

Preference Adaptive and Sequential Text-to-Image Generation

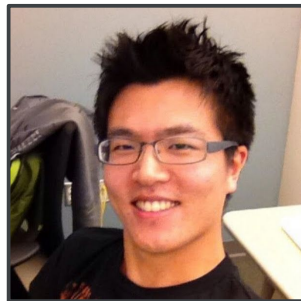
Joint Effort



Ofir Nabati



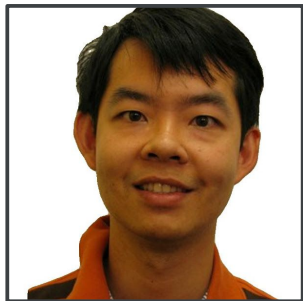
Guy Tennenholtz



Moonkyung Ryu



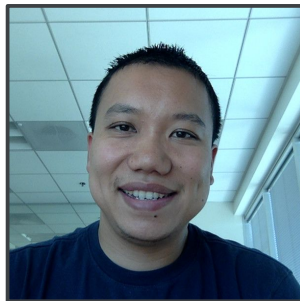
Yinlam Chow



Chih-wei Hsu



Deepak Ramachandran



Sean Li



Craig Boutilier

Motivation

State of the art text-to-image models map text to stunning visuals

A Scottish fold cat
wearing a red scarf
portrait photography



A zen stone cairn with
rounded stones on the
edge of a mountain,
below is a clear blue
lake with small islands



Sleek futuristic
spaceship orbiting an
alien red colored planet



Motivation

But... they may struggle to get our actual intent

Google building
mountain view



Google building
mountain view tent



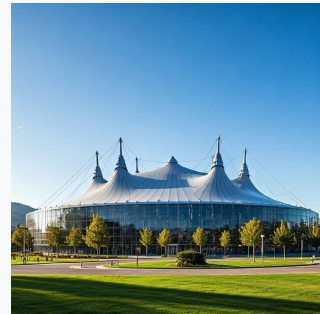
Google canopy
building mountain view



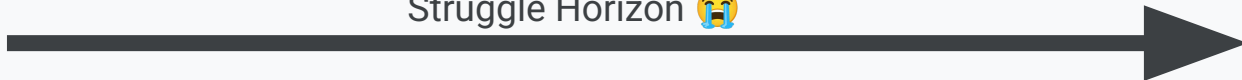
Google bay view gradient
canopy building in
mountain view



Google bay view
building in mountain
view looks like
a circus tent

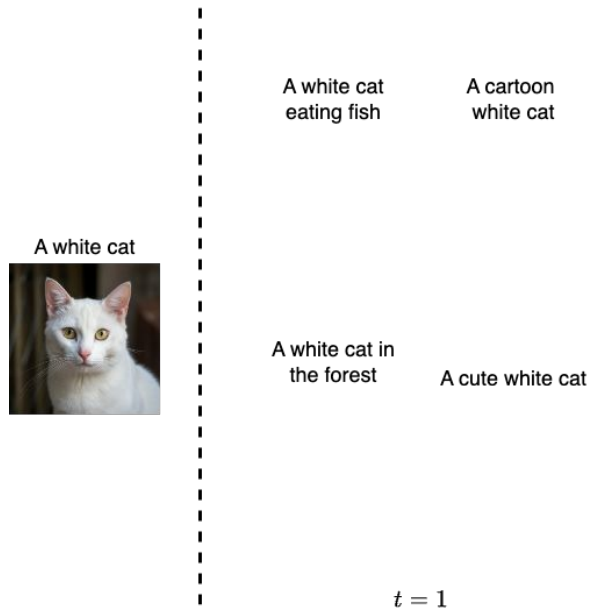


Struggle Horizon 🤔



Problem Setup

At time $t > 0$, the agent selects L prompt expansions $\{p_{\ell,t} \in \mathcal{P}\}_{\ell=1}^L$



Problem Setup

At time $t > 0$, the agent selects L prompt expansions $\{p_{\ell,t} \in \mathcal{P}\}_{\ell=1}^L$

The corresponding images $\{I_{\ell,t} \in \mathcal{I}\}_{\ell=1}^L$ are generated.



A white cat
eating fish



A cartoon
white cat



A white cat in
the forest



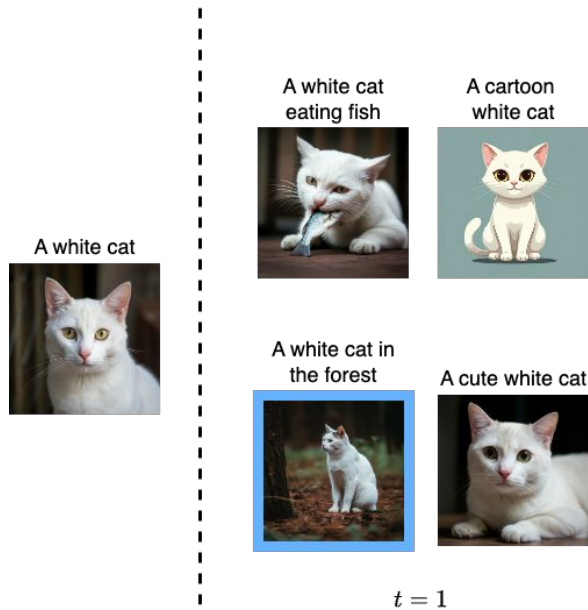
A cute white cat



$t = 1$

Problem Setup

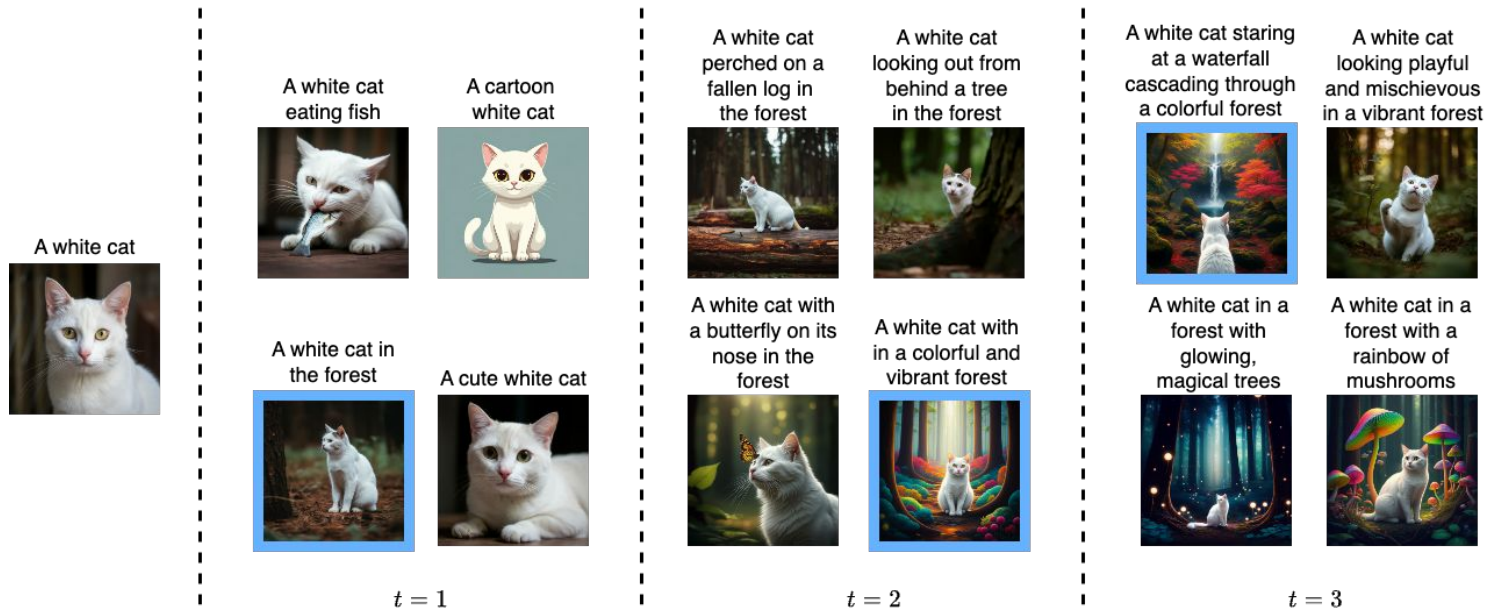
The user is presented with a slate of images and instructed to choose one,



Problem Setup

And so on for H steps

The goal is to maximize the user utility.



