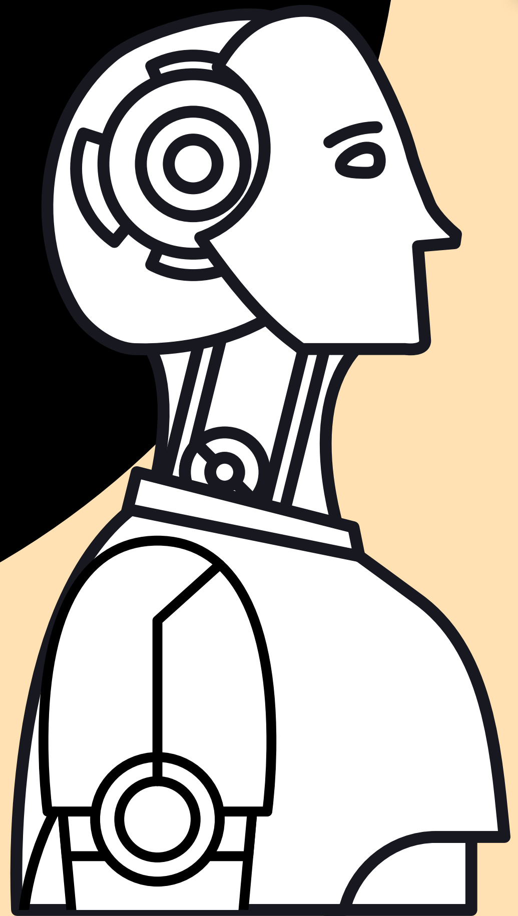
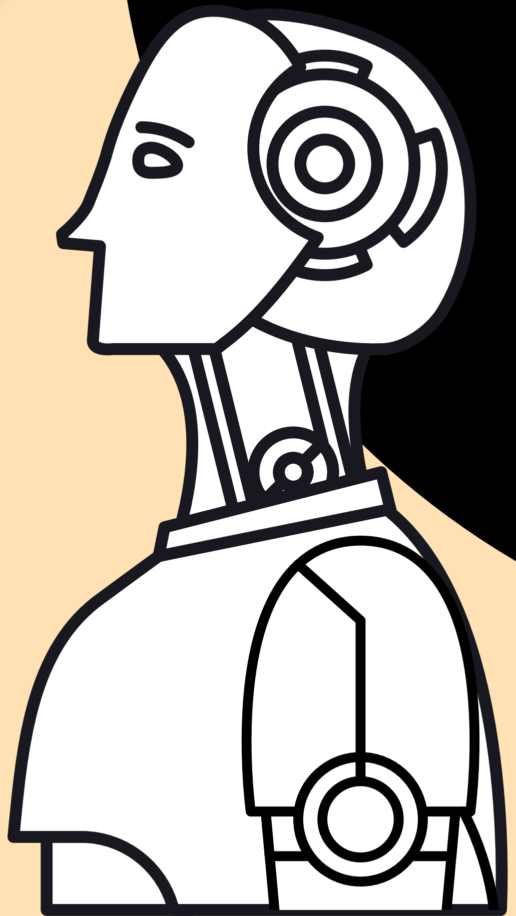
PROJECT TITLE :

IMAGE COLORIZATION, FROM BLACK AND WHITE TO COLOR, USING SELF SUPERVISED DEEP LEARNING MODELS



P R E S E N T A T I O N   B Y :

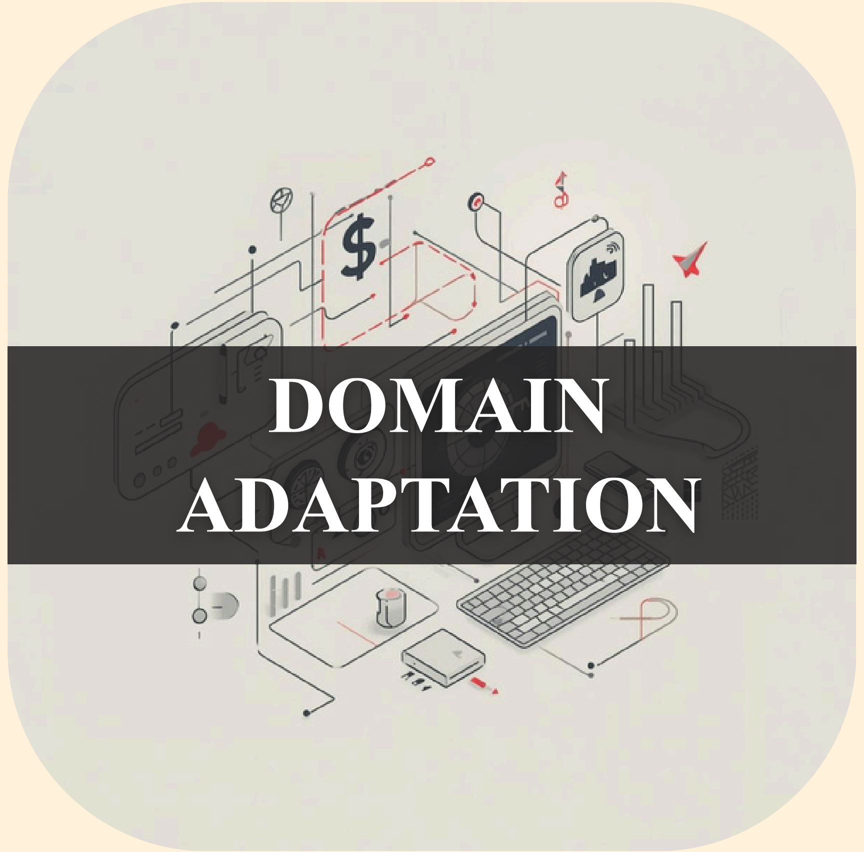
SAYAN ROY



Problem & Motivation: Why Colorize?

