

# Assemblage: Chipping Away at Censorship with Generative Steganography

Tushar M. Jois, Cora Rowena Ruiz, Gabriel Kaptchuk

*Free and Open Communications on the Internet 2026 (FOCI '26)*  
*February 19, 2026*

# Steganography

Anything not viewable  
treated as suspicious



Sender

News Report



**Enc(News Report)**



Censored  
Social Media  
Platform



Receiver

**Encode(News Report)**  
→ **“Here’s a recipe ...”**



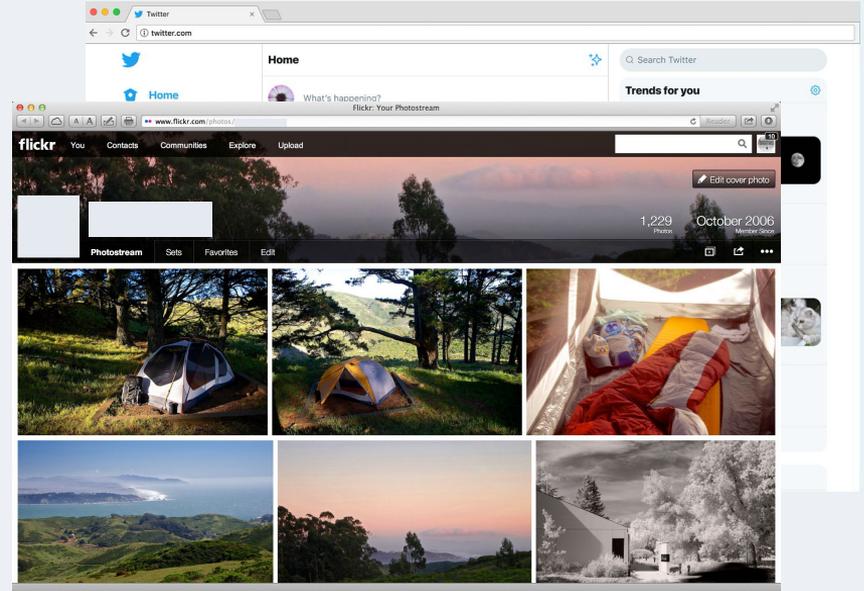
→

**Decode(“Here’s a recipe ...”)**  
→ **News Report**

How would this work in practice?

# Collage

(USENIX '10)



*User-generated content*

## Meteor: Cryptographically Secure Steganography for Realistic Distributions

## Discop: Provably Secure Steganography in Practice Based on “Distribution Copies”

## Pulsar: Secure Steganography for Diffusion Models

## StegaDDPM: Generative Image Steganography based on Denoising Diffusion Probabilistic Model

Yinyin Peng  
School of Computer Science and Information Engineering, Hefei University of Technology  
Hefei, China  
yinyinpeng@mail.hfut.edu.cn

Kejiang Chen  
University of Science and Technology of China  
Hefei, China

Donghui Hu<sup>\*</sup>  
School of Computer Science and Information Engineering, Hefei University of Technology  
Hefei, China  
huhd@hfut.edu.cn

Gang Pei  
School of Computer Science and Information Engineering, Hefei University of Technology  
Hefei, China

Yaofei Wang<sup>\*</sup>  
School of Computer Science and Information Engineering, Hefei University of Technology  
Hefei, China  
wyf@hfut.edu.cn

Weiming Zhang  
University of Science and Technology of China  
Hefei, China

### ABSTRACT

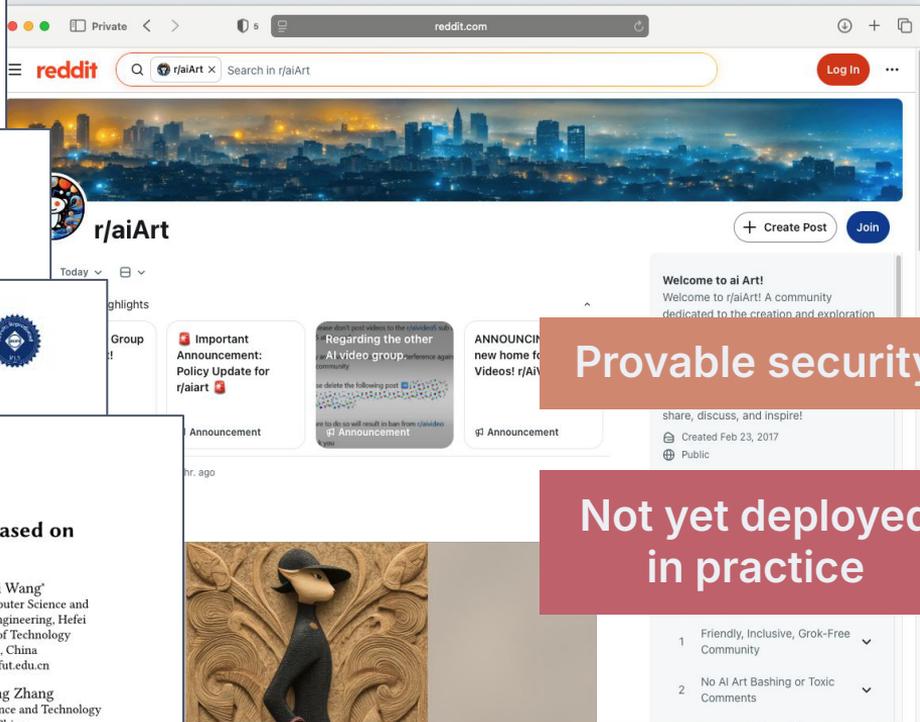
Image steganography is the technology of concealing secret messages within an image. Recently, generative image steganography has been developed, which conceals secret messages during image generation. However, existing generative image steganography schemes are often criticized for their poor steganographic capacity and extraction accuracy. To ensure secure and dependable communication, we propose a novel generative image steganography based on the denoising diffusion probabilistic model, called StegaDDPM. StegaDDPM utilizes the probability distribution between the intermediate state and generated image in the reverse process of the diffusion model. The secret message is hidden in the generated image through message sampling, which follows the same probability distribution as normal generation. The receiver uses two shared random seeds to reproduce the reverse process and accurately extract secret data. Experimental results show that StegaDDPM outperforms state-of-the-art methods in terms of steganographic capacity,