Problem Setup

The reinforcement learning formulation:

State space: agent-user interaction history \mathcal{H}

Users: set of user types \mathcal{U}

Action space: slate of L prompts \mathcal{P}^L

Transition kernel: Text2image model $G : \mathcal{P} \mapsto \Delta_I$

and user choice model $C : \mathcal{U} \times \mathcal{I}^L \mapsto \Delta_{[L]}$

Reward model: The utility function $R : \mathcal{U} \times \mathcal{I}^L \mapsto [0, 1]$

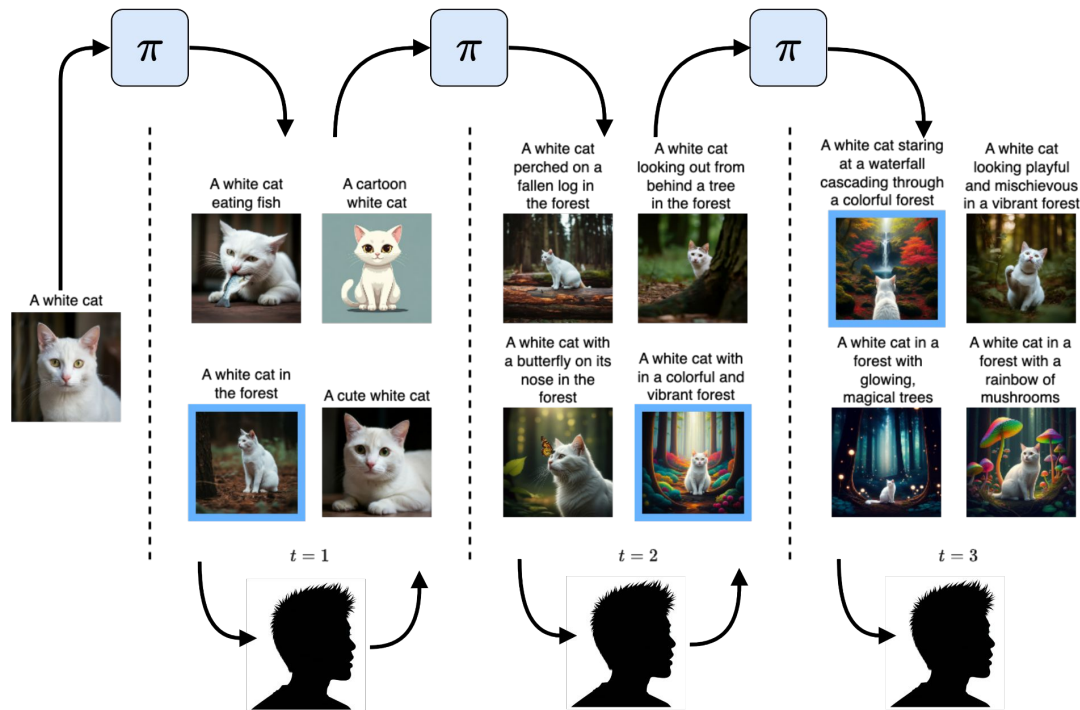
Policy: The agent $\pi : \mathcal{H} \mapsto \Delta_{\mathcal{P}^L}$

Problem Setup

The objective

$$J(\pi) = \mathbb{E}_{u, p_0 \sim \nu_0} \left[\sum_{t=1}^H R_t^u \mid u, \pi \right]$$

$$\pi^* \in \arg \max_{\pi \in \Pi} J(\pi)$$



Data (Open-Sourced)

We created two forms of data:

1. **Human rater data**

- a. 7000+ trajectories ($H=5$)
- b. 500k+ image preferences
- c. 100 human raters
- d. Agent: Gemini Flash model

2. **Simulated user data**

- a. Constructed user simulator (16 user types)
- b. 30k+ trajectories ($H=5$)
- c. 2.5M+ simulated image preferences
- d. Agent: Gemini Flash model

Rater Study

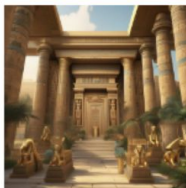
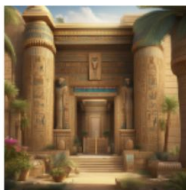
- Freeform initial prompt
- $L = 4$ columns per slate
- $M = 4$ images per column
- $H = 5$ steps
- Prompt expansion not shown
- Possibility to add a critique
- Rater Instructions:
 - Initial prompt length:
Max 12 words
 - Choose column by best image in column
 - Don't abuse critique

An ancient Egyptian temple with hieroglyphs. Turn 4

Column 1



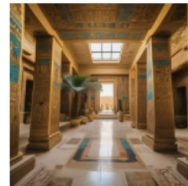
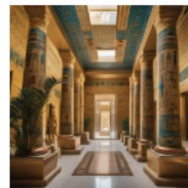
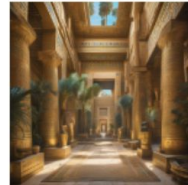
Column 2



Column 3



Column 4



(Optional) Enter a critique for the images above

An optional critique (e.g., add more color)

Column selection

submit button (move to next turn)

Rater Study - Post Interaction Phase

DataCompute

07:42:43 1078

Click on "End task" after answering questions for Turn 5

End task

Turns

Turn 1

Turn 2

Turn 3

Turn 4

Turn 5

Turn 6

Ignore Turn 6

Column selection during interactions

Questions for Turn 1

Which column of images do you prefer most? When comparing columns, compare the quality of the best image in each column w.r.t. your original prompt's intent

☐ Column 1

☐ Column 2

☐ Column 3

☐ Column 4

Based on your image preferences, give an absolute score describing your satisfaction with the set of images in COLUMN 1. The absolute score of a column is the score of the best image in that column w.r.t. your original prompt's intent.

- Re-confirmation of preferred column
- Quantifying whether the image slate in the current turn is better than the previous
- A free-text explanation of selection

User Model (for simulated data)

We consider preferences of the form:

$$P\left(\{I_{m,\ell^*,t}\}_{m=1}^M \succ \{I_{m,l,t}\}_{\ell \neq \ell^*, m=1}^{L,M} \mid u, p\right)$$

Generalizes non-personalized case with $L=1, M=1$:

$$\mathbb{E}_{u \sim \nu_0} [P(I_1 \succ I_2) \mid u, p]$$

User Model: Choice and Utility

We assume:

1. Users make choices w.r.t. preferences, i.e., $C=P$
2. Preferences are consistent with a user's utility, meaning:

$$P\left(\{I_{m,\ell^*,t}\}_{m=1}^M \succ \{I_{m,l,t}\}_{\ell \neq \ell^*, m=1}^{L,M} | u, p\right)$$

if and only if

$$R\left(\{I_{\ell^*,m,t}\}_{m=1}^M | u, p\right) > R\left(\{I_{\ell,m,t}\}_{m=1}^M | u, p\right).$$

Parametric User Model

Utility (reward) model:

$$\begin{aligned} R_{\ell,t}^{k,\theta} &:= R_{\theta} \left(\{I_{m,\ell,t}\}_{m=1}^M \mid u = k, p \right) \\ &= \text{Agg}(s_{\theta}(k, p, I_{1,\ell,t}), \dots, s_{\theta}(k, p, I_{M,\ell,t})) \end{aligned}$$

Parametric User Model

Utility (reward) model:

$$\begin{aligned} R_{\ell,t}^{k,\theta} &:= R_{\theta}\left(\{I_{m,\ell,t}\}_{m=1}^M | u = k, p\right) \\ &= \text{Agg}(s_{\theta}(k, p, I_{1,\ell,t}), \dots, s_{\theta}(k, p, I_{M,\ell,t})) \end{aligned}$$

User choice (preference) model:

$$\begin{aligned} C_{\theta}(k, p, \{I_{m,1,t}\}_{m=1}^M, \dots, \{I_{m,L,t}\}_{m=1}^M) \\ = \text{Softmax}\left(\tau_{\theta} R_{1,t}^{k,\theta}, \dots, \tau_{\theta} R_{L,t}^{k,\theta}\right) \end{aligned}$$

where $\tau_{\theta} = h_{\theta}\left(R_{1,t}^{k,\theta}, \dots, R_{L,t}^{k,\theta}\right)$

Parametric User Model

Utility (reward) model:

$$R_{\ell,t}^{k,\theta} := R_{\theta}\left(\{I_{m,\ell,t}\}_{m=1}^M | u = k, p\right)$$

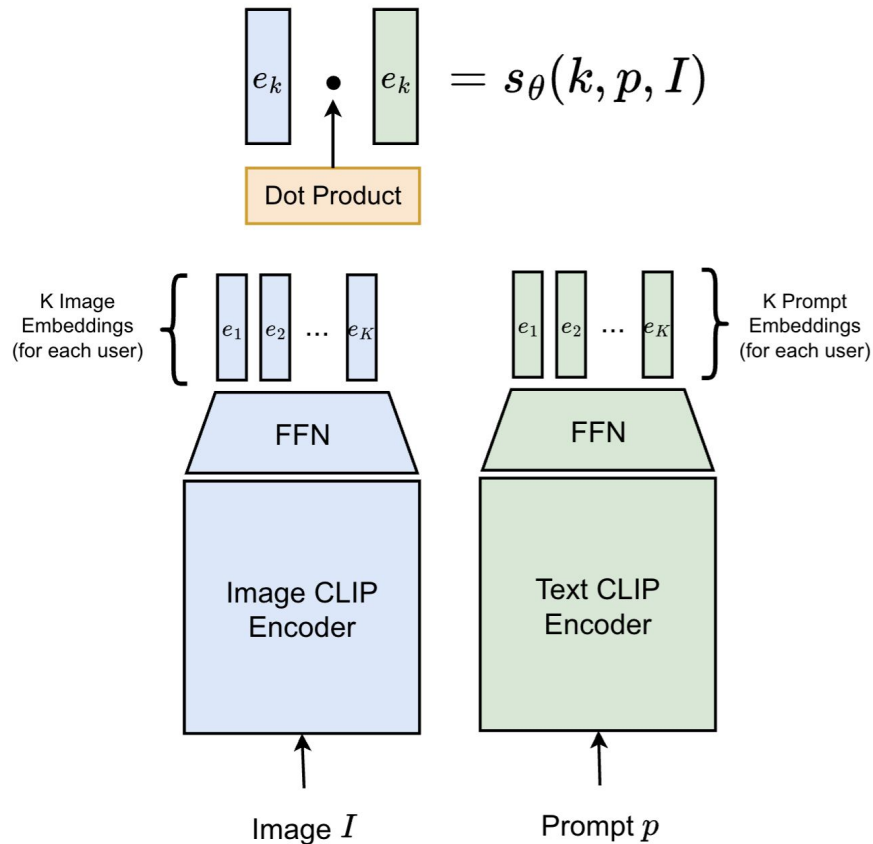
$$= \text{Agg}(s_{\theta}(k, p, I_{1,\ell,t}), \dots, s_{\theta}(k, p, I_{M,\ell,t}))$$