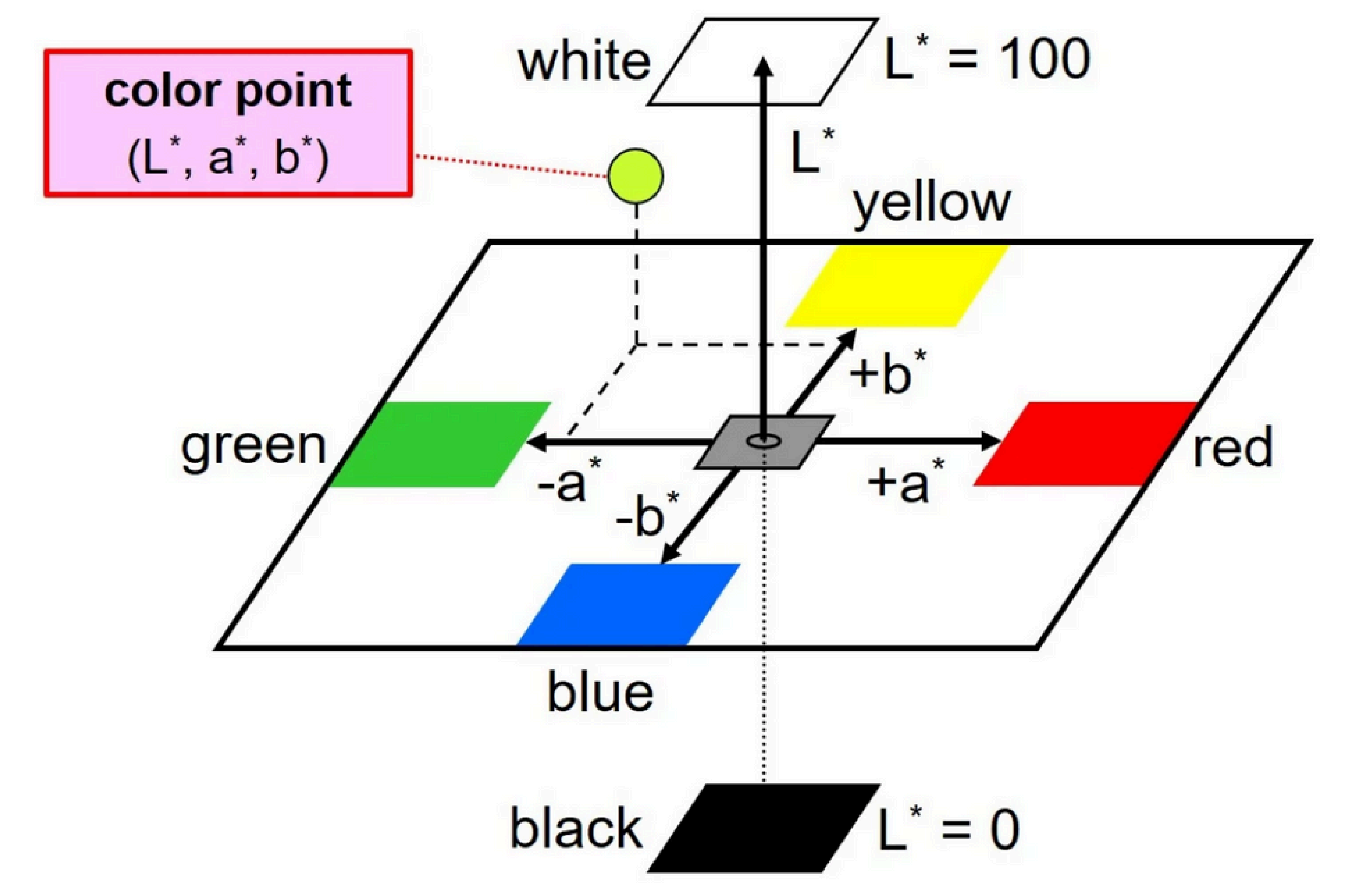
Bring historical photos to life, preserving memories with added visual context and emotional depth.

Empower artists and designers with tools for rapid prototyping and style transfer in various media.



Enhance datasets for downstream computer vision tasks where color information is beneficial but scarce

LAB Colour Space



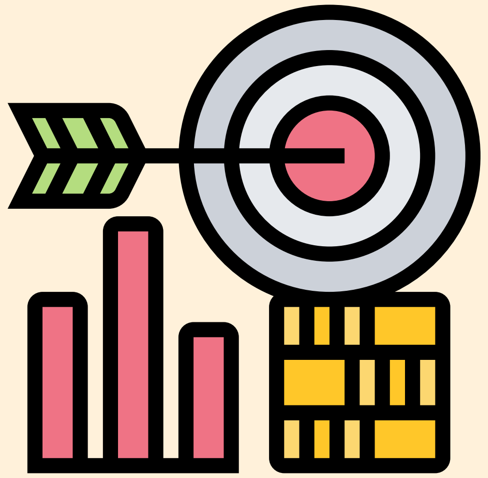
What is LAB color space?

