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Efficient Audio Encryption Using a Discrete Cosine Transform and Baker Map

Ghadah Alzeer
College of Computers and Information Technology
Taif University
Taif, KSA
s44181669@students.tu.edu.sa

Hisham Alhumyani
College of Computers and Information Technology
Taif University
Taif, KSA
h.alhumyani@tu.edu.sa

Abstract

With the expansion and improvement of technology and communication in recent years, the necessity to secure and defend these communications from various threats has increased. In this research, we provide a novel method for encrypting audio signals utilizing Baker and discrete cosine transform (DCT) chaotic maps. Three typical audio samples of funky, muted trumpet, and flute are converted into 2D to enable the use of chaotic maps. Then, a DCT is used to extract the coefficients, and the Baker chaotic map is used to replace them. Finally, an inverse DCT is used to perform the encryption. The DCT is applied to the sample during the decryption stage, and the coefficients are altered using the Baker map. An inverse DCT is then applied, and the output is transformed from 2D to 1D to obtain the original audio signal. The effectiveness of the proposed coding model based on Baker maps and DCT is evaluated using a variety of measures, including entropy, histogram, correlation coefficient, spectrogram, noise effect, and differential tests, and the results demonstrate the effectiveness of the proposed encryption model.

Research problem

This research proposes to encrypt audio data during transmission through various media types by using the advantages of both Baker chaotic maps and DCT to build a highly efficient secure cipher.

Research Methodology

Encryption Stage

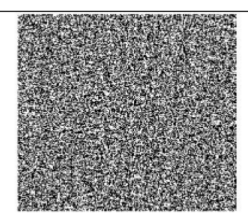
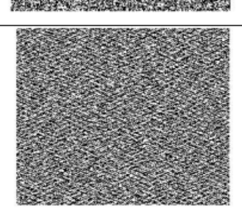
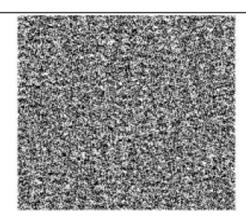
- Audio Signals Samples
- ↓ Converting from 1D to 2D
- ↓ Apply DCT
- ↓ Apply Baker Map
- ↓ Apply inverse DCT
- ↓ Encrypted Samples

Decryption Stage

- Encrypted Samples
- ↓ Apply DCT
- ↓ Apply Baker Map
- ↓ Apply inverse DCT
- ↓ Converting From 2D to 1D
- ↓ Audio Signals Samples

Experimentation And Evaluation

Several experiments were conducted to demonstrate the efficacy of the suggested encryption model based on DCT and Baker chaotic maps. Three audio samples were used: funky, muted trumpet, and flute. These data were translated from 1D to 2D to apply the proposed chaos maps effectively.

Audios	Encryption of 2D audios
Funky	
Muted trumpet	
Flute	

Analysis of quality metrics

Entropy Analysis

Audio	Entropy before encryption	Entropy after encryption
Funky	4.1144	4.9733
Muted trumpet	3.8053	5.6961
Flute	3.1634	6.3095

Correlation Coefficient

Audio	Correlation coefficient
Funky	-0.0011
Muted trumpet	-0.0043
Flute	-7.22*10-4

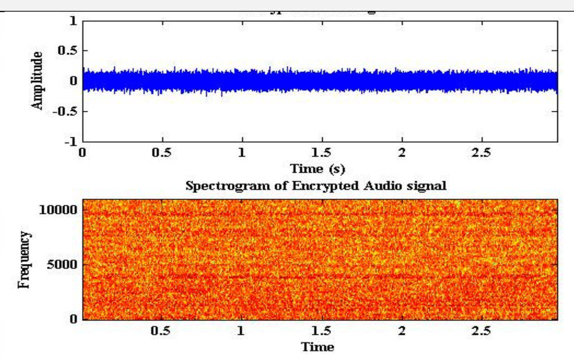
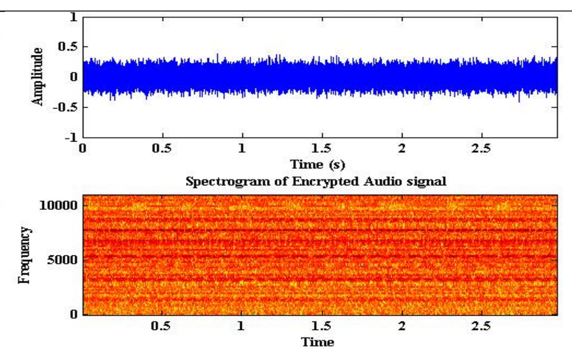
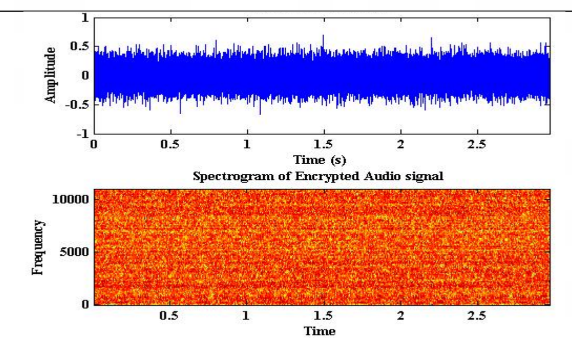
Analysis of Encryption Quality

Audio	H_D	I_D
Funky	0.2003	0.4980
Muted trumpet	0.4979	0.4979
Flute	0.1850	0.4961

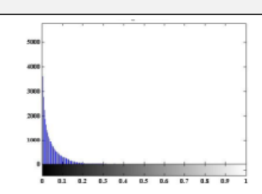
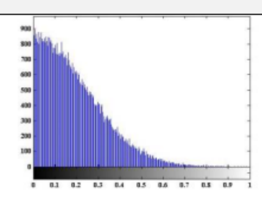
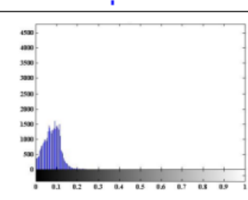
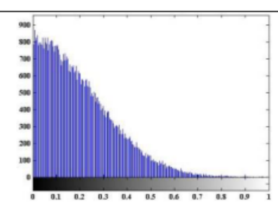
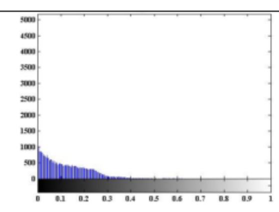
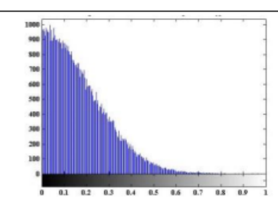
Differential Examination

Audio	NCPR	UACI
Funky	100	4.6599
Muted trumpet	100	7.7504
Flute	100	11.8843

Spectrogram Analysis

Audios	Encryption and Spectrogram of 1-D results Audios
Funky	
Mutedtrumpet	
Flute	

Histogram Analysis

Audio	Histogram of audios	Histogram of encrypted audios
Funky		
Muted trumpet		
Flute		

Noise Effect Test

Audio	Correlation				
	μ=0 σ = 0.01	μ=0 σ = 0.05	μ=0 σ = 0.1	μ=0 σ = 0.15	μ=0 σ =0.20
Funky	-0.0015	-0.0037	$1.8*10^{-4}$	0.0025	-0.0027
Muted trumpet	0.0013	-0.0011	$-6.7*10^{-4}$	$-9.9*10^{-4}$	$-9.7*10^{-4}$
Flute	0.0051	$1.32*10^{-4}$	-0.0067	$-4.2*10^{-4}$	-0.0060