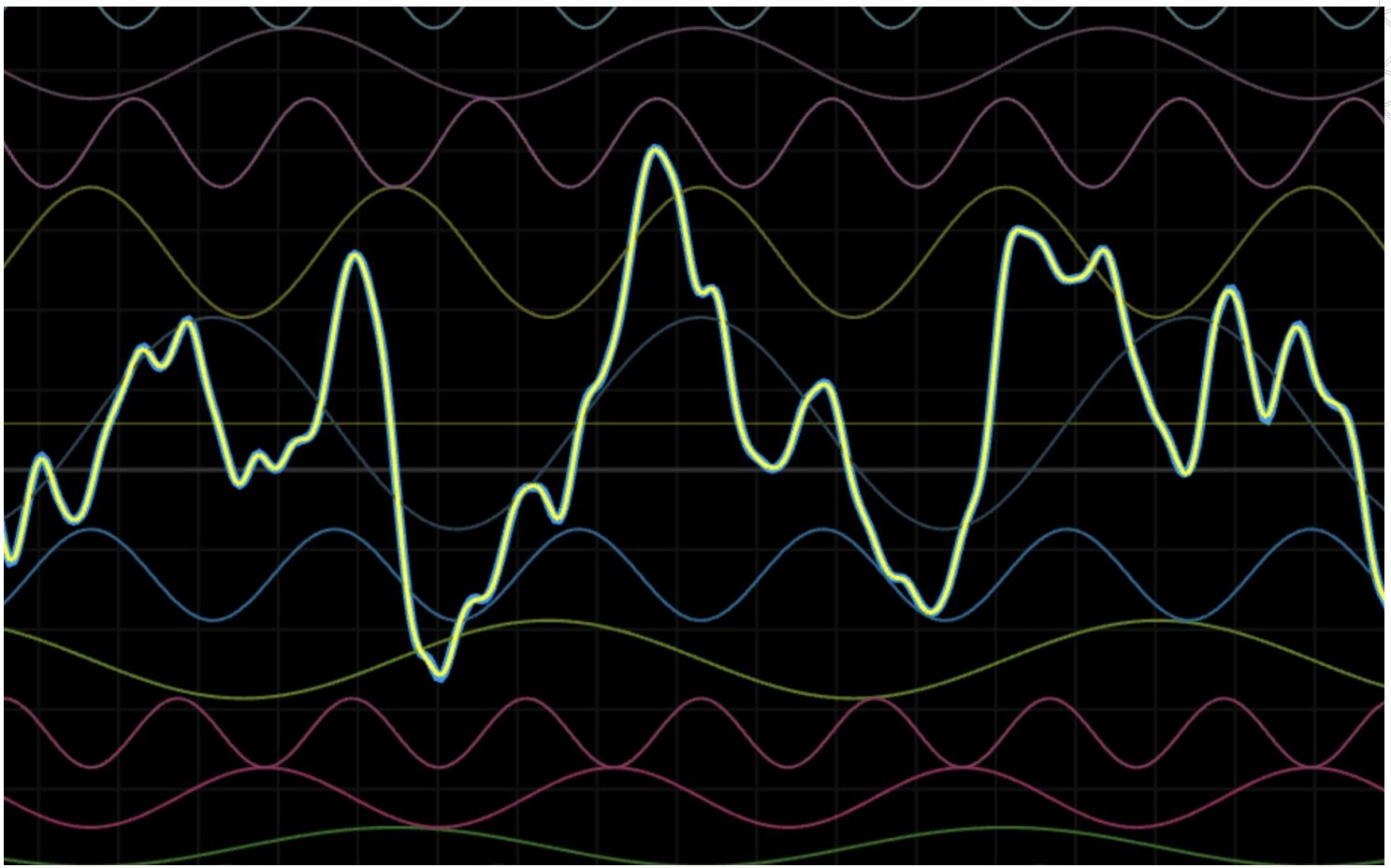
A WAV file opened in Adobe Soundstudio
It is essentially a representation in the time domain.

