

# AAAI 2026 Supplementary Material Camera Ready

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## More details of RetouchAgent

### Prompt of RetouchAgent

Table 1 present the prompt employed by RetouchAgent. By assigning specialized prompts to different agents, our method supports effective interaction and high-quality retouching. (Due to space constraints, only a subset of prompts related to the operation library is included as illustrative examples.)

### Details of Operation Library

Drawing inspiration from professional image editing software and expert workflows, we organize our operation library into four main categories. Basic adjustments control global image attributes such as exposure, contrast, saturation, white balance, color temperature, tint, and so on, allowing for quick overall tone shaping. Tone curve operations refine the image's lighting characteristics by enabling precise control over highlights, shadows, midtones, and more, enhancing depth and dynamic range. Color curve operations support targeted editing of individual RGB channels through per-channel curves, making it easy to fine-tune elements like sky blues, skin tones, cinematic color effects, and so forth. Detail controls focus on enhancing the image's clarity and texture through tools like sharpening, vignetting, noise reduction, etc., helping to create refined and visually appealing results.

## More experimental results

### Case Study

Fig. 1 presents the complete output traces corresponding to the Case Study discussed in the main text.

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Prompt	Content
prompt for database agent	<p>You are a professional photo editing analyst. Please complete the two tasks below:</p> <p>Original Image: &lt;&lt;IMG&gt;&gt;</p> <p>Edited Image: &lt;&lt;IMG&gt;&gt;</p> <p>Editing Steps: \$edit_text\$</p> <p><b>Task 1 – Image Description</b></p> <p>Describe only what is visually observable in the image. Focus on subject, environment, lighting, mood, textures, and other visual elements. Be objective and specific.</p> <p><b>Task 2 – Editing Intention Analysis</b></p> <p>Compare the original and edited images, taking the provided editing steps into account. Analyze what the editor aimed to achieve, either visually or emotionally. Use precise photography terminology (e.g., tonal contrast, vibrance, cool tones, detail recovery). Avoid vague or generic statements.</p> <p><b>Output format (each paragraph should not exceed 50 words):</b></p> <p>[Image Description]:</p> <p>[Editing Intention]:</p>
system prompt for engine agent	<p>&lt;&lt;IMG&gt;&gt; This is the target image to be edited.</p> <p>&lt;&lt;IMG&gt;&gt; This is the original image from the database. &lt;&lt;IMG&gt;&gt; This is the expert-retouched version of the same image. The expert applied the following edits:</p> <p>&lt;&lt;IMG&gt;&gt; This is the original image from the database. &lt;&lt;IMG&gt;&gt; This is the expert-retouched version of the same image. The expert applied the following edits:</p> <p>&lt;&lt;IMG&gt;&gt; This is the original image from the database. &lt;&lt;IMG&gt;&gt; This is the expert-retouched version of the same image. The expert applied the following edits:</p> <p>You are a multi-modal large language model (MLLM) acting as a professional photo retouching assistant. You are provided with the following: - A set of reference image pairs: each consisting of an original input image and its corresponding expert-retouched version. - The editing steps applied by the expert to transform the original into the retouched version. - A target image that requires enhancement, guided by the visual style and methodology of the expert examples. Your task is to analyze the expert editing strategies, interpret their visual and technical implications, and apply corresponding operations to the target image using only the supported operations from the defined editing library.</p> <p><b>Please produce your response in the following format:</b></p> <p><b>Step 1: Target image analysis.</b> A concise description of the target image's visual properties, including brightness, contrast, color balance, saturation, and any observable flaws such as dull tones, over/underexposure, unnatural color cast, or lack of structure.</p> <p><b>Step 2: Expert example analysis.</b> Exposure/Brightness: (Summarize how brightness was handled across expert examples) Contrast: (Highlight general contrast patterns or preferences)</p> <p>Saturation/Vibrance: (Describe overall color intensity tendencies)</p> <p>Tone Curves: (Summarize highlight and shadow adjustments)</p> <p>Color Temperature/Tint: (Note any global color balance shifts)</p> <p><b>Step 3: Difference and historical analysis.</b></p> <p>Identify key visual or stylistic gaps between the target image and expert references. If applicable, incorporate context from prior reflection rounds or historical iterations.</p> <p><b>Step 4: Retouching operation generation.</b></p> <p>Provide a JSON array containing selected operations and values from the supported operation library:</p> <pre data-bbox="523 1564 1204 1769">[   {"name": "Contrast", "value": 10},   {"name": "Brightness", "value": 5},   {"name": "Color Temperature", "value": 4},   {"name": "Darken Highlights", "value": 20},   {"name": "B Sigmoid High", "value": 20} ]</pre> <p>Use only supported operations with correct naming and valid value ranges. Do not include any extra commentary or explanations outside the structured format.</p>

