Color Image Encryption in YCbCr Space

Xin Jin[1], Sui Yin[1], Xiaodong Li[1], Geng Zhao[1], Zhaohui Tian[2], Nan Sun[1], Shuyun Zhu[2]

[1]Beijing Electronic Science and Technology Institute
GOCPCCC Key Laboratory of Information Security
[2]Xidian University
Corresponding authors: {jinxin,lxd}@besti.edu.cn

北京電子科技学院
Beijing Electronic Science and Technology Institute

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西安電子科技大學
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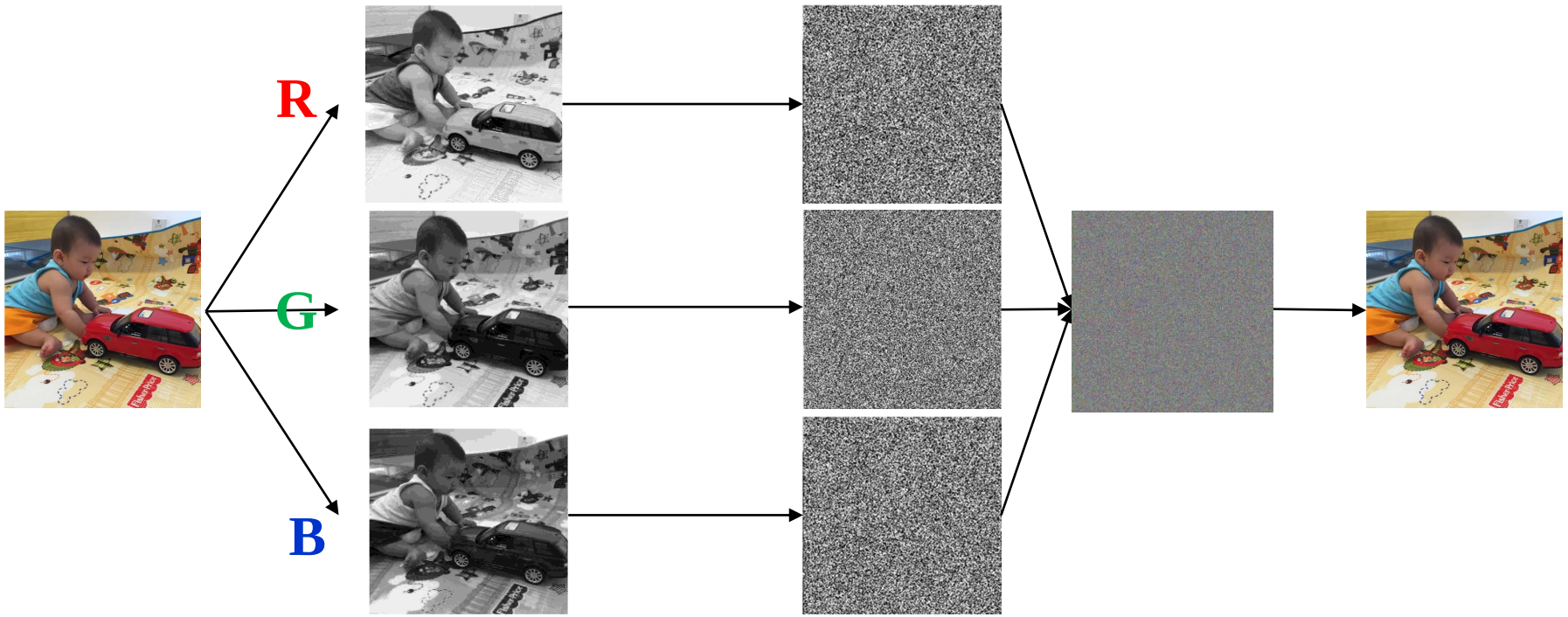
Outline