LAB color space is a three-dimensional color model that includes three components:

- L*: Represents lightness, ranging from 0 (black) to 100 (white).
- a*: Represents the green-red axis, where negative values indicate green and positive values indicate red.
- b*: Represents the blue-yellow axis, with negative values indicating blue and positive values indicating yellow

OBJECTIVE

Train a model without manual labels to recover plausible color (a and b) from grayscale L channel input.



Main Challenges in Colorization

Ambiguous Color Priors

A single grayscale pixel can correspond to many possible colors.

High-Frequency Detail

Maintaining sharp edges and textures while applying color.

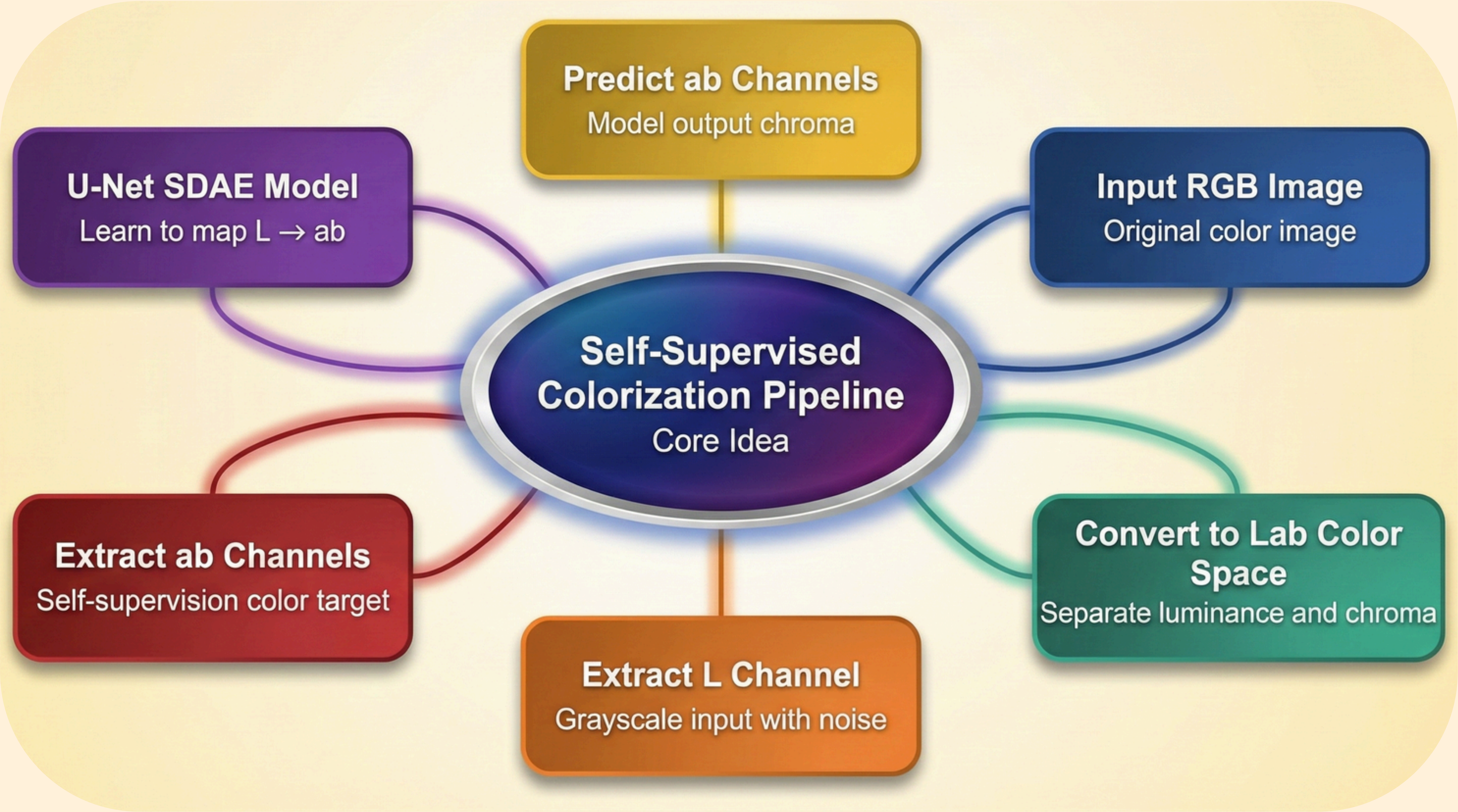
Color Bleeding

Preventing color from spreading into unintended regions.