What is Audio？



Time Domain VS Frequency Domain

Fourier Transform [Demo]



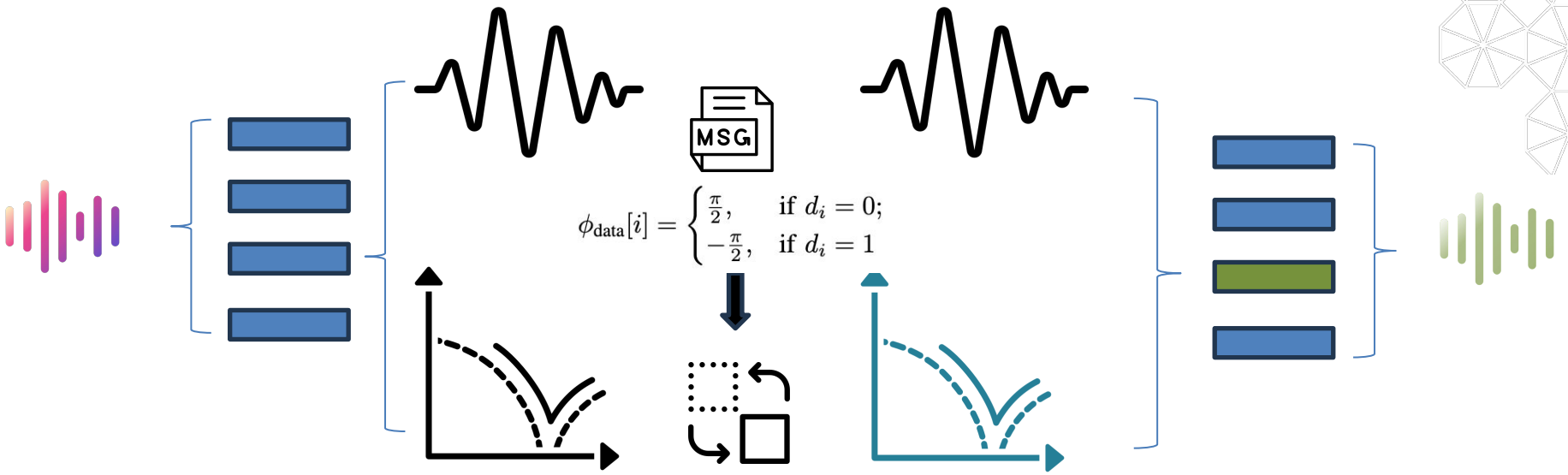
What can we do?

- Modify amplitude
- Modify frequency
- Modify phase

Why phase?

- Minimal impact on quality
- Difficult to detect

An Improved Phase Coding Audio Steganography Algorith...



$$\phi_{\text{data}}[i] = \begin{cases} \frac{\pi}{2}, & \text{if } d_i = 0; \\ -\frac{\pi}{2}, & \text{if } d_i = 1 \end{cases}$$

1

$S_i \ (i \in \{1, \ldots, n\})$

2

$A_i = |\text{FFT}(S_i)|$

$\phi_i = \text{angle}(\text{FFT}(S_i))$

3

$$\phi_i'[\text{seg\_mid} - (j-1)] = \phi_{\text{data}}[j] \quad \text{for } j = 1, 2, \ldots, \frac{m}{n}$$