Motivation



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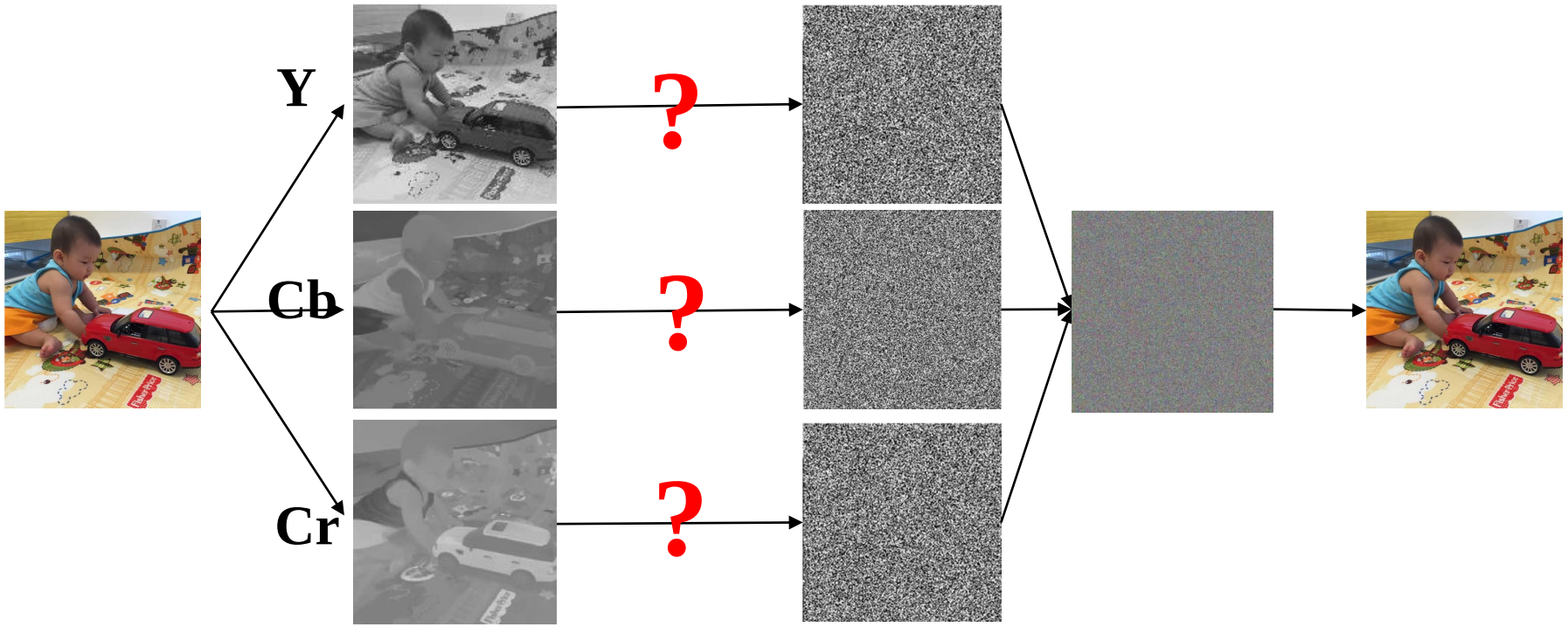


Outline

Preliminaries

- RGB→YCbCrr
- 1D Logistic map
- 2D Arnold cat map
- 3D Lu map
- DNA Computing

Preliminaries

RGB ⇒ YCbCr

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0.257 & 0.504 & 0.098 \\ -0.148 & -0.291 & 0.439 \\ 0.439 & -0.368 & -0.071 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 1.164 & 0.000 & 1.596 \\ 1.164 & -0.392 & -0.813 \\ 1.164 & 2.0017 & -0.000 \end{bmatrix} * \begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix}$$

Preliminaries

1D Logistic map

$$x_{n+1} = \mu x_n (1 - x_n)$$

$$3.569945672... < \mu \leq 4, 0 \leq x_n \leq 1$$

$$n = 0, 1, 2, ...$$

Preliminaries

2D Arnold cat map

$$\begin{bmatrix} X' \\ Y' \end{bmatrix} = \begin{bmatrix} 1 & p \\ q & p*q+1 \end{bmatrix} * \begin{bmatrix} X \\ Y \end{bmatrix} \bmod 256$$

$$\begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} 1 & p \\ q & p*q+1 \end{bmatrix}^{-1} * \begin{bmatrix} X' \\ Y' \end{bmatrix} \bmod 256$$

Preliminaries

3D Lu Map

$$\begin{cases} \dot{x} = a(y - x) \\ \dot{y} = -xz + cy \\ \dot{z} = xy - bz \end{cases}$$