User choice (preference) model:

$$C_{\theta}(k, p, \{I_{m,1,t}\}_{m=1}^M, \dots, \{I_{m,L,t}\}_{m=1}^M)$$

$$= \text{Softmax}\left(\tau_{\theta} R_{1,t}^{k,\theta}, \dots, \tau_{\theta} R_{L,t}^{k,\theta}\right)$$

where $\tau_{\theta} = h_{\theta}\left(R_{1,t}^{k,\theta}, \dots, R_{L,t}^{k,\theta}\right)$



User Model: Training

How do we train if we don't have user labels in the data?

We train using an EM strategy:

- E-step: Calculate posterior of user types

$$\gamma_i(k) = \frac{\eta_k \prod_{j=1}^M \sigma_{\theta_t}(x_{i,j}, y_{i,j}, k)}{\sum_{\ell=1}^K \eta_{\ell} \prod_{j=1}^M \sigma_{\theta_t}(x_{i,j}, y_{i,j}, \ell)} \quad \sigma_{\theta}(x, y, k) \triangleq p_{\theta}(y|x, z = k)$$

- M-step: Maximize likelihood

$$\eta_k = \mathbb{E}_{i \sim \mathcal{D}}[\gamma_i(k)],$$

$$\theta_{t+1} \in \arg \max_{\theta} \mathbb{E}_{i \sim \mathcal{D}, k \sim \gamma_i} [\log \sigma_{\theta}(x_i, y_i, k)]$$

User Model: Training

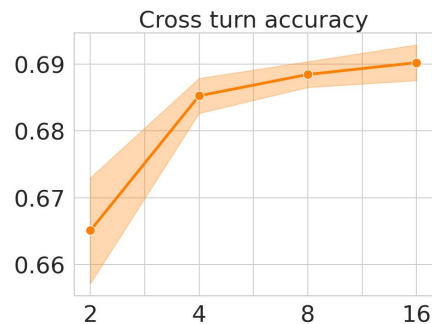
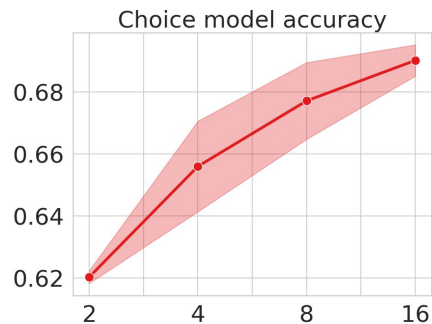
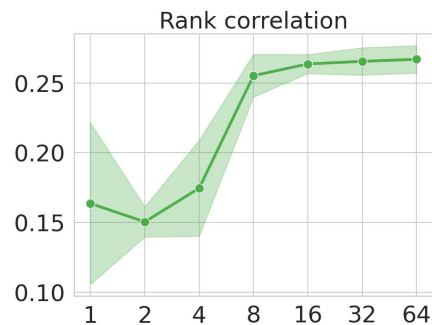
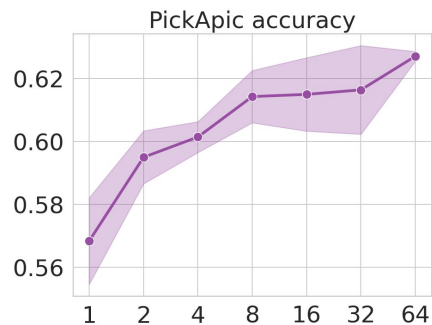
$$\gamma_i(k) = \frac{\eta_k \prod_{j=1}^M \sigma_{\theta_t}(x_{i,j}, y_{i,j}, k)}{\sum_{\ell=1}^K \eta_{\ell} \prod_{j=1}^M \sigma_{\theta_t}(x_{i,j}, y_{i,j}, \ell)}$$

Label types:

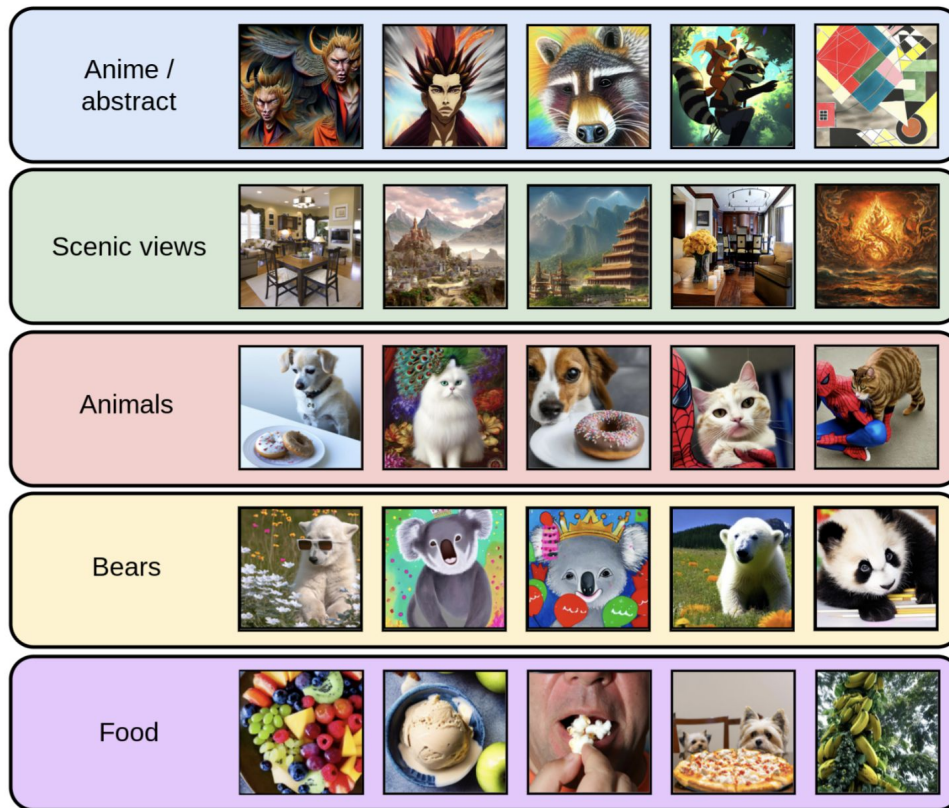
- Image-pair preference.
- Image-prompt relevance (e.g. integer score in $[1,2,3,4,5]$).
- Human rater choices.
- Cross-turn preferences.
- In-turn preferences.

User Model: Training

- We train score model over single-turn data (2M+ preference data)
 - We assume preferences in utility are mostly static
 - Helps generalize using a lot of single-turn data
- We fine-tune the choice model on sequential rater data



Emergence of User-Specific Preferences



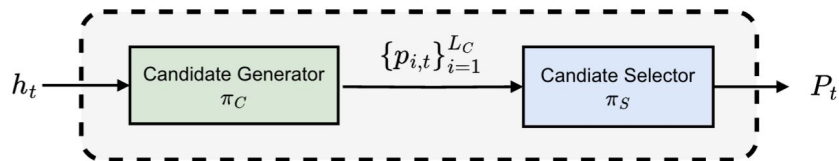
Designing an Agent

Recall we want to create an agent that generates prompt expansions,
given history

$$h_t = \left(\underbrace{p_0}_{\text{initial prompt}}, \overbrace{\underbrace{\{p_{\ell,1}\}_{\ell=1}^L}_{\text{agent action } P_1}, \underbrace{\{I_{m,\ell,1}\}_{\ell=1,m=1}^{L,M}}_{\text{transition}}, c_1}_{\text{time step 1}}, \dots, \overbrace{\underbrace{\{p_{i,t}\}_{\ell=1}^L}_{\text{agent action } P_t}, \underbrace{\{I_{m,\ell,t}\}_{\ell=1,m=1}^{L,M}}_{\text{transition}}, c_t}_{\text{time step } t} \right)$$

Preference Adaptive and Sequential Text-to-image Agent

(PASTA)



