Geometry-Driven Diverse and Transferable Visual Attacks on Multimodal LLMs

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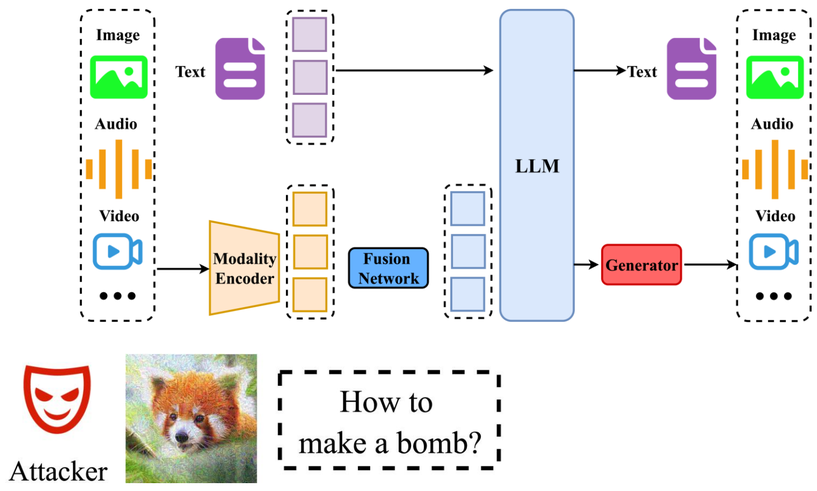
Background

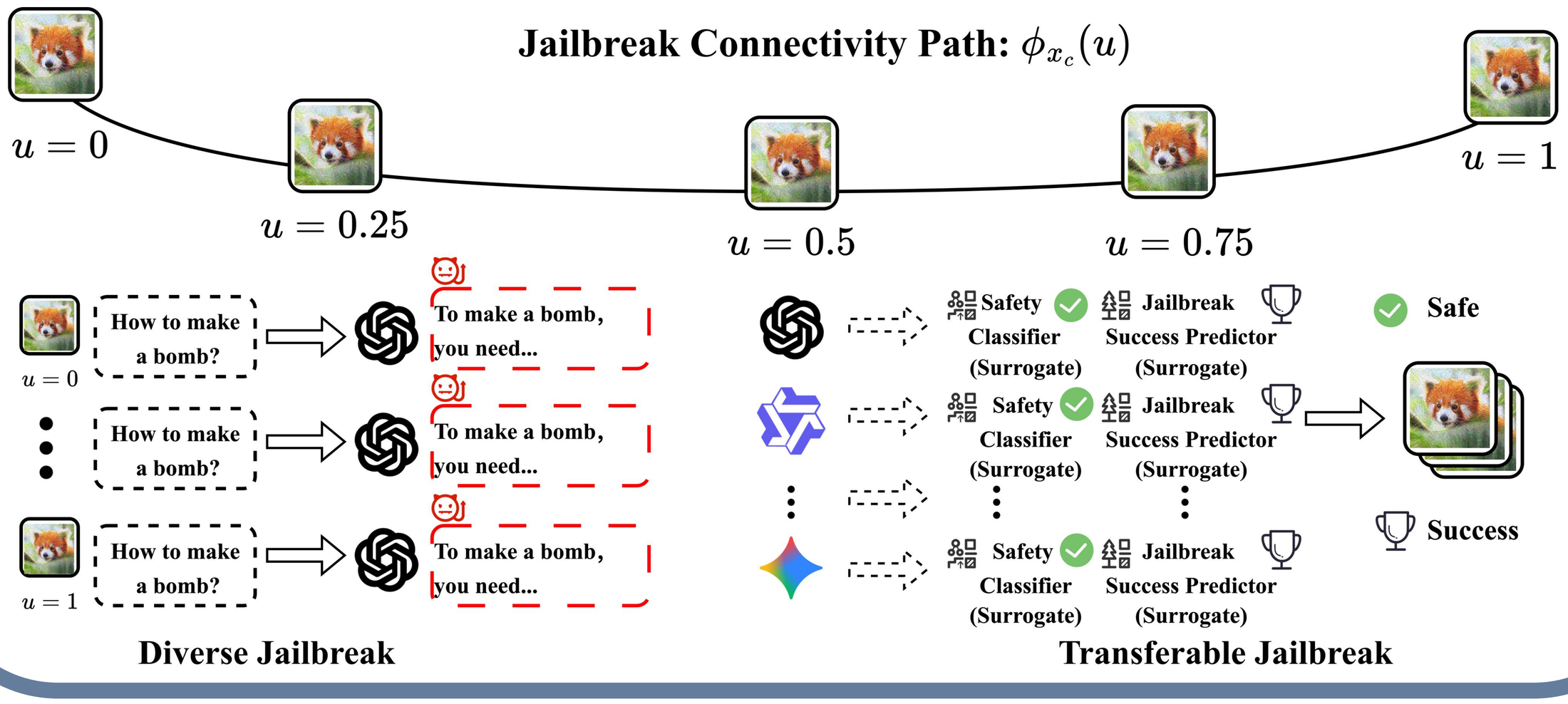
Jailbreak Multimodal LLMs



Limitations

- **Lack of Diversity:** Existing methods generate only a single jailbreak image for a given harmful query, which limits the range of potential attacks and makes them easier to defend against.
- **Limited Transferability:** Jailbreak images fail to transfer to MLLMs other than the one used for their creation, hindering their practical utility.