### ACM Reference Format:

Yinyin Peng, Donghui Hu, Yaofei Wang, Kejiang Chen, Gang Pei, and Weiming Zhang. 2023. StegaDDPM: Generative Image Steganography based on Denoising Diffusion Probabilistic Model. In *Proceedings of the 31st ACM International Conference on Multimedia (MM '23)*, October 29–November 3, 2023, Ottawa, ON, Canada. ACM, New York, NY, USA, 9 pages. <https://doi.org/10.1145/3581783.3612514>

### 1 INTRODUCTION

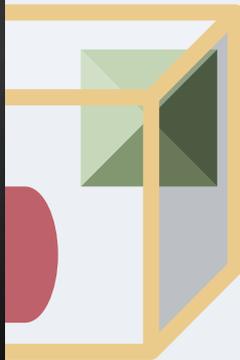
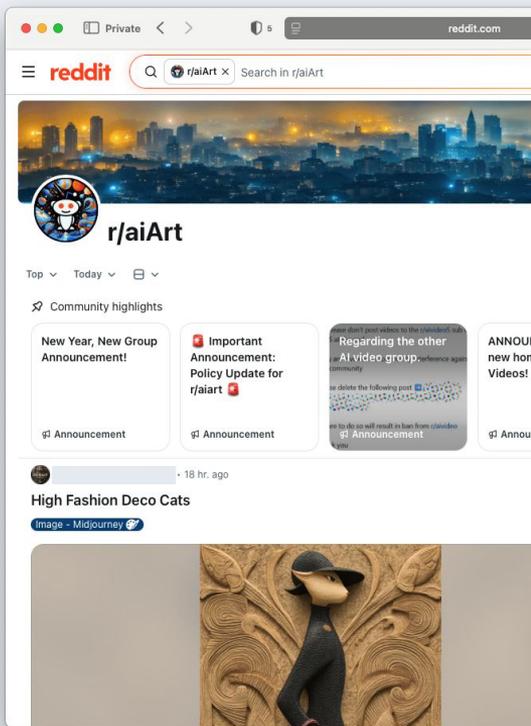
Image steganography [9] is the technology that conceals secret data within an image without arousing notice, which can be classified into steganography based on embedding [8, 11, 14, 18–20, 26, 29, 32, 33, 38, 44, 48] and steganography without embedding (SWE) [15, 21–23, 34–36, 42, 45–47] depending on whether the cover image is modified. Steganography with embedding has an inherent risk that modification traces of the cover image are inevitably left,



Provable security

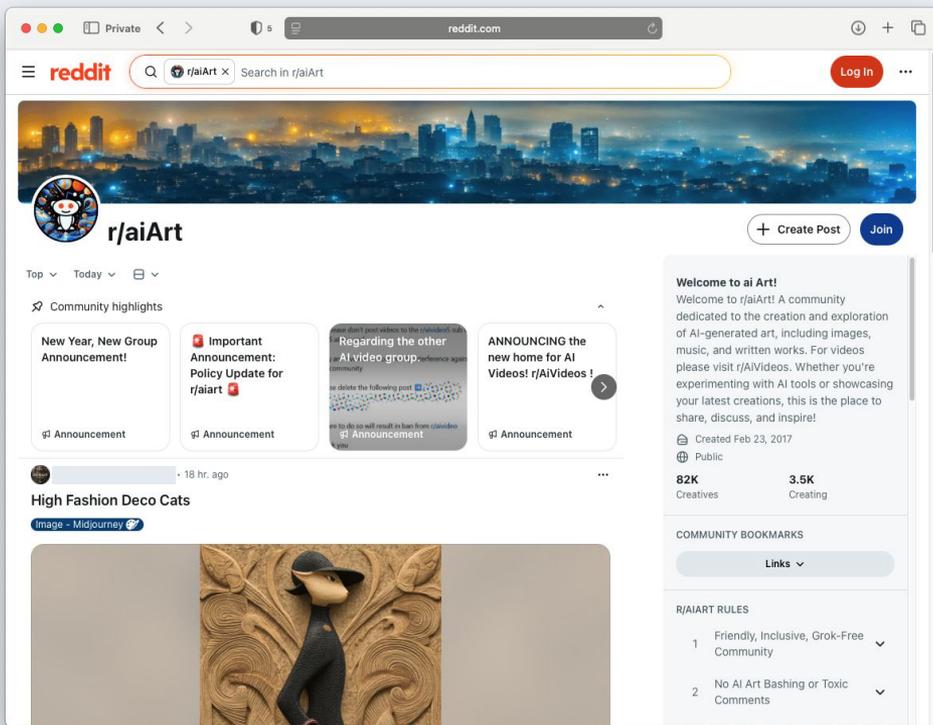
Not yet deployed in practice

Use AI-generated  
steganography?