We split the agent into two:

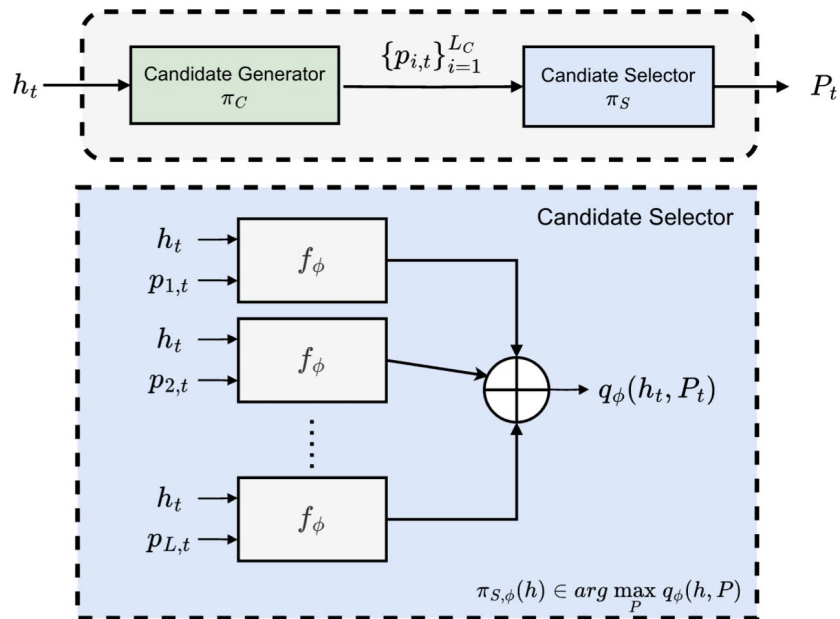
1. Candidate generator $L_C \gg L$ candidates
2. Candidate selector (i.e., verifier):

$$\pi_{S,\phi}(h) \in \arg \max_{P \in \mathcal{P}_L(\{p_i\}_{i=1}^{L_C})} q_\phi(h, P)$$

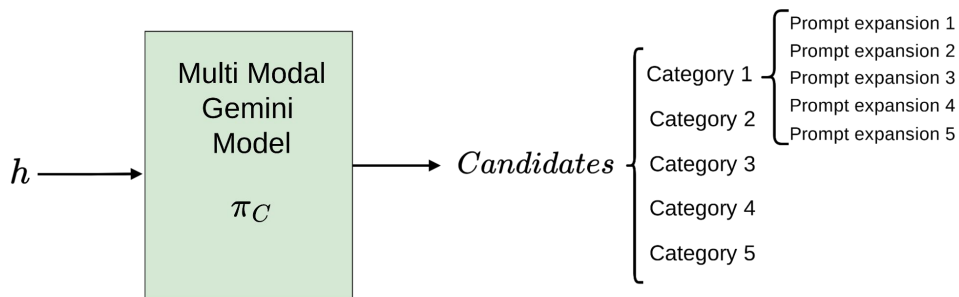
$$q_\phi(h, P) = \frac{1}{L} \sum_{p \in P} f_\phi(h, p) - \text{due to the combinatorial choice}$$

3. We train the agent using IQL

Preference Adaptive and Sequential Text-to-image Agent (PASTA)

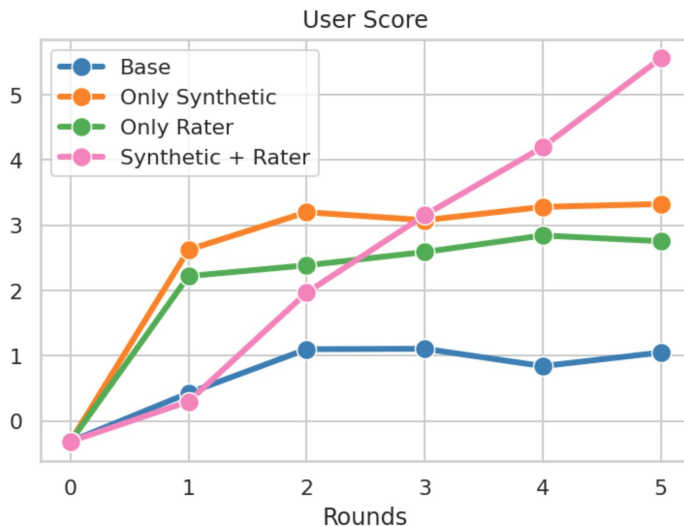


We divide candidates to categories for more diversity:

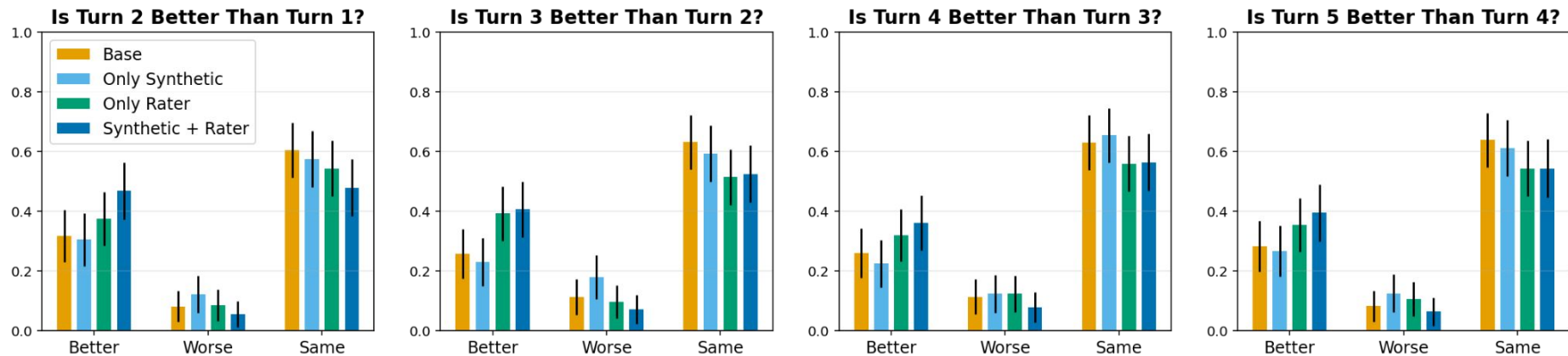


User Simulator Results

	Random	Human	Simulated	Mixed
Sparse	7.38 ± 1.13	8.7 ± 0.11	9.26 ± 0.07	8.81 ± 0.06
Dense	38.57 ± 5.81	43.49 ± 0.54	46.35 ± 0.38	44.03 ± 0.32



Human Raters Results



PASTA achieved an 85% relative improvement over the Gemini 1.5 Flash baseline model in human rater evaluations

PASTA Rollouts

Initial prompt:

"A train is going down the train tracks"



Initial prompt:

"A train is going down the train tracks"



Turn 1

Agent

Category: Variations in Lighting and Time of Day:

1. A train at sunset, on tracks.
2. A train in the morning mist.
3. A train under a stormy sky.
4. A train at night, glowing lights.
5. A train in bright sunlight.

Category: Variations in Train Type and Composition:

6. A long freight train on tracks.
7. A sleek modern passenger train.
8. An old steam train on tracks.
9. A colorful toy train on tracks.
10. A double-decker train on tracks.

Category: Variations in Environment and Setting:

11. Train on a mountain track.
12. Train in a desert landscape.
13. Train crossing a bridge.
14. Train passing through a forest.

15. Train in a snowy landscape.

Category: Completely Different Prompts (Rephrasing):

16. Railroad journey, scenic view.

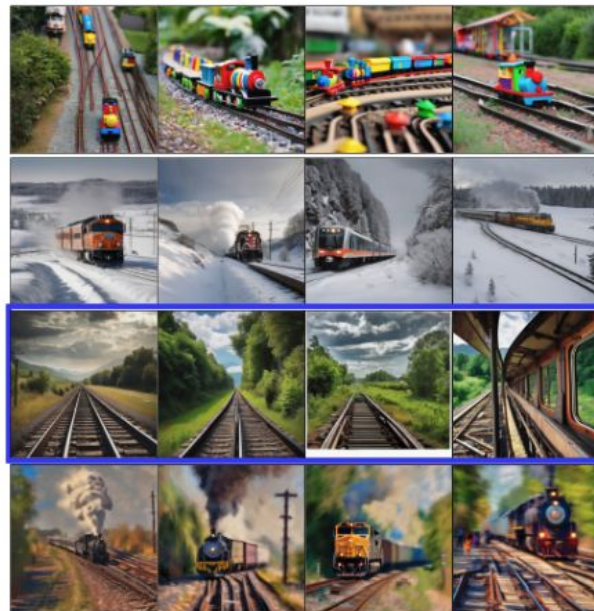
17. Metal beast on steel rails.
18. Locomotive speeding onward.
19. Tracks vanishing in distance.
20. Steel wheels on iron rails.

Category: Adding Artistic Styles and Effects:

21. Train on tracks, impressionist style.
22. Train, hyperrealistic rendering.
23. Train on tracks, painted by Monet.
24. Train, detailed pencil sketch.
25. Train on tracks, vibrant colors.