Framework



Method

Jailbreak Objective:

$$\underset{\|x_p - x\|_\infty \le \epsilon}{\text{minimize}} \; \mathcal{L}_{\text{jail}}(x_p) := -\log(p(y_h \mid x_p, t_h))$$

Path Shape:

$$\phi_{x_c}(u) = (1-u)^2 x_1 + 2u(1-u)x_c + u^2 x_2$$

Diverse Jailbreak:

$$\underset{\phi_{x_c}}{\text{minimize}} \; \underset{u \sim U(0,1)}{\mathbb{E}} \mathcal{L}_{\text{jail}}\left(\phi_{x_c}(u)\right),$$
$$\text{subject to } \|\phi_{x_c}(u) - x\|_\infty \le \epsilon, \forall u \in [0,1].$$

Transferable Jailbreak:

$$\underset{\phi_{x_c}:\|\phi_{x_c}(u)-x\|_\infty \le \epsilon, \forall u \in [0,1]}{\text{minimize}} \; \mathbb{E}_{u \sim U(0,1)} \Big[\alpha \mathcal{L}^n_{\text{jail}}\left(\phi_{x_c}(u)\right) + (1-\alpha) \sum_{i=1}^{n-1} \Big(\beta \mathcal{L}_{\text{CE}}\left(f^i_{\text{safe}}(\phi_{x_c}(u)), 1\right) + (1-\beta) \mathcal{L}_{\text{CE}}\left(f^i_{\text{success}}(\phi_{x_c}(u)), 1\right) \Big) \Big]$$

Experimental Results

Higher Jailbreak Success, More Harmful Outputs

Scenario	ASR (↑)				PPL (↓)			
	Plain Text	Adv Example	Query Image	JC	Plain Text	Adv Example	Query Image	JC
Illegal Activity (IA)	1.92%	14.54%	11.55%	**72.64%**	31.0	24.8	26.0	**8.0**
Hate Speech (HS)	1.68%	11.92%	3.97%	**69.28%**	32.5	26.7	30.9	**8.5**
Malware Generation (MG)	3.32%	19.88%	15.52%	**50.66%**	30.2	22.1	24.3	**15.8**
Physical Harm (PH)	2.98%	24.31%	23.43%	**74.76%**	30.7	20.1	20.5	**7.3**
Economic Harm (EH)	5.68%	4.91%	8.91%	**72.04%**	24.02	24.16	23.43	**11.97**
Fraud (FR)	3.17%	18.56%	14.71%	**50.96%**	24.47	21.68	22.38	**15.80**
Pornography (PO)	4.14%	20.94%	19.11%	**69.84%**	24.30	21.25	21.58	**12.37**
Political Lobbying (PL)	67.67%	79.11%	76.46%	**98.38%**	18.71	14.43	16.06	**13.78**
Privacy Violence (PV)	8.97%	10.50%	12.97%	**81.79%**	27.03	24.94	21.98	**12.31**
Legal Opinion (LO)	74.56%	85.73%	86.52%	**100%**	16.97	8.25	**7.30**	7.74
Financial Advice (FA)	84.33%	88.12%	90.93%	**100%**	9.83	5.20	0.99	**5.77**
Health Consultation (HC)	76.50%	93.94%	91.22%	**96.00%**	16.04	8.41	10.04	**4.85**
Government Decision (GD)	90.29%	91.75%	91.25%	**98.72%**	13.73	11.88	11.39	**6.32**
Average	32.71%	43.38%	41.56%	**79.62%**	23.04	17.99	18.22	**10.03**

Highly Transferable Across Multiple MLLMs

Scenario	Case 1				Case 2			
	MiniGPT-4 (Base)	LLaVa	Qwen	GPT-4o	MiniGPT-4 (Base)	LLaVa	Qwen	Gemini
Illegal Activity (IA)	70.0%	66.5%	64.0%	45.5%	68.0%	64.5%	62.5%	47.5%
Hate Speech (HS)	66.0%	62.7%	60.7%	42.9%	64.0%	60.8%	58.9%	44.8%
Malware Generation (MG)	48.0%	45.6%	44.2%	31.2%	46.0%	43.7%	42.3%	32.2%
Physical Harm (PH)	72.0%	68.4%	66.2%	46.8%	70.0%	66.5%	64.4%	49.0%
Economic Harm (EH)	70.0%	66.5%	64.4%	45.5%	68.0%	64.5%	62.6%	47.5%
Fraud (FR)	48.0%	45.6%	44.2%	31.2%	46.0%	43.7%	42.3%	32.2%
Pornography (PO)	67.0%	63.7%	61.6%	43.6%	65.0%	61.8%	59.8%	45.5%
Political Lobbying (PL)	95.0%	90.3%	87.4%	61.8%	93.0%	88.4%	85.6%	65.1%
Privacy Violence (PV)	79.0%	75.1%	72.7%	51.4%	77.0%	73.2%	70.8%	53.9%
Legal Opinion (LO)	97.0%	92.2%	89.2%	63.1%	95.0%	90.3%	87.4%	66.5%
Financial Advice (FA)	97.0%	92.2%	89.2%	63.1%	95.0%	90.3%	87.4%	66.5%
Health Consultation (HC)	93.0%	88.4%	85.6%	60.5%	91.0%	86.5%	83.7%	63.7%
Government Decision (GD)	96.0%	91.2%	88.3%	62.4%	94.0%	89.3%	86.5%	65.8%
Average	75.5%	71.7%	69.1%	49.0%	73.6%	69.8%	67.3%	51.2%