$$\phi_i'[\text{seg\_mid} + j] = -\phi_{\text{data}}[\frac{m}{n} - j + 1]$$

4

$S' = \text{IFFT}(A_i \cdot \exp(j\phi_i'))$

5

$S' = S_1' \| S_2' \| \ldots \| S_n'$

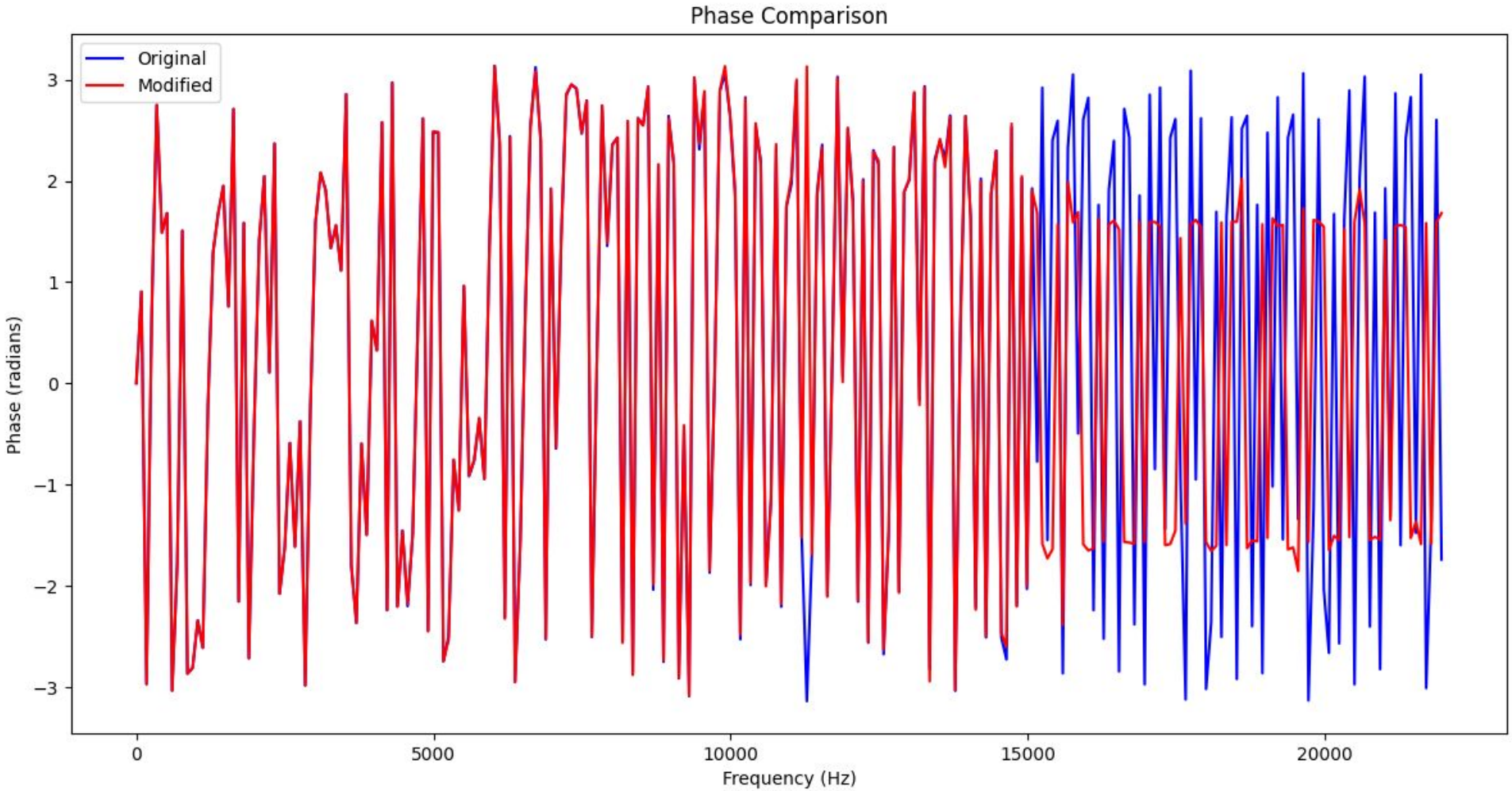
Berkeley
UNIVERSITY OF CALIFORNIA

Improved Modifications

- Mid-frequency phase encoding
- Direct phase update