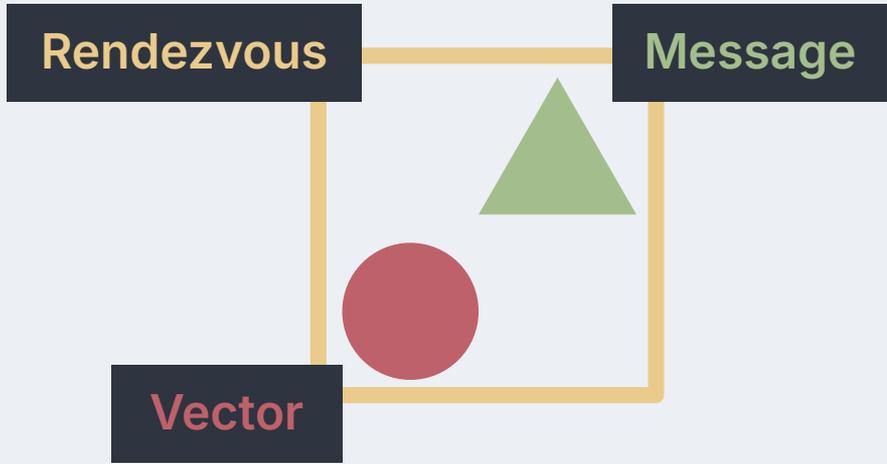


emblage

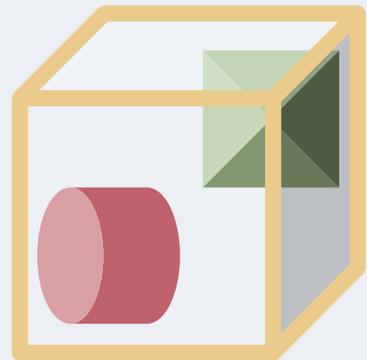
(USENIX 10)



- We do not settle the societal debate around AI-generated content with this work
- Sharing AI outputs are popular (even in censored regimes)
- Popularity means that censoring it leads to collateral damage → potential circumvention mechanism



**Collage**  
(USENIX '10)

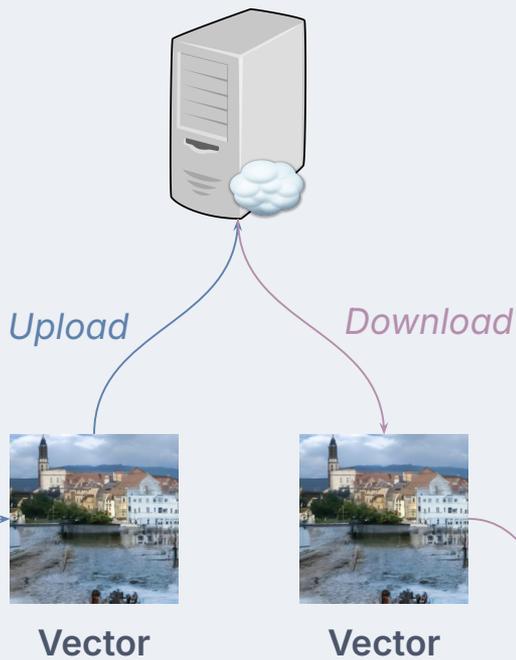
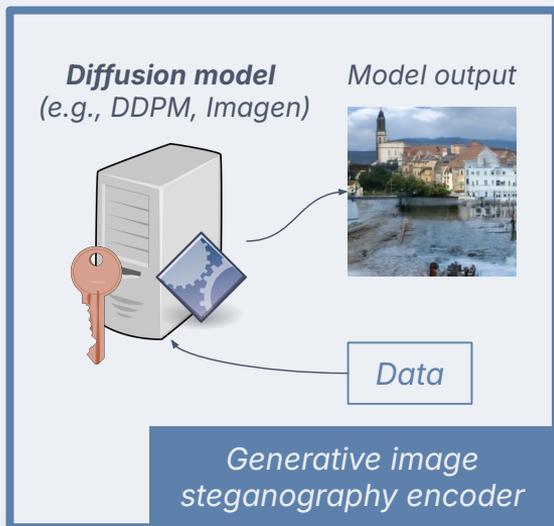


**Assemblage**

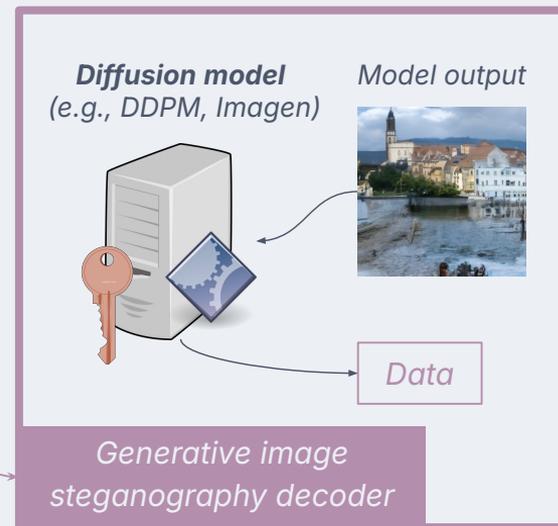
# Assemblage

## Vector layer

Pulsar (CCS '24)