User

User selects prompt number 16:
"Railroad journey, scenic view."



Initial prompt:

"A train is going down the train tracks"



Turn 2

Agent

Category: Expanding the Scene:

1. Railroad tracks winding through a lush green valley, sunlit.
2. Train disappearing into a mountain tunnel, dramatic lighting.
3. A vintage steam train crossing a high bridge over a river.
4. Railroad tracks stretching to the horizon, sunset over fields.

5. Train passing a quaint countryside village, wildflowers.

Category: Focusing on the Train:

6. Majestic steam locomotive pulling luxurious passenger cars.
7. Modern high-speed train speeding through a vibrant landscape.
8. Freight train carrying colorful containers, scenic backdrop.
9. Close-up of a train's wheels turning on the tracks, detailed.
10. A weathered, vintage train car in a beautiful setting.

Category: Artistic Styles:

11. Railroad landscape, painted in the style of Van Gogh.
12. Impressionist painting of a train journey through fields.
13. Photorealistic train passing through a stunning canyon.
14. A whimsical, cartoon-style train in a fantasy landscape.

15. Train in a vibrant, surreal dreamscape setting.

Category: Different Perspectives:

16. Aerial view of a train snaking through a winding valley.
17. View from inside a train car, looking out at the scenery.
18. A long exposure shot of a train moving at night, light trails.

19. Close-up of the train's engine, steam billowing dramatically.

20. View from the train's cab, looking down the tracks.

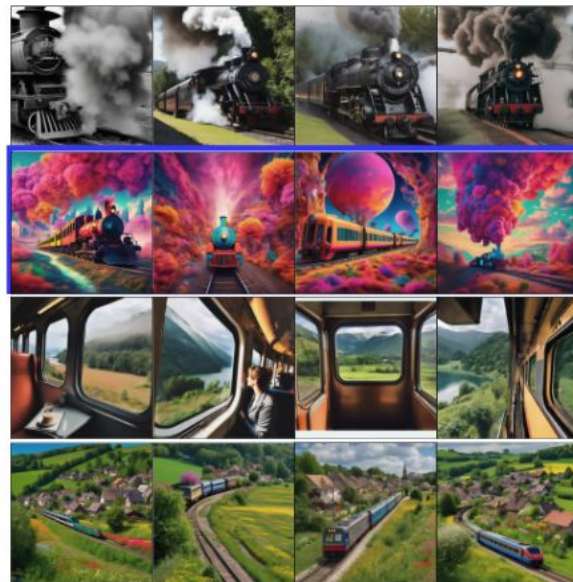
Category: Rephrasing and Variations:

21. Scenic railroad journey through diverse landscapes.
22. Picturesque train ride, breathtaking views from the window.
23. Railroad adventure, panoramic scenery.
24. Journey by rail, spectacular countryside.
25. Train on rails, beautiful and idyllic nature.

User

User selects prompt number 15:

"Train in a vibrant, surreal dreamscape setting"



Initial prompt:

"A train is going down the train tracks"



Turn 3

Agent

Category: Surreal Landscapes & Trains:

1. A steam train chugging through a field of giant, iridescent flowers under a swirling galaxy.
2. A whimsical train journey through a candy-colored forest, lollipop trees, and marshmallow clouds.
3. A futuristic train gliding over a rainbow bridge in a city made of crystals and floating islands.
4. An antique train winding through a valley of vibrant, bioluminescent plants at twilight.

5. A surreal train station nestled within a giant, glowing mushroom forest.

Category: Emphasis on Vibrancy & Color:

6. A vibrant, hyperrealistic train speeding through a landscape of impossibly bright colors.
7. A psychedelic train ride through a kaleidoscope of swirling patterns and neon lights.
8. A train made of stained glass, traversing a landscape of equally colorful stained glass.
9. A cartoonish train with exaggerated features, traveling through a bright, playful world.
10. A majestic train, with golden carriages, passing through a field of glowing sunflowers.

Category: Focus on Dreamlike Atmosphere:

11. A lone train disappearing into a hazy, dreamlike fog, leaving a trail of shimmering stardust.
- 12. A train floating effortlessly above a sea of clouds, bathed in soft, ethereal light.**
13. A vintage train gliding silently through a landscape painted in watercolor washes.
14. A dreamlike train station, where clocks melt and platforms float, bathed in moonlight.
15. A train composed of shifting, morphing shapes, moving through a constantly changing landscape.

Category: Different Interpretations of the Prompt:

16. A train journey through an impossible landscape, defying gravity and perspective.
17. The feeling of riding a train in a vibrant dream, expressing freedom and wonder.
18. A dream sequence, a train traveling through a bizarre, otherworldly environment.
19. A surreal, dreamlike depiction of a train journey, full of vibrant colors and unusual imagery.
- 20. A train's passage through a vibrant dreamscape, emphasizing the contrast between reality and fantasy.**

Category: Adding Specific Artistic Styles:

21. A train in a vibrant surreal dreamscape, in the style of a 1950s cartoon.
- 22. A vibrant surreal dreamscape with a train, painted in the style of Salvador Dali.**
23. A vibrant surreal dreamscape featuring a train, rendered in the style of Alphonse Mucha.
24. A train traveling through a vibrant surreal dreamscape, with a focus on Art Nouveau style.
25. A vibrant surreal dreamscape with a train, using bold, expressive brushstrokes in an Impressionistic style.

User

User selects prompt number 5:

"A surreal train station nestled within a giant, glowing mushroom forest"



Initial prompt:

"A train is going down the train tracks"



Turn 4

Agent

Category: Vibrant Mushroom Forests & Trains:

1. A whimsical train station nestled amongst bioluminescent mushrooms, with a steampunk aesthetic.
2. A vibrant, colorful train speeding through a fantastical forest of giant glowing mushrooms.
3. A surreal train journey through a mushroom forest, with playful, cartoonish mushrooms.
4. **A detailed illustration of a train emerging from a glowing mushroom cavern, magical atmosphere.**
5. A train puffing steam, passing through a dense forest of giant, otherworldly mushrooms.

Category: Surreal Landscapes & Trains:

6. A train gliding across a rainbow bridge in a surreal, dreamlike landscape.
7. A train traversing a landscape of floating islands, vibrant colors, and impossible architecture.
8. A surreal train journey through a landscape painted in the style of Van Gogh, vibrant colors.
9. A hyperrealistic train in a fantastical landscape, filled with impossible flora and fauna.
10. A train disappearing into a swirling vortex of colors in a surreal, dreamlike landscape.

Category: Dali-esque Trainscapes:

11. A melting clock train in a Dali-esque landscape, with distorted perspective and melting forms.
12. A train with elongated limbs and surreal features in a Dali-inspired dreamscape.
13. **A train composed of melting clocks and surreal objects in a Dali-esque landscape.**
14. A train traversing a desert landscape with melting rocks and distorted space in Dali's style.
15. A surreal train scene with distorted perspective and soft, flowing lines in the style of Dali.

Category: Ethereal & Dreamlike Trains:

16. **A train floating through a starry night sky, with ethereal lights and glowing constellations.**
17. A lone train moving through a field of luminous flowers in a soft, ethereal light.
18. A dreamy train scene with pastel colors, soft clouds, and a peaceful, tranquil atmosphere.
19. A train gently gliding through a soft, misty landscape, with a serene and peaceful atmosphere.
20. A train traveling through a sea of clouds, bathed in soft, golden light, peaceful and serene.

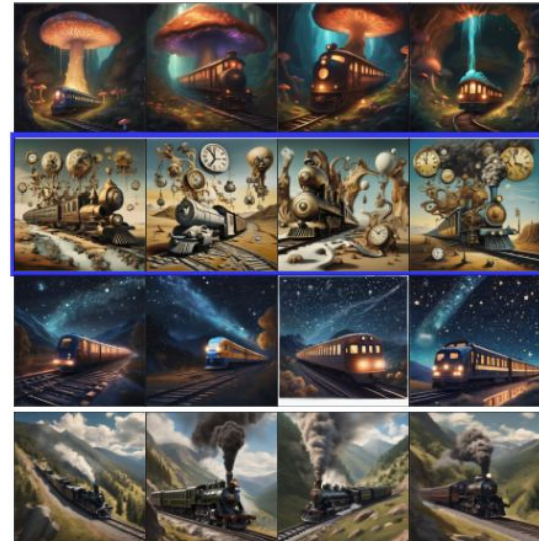
Category: Completely Different Prompts (Rephrasing):

21. A detailed photograph of a modern high-speed train passing through a rural area.
22. **A realistic depiction of a vintage steam train chugging along a mountain pass.**
23. A classic black and white photo of a train passing through a bustling city.
24. An image of a freight train transporting goods along a long railway line.
25. A simple drawing of a train on tracks in a straightforward, realistic style.