- Odd symmetry preservation

Benefits

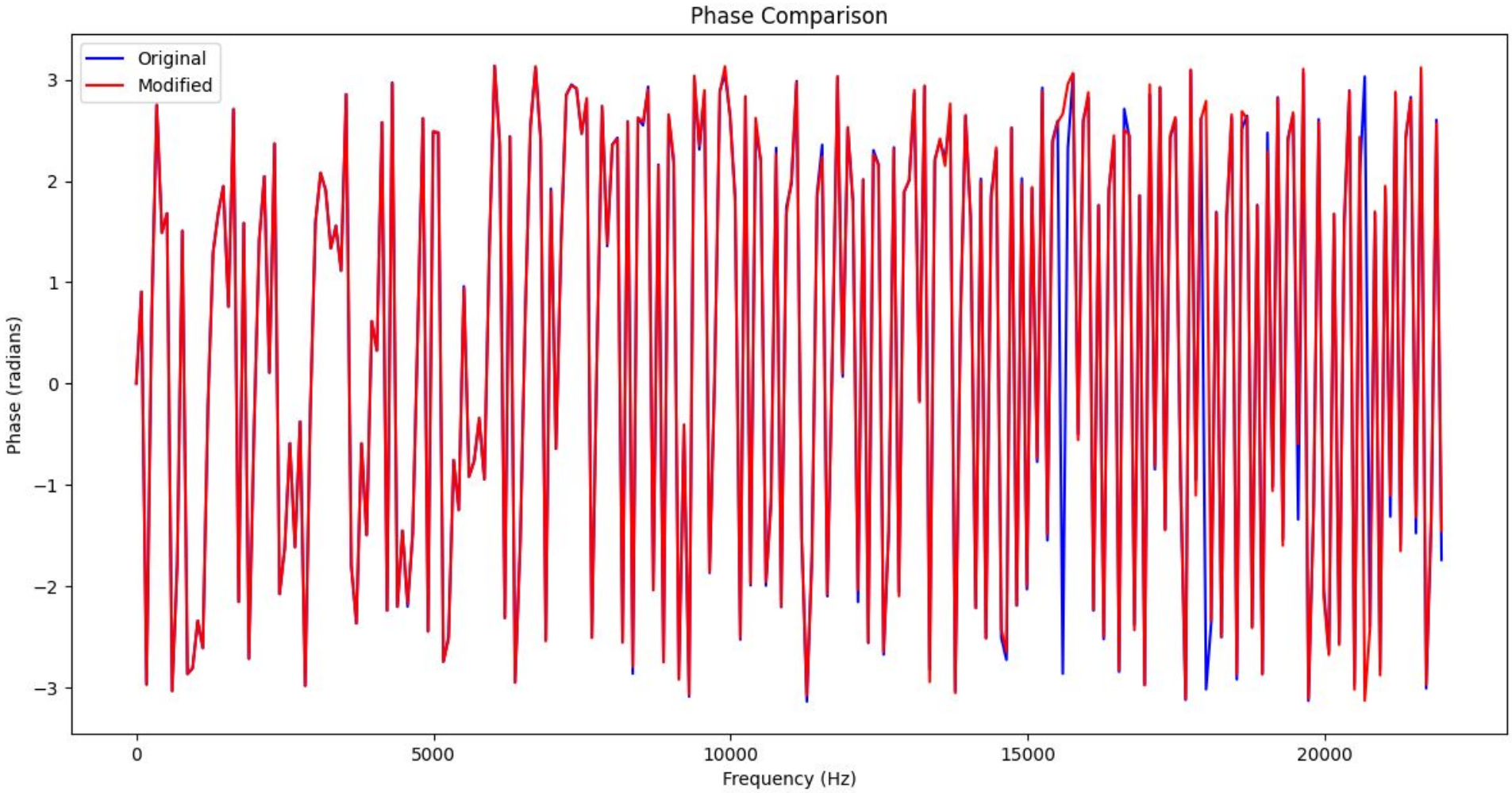
- Effectively ensures the integrity of encrypted information
- Reduces detectable phase analysis features
- Lowers error rate
- Improved sound quality
- Higher computational efficiency (requires only one FFT and one IFFT)