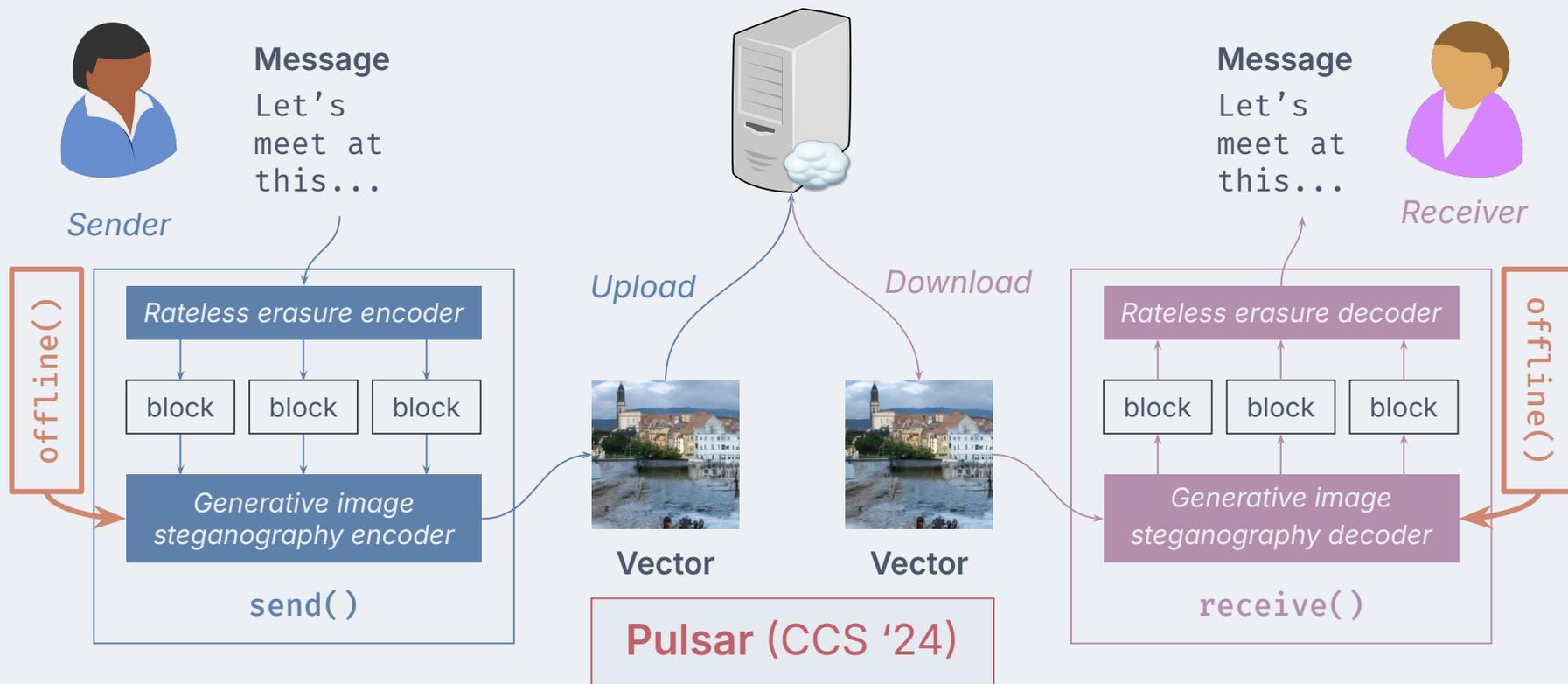


Provable security



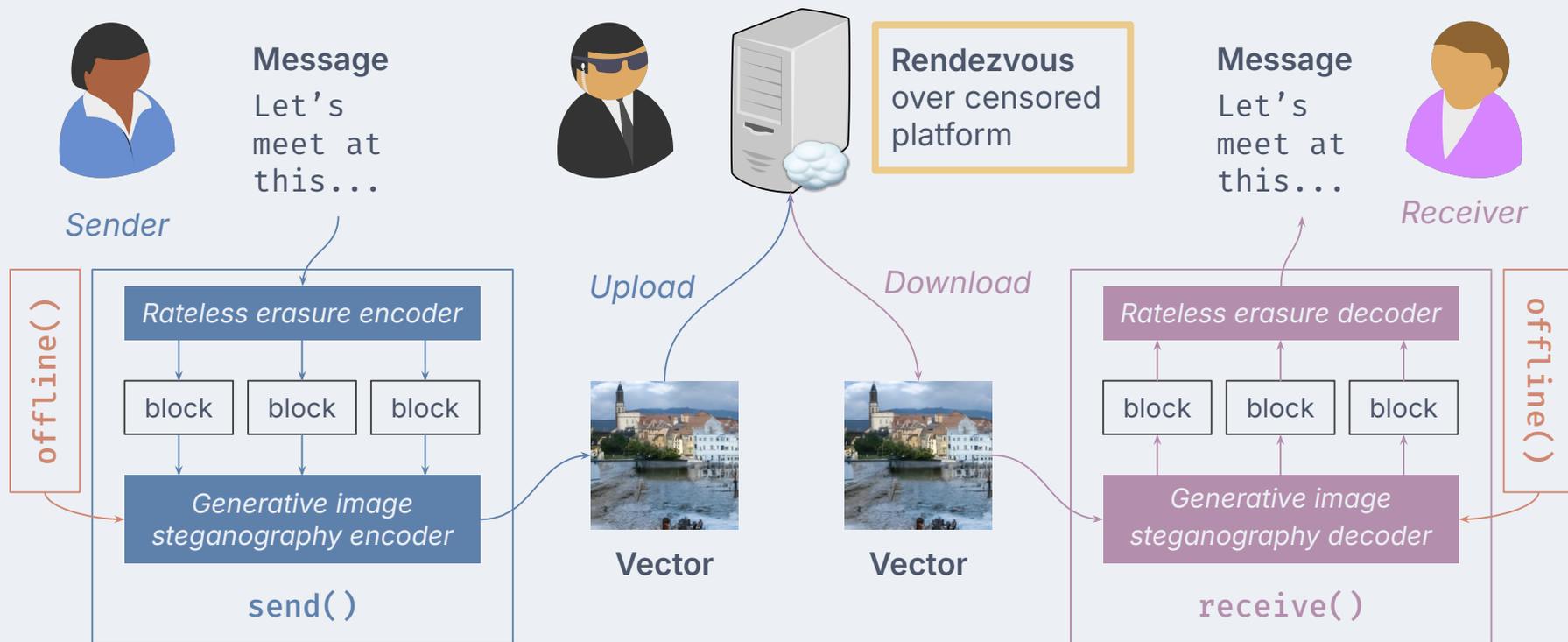
# Assemblage

## Message layer



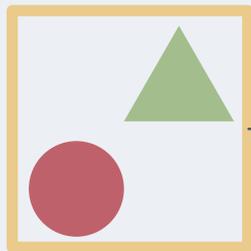
# Assemblage

## Rendezvous



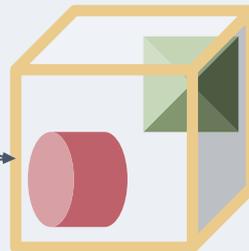
**Collage**

(USENIX '10)