Prompt	Content
CoT prompt for Engine Agent	<p>Your reasoning process should follow this four-stage structure:</p> <p><b>Step 1: Target image analysis.</b> Analyze the target image to define actionable retouching objectives. Transform subjective visual qualities into measurable directives, and identify regions or attributes requiring enhancement.</p> <p><b>Step 2: Expert example analysis.</b> Examine the provided image-editing examples. Identify stylistic tendencies, preferred parameter directions, and any consistent use of specific operations (e.g., tone curves, vibrance adjustments, global temperature shifts). Focus on how experts balance tonal range, color, and depth.</p> <p><b>Step 3: Difference and historical analysis.</b> Compare the target image to the expert results and determine areas of deviation. Highlight what needs to change to bring the target closer to the expert style. If applicable, integrate context or feedback from prior reasoning steps to refine your adjustment path.</p> <p><b>Step 4: Retouching operation generation.</b> Select appropriate operations and values from the predefined editing library. All operations must be semantically valid and chosen based on the visual goals identified in prior steps. Values should be perceptually significant (typically <math>\pm 5</math> or more unless fine-tuning).</p>
Operation Library (partial list)	<p><b>Supported Operations (Partial List)</b></p> <p>All operations must be selected from the following controlled library. Each operation takes a normalized value in the range [-100, 100] and affects a specific global or tonal attribute of the image. This design supports continuous control while reducing complexity for interpretability.</p> <p><b>Brightness</b></p> <ul style="list-style-type: none"> <li>• Range: [-100, 100]</li> <li>• Affected Aspect: Global Exposure</li> <li>• Effect: Adjusts the overall luminance of the image. Positive values brighten, while negative values darken the scene.</li> </ul> <p><b>Contrast</b></p> <ul style="list-style-type: none"> <li>• Range: [-100, 100]</li> <li>• Affected Aspect: Global Tonal Separation</li> <li>• Effect: Modifies contrast between highlights and shadows through linear tonal remapping.</li> </ul> <p><b>Saturation</b></p> <ul style="list-style-type: none"> <li>• Range: [-100, 100]</li> <li>• Affected Aspect: Global Color Intensity</li> <li>• Effect: Increases or decreases the intensity of all colors uniformly.</li> </ul> <p><b>Vibrance</b></p> <ul style="list-style-type: none"> <li>• Range: [-100, 100]</li> <li>• Affected Aspect: Muted Color Boosting</li> <li>• Effect: Boosts low-saturation colors while protecting highly saturated regions (e.g., skin tones).</li> </ul> <p><b>Color Temperature</b></p> <ul style="list-style-type: none"> <li>• Range: [-100, 100]</li> <li>• Affected Aspect: Global Color Warmth</li> <li>• Effect: Shifts the white balance toward warmer (red/yellow) or cooler (blue) tones.</li> </ul> <p><b>Color Tint</b></p> <ul style="list-style-type: none"> <li>• Range: [-100, 100]</li> <li>• Affected Aspect: Green–Magenta Shift</li> <li>• Effect: Adjusts the overall green–magenta balance to correct color casts.</li> </ul> <p><b>Brighten Highlights</b></p> <ul style="list-style-type: none"> <li>• Range: [-100, 100]</li> <li>• Affected Aspect: Highlight Regions</li> <li>• Effect: Increases brightness in highlight areas without affecting midtones or shadows.</li> </ul> <p><b>Darken Shadows</b></p> <ul style="list-style-type: none"> <li>• Range: [-100, 100]</li> <li>• Affected Aspect: Shadow Regions</li> <li>• Effect: Deepens dark regions to enhance depth and tonal contrast.</li> </ul> <p>.....</p>