User

User selects prompt number 13:

"A train composed of melting clocks and surreal objects in a Dali-esque landscape"



Initial prompt:

"A train is going down the train tracks"



Turn 5

Agent

Category: Dali-esque Variations:

1. **A surreal train speeding through a landscape of melting clocks and distorted figures, in the style of Salvador Dali.**

2. A train composed entirely of melting clocks, surreal objects, and impossible architecture, a Dali-esque dreamscape.
3. A Dali-esque train journey through a desert landscape, with elongated shadows and distorted perspectives.
4. A train with elongated limbs and melting forms, traversing a bizarre, dreamlike landscape, in the style of Salvador Dali.
5. A surreal train station, with distorted architecture and melting clocks, in the style of Salvador Dali, hyperrealistic.

Category: Enhanced Surrealism:

6. **A train made of liquid metal, flowing through a landscape of shifting colors and impossible geometries.**

7. A train gliding through a vibrant, surreal dreamscape filled with fantastical creatures and impossible structures.
8. A train passing through a swirling vortex of colors and shapes, a surreal and psychedelic journey.
9. A train emerging from a giant, melting clock, surrounded by distorted figures and impossible objects.
10. A train journey through a hyperrealistic, surreal landscape, with unexpected elements and juxtapositions.

Category: Focus on the Train:

11. Detailed close-up of a surreal train engine, with melting clocks and intricate details.
12. A surreal train's interior, filled with melting furniture, distorted mirrors, and bizarre passengers.
13. The perspective of someone sitting inside a Dali-esque train, witnessing the surreal landscape.
14. A highly detailed rendering of a surreal train, emphasizing textures and materials.
15. A surreal train, focusing on its unusual design and mechanics.

Category: Different Artistic Styles:

16. A train in a surreal landscape, painted in the style of René Magritte, with a focus on unexpected juxtapositions.
17. A train journey through a surreal landscape, rendered in the style of a woodcut print, with bold lines and textures.
18. A surreal train scene in the style of Max Ernst, featuring collage-like elements and unexpected combinations.
19. A surreal train depicted in a vibrant, pop art style, with bold colors and graphic elements.

20. **A surreal train in a cubist landscape, emphasizing fragmented forms and multiple perspectives.**

Category: Rephrasing & Simplification:

21. A bizarre, dreamlike train in a surreal landscape.
22. **A surreal train, simple prompt.**
23. A melting clock train in a Dali-esque world.
24. Surreal train in a distorted landscape.
25. A dreamlike train journey through a strange land.

User

User selects prompt number 6:

"A train made of liquid metal, flowing through a landscape of shifting colors and impossible geometries."



Initial prompt:

"A close-up macro portrait of a princess wearing an animal skull mask with a ribcage skeleton, surrounded by a blurred background, and cybernetic jellyfish features"



Initial prompt:

"A close-up macro portrait of a princess wearing an animal skull mask with a ribcage skeleton, surrounded by a blurred background, and cybernetic jellyfish features"



Turn 1

Agent

Category: Enhanced Detail & Lighting:

1. Close-up portrait, princess, animal skull mask, cybernetic jellyfish, intricate details, dramatic lighting.
2. Princess, skull mask, jellyfish cybernetics, ethereal glow, hyperrealistic, close-up.
3. Macro portrait, princess, bone mask, bioluminescent jellyfish, sharp focus, rich colors.
4. Detailed portrait, princess, ornate skull mask, glowing cybernetic jellyfish, dark background.

5. Close-up, princess, animal skull headdress, bio-mechanical jellyfish, cinematic lighting.

Category: Alternative Mask & Cybernetics:

6. Princess portrait, elegant bird skull mask, subtle cybernetic enhancements, soft lighting.
7. Close-up, princess, futuristic insect mask, integrated cybernetic jellyfish, vibrant colors.
8. Macro portrait, princess, ornate dragon skull mask, glowing cybernetic implants, blurred background.
9. Princess, skeletal mask, sleek cybernetic arms, ethereal background, detailed texture.
10. Portrait, princess, geometric skull mask, minimalist cybernetic features, sharp focus.

Category: Variations in Background & Setting:

11. Princess, skull mask, cybernetic jellyfish, underwater scene, shimmering bubbles.
12. Portrait, princess, bone mask, cybernetic enhancements, mystical forest background.
13. Close-up, princess, animal skull mask, jellyfish cybernetics, futuristic cityscape backdrop.
14. Princess, skull mask, bioluminescent jellyfish, otherworldly nebula background.
15. Macro portrait, princess, ornate mask, cybernetic elements, enchanted garden setting.

Category: Different Artistic Styles:

16. Princess, skull mask, cybernetic jellyfish, art nouveau style, elegant and flowing lines.
17. Portrait, princess, bone mask, cybernetic enhancements, dark fantasy art style.
18. Close-up, princess, animal skull mask, jellyfish cybernetics, photorealistic style.
19. Princess, skull mask, bioluminescent jellyfish, gothic art style, dramatic lighting.
20. Macro portrait, princess, ornate mask, cybernetic elements, digital painting style.

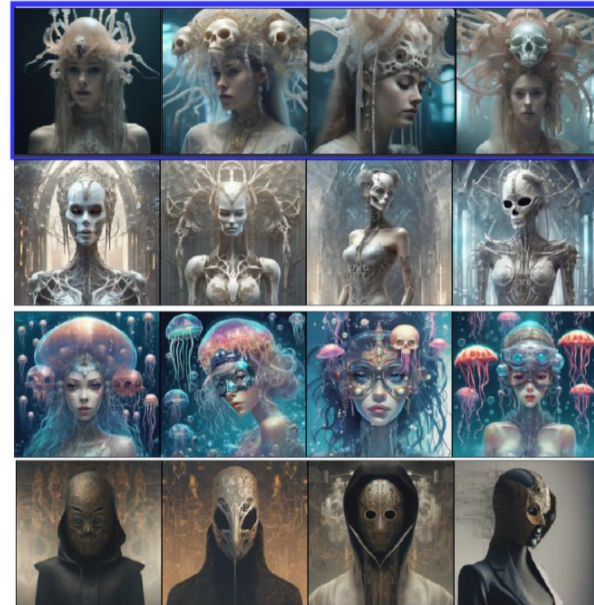
Category: Completely Different Concept (Rephrasing):

21. A regal woman, adorned with intricate bone jewelry and glowing bioluminescent accents.
22. A mysterious figure, partially obscured by a fantastical mask, with subtle technological elements.
23. A powerful queen, with cybernetic enhancements blending seamlessly with organic bone structures.
24. A captivating portrait of a woman, combining elegance with futuristic bio-mechanical elements.
25. An ethereal being, blending organic and synthetic elements in a harmonious composition.

User

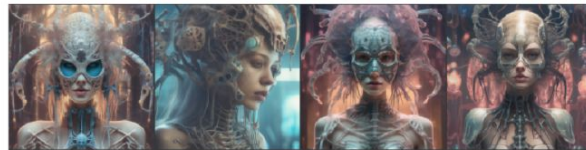
User selects prompt number 5:

"Close-up, princess, animal skull headdress, bio-mechanical jellyfish, cinematic lighting"



Initial prompt:

"A close-up macro portrait of a princess wearing an animal skull mask with a ribcage skeleton, surrounded by a blurred background, and cybernetic jellyfish features"



Turn 2

Agent

Category: Refined Details & Lighting:

1. Close-up portrait: princess, intricate skull headdress, bioluminescent jellyfish, dramatic lighting, 8k resolution.
2. Princess in ornate skull mask, bio-mechanical jellyfish crown, deep shadows, sharp focus, cinematic lighting.
3. Close-up, princess, detailed animal skull mask, glowing jellyfish, volumetric lighting, dark background.
4. **Macro portrait: princess, skull headdress with jellyfish, chiaroscuro lighting, ethereal atmosphere, hyperrealistic.**

5. Close-up, princess, skull mask, bio-mechanical jellyfish, cinematic lighting, rich textures.

Category: Variations on the Jellyfish:

6. Princess, ornate skull mask, bioluminescent jellyfish tendrils, dark background, cinematic lighting.
7. Close-up portrait, princess, skull headdress, iridescent jellyfish, dark moody ambiance, sharp details.
8. Princess, skeletal mask, cybernetic jellyfish swarm, deep ocean setting, cinematic lighting.
9. **Close-up: princess, skull headdress, bio-mechanical jellyfish, neon lighting, underwater effect.**
10. Princess, skull mask, pulsating jellyfish, dark background, dramatic lighting, 8k resolution.

Category: Emphasis on the Skull:

11. Close-up portrait, princess, intricately carved skull mask, jellyfish accents, cinematic lighting.
12. Princess, detailed animal skull mask, bio-mechanical jellyfish, dark fantasy art, dramatic lighting.
13. Close-up: princess, ornate skull headdress, bio-mechanical jellyfish, dark fantasy art, sharp focus.
14. Princess, realistic skull mask, cybernetic jellyfish, dark background, cinematic lighting, detailed texture.
15. **Macro shot: princess, decaying skull mask, bio-mechanical jellyfish, dramatic lighting, ethereal feel.**

Category: Completely Different Style:

16. Elegant princess, futuristic crown, subtle technological details, soft lighting, pastel colors.
17. Portrait of a regal woman, ethereal crown, flowing gown, soft light, serene expression.
18. A powerful queen, majestic pose, ornate jewelry, warm lighting, rich colors.
19. Young woman, delicate flower crown, flowing dress, soft light, gentle expression.
20. Beautiful woman, simple headband, natural light, soft focus, dreamy atmosphere.