a = 36, b = 3, c = 20

Preliminaries

DNA Encoding

8 bit Pixel 00011011

00 A ⟷ T 11

01 G ⟷ C 10

Preliminaries

DNA Computing

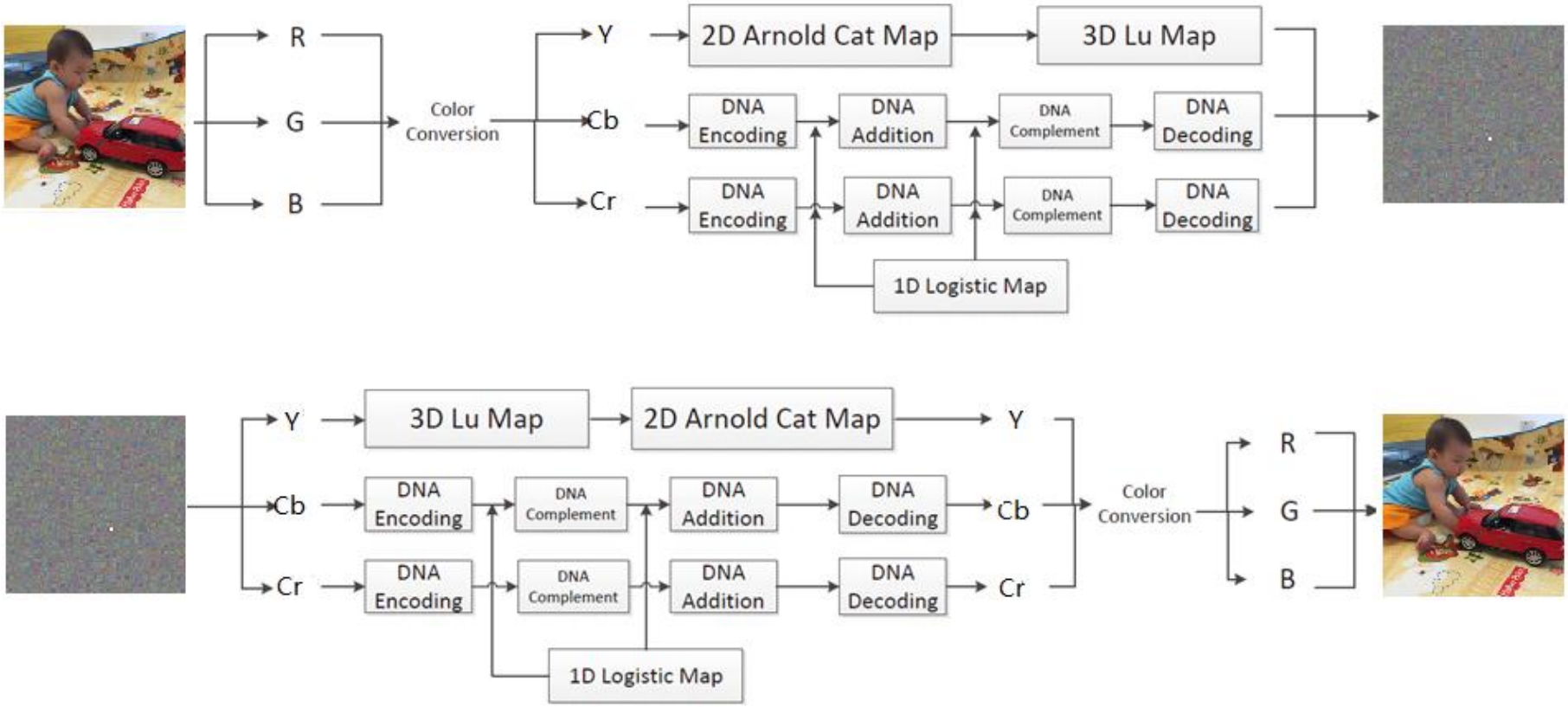
+	T	A	C	G
T	C	G	T	A
A	G	C	A	T
C	T	A	C	G
G	A	T	G	C