Table 1: Prompts used for RetouchAgent system

**Retrieval**

I want the sky to take on a golden, while the surrounding environment gradually darkens. Just like when the sun sets and the world gradually sinks into darkness, creating a rich evening atmosphere.

You could increase the color saturation and contrast to bring out warm tones, creating an orange-red gradient that highlights the sunset clouds and adds more layers to the image. Meanwhile, gradually darkening the surrounding areas will change the environment into an evening atmosphere, as the sun sets and the world gets darker.

I want to make the sky colors more vivid, brighten the snow on the mountains, and make the water clearer so it looks more stunning?

You could increase the overall brightness and contrast to make the sky's colors more vivid and add stronger depth to the scene. Moderately lowering the color temperature can enhance the tranquil atmosphere, and brightening the shadows can reveal more details in the snowy mountains. Finally, subtle adjustments to the RGB curves would help balance the colors between the sky and water, creating a natural look.

**Step 1: Target image analysis**  
 The image shows a serene lakeside scene at dusk with snowy mountains in the distance and a wide sky. The lighting is soft and neutral, but the sky lacks vibrant warm tones, and the surrounding environment appears evenly lit without a strong evening transition. Contrast is moderate, with no distinct glow or deepening shadows typical of sunset scenes.

**Step 2: Expert example analysis**  
 Exposure/Brightness: Experts often retain a balanced exposure but slightly boost brightness in selective areas like sky highlights to draw focus.  
 Contrast: Moderate to high contrast is applied to enhance shape separation and depth.  
 Saturation/Vibrance: Experts tend to increase saturation and vibrance to emphasize warm sunset hues.  
 Tone Curves: Highlights are gently brightened; shadows are deepened for mood and dimensionality.  
 Color Temperature/Tint: A warm temperature shift is commonly applied to emulate golden hour light.

**Step 3: Difference analysis**  
 The current image lacks that golden sunset vibrancy and the gradual darkening of surroundings. To adapt, I should increase vibrance, deepen shadows, and slightly reduce highlight brightness to shape a stronger sunset look while keeping enough detail in the sky, and I should shift the color temperature toward warm tones to introduce a rich golden glow while leaving the lower part of the image cooler and darker to simulate the descent into night.

**Step 4: Retouching operation generation**  
`[{"name": "Brightness", "value": 20}, {"name": "Contrast", "value": 10}, {"name": "Saturation", "value": 40}, {"name": "Vibrance", "value": 40}, {"name": "Brighten Highlights", "value": 5}, {"name": "Darken Shadows", "value": 20}, ...]`

**Step 1: Target image analysis**  
 The image presents a scenic mountain-lake view during sunset, with a warm sky and darkened foreground. While the golden tones in the sky are present, they appear slightly muted. The snowy mountain areas are somewhat underexposed, lacking crisp detail. The water surface reflects the sky, but lacks clarity and tonal separation. Overall, the scene feels slightly heavy and could benefit from more vivid lighting and cooler tonality.

**Step 2: Expert example analysis**  
 Exposure/Brightness: Experts often increase brightness selectively to draw attention to highlights like snow or sky edges.  
 Contrast: Frequently used to separate elements—mountains, clouds, water—through deeper blacks and crisper whites.  
 Saturation/Vibrance: Color vividness is enhanced through vibrance boosts, especially in skies and reflections.  
 Tone Curves: Adjustments to RGB channels fine-tune harmony between sky and water, especially in sunset scenes.  
 Color Temperature/Tint: Cooler temperatures are used to evoke stillness, especially when paired with high clarity and snow detail.