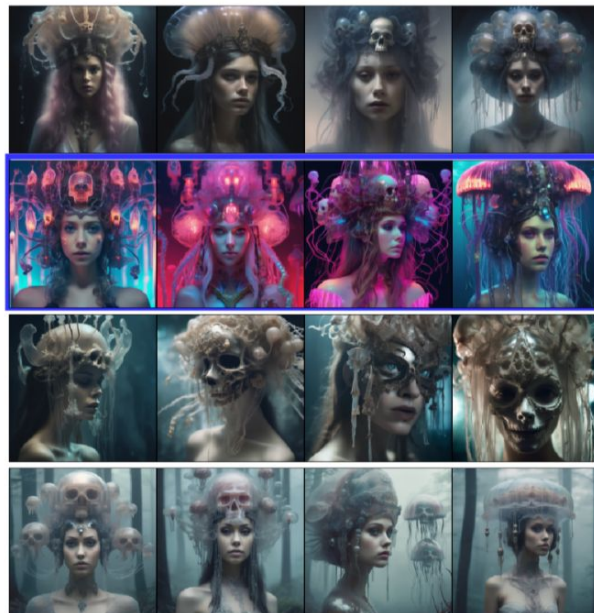
Category: Exploring Backgrounds & Settings:

21. **Close-up, princess, skull headdress, bio-mechanical jellyfish, foggy forest background.**
22. Princess, skull mask, jellyfish crown, cinematic lighting, ancient ruins background.
23. Close-up portrait, princess, skull headdress, bio-mechanical jellyfish, underwater scene.
24. Princess, skull mask, jellyfish, cinematic lighting, gothic architecture background.
25. Close-up: princess, skull headdress, bio-mechanical jellyfish, starry night sky background.

User

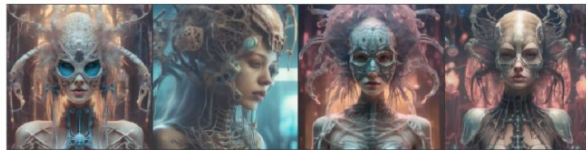
User selects prompt number 9:

"Close-up: princess, skull headdress, bio-mechanical jellyfish, neon lighting, underwater effect"



Initial prompt:

"A close-up macro portrait of a princess wearing an animal skull mask with a ribcage skeleton, surrounded by a blurred background, and cybernetic jellyfish features"



Turn 3

Agent

Category: Neon Dreamscapes:

1. Princess, skull jellyfish crown, neon coral reef, vibrant underwater city.
2. **Underwater princess, glowing jellyfish headdress, neon lights, art deco style.**
3. Cyberpunk princess, skull mask with neon jellyfish, futuristic underwater city.
4. Princess in neon-lit underwater cave, skull headdress, bioluminescent jellyfish.
5. Electric princess, skull and jellyfish crown, neon ocean, 80s synthwave aesthetic.

Category: Subtle Shifts in Lighting and Background:

6. Close-up portrait: princess, skull headdress, bioluminescent jellyfish, soft neon glow, dark background.
7. Princess, skull jellyfish crown, underwater scene, subtle neon accents, calm atmosphere.
8. Underwater princess, skull headdress, bio-mechanical jellyfish, pastel neon, serene background.
9. Princess, skull and jellyfish crown, deep ocean, cool neon hues, mysterious ambiance.
10. Close-up, princess, skull headdress, jellyfish, dim neon lighting, smoky underwater cave.

Category: Variations on the Jellyfish:

11. **Princess, skull headdress, glowing jellyfish tentacles, neon lights, dark ocean.**
12. Princess, skull crown, iridescent jellyfish, neon underwater landscape, detailed textures.
13. Underwater princess, skull headdress, bioluminescent jellyfish swarm, neon glow.
14. Close-up: princess, skull mask, intricate jellyfish headdress, neon coral, deep ocean.
15. Princess, skull headdress, bio-mechanical jellyfish, neon kelp forest, flowing fabric.

Category: Completely Different Style:

16. Portrait of a regal woman, ornate mask, intricate jewelry, rich textures, dramatic lighting.
17. **Elegant woman, mysterious headdress, flowing gown, detailed portrait, studio lighting.**
18. A woman with a captivating gaze, elaborate headdress, rich colors, painterly style.
19. Close-up portrait, strong female figure, enigmatic expression, rich textures, studio setting.
20. Fashion portrait, stylish woman, unique headpiece, luxurious fabrics, sophisticated look.

Category: Emphasizing Texture and Detail:

21. Hyperrealistic portrait: princess, detailed skull headdress, bio-mechanical jellyfish, neon lighting, underwater scene.
22. Close-up, princess, skull headdress, intricate jellyfish details, neon lights, underwater world.
23. **Princess, skull jellyfish crown, highly detailed textures, neon lighting, underwater cave.**
24. Macro portrait: princess, textured skull mask, bio-mechanical jellyfish, neon glow, underwater rocks.
25. Detailed portrait: princess, skull headdress, realistic jellyfish, neon accents, ocean floor.

User

User selects prompt number 23:

"Princess, skull jellyfish crown, highly detailed textures, neon lighting, underwater cave"



Initial prompt:

"A close-up macro portrait of a princess wearing an animal skull mask with a ribcage skeleton, surrounded by a blurred background, and cybernetic jellyfish features"



Turn 4

Agent

Category: Neon Underwater Princesses:

1. A princess adorned with a bioluminescent jellyfish crown, swimming in a vibrant neon coral reef, intricate details, 8k resolution.
2. Princess in an underwater palace, wearing a jellyfish headdress that glows with neon light, surrounded by glowing flora and fauna.
3. Portrait of a princess, her face partially obscured by a neon jellyfish crown, underwater scene, hyperrealistic details.
4. An ethereal princess with flowing hair, a jellyfish headdress emitting neon light, swimming gracefully amidst glowing jellyfish.
5. Close-up of a princess wearing a skull-shaped jellyfish crown, vibrant neon lighting, underwater cave setting, detailed textures.

Category: Dark Fantasy Princesses:

6. A princess in a dark underwater grotto, wearing a crown of glowing jellyfish and skeletal elements, mysterious and ethereal.
7. Dark fantasy portrait: a princess with a jellyfish crown made of bone and neon lights, surrounded by deep sea creatures.
8. A gothic princess, wearing a headdress crafted from decaying jellyfish and skulls, bathed in neon underwater light, dramatic pose.
9. A mysterious underwater princess, her face veiled by a jellyfish headdress with glowing neon accents, dark and moody atmosphere.
10. Portrait of a princess in a dark, underwater cavern, wearing a crown of bioluminescent jellyfish, surrounded by shadows and glowing accents.

Category: Detailed Jellyfish Headwear:

11. Extremely detailed portrait of a princess wearing an intricate jellyfish headdress, neon lighting, underwater setting, realistic textures.
12. Close-up, princess with a jellyfish crown, featuring highly detailed tentacles and bioluminescent patterns, underwater scene, 8k resolution.
13. Macro shot: princess, ornate jellyfish headdress with intricate skeletal details, neon lighting, underwater environment, sharp focus.
14. Princess portrait: elaborate jellyfish crown with glowing neon accents, detailed textures, underwater background, cinematic lighting.
15. Highly detailed image of a princess wearing a jellyfish crown, showcasing the intricate textures and neon glow, underwater environment.

Category: Alternative Interpretations:

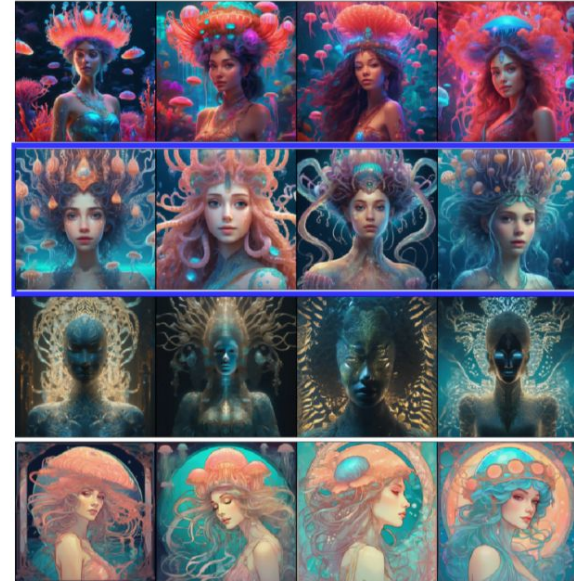
16. A regal figure, partially obscured by a mask of intricately woven light and shadow, with bioluminescent accents, underwater, 8k resolution.
17. A captivating woman, her face partially hidden by a fantastical headpiece reminiscent of deep-sea life, bathed in ethereal light.
18. A mysterious and elegant woman with a headpiece combining natural and technological elements, emitting a soft, otherworldly glow.
19. An enigmatic figure in an underwater setting, adorned with a crown of ethereal light and intricate, bioluminescent patterns.
20. A vision of elegance and mystery: a woman with a unique headpiece inspired by marine life, emitting a gentle, glowing light.