—	T	A	C	G
T	C	G	T	A
A	A	C	G	T
C	T	A	C	G
G	G	T	A	C

X	Complement(X)
A	T
T	A
C	G
G	C

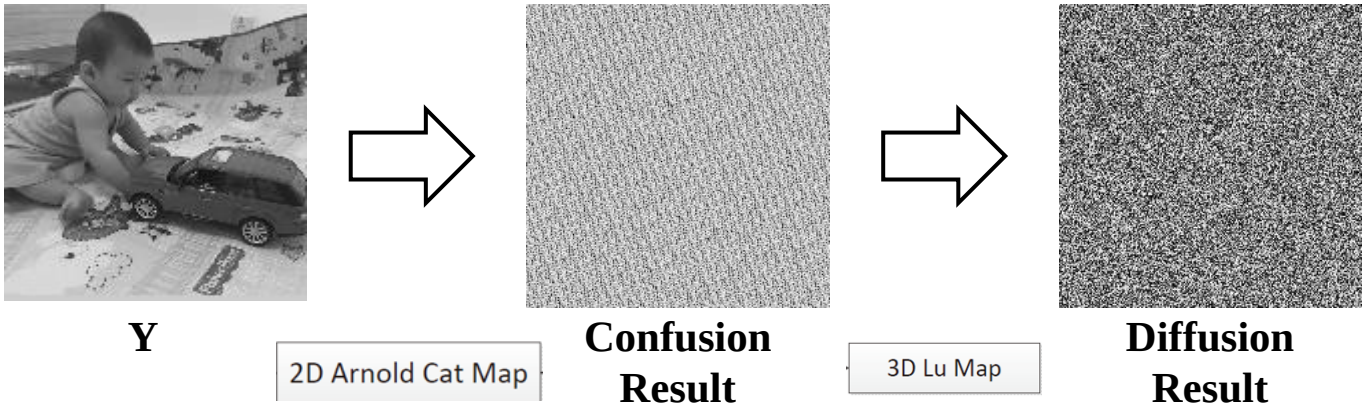
Outline

Color Image Encryption in YCbCr



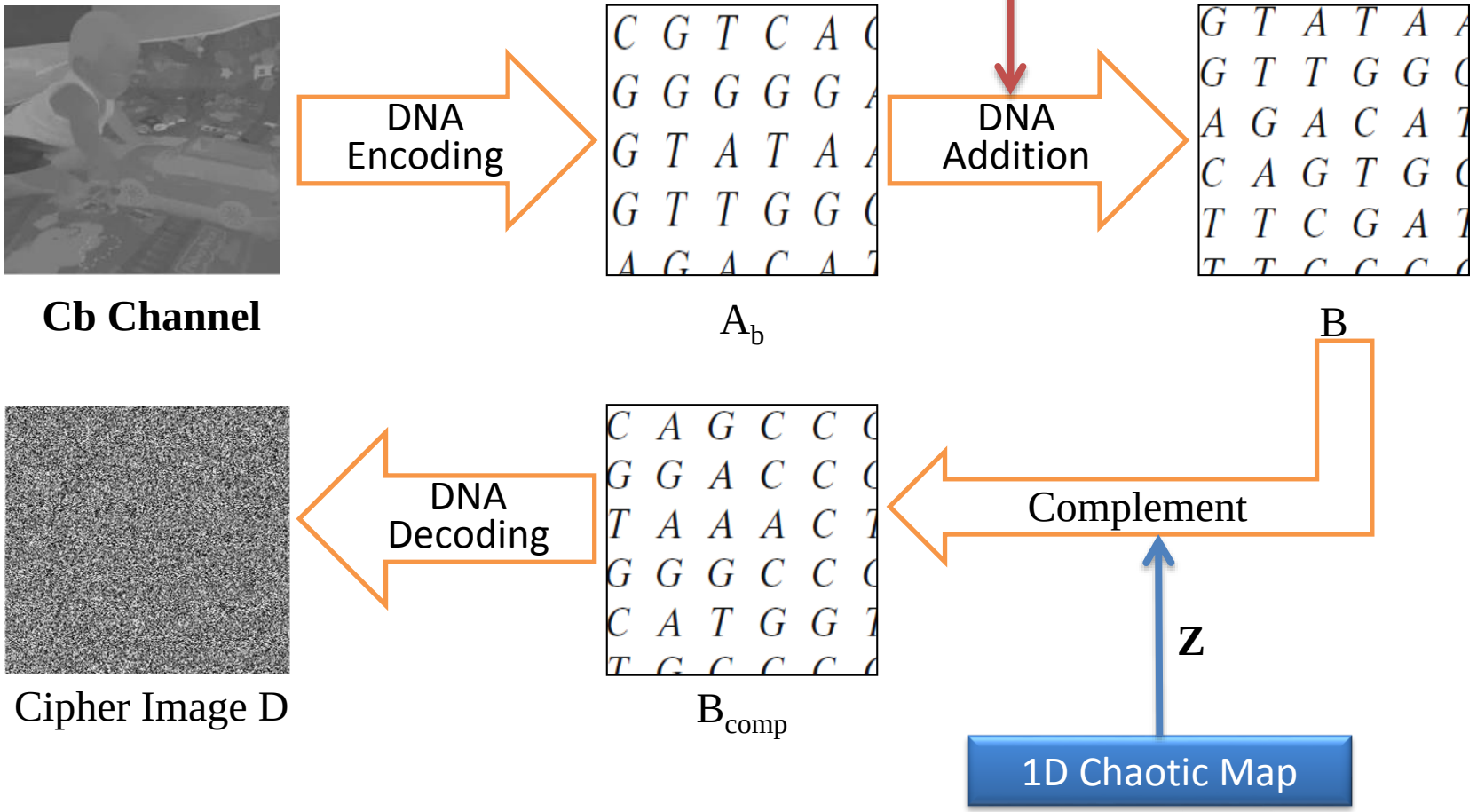
Color Image Encryption in YCbCr

The Y Channel



Color Image Encryption in YCbCr

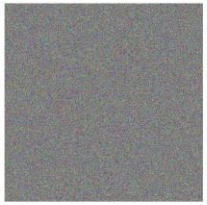
The CbCr Channel



Outline

The Encryption Results


lena

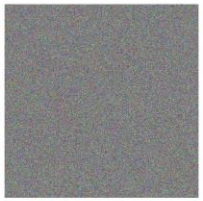



peppers


couple

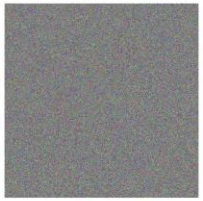

girl


airplane

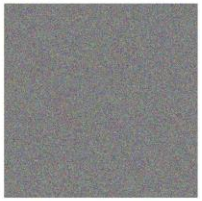



gorilla


sunset




snow



Key Space

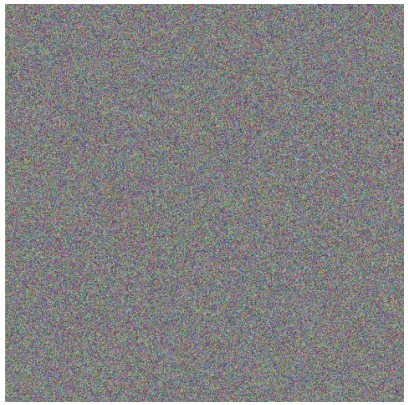
$$\begin{cases} \text{1D logistic: } 3.569945672... < \mu \leq 4, x_0 \in [0,1] \\ \text{2D Arnold: } N_{iteration} > 15, p, q \ are \ positive \ integers \\ \text{3D Lu:} a = 36, b = 3, c = 20, -40 < x_0 < 50, -100 < y_0 < 80, 0 < z_0 < 140 \end{cases}$$

The precision of 64-bit double data is 10^{-15}
The key space is about $(10^{15})^8 = 10^{120} \approx 2^{399}$
The max key space of AES = (2^{256})

Sensitivity of Secret Key

$$\begin{cases} x_0 \text{ from } -6.045 \text{ to } -6.045000000000001 \\ x_0^{a*} \text{ from } 0.62 \text{ to } 0.620000000000001 \\ x_0^{b*} \text{ from } 0.26 \text{ to } 0.260000000000001 \end{cases}$$