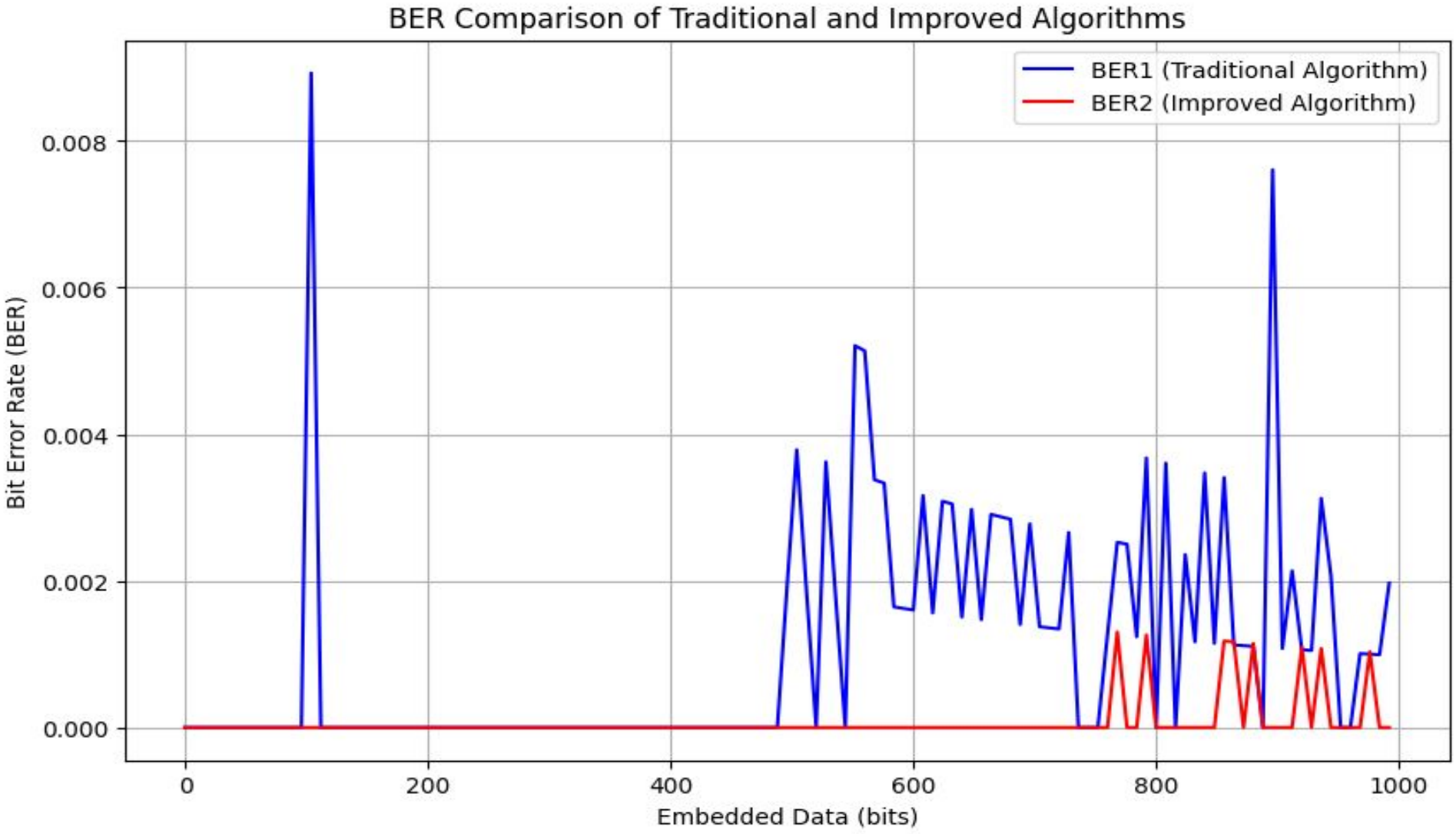
Phase Comparison of the traditional Phase Coding algorithm

Berkeley
UNIVERSITY OF CALIFORNIA

CISSE™



Phase Comparison of the improved Phase Coding algorithm



CISSE™

Berkeley
UNIVERSITY OF CALIFORNIA

Live demo

- Before
- https://drive.google.com/file/d/1CqgpZg0-PTYCn_eDxEWvOUnjzDYMyiIA/view?usp=sharing