Metric Mismatch

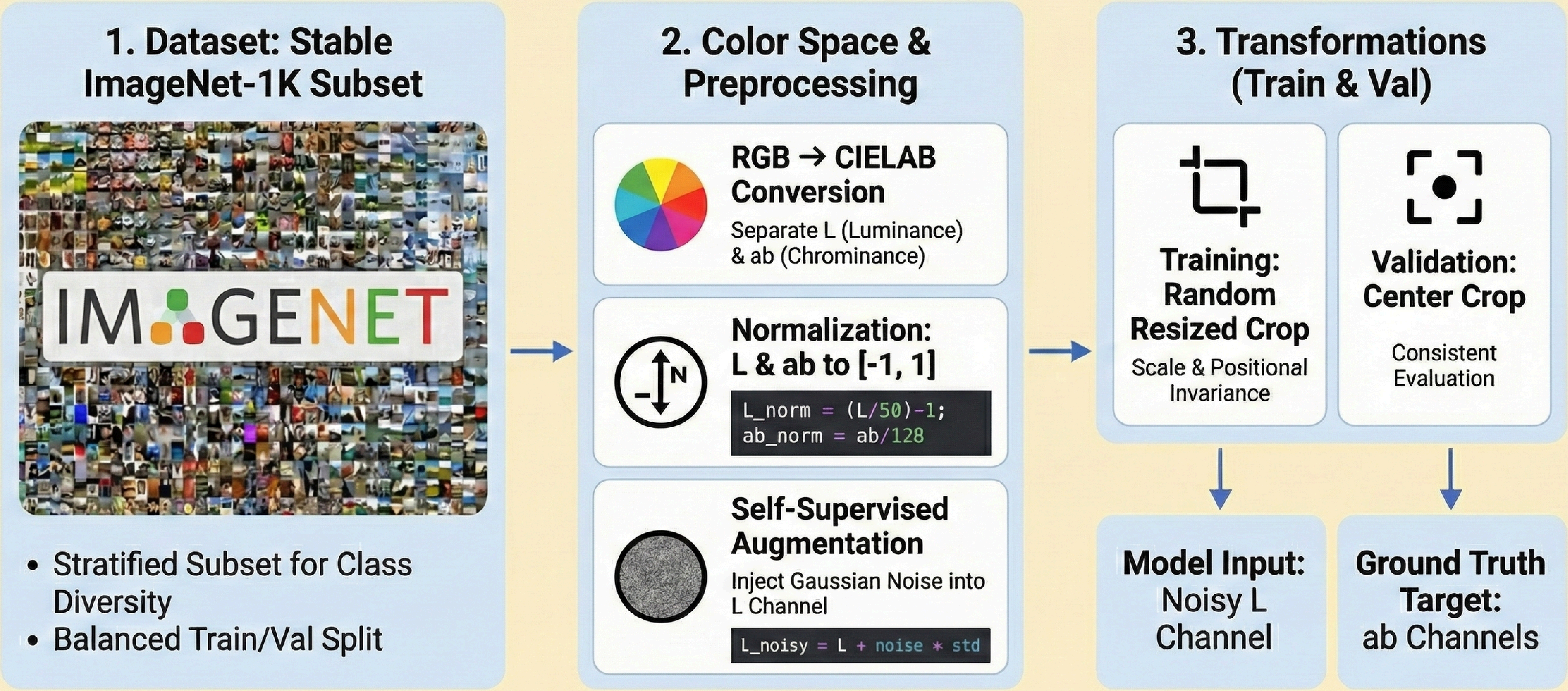
Standard metrics (PSNR, SSIM) often fail to capture perceptual quality.

Core Idea: Self-Supervised Method Overview



- **Input-Target Split** : Automatically decomposes RGB images into grayscale (L) inputs and chromatic (ab) targets
- **Denoising Strategy** : Injects Gaussian noise to drive restorative generation, ensuring robust feature extraction over simple pixel memorization.
- **U-Net Architecture :** Leverages an SDAE with skip connections to preserve high-frequency spatial details for precise edge alignment.