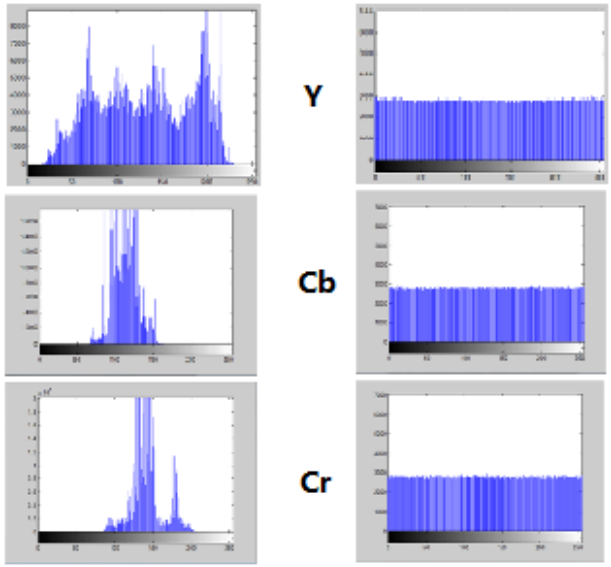
dubao

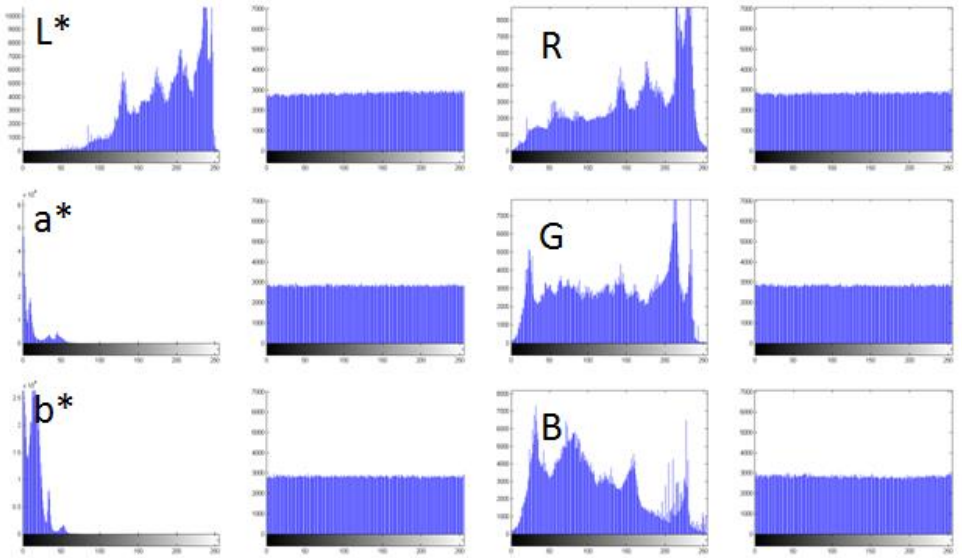


Cipher *dubao*

Decrypted with wrong key

The Histogram Analysis



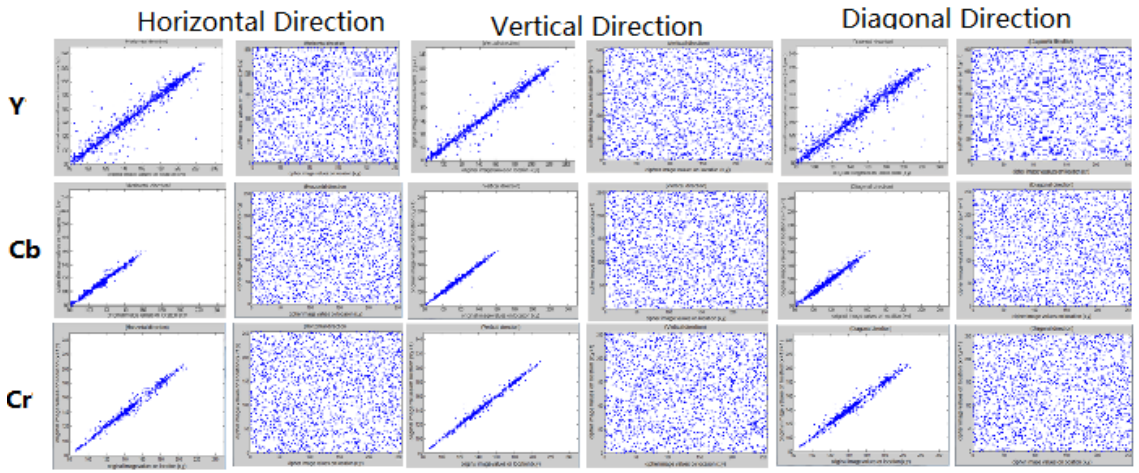


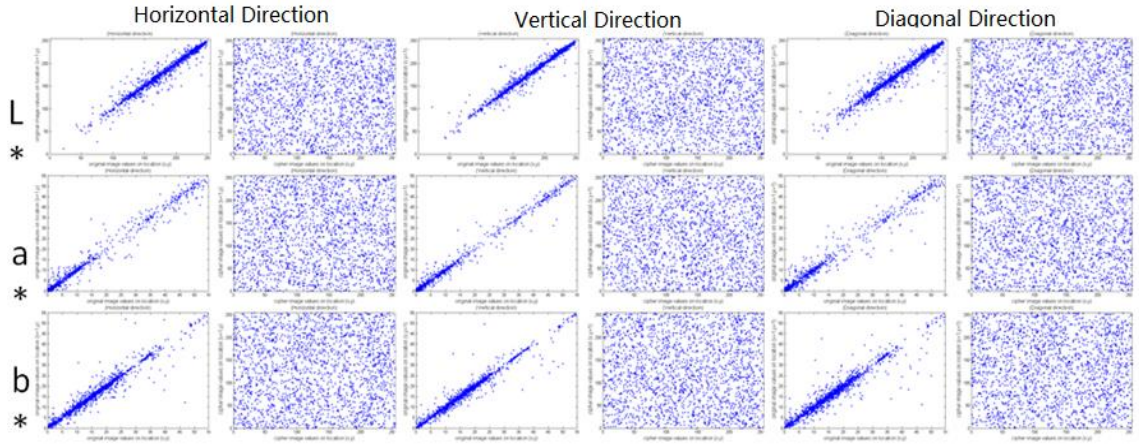
