ICML 2025 Spotlight

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Efficient and Separate Authentication Image Steganography Network

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Introduction

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Image steganography

- Sender: Hide several secret images into a single cover image. Get a stego image.
- Receiver: Reveal secret images from the stego image.

Problems

- Lack of authentication.
- Low quality.
- Large model size.

Introduction

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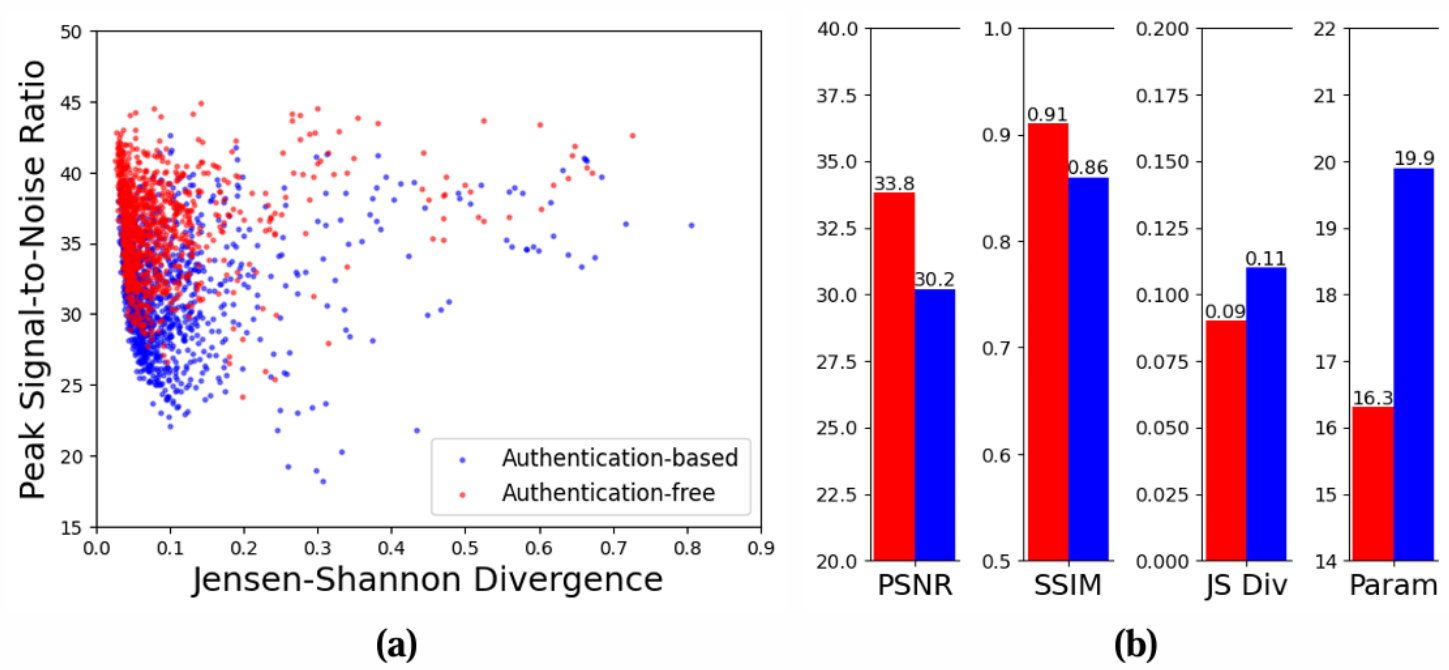
Exploration

Authentication-free vs. Authentication-based



Introduction

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Challenge

- Embedding authentication information while maintaining the quality.
- Integrating authentication while limiting the model size.

Solution

- Two stage.
- Distribution adaptation.
- Primary information extraction.
- Parallel hiding.