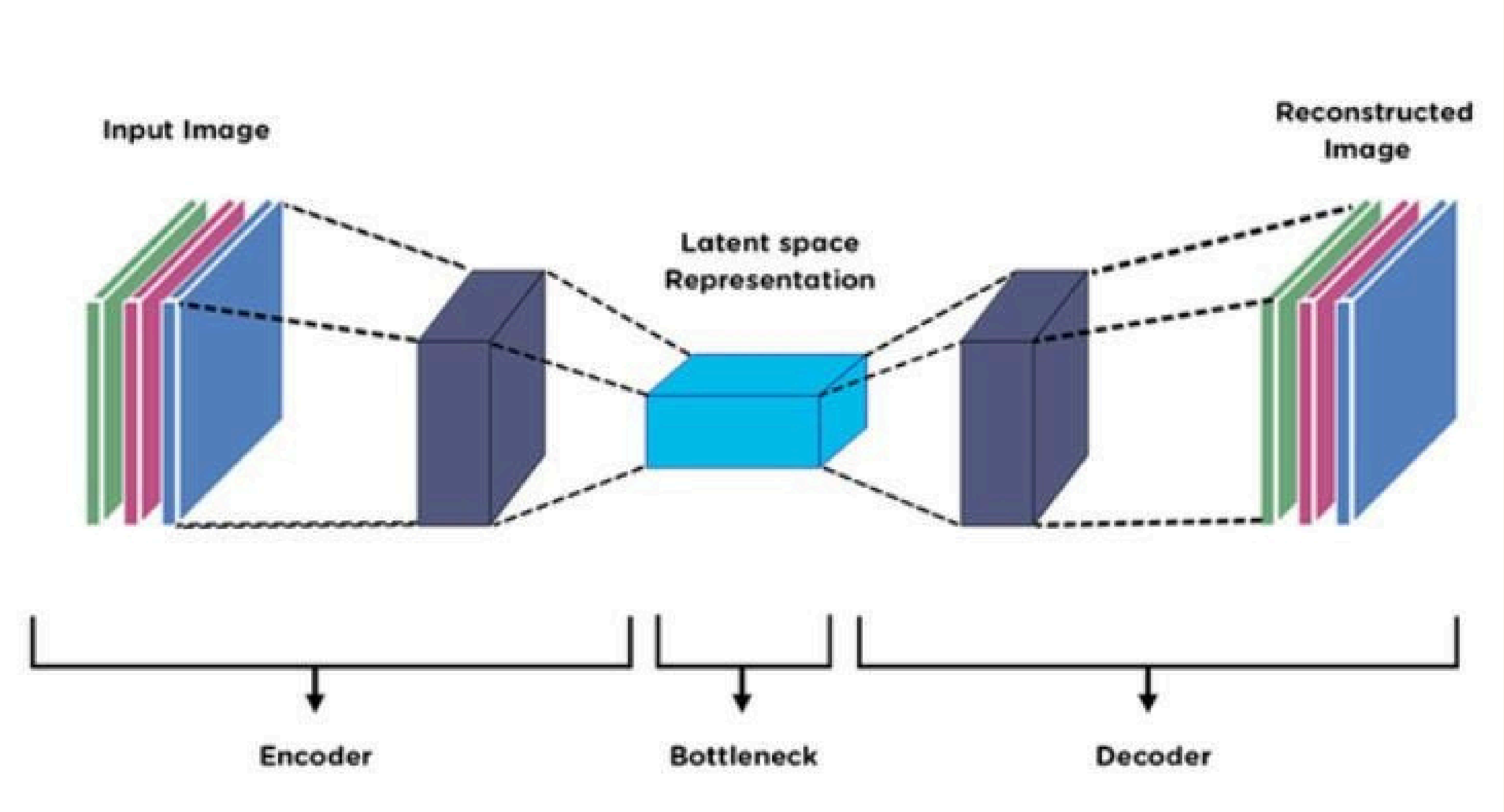
Dataset & Preprocessing



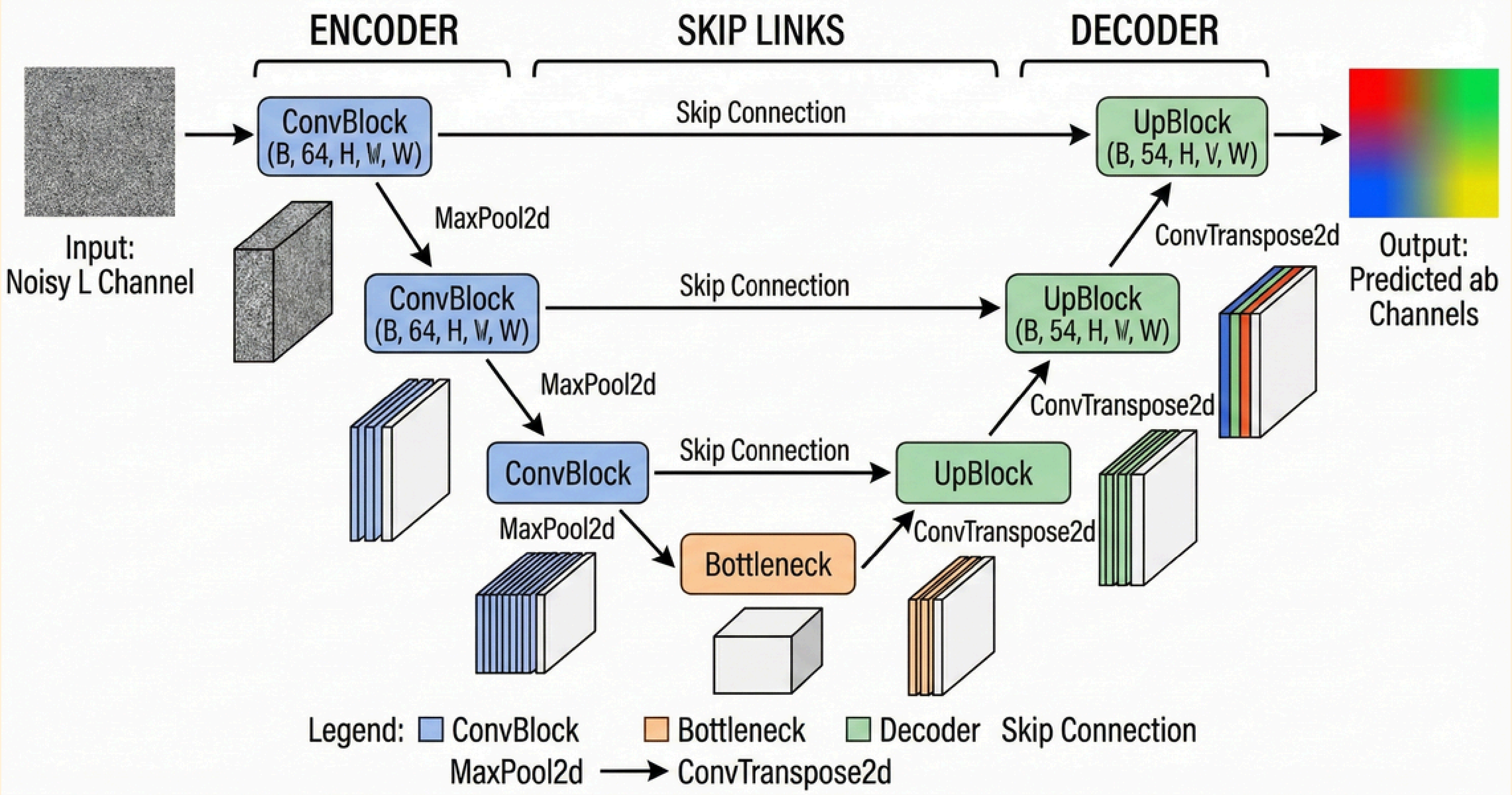
Model Architecture: U-Net SDAE

- Our model, a U-Net adapted as a **Self-Denoising Autoencoder (SDAE)**, predicts ‘ab’ color channels from a noisy ‘L’ input.
- **Key features**: captures high-level semantic information and fine-grained spatial details.