**Step 3: Difference analysis**  
 The target's current warmth flattens its atmosphere. Lowering color temperature can help create a calmer, more tranquil mood. The shadows could be lifted to show more snow detail, while slight RGB curve tuning would improve color balance across the scene, and the brightness should be increased to enhance the sky's vibrancy and bring clarity to the water reflections without overexposing the highlights.

**Step 4: Retouching operation generation**  
`[{"name": "Brightness", "value": 8}, {"name": "Contrast", "value": 10}, {"name": "Saturation", "value": 30}, {"name": "Vibrance", "value": 40}, {"name": "Color Temperature", "value": -20}, ...]`

**Engine**

**Step 1: Target image analysis**  
 The sky presents a pleasant golden warmth with moderately deepened shadows, which helps build a stronger evening mood. However, the highlights on the clouds still look somewhat flat and could use more glow. Darkening both shadows and highlights can improve depth and shape, while slightly increasing color temperature and red highlights will enrich the warm sunset tones. A gentle contrast boost could further enhance the tonal separation between sky and mountain range, allowing cloud layers to stand out more vividly. Additionally, applying a subtle increase in vibrance can bring out the orange and magenta transitions, adding emotional richness and cinematic warmth to the composition.

**Step 1: Target image analysis**  
 The image now shows improved sunset coloration, with a golden sky and slightly deepened shadows. However, the overall tonal depth is still limited. The highlights on the clouds remain too flat to create a luminous effect, and the foreground lacks sufficient contrast to distinguish spatial layers. Saturation is high but borders on unnatural in some midtone areas.

**Step 2: Expert example analysis**  
 Exposure/Brightness: Experts often avoid excessive brightness to retain mood; instead, they balance localized light to preserve atmosphere.  
 Contrast: Moderate contrast is consistently used to carve depth, particularly in sky structures and land silhouettes.  
 Saturation/Vibrance: Vibrance is used more than saturation to boost warm colors selectively, preserving realism.  
 Tone Curves: Shadows are noticeably darkened, and highlight glow is controlled through gentle tonal shaping rather than broad brightening.  
 Color Temperature/Tint: A warm shift is applied, sometimes with red-channel tweaks to enhance sunset hues.

**Step 2: Expert example analysis**  
 Exposure/Brightness: Experts apply controlled brightness to maintain mood while ensuring key areas like snow and clouds remain visible.  
 Contrast: Used to enhance separation between cloud layers and terrain, typically applied subtly.  
 Saturation/Vibrance: Vibrance is used more heavily than saturation to bring out warmth without oversaturating shadows.  
 Tone Curves: Cloud highlights are often lifted through red and blue channels to simulate warm, reflective light.

**Step 3: Historical analysis**  
 By analyzing the operations in the last round, the big jump in saturation and vibrance created strong color but feels a bit artificial. Shadows were darkened, but not enough to fully convey sunset darkness, and the highlights were still left quite bright. And I should now reduce highlight intensity to restore cloud detail, deepen shadows further for stronger dusk presence, and shift color warmth more subtly. Red highlights can be enhanced to recover sunset glow without oversaturation, and contrast should be used more delicately to avoid harsh transitions.

**Step 3: Historical analysis**  
 By analyzing the operations in the last round, these changes improved vividness and snow detail, but the large negative color temperature has cooled the scene too much, while cloud highlights still lack sufficient glow. No major repeated mistakes, but there is a drift away from a natural sunset feel.

**Step 4: Retouching operation generation**  
`[{"name": "Darken Shadows", "value": 30}, {"name": "Darken Highlights", "value": 20}, {"name": "Color Temperature", "value": 10}, {"name": "Contrast", "value": 5}, {"name": "Red Highlights", "value": 10}, ...]`

**Step 4: Retouching operation generation**  
`[{"name": "Color Temperature", "value": 10}, {"name": "Brighten Highlights", "value": 15}, {"name": "Red Highlights", "value": 10}]`

**Reflection**

**Step 1: Target image analysis**  
 Overall Score = 8.0  
 Color Score = 8.5  
 Light Score = 8.2  
 Alignment Score = 7.0

**Step 1: Target image analysis**  
 Overall Score = 8.3  
 Color Score = 8.0  
 Light Score = 7.5  
 Alignment Score = 7.5

The sky shows a calm, cool-toned look with richer colors thanks to higher vibrance and saturation, and the brightened shadows nicely bring out snowy mountain details. However, the cloud highlights still appear a bit flat and could use more glow to reflect the evening light better. The strong cool tone slightly takes away from the sunset warmth, so a gentle color temperature increase and subtle red highlight adjustment could help restore balance between tranquility and radiance. Enhancing contrast slightly would also add dimension to the sky layers and help water reflections pop more crisply, making the overall scene feel more vivid yet natural.

The sky shows improved sunset coloration, with a golden sky and slightly deepened shadows. However, the overall tonal depth is still limited. The highlights on the clouds remain too flat to create a luminous effect, and the foreground lacks sufficient contrast to distinguish spatial layers. Saturation is high but borders on unnatural in some midtone areas.

**Step 2: Expert example analysis**  
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 Contrast: Moderate contrast is consistently used to carve depth, particularly in sky structures and land silhouettes.  
 Saturation/Vibrance: Vibrance is used more than saturation to boost warm colors selectively, preserving realism.  
 Tone Curves: Shadows are noticeably darkened, and highlight glow is controlled through gentle tonal shaping rather than broad brightening.  
 Color Temperature/Tint: A warm shift is applied, sometimes with red-channel tweaks to enhance sunset hues.

**Step 2: Expert example analysis**  
 Exposure/Brightness: Experts apply controlled brightness to maintain mood while ensuring key areas like snow and clouds remain visible.  
 Contrast: Used to enhance separation between cloud layers and terrain, typically applied subtly.  
 Saturation/Vibrance: Vibrance is used more heavily than saturation to bring out warmth without oversaturating shadows.  
 Tone Curves: Cloud highlights are often lifted through red and blue channels to simulate warm, reflective light.

**Step 3: Historical analysis**  
 By analyzing the operations in the last round, the big jump in saturation and vibrance created strong color but feels a bit artificial. Shadows were darkened, but not enough to fully convey sunset darkness, and the highlights were still left quite bright. And I should now reduce highlight intensity to restore cloud detail, deepen shadows further for stronger dusk presence, and shift color warmth more subtly. Red highlights can be enhanced to recover sunset glow without oversaturation, and contrast should be used more delicately to avoid harsh transitions.

**Step 3: Historical analysis**  
 By analyzing the operations in the last round, these changes improved vividness and snow detail, but the large negative color temperature has cooled the scene too much, while cloud highlights still lack sufficient glow. No major repeated mistakes, but there is a drift away from a natural sunset feel.

**Step 4: Retouching operation generation**  
`[{"name": "Darken Shadows", "value": 30}, {"name": "Darken Highlights", "value": 20}, {"name": "Color Temperature", "value": 10}, {"name": "Contrast", "value": 5}, {"name": "Red Highlights", "value": 10}, ...]`

**Step 4: Retouching operation generation**  
`[{"name": "Color Temperature", "value": 10}, {"name": "Brighten Highlights", "value": 15}, {"name": "Red Highlights", "value": 10}]`

**Step 1: Target image analysis**  
 Overall Score = 8.5  
 Color Score = 8.5  
 Light Score = 8.4  
 Alignment Score = 8.5

**Step 1: Target image analysis**  
 Overall Score = 8.5  
 Color Score = 8.2  
 Light Score = 8.0  
 Alignment Score = 8.0

**Output**

**Output**

Figure 1: Two complete case examples