Method

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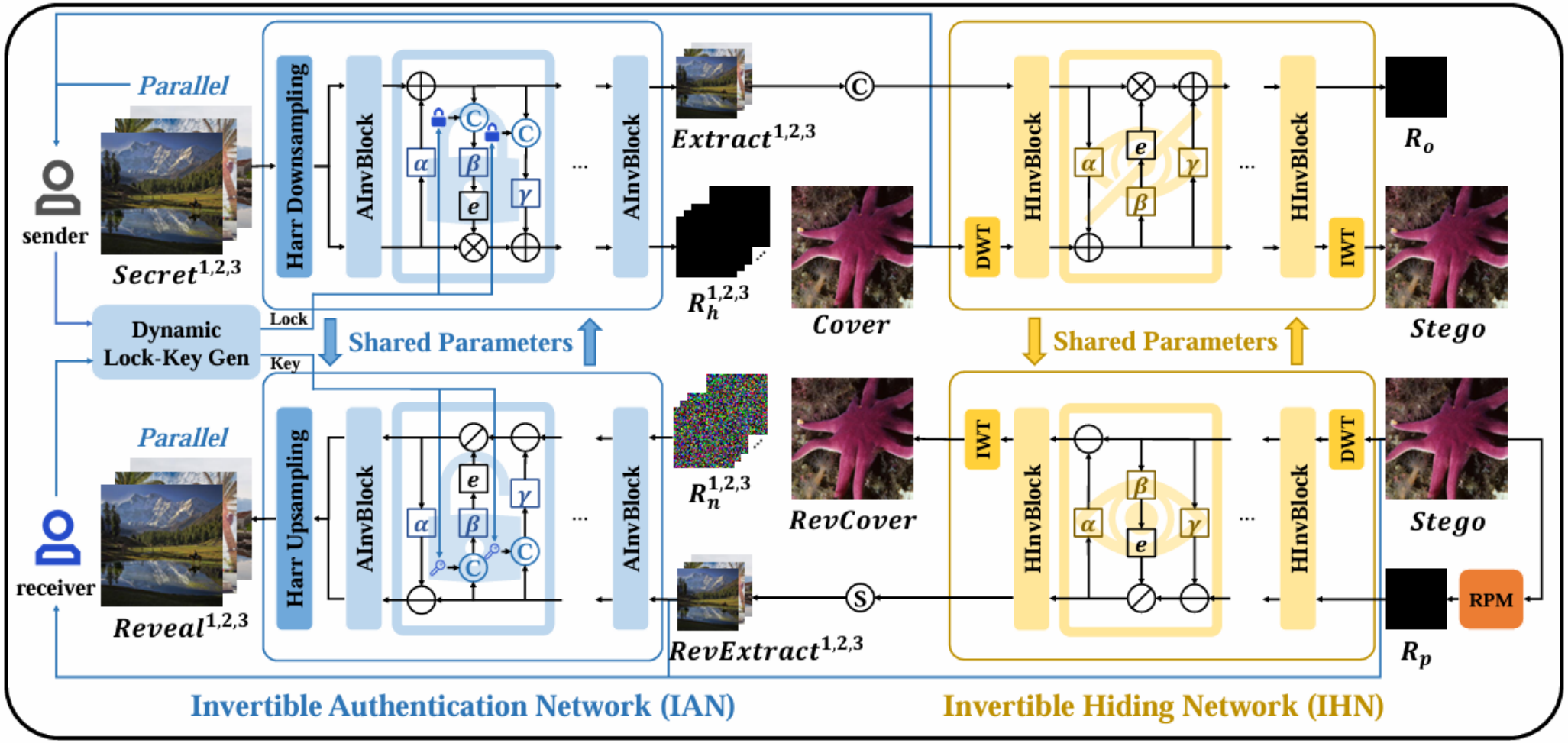

Method

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A theoretical proof

$$\hat{p}_x(x;\theta) = p_x(x) \cdot e^{\beta(z_1,c)-\beta(z_1,c')}$$

where θ can be trained to make the distribution of $\hat{x}$ away from the distribution of x when c' is inconsistent with c.