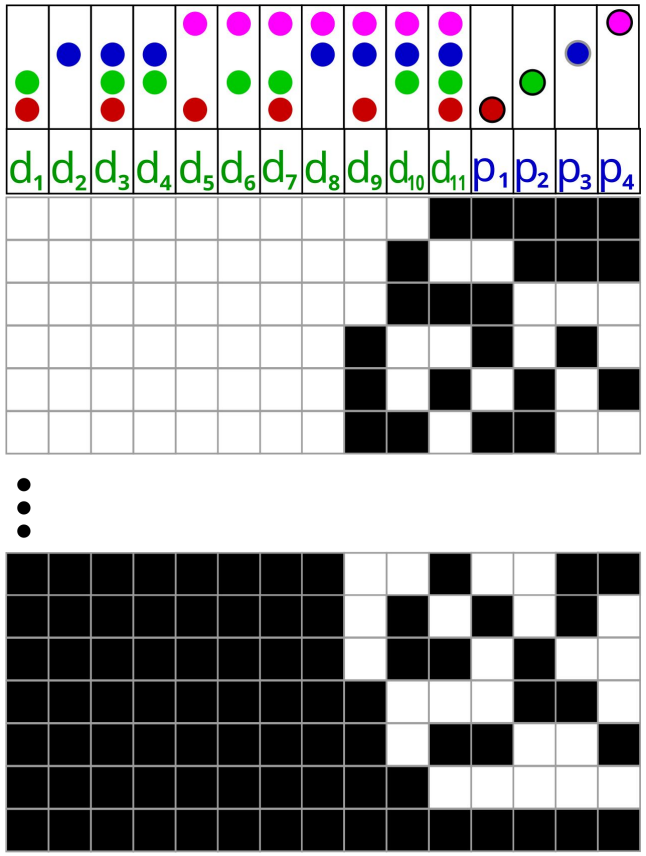
- After
- https://drive.google.com/file/d/15lI_aZK5vrOjcQQrkqpu-bNNd3u-4bB-/view?usp=sharing

Continuous improvement of the algorithm

In the future, I plan to optimize the algorithm by implementing it with WebAssembly technology and providing an open-source library that is easy to integrate, facilitating broader use in communication and social media applications.

Continuous improvement of the algorithm

I also intend to add error-correction features, such as Hamming codes and Low-Density Parity-Check Codes (LDPC), to enhance fault tolerance for large-capacity data embedding.



Acknowledgments

- First, I would like to express my deepest gratitude to my advisor, Matthew Holmes from the UC Berkeley School of Information, for his invaluable insights and guidance.

- I am also very grateful to the CISSE for giving me the opportunity to present my work here.

Berkeley
UNIVERSITY OF CALIFORNIA

References

T. Brewster, “Huge bank fraud uses deep fake voice tech to steal millions,” October 2021.Accessed: 2024-08-17.

V. V. Kumar, K. Srividya, D. Bhavani, and B. Shobha, “A comparative study of audio steganography techniques,” *International Journal of Engineering Research and Applications (IJERA)*, vol. 4, no. 6 (Version 5), pp. 94–100, 2014.Accessed: 2024-08-17.

S. B. Rajane, V. S. Pawar, P. A. Pawar, and S. B. Jagtap, “Comparative study of digital audio steganography techniques,” *International Research Journal of Engineering and Technology (IRJET)*, vol. 3, no. 4, pp. 804–807, 2016.Accessed: 2024-08-17.

D. Oak, “Audio steganography using phase encoding technique,” 2013.Accessed: 2024-08-17.

W. Zeng, H. Ai, and R. Hu, “A novel steganalysis algorithm of phase coding in audio signal,” in *Sixth International Conference on Advanced Language Processing and Web Information Technology (ALPIT 2007)*, pp. 261–264, 2007.

N. Janakiraman, M. S. Samuel, M. R. Sumalatha, and T. John, “The adaptive multi-level phase coding method in audio steganography,” in *2019 IEEE 5th International Conference for Convergence in Technology (I2CT)*, pp. 1–5, 2019.Accessed: 2024-08-17.

Haskasu, https://fourier-transform.gamelet.online/

Thank You!