The Information Entropy

$$\mathrm{H}(m) = -\sum_{l=0}^{L} \mathrm{P}(m_i)\log_2(m_i)$$

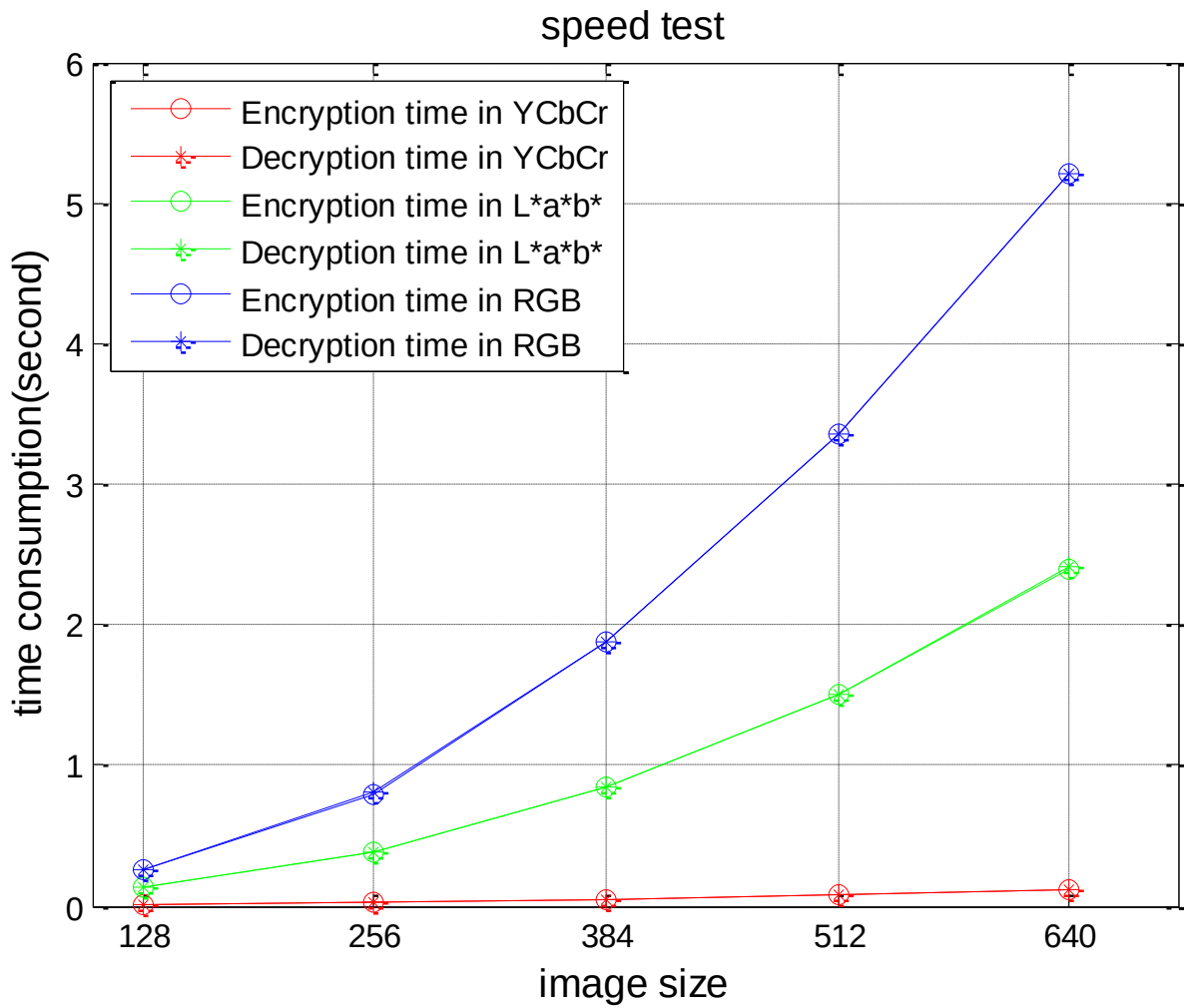
YCbCr	H(m)	L*a*b*	H(m)	RGB	H(m)
Y	7.9996	L*	7.9961	R	7.9815
Cb	7.9998	a*	7.9952	G	7.9815
Cr	7.9997	b*	7.9815	B	7.9815