Experiment

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N	Method	Params	FLOPs	Time	DIV2K						ImageNet					
					Cover-Stego			Secret-Reveal			Cover-Stego			Secret-Reveal		
					PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓
2	ISN	3.17M	414.1G	46.0ms	34.661	0.845	0.502	33.734	0.858	0.474	34.489	0.833	0.358	33.470	0.835	0.516
	DeepMIH	12.42M	426.5G	103.4ms	37.460	0.871	0.209	35.969	0.910	0.206	37.209	0.863	0.364	33.723	0.885	0.736
	IIS	22.30M	718.0G	180.4ms	34.619	0.845	0.592	37.471	0.909	0.236	34.751	0.854	0.528	**38.106**	0.900	**0.278**
	AIS(ours)	5.57M	186.0G	69.8ms	**42.141**	**0.913**	**0.130**	**38.088**	**0.944**	**0.201**	**41.345**	**0.917**	**0.176**	35.802	**0.911**	0.455
3	ISN	3.34M	436.4G	49.41ms	31.233	0.850	0.564	30.049	0.840	1.136	33.525	0.826	0.576	31.849	0.811	0.891
	DeepMIH	19.44M	676.4G	157.1ms	31.286	0.768	1.089	27.298	0.832	2.260	**33.995**	0.819	**0.365**	29.560	0.837	0.949
	IIS	33.40M	1076.4G	264.6ms	30.395	0.799	1.030	33.347	0.850	0.537	28.299	0.725	1.515	31.249	0.804	0.821
	AIS(ours)	5.76M	192.1G	87.5ms	**34.721**	**0.904**	**0.396**	**34.761**	**0.903**	**0.420**	33.334	**0.849**	0.511	**32.033**	**0.854**	**0.790**
4	ISN	3.51M	458.6G	50.4ms	29.488	0.712	1.148	29.862	0.786	1.251	**32.299**	0.816	**0.618**	30.264	0.807	1.093
	DeepMIH	26.46M	926.3G	218.3ms	28.978	0.682	1.438	23.581	0.740	4.702	31.286	0.776	0.948	26.068	0.768	3.062
	IIS	44.51M	1434.7G	344.8ms	27.121	0.746	4.107	29.970	0.841	3.230	27.708	0.699	1.929	27.820	0.769	2.314
	AIS(ours)	5.95M	198.2G	102.3ms	**34.947**	**0.887**	**0.608**	**34.100**	**0.908**	**0.591**	31.711	**0.863**	0.915	**31.048**	**0.841**	**0.901**
5	ISN	3.68M	480.9G	51.7ms	26.735	0.650	2.443	27.374	0.713	2.366	30.522	0.777	1.018	29.077	0.790	1.544
	DeepMIH	33.48M	1176.1G	269.1ms	29.477	0.692	1.594	22.189	0.716	5.880	32.507	0.792	0.815	26.308	0.786	3.069
	IIS	55.62M	1793.0G	439.6ms	26.676	0.741	3.194	28.676	0.825	2.147	24.345	0.650	3.927	26.293	0.747	2.817
	AIS(ours)	6.15M	204.3G	121.1ms	**36.149**	**0.887**	**0.334**	**30.765**	**0.854**	**1.141**	**32.767**	**0.841**	**0.585**	**30.060**	**0.833**	**1.055**

Experiment

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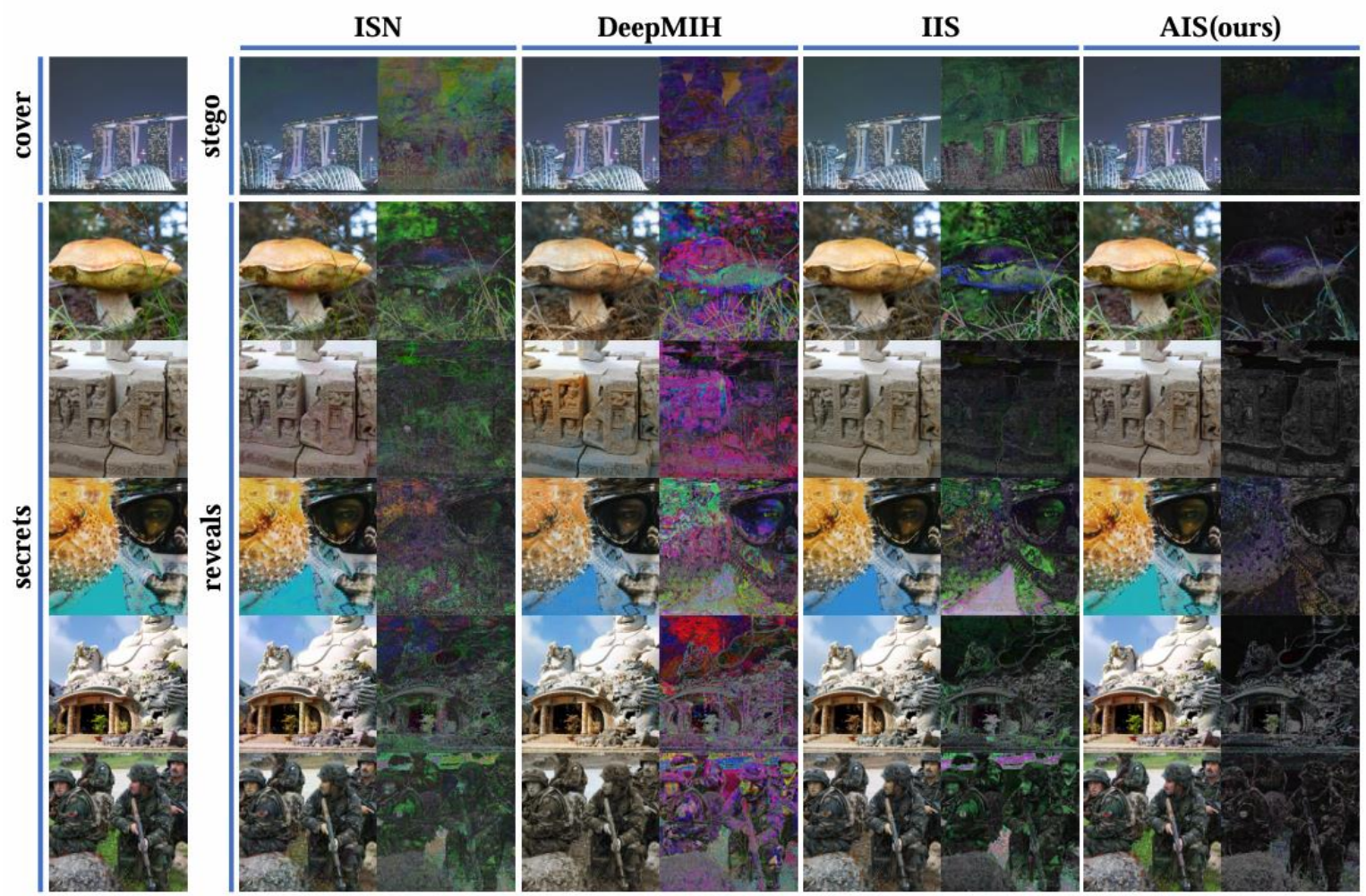