*Availability*

*Deniability*



**Assemblage**

1. Choosing deniable tasks

2. Identifying suitable vectors

3. Agreeing on tasks for a message

Platform	Style	Viable Drop Locations	Reach
DeviantArt	Media sharing	Platform-wide Public AI image communities	65 mil MAU [25] 800+ groups [3]
Discord	Messaging	Platform-wide “AI Hub by Weights” “ai Art” “NightCafeLounge”	200 mil MAU [22] 521k members [21] 6k members [19] 78.2k members [20]
Imgur	Media sharing	Platform-wide “aiart” hashtag	300 mil MAU [40] 1k posts [41]
Rednote	Media sharing	Platform-wide	300 mil MAU [28]
Reddit	Discussion board	Platform-wide “/r/AIArt” subreddit “/r/AIArtwork” subreddit	1.21 bil MAU [16] 608k members [52] 83k members [53]
X (Twitter)	Micro-blogging	Platform-wide “Generative AI Community”	611 mil MAU [64] 191.7k members [63]
Telegram	Messaging	Broadcast groups “Robots and Art” group “Atlas AI Art” group	1 bil MAU [17] 103.3k members [54] 1.2k members [2]
WeChat	Messaging	Broadcast groups	1.3 bil MAU [57]

Provable security

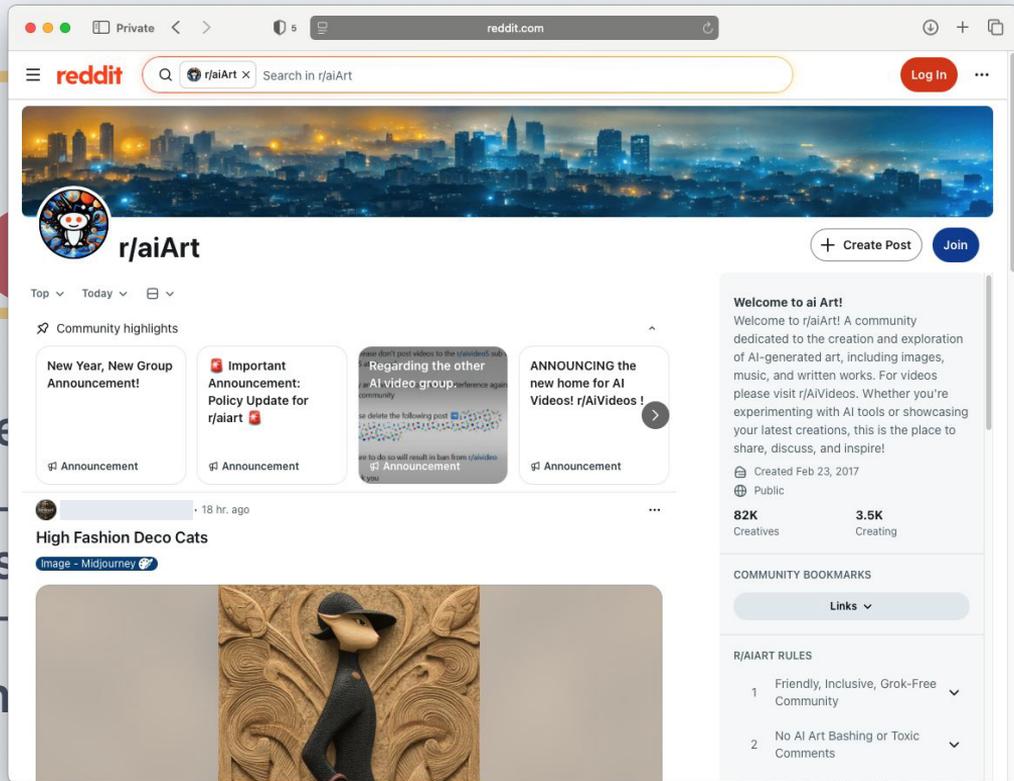
# Collage

(USENIX '10)

1. Choosing de

2. Identifying s

3. Agreeing on



# Assemblage

g platforms

Platform	Style	Viable Drop Locations	Reach	Metadata Required?
DeviantArt	Media sharing	Platform-wide Public AI image communities	65 mil MAU [25] 800+ groups [3]	✓
Discord	Messaging	Platform-wide “AI Hub by Weights” “ai Art” “NightCafeLounge”	200 mil MAU [22] 521k members [21] 6k members [19] 78.2k members [20]	✗
Imgur	Media sharing	Platform-wide “aiart” hashtag	300 mil MAU [40] 1k posts [41]	✓
Rednote	Media sharing	Platform-wide	300 mil MAU [28]	✓
Reddit	Discussion board	Platform-wide “/r/AIArt” subreddit “/r/AIArtwork” subreddit	1.21 bil MAU [16] 608k members [52] 83k members [53]	✓
X (Twitter)	Micro-blogging	Platform-wide “Generative AI Community”	611 mil MAU [64] 191.7k members [63]	✓
Telegram	Messaging	Broadcast groups “Robots and Art” group “Atlas AI Art” group	1 bil MAU [17] 103.3k members [54] 1.2k members [2]	✗
WeChat	Messaging	Broadcast groups	1.3 bil MAU [57]	✗

## Messaging

*No metadata required*

## Micro-blogging

*Minimal metadata required*

## Media sharing

*Minimal metadata required*

## Discussion board

*Metadata required*



generate some post titles for this ai art image that match the style of this reddit community, r/aiart: <https://www.reddit.com/r/aiArt/>