The Correlation Analysis





The Speed of the Encryption and Decryption



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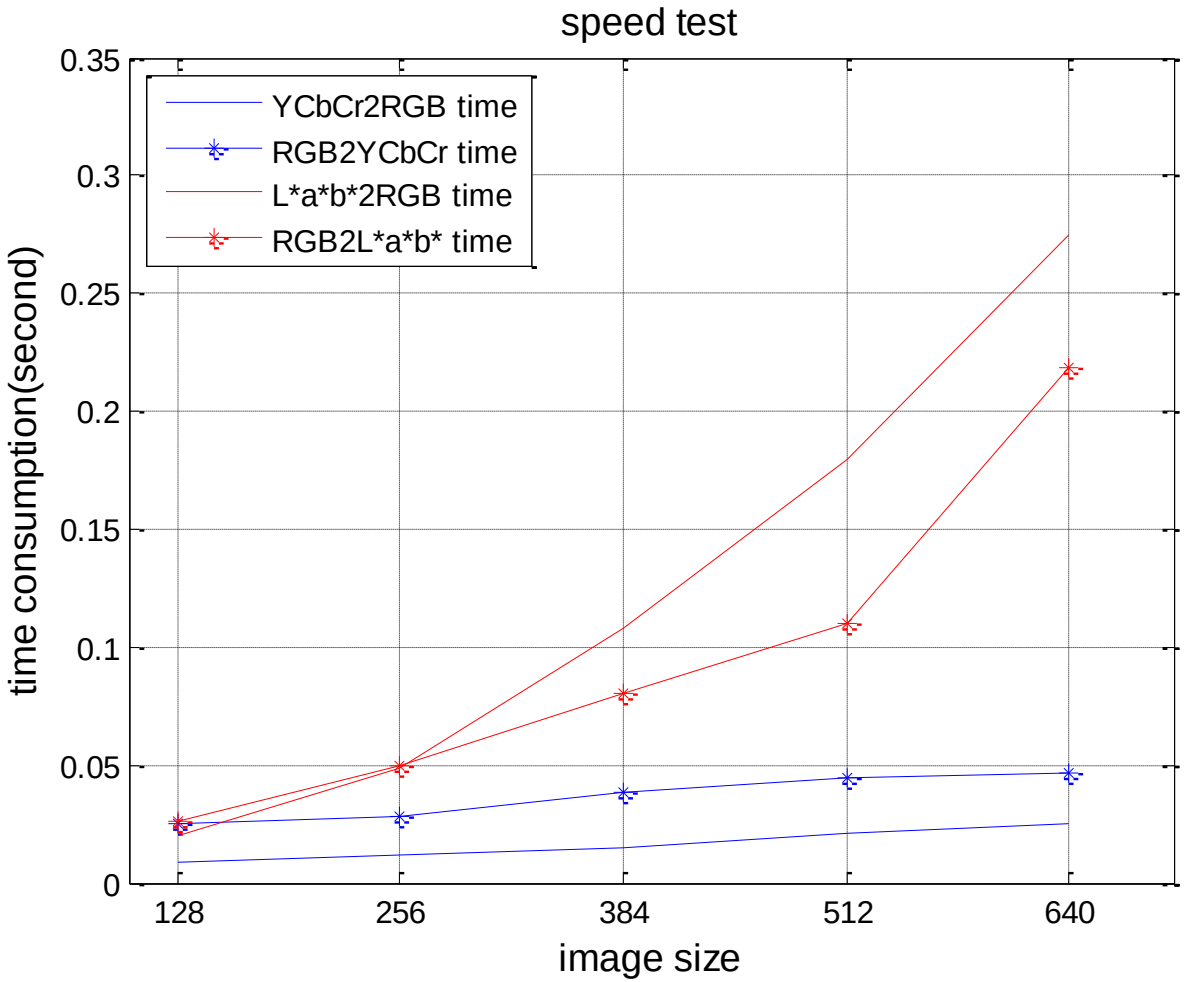

Outline

1. Motivation
2. Preliminaries
3. Color Image Encryption in YCbCr Space
4. Results and Security Analysis
5. Conclusion and Discussion

Conclusion and Discussion

- **A color image encryption algorithm in YCbCr space.**

- **In future work, we will utilize the fast speed of the YCbCr method and continue to improve the encryption algorithm to have a better and faster way.**

Thanks !

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