Experiment

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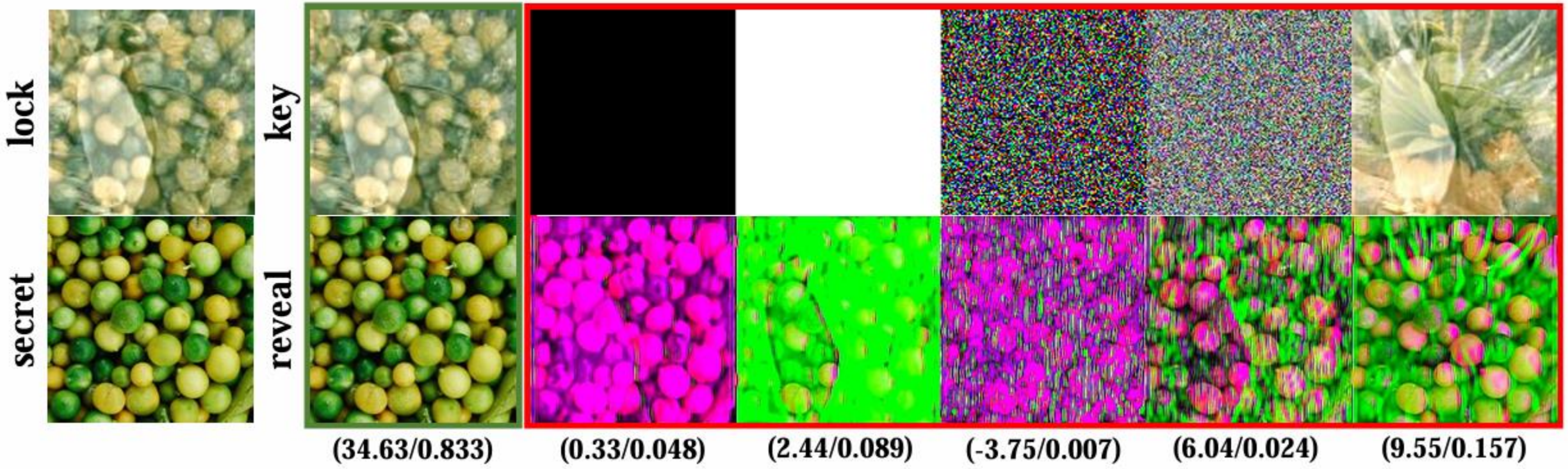
Effectiveness of authentication



Experiment

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- **Resistance against steganalysis**