Here are some post title ideas for your AI-generated bedroom scene, styled to match the aesthetic and vibe of the [r/aiArt](https://www.reddit.com/r/aiArt/) community:

1. "Dreamscape Chamber: Where Light Whispers Through Linen"
2. "AI-Rendered Bedroom Elegance – Victorian Dreams in Pastel"
3. "Tranquil Textures and Soft Sunlight – Neural Networks at Rest"
4. "When the Algorithm Dreams of Soft Mornings"
5. "Florals and Glows: A Neural Interpretation of Comfort"
6. "Delicate Chaos: GAN's Take on a Morning Bed"
7. "Snooze to WeChat: A Surreal Bedroom in Neural Pastels" *(title based on your file name!)*
8. "Where Time Melts Between Curtains – AI Interior Art"
9. "Faded Florals in Latent Space"
10. "A Model's Morning: Blurred Boundaries Between Sleep and Light"

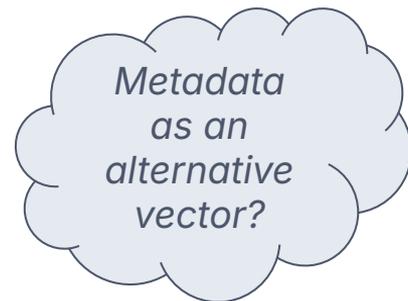
Want help writing a short artist's statement or prompt credit to go with it?

generate some post titles for this ai art image that match the style of this reddit community, r/aiart: <https://www.reddit.com/r/aiArt/>, make them simple and short like the other ones are

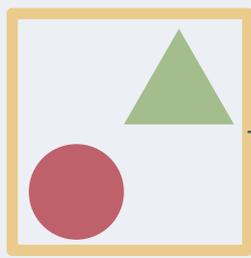
Absolutely! Here are some short and simple r/aiArt-style post titles for your image:

1. "Soft morning light"
2. "AI bedroom dream"
3. "Cozy neural nook"
4. "Pastel sleep space"
5. "Dreamy bed scene"
6. "Morning haze"
7. "AI-generated comfort"
8. "Vintage vibes"
9. "Where dreams rest"
10. "Tranquil AI room"

Let me know if you want a version that includes the model or prompt too!

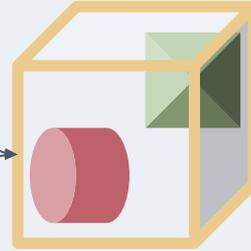


**Collage**  
(USENIX '10)



*Availability*

*Deniability*

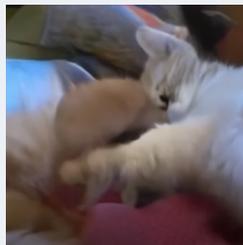


**Assemblage**

1. **Choosing deniable tasks** → *AI-generated content sharing platforms*
2. **Identifying suitable vectors** → *Post style and metadata*
3. **Agreeing on tasks for a message**



Sender



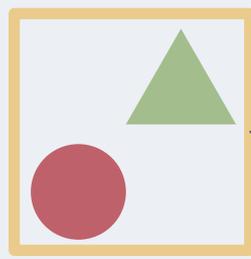
Receiver



offline()