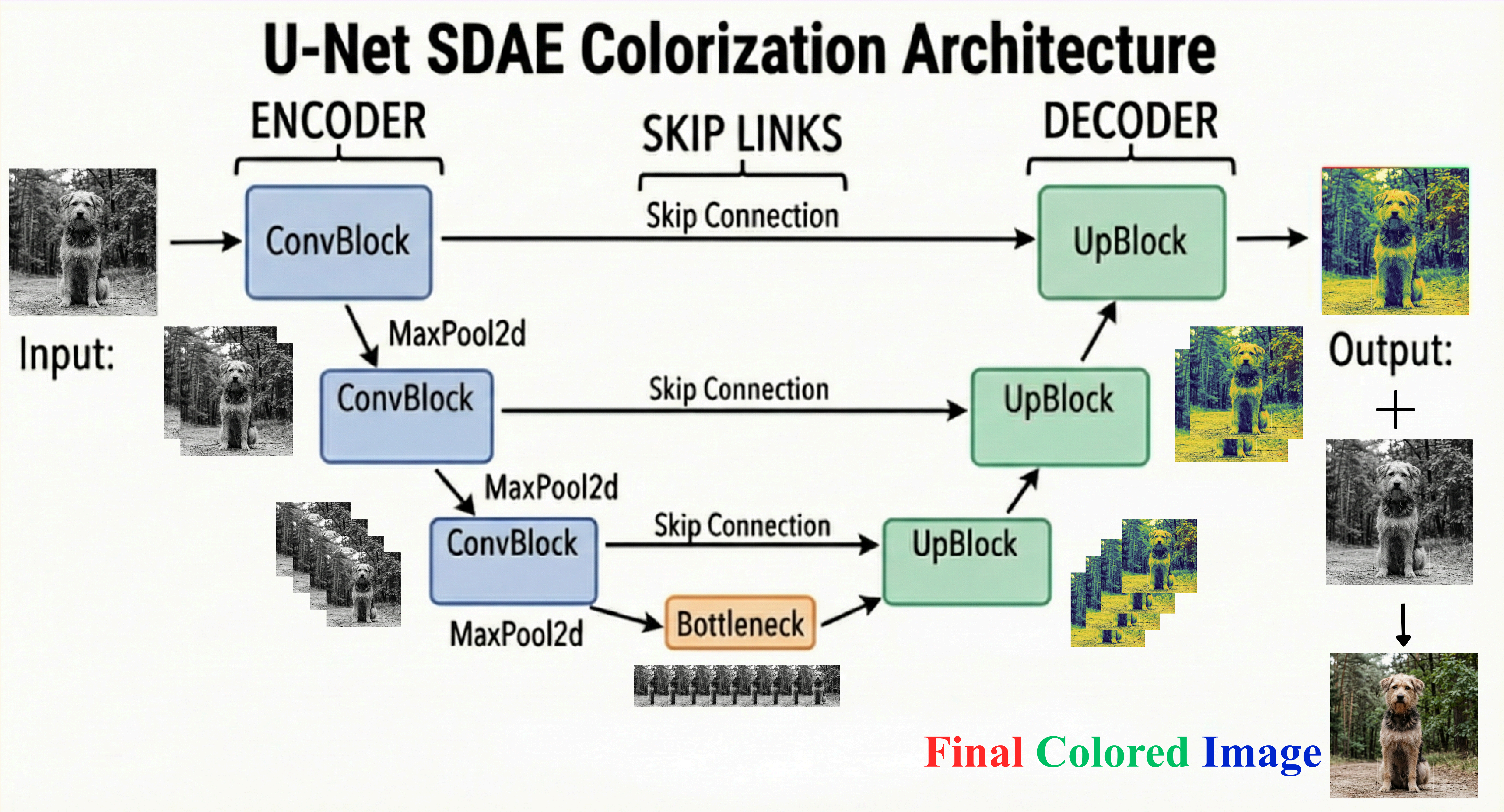
1. Basic Encoder-Decoder Concept



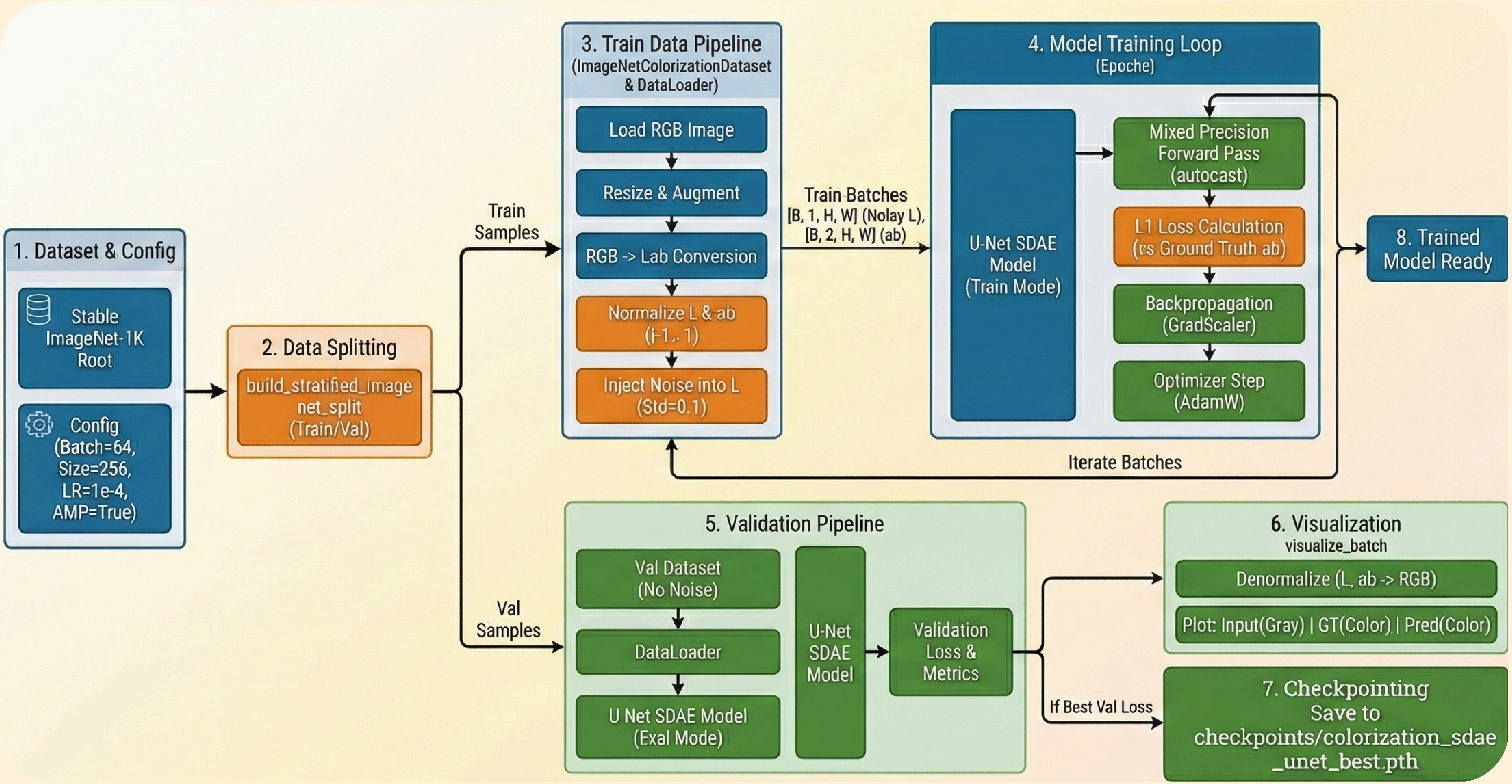
2. Our U-Net SDAE Colorization Architecture



Visualization of the Model's Working



End to End System Training Pipeline



Results & Visualizations