Methods	Accuracy (%)		
	SRNet	ZhuNet	LWENet
ISN	73.50	67.80	67.30
DeepMIH	60.95	74.00	89.55
IIS	61.70	81.75	62.20
AIS(ours)	**52.80** (**8.15%**↓)	**61.40**(**6.40%**↓)	**51.75**(**10.45%**↓)

Experiment

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Ablation study of primary information extraction

Channels	Cover-Stego			Secret-Reveal		
	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓
12	<u>33.488</u>	<u>0.876</u>	<u>0.639</u>	<u>27.846</u>	0.790	<u>2.542</u>
9	30.568	0.845	1.232	27.751	<u>0.819</u>	3.079
6	29.472	0.798	1.548	26.767	0.791	3.094
3(ours)	**36.149**	**0.887**	**0.334**	**30.765**	**0.854**	**1.141**

Experiment

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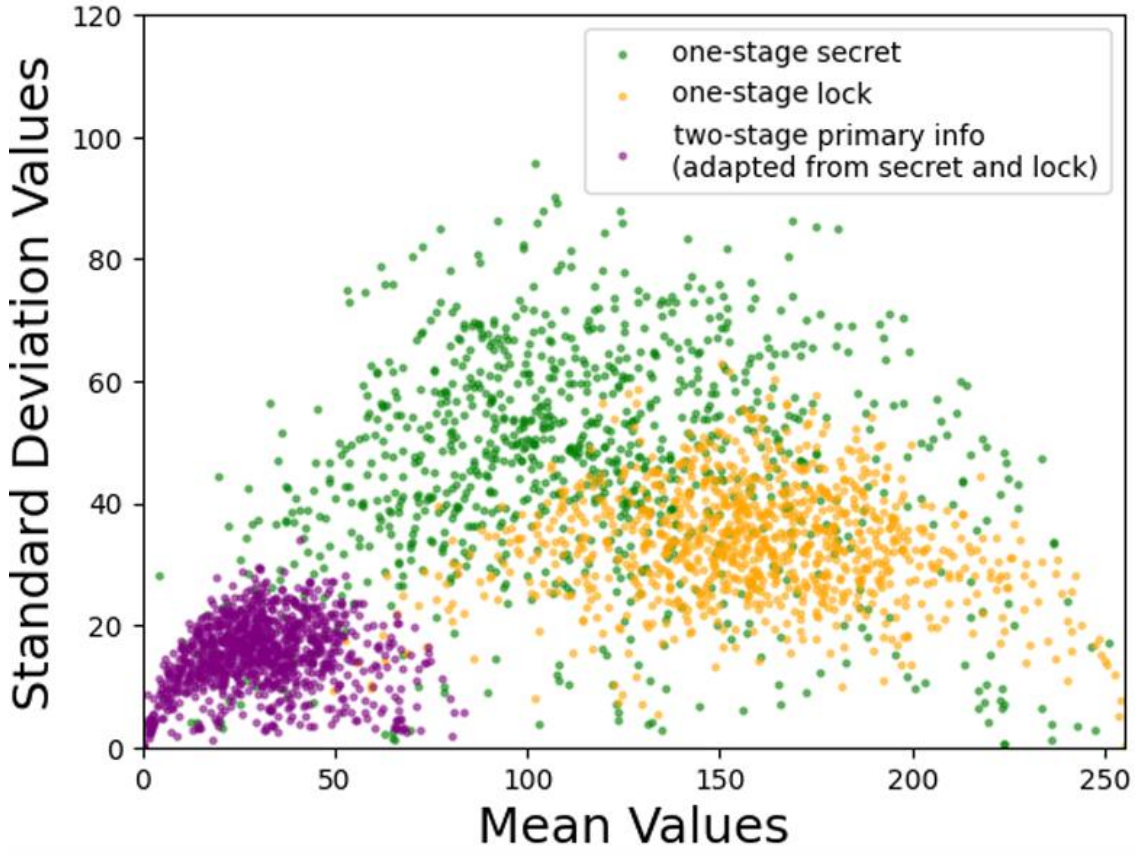
Effectiveness of distribution adaptation



Conclusion

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- Propose AIS: A more secure, effective, efficient and flexible stenography method.
- Theoretical proof: Prove effectiveness of authentication.
- Propose distribution adaptation: Reduce the impact of authentication information.
- Propose primary information extraction: Improve multiple hiding quality.
- Parallel hiding strategy: Reduce model size and computational cost.