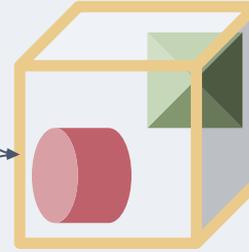
Perceptual hashing

**Collage**  
(USENIX '10)



*Availability*

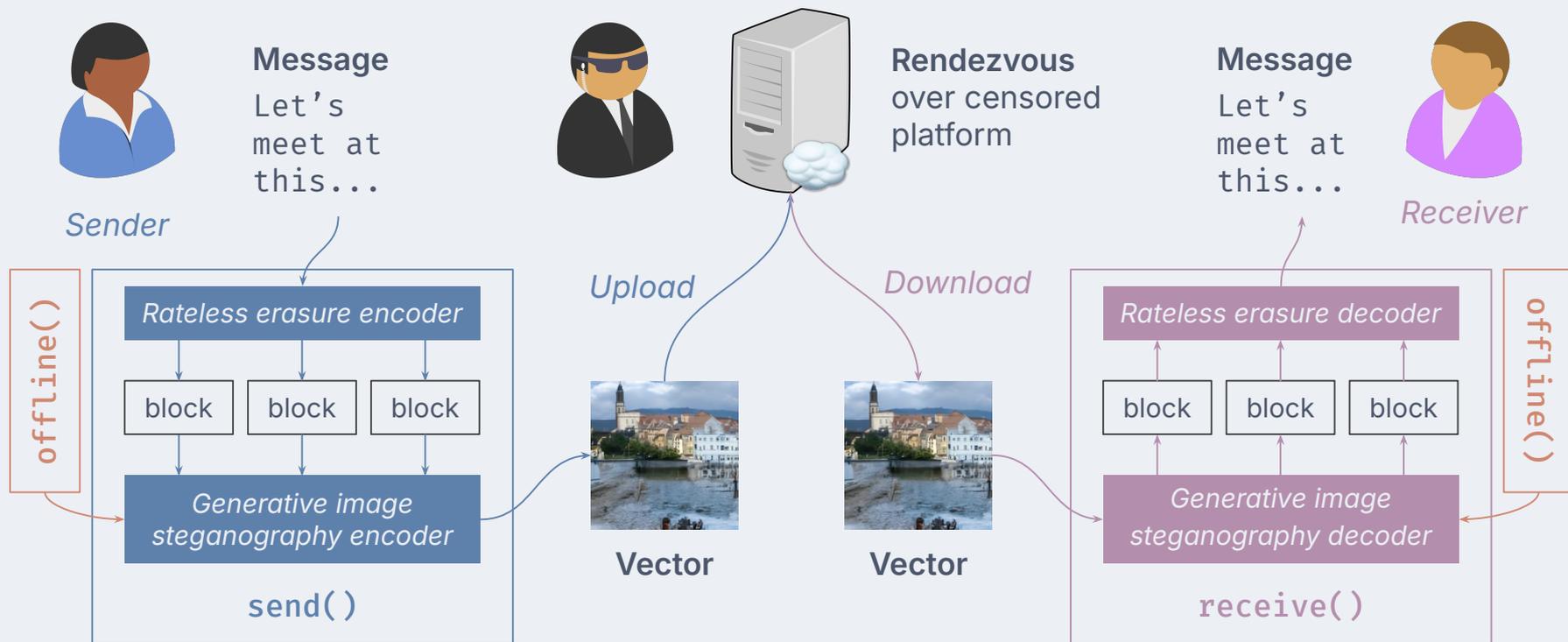
*Deniability*



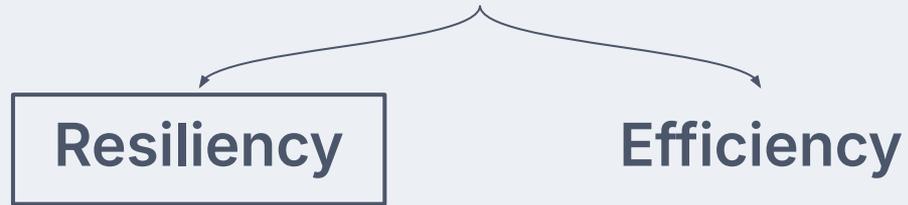
**Assemblage**

1. **Choosing deniable tasks** → *AI-generated content sharing platforms*
2. **Identifying suitable vectors** → *Post style and metadata*
3. **Agreeing on tasks for a message** → *Perceptual hashing*

# Assemblage



# Evaluation





r/aiArt bedroom



r/aiArt · 7mo ago

**Which room are you sleeping in?** 🇺🇸

247 votes · 230 comments



r/aiArt · 8mo ago

**bedroom**

5 votes · 2 comments



r/aiArt · 17m ago

**Dreamy Bedroom Vibes**

1 vote · 1 comment



r/aiArt · 2y ago

**Imaginary Bedrooms**

3 votes · 1 comment



r/aiArt · 1y ago

**Which one is your dream bedroom?**

113 votes · 76 comments



r/aiArt · 10mo ago

**bedroom**

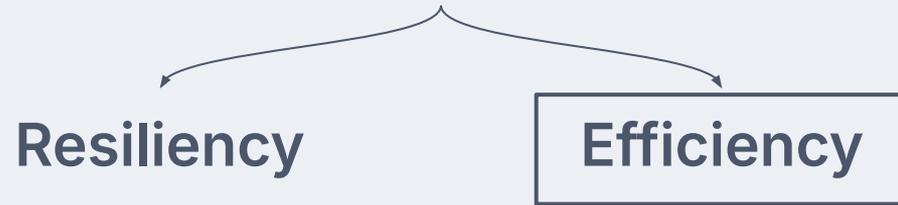
5 votes · 1 comment



Platform	Style	Viable Drop Locations	Reach	Metadata Required?	Compresses Images?	Successful?
DeviantArt	Media sharing	Platform-wide Public AI image communities	65 mil MAU [25] 800+ groups [3]	✓	✗	✓
Discord	Messaging	Platform-wide “AI Hub by Weights” “ai Art” “NightCafeLounge”	200 mil MAU [22] 521k members [21] 6k members [19] 78.2k members [20]	✗	✓	✓
Imgur	Media sharing	Platform-wide “aiart” hashtag	300 mil MAU [40] 1k posts [41]	✓	✓	✓
Rednote	Media sharing	Platform-wide	300 mil MAU [28]	✓	✓	✗
Reddit	Discussion board	Platform-wide “/r/AIArt” subreddit “/r/AIArtwork” subreddit	1.21 bil MAU [16] 608k members [52] 83k members [53]	✓	✗	✓
X (Twitter)	Micro-blogging	Platform-wide “Generative AI Community”	611 mil MAU [64] 191.7k members [63]	✓	✗	✓
Telegram	Messaging	Broadcast groups “Robots and Art” group “Atlas AI Art” group	1 bil MAU [17] 103.3k members [54] 1.2k members [2]	✗	✓	✓
WeChat	Messaging	Broadcast groups	1.3 bil MAU [57]	✗	✓	✗