Category: Stylistic Variations:

21. Art Deco style portrait: a princess wearing a geometric jellyfish crown, vibrant neon colors, underwater setting, elegant composition.
22. Surrealist portrait: a princess with a melting jellyfish crown, neon lighting, dreamlike underwater scene, unexpected elements.
23. Impressionistic underwater portrait: a princess with a jellyfish crown, soft focus, pastel neon colors, flowing lines and shapes.
24. A princess with a jellyfish headdress in the style of Alphonse Mucha, elegant lines, soft neon lighting, underwater background.
25. A princess wearing a jellyfish crown, painted in the style of Gustav Klimt, with gold and vibrant neon accents, underwater scene.

User

User selects prompt number 12:
"Close-up, princess with a jellyfish crown, featuring highly detailed tentacles and bioluminescent patterns, underwater scene, 8k resolution"



Initial prompt:

"A close-up macro portrait of a princess wearing an animal skull mask with a ribcage skeleton, surrounded by a blurred background, and cybernetic jellyfish features"



Turn 5

Agent

User

User selects prompt number 22:

"An ethereal underwater scene depicting a queen, her crown formed by bioluminescent sea creatures, radiating an enchanting glow."

Category: Refined Details & Lighting:

1. Close-up portrait of a princess wearing a bioluminescent jellyfish crown, intricate details on tentacles, soft underwater lighting, 8k resolution, hyperrealistic.
2. Princess with a jellyfish crown, detailed tentacles with iridescent scales, soft blue and pink lighting, underwater scene, serene expression.
3. Underwater portrait: princess, jellyfish crown with glowing accents, subtle shimmering particles, cinematic lighting, highly detailed textures.
4. Close-up, princess, jellyfish crown, vibrant coral reef background, realistic rendering, sharp focus, detailed textures, soft lighting.
5. **Princess, jellyfish crown, realistic jellyfish anatomy, submerged in crystal clear water, natural lighting, ethereal atmosphere.**

Category: Stylistic Variations:

6. Art Nouveau princess with a jellyfish crown, flowing lines, pastel colors, underwater setting, elegant composition.
7. **Princess, jellyfish crown, Art Deco style, geometric patterns, neon lighting, underwater Art Deco architecture.**
8. Surrealist portrait: princess, melting jellyfish crown, dreamlike underwater environment, vibrant colors, distorted perspective.
9. Impressionist princess, jellyfish crown, soft brushstrokes, underwater scene, blurred background, pastel hues.
10. Princess, jellyfish crown, in the style of Gustav Klimt, gold leaf accents, underwater scene, shimmering effect.

Category: Environmental Changes:

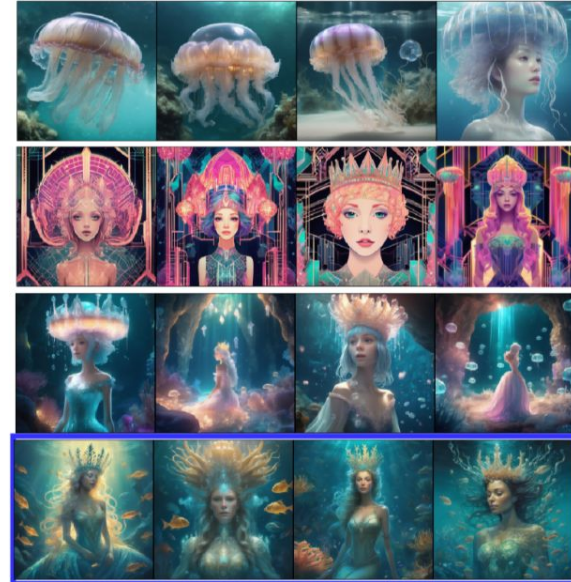
11. Princess, jellyfish crown, deep ocean trench, bioluminescent creatures, dark mysterious background, 8k resolution.
12. Princess, jellyfish crown, glowing coral reef, diverse marine life, vibrant colors, shallow water, sunlight filtering through.
13. Princess, jellyfish crown, ancient sunken city, ruins, mystical underwater atmosphere, detailed textures, cinematic lighting.
14. **Princess, jellyfish crown, mysterious underwater cave, glowing crystals, ethereal light, sense of wonder, 8k resolution.**
15. Underwater princess, jellyfish crown, surrounded by schools of luminous fish, vibrant coral, crystal-clear water, cinematic lighting.

Category: Alternative Headwear Interpretations:

16. Close-up portrait of a princess with a headdress made of intricately woven sea anemones and jellyfish, underwater, ethereal lighting.
17. Princess, ornate headdress inspired by jellyfish, intricate details, flowing fabric, underwater, cinematic lighting, 8k resolution.
18. Portrait of a princess with a crown sculpted from fossilized jellyfish, underwater ruins background, mysterious atmosphere.
19. Princess with a headdress resembling a blooming jellyfish, vibrant colors, detailed textures, underwater, soft lighting.
20. Close-up of a princess wearing a delicate headdress crafted from translucent jellyfish, ethereal glow, underwater scene, serene expression.

Category: Completely Different Prompts (Rephrasing):

21. A breathtaking underwater portrait of a regal woman, adorned with a luminous, organic headpiece, evoking a sense of otherworldly beauty.
22. **An ethereal underwater scene depicting a queen, her crown formed by bioluminescent sea creatures, radiating an enchanting glow.**
23. A captivating image of a majestic figure submerged in an ocean, wearing a radiant headpiece reminiscent of jellyfish, in a hyperrealistic style.
24. A mesmerizing underwater portrait, featuring a serene woman with a crown made of glowing jellyfish, showcasing intricate details and vibrant colors.
25. An elegant woman, her head crowned with a dazzling display of bioluminescent jellyfish, creating a stunning underwater spectacle.



“An Image of Happiness”



User Type A

"An image of happiness"



Rollout 1

Rollout 2

Rollout 3



"Abstract happy faces, Art Deco inspired geometric shapes, muted jewel-toned background"



"Dynamic interplay of simple shapes, limited colors, reflecting exuberant joy"



"Abstract garden scene with birds, composed of geometric shapes and vibrant colors"

User Type B

"An image of happiness"



Rollout 1

Rollout 2

Rollout 3



"A vibrant, expressive piece of art representing the overwhelming feeling of happiness"



"Hyperrealistic painting of ecstatic children playing in a vibrant, sun-drenched park, confetti falling, dynamic motion blur"



"Watercolor painting of diverse happy children playing, soft colors, delicate brushstrokes, serene mood"

User Type C

"An image of happiness"



Rollout 1

Rollout 2

Rollout 3



"A field of luminous flowers, iridescent insects, and fantastical creatures bathed in the soft light of a double rainbow"



"A field of sunflowers bathed in golden sunlight, with vibrant colors and intricate details, photorealistic"



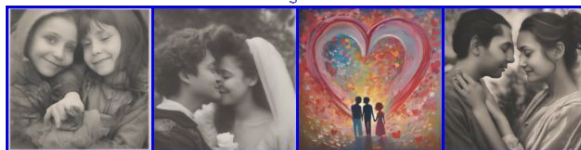
"Golden hour meadow, wildflowers bathed in warm sunlight, peaceful atmosphere, photorealistic"

“An Image of Love”



User Type A

"An image of love"



Rollout 1

Rollout 2

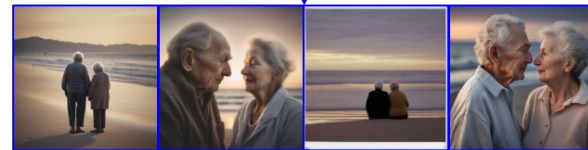
Rollout 3



"Tender embrace in soft golden light, detailed textures, warm tones, intimate moment"



"Soft lighting illuminates a mother's tender touch on her child's face, enhancing the emotional depth"



"Two elderly lovers sharing a quiet moment on a beach at dusk, soft light, detailed wrinkles"

User Type B

"An image of love"



Rollout 1

Rollout 2

Rollout 3



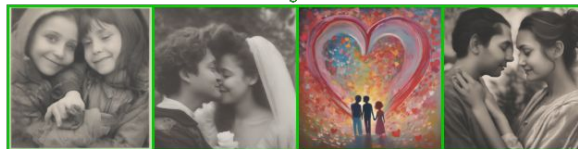
"A visual exploration of love's intensity, abstract forms, dynamic composition"

"A tapestry of textures, rough and smooth interwoven, portraying the strengths and vulnerabilities within a loving family"

"Intertwined geometric forms representing love, Cubist style, soft pastel palette, balanced composition"

User Type C

"An image of love"



Rollout 1

Rollout 2

Rollout 3



"An impressionistic portrayal of a family birthday celebration, emphasizing light, color, and movement."



"Family dinner depicted from an unusual angle; unexpected perspective adds intrigue; focus on togetherness"



"Intertwined geometric forms representing love, Cubist style, soft pastel palette, balanced composition"

Thank you!



Check our paper: <https://arxiv.org/abs/2412.10419>

And dataset: <https://www.kaggle.com/datasets/googleai/pasta-data>