Quantitative Evaluation: Visual Results (After only 30+ epochs)

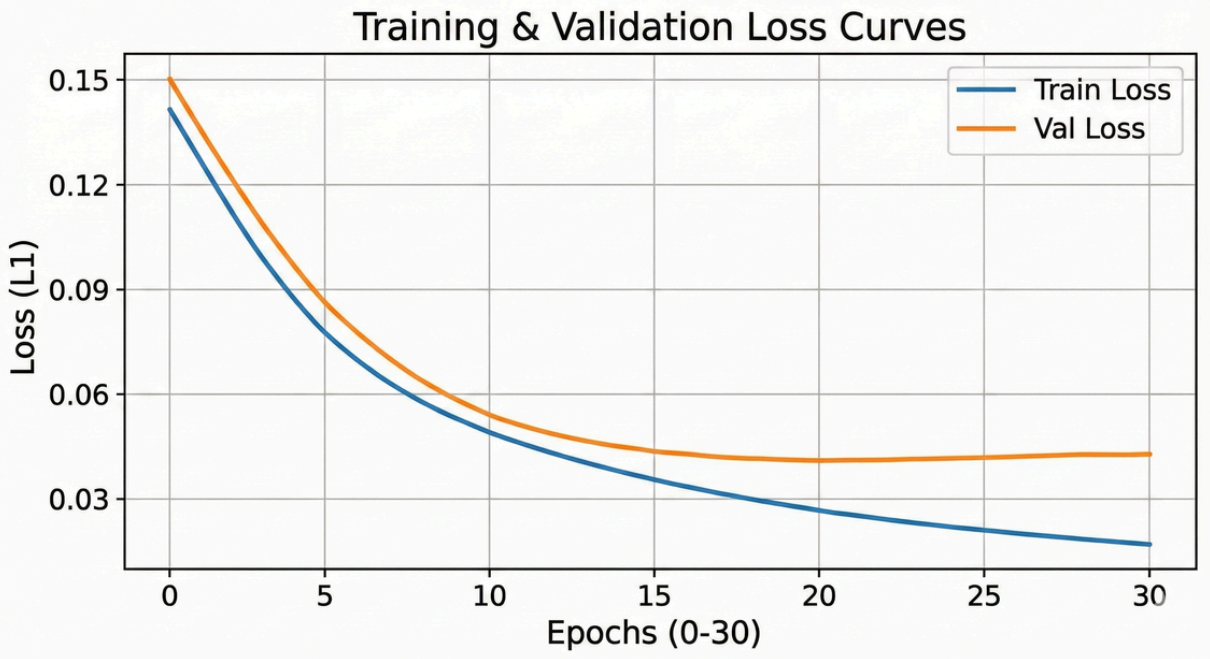
Model successfully distinguishes semantic regions (e.g. **red berry vs green stem**) and preserves high-frequency details, independent of gray scale intensity

Quantitative Metrics & Training Dynamics

Key Performance Metrics

Metric	Value	Interpretation
Final Validation L1 Loss	~0.04	Low pixel-level error
Peak Signal-to-Noise Ratio (PSNR)	~26.0 dB	High reconstruction quality

Note: Metrics indicate strong alignment with ground truth.



Analysis & Limitations:

- **Stable Convergence**: SDAE approach (noise injection) acts as an effective regularizer, preventing overfitting.
- **Color Ambiguity**: Model may predict desaturated tones in ambiguous, untextured areas to minimize L1 error.
- **L1 Loss Trade-off**: Slight 'averaging' effect can lead to less vibrant colors in complex scenes compared to ground truth.

Real-World Application: Cultural Heritage Preservation

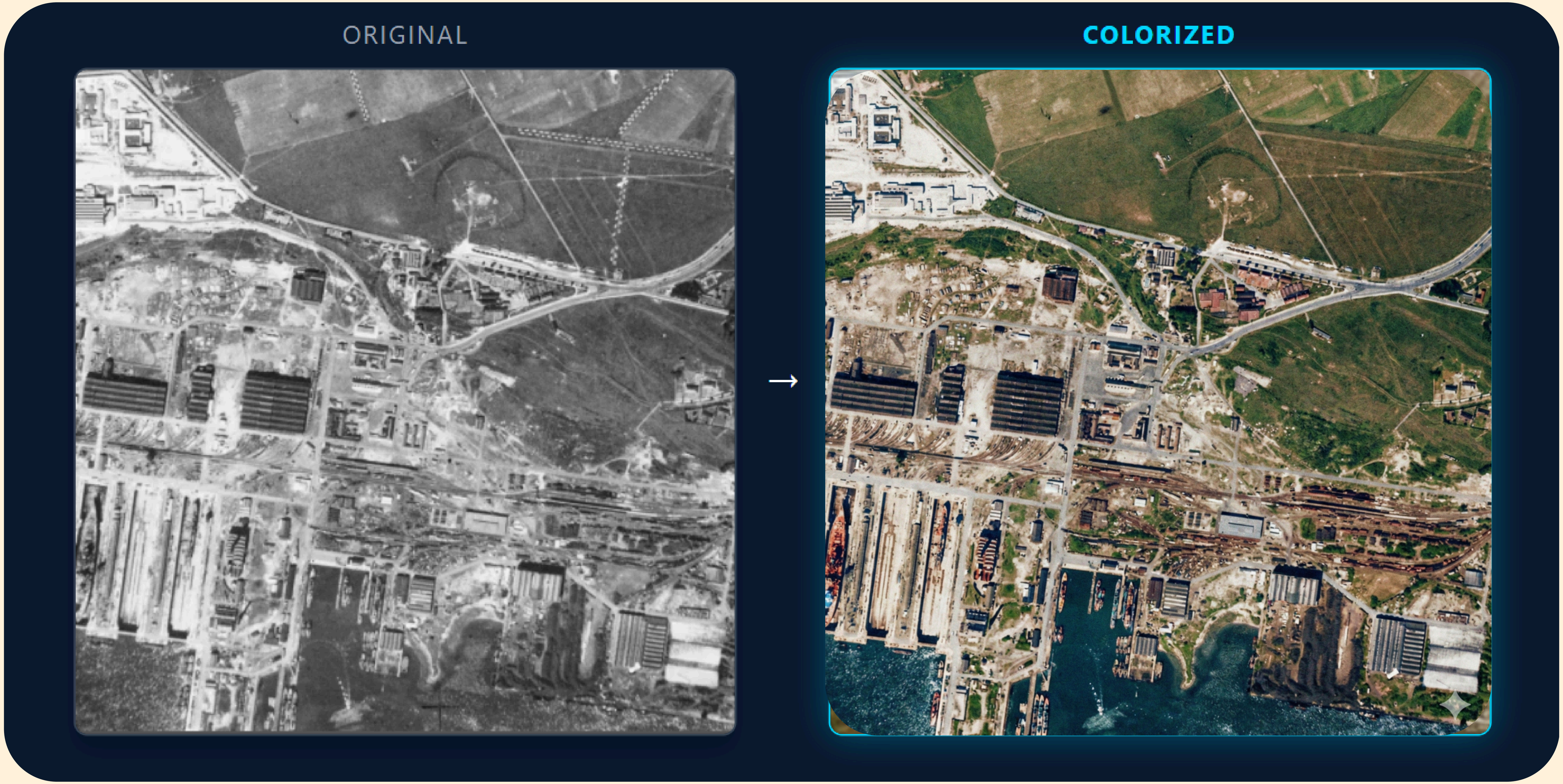
Restoring Masterpieces: Satyajit Ray’s Pather Panchali (1955)

ORIGINAL