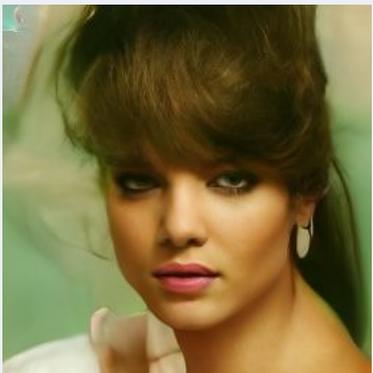
Lossy compression

# Evaluation



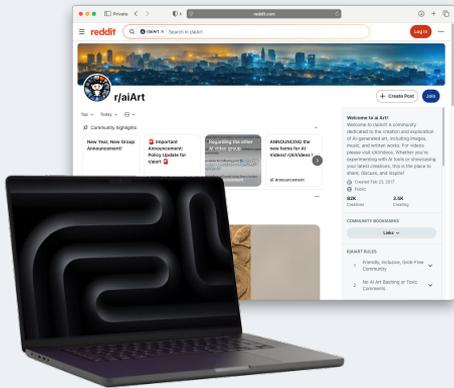


*More details in the paper!*

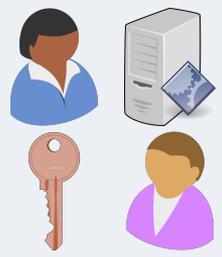


Operation	church-256 [32]
<hr/>	
offline()	
<hr/>	
Model Load Runtime	$0.4239 \pm 0.0935$ sec
Model Runtime	$9.2893 \pm 0.3073$ sec
State Serialization Runtime	$0.0073 \pm 0.0005$ sec
Perceptual Hash Runtime	$0.0046 \pm 0.0023$ sec
<hr/>	
Vector Capacity	$618.21 \pm 210.28$ bytes
Serialized Local State Size	$5.7597 \pm 0.0849$ MB
Local State Hash Size	$3.9545 \pm 0.0010$ KB
<hr/>	
send()	
<hr/>	
Local State Deserialization Runtime	$0.0028 \pm 0.0003$ sec
Model Load Runtime	$0.0213 \pm 0.0213$ sec
Pulsar Encoding Runtime	$4.2293 \pm 0.2127$ sec
Image Save Runtime	$0.0567 \pm 0.0007$ sec
<hr/>	
Image Size	$378.6861 \pm 7.4133$ KB
<hr/>	
Perceptual Hash Runtime	$3.00 \times 10^{-4}$ sec
Perceptual Match Runtime	$3.53 \times 10^{-5}$ sec
Perceptual Deserialization Runtime	$0.0036 \pm 0.0002$ sec
Perceptual Runtime	$0.0103 \pm 0.0076$ sec
Perceptual Encoding Runtime	$4.3999 \pm 0.2671$ sec
<hr/>	

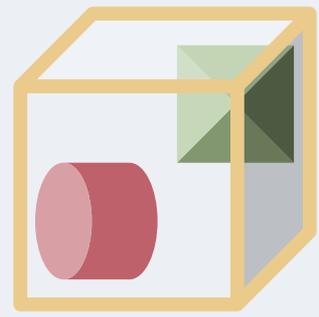




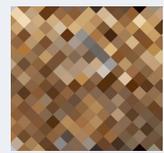
# Feasibility



# Bootstrapping



# Society



# Image compression



WeChat



小红书

标记我的生活



## Graphically Secure Steganography with Realistic Distributions

## Graphically Secure Steganography in Practice and on “Distribution Copies”



## Graphically Secure Steganography for Diffusion Models

## StegaDDPM: Generative Image Steganography based on Denoising Diffusion Probabilistic Model

Yinyin Peng  
School of Computer Science and Information Engineering, Hefei University of Technology  
Hefei, China  
yipeng@mail.hfut.edu.cn

Donghui Hu<sup>\*</sup>  
School of Computer Science and Information Engineering, Hefei University of Technology  
Hefei, China  
hudh@hfut.edu.cn

Yaofei Wang<sup>\*</sup>  
School of Computer Science and Information Engineering, Hefei University of Technology  
Hefei, China  
wyf@hfut.edu.cn

Kejiang Chen  
School of Science and Technology of China  
Hefei, China

Gang Pei  
School of Computer Science and Information Engineering, Hefei University of Technology  
Hefei, China

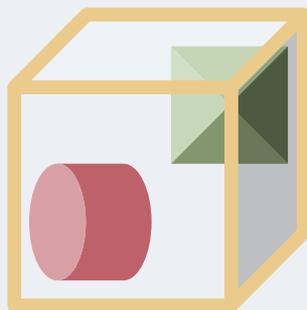
Weiming Zhang  
University of Science and Technology of China  
Hefei, China

### ACM Reference Format:

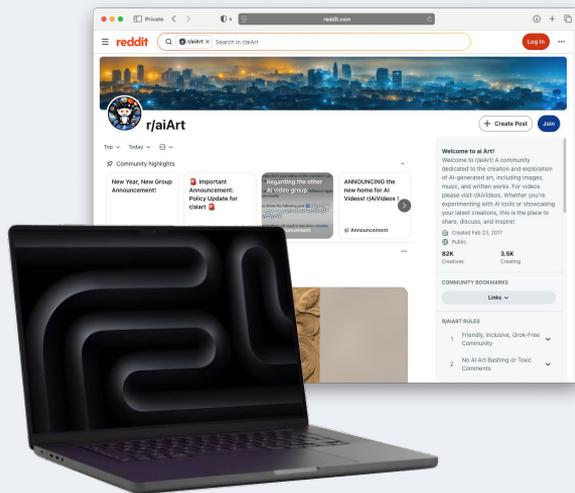
Yinyin Peng, Donghui Hu, Yaofei Wang, Kejiang Chen, Gang Pei, and Weiming Zhang. 2023. StegaDDPM: Generative Image Steganography based on Denoising Diffusion Probabilistic Model. In *Proceedings of the 31st ACM International Conference on Multimedia (MM '23)*, October 29–November 3, 2023, Ottawa, ON, Canada. ACM, New York, NY, USA, 9 pages. <https://doi.org/10.1145/3581783.3612514>

### 1 INTRODUCTION

Image steganography [9] is the technology that conceals secret data within an image without arousing notice, which can be classified into steganography based on embedding [8, 11, 14, 18–20, 26, 29, 32, 33, 38, 44, 48] and steganography without embedding (SWE) [15, 21–23, 34–36, 42, 45–47] depending on whether the cover image is modified. Steganography with embedding has an inherent risk that modification traces of the cover image are inevitably left,



# Assemblage





## Tushar Jois

✉ [tjois@ccny.cuny.edu](mailto:tjois@ccny.cuny.edu)

💻 <https://tjo.is>

🦋 [@tjo.is](#)



## Assemblage: Chipping Away at Censorship with Generative Steganography

Tushar M. Jois, Cora Rowena Ruiz, Gabriel Kaptchuk  
*FOCI 2026(1)*

<https://github.com/spacelab-ccny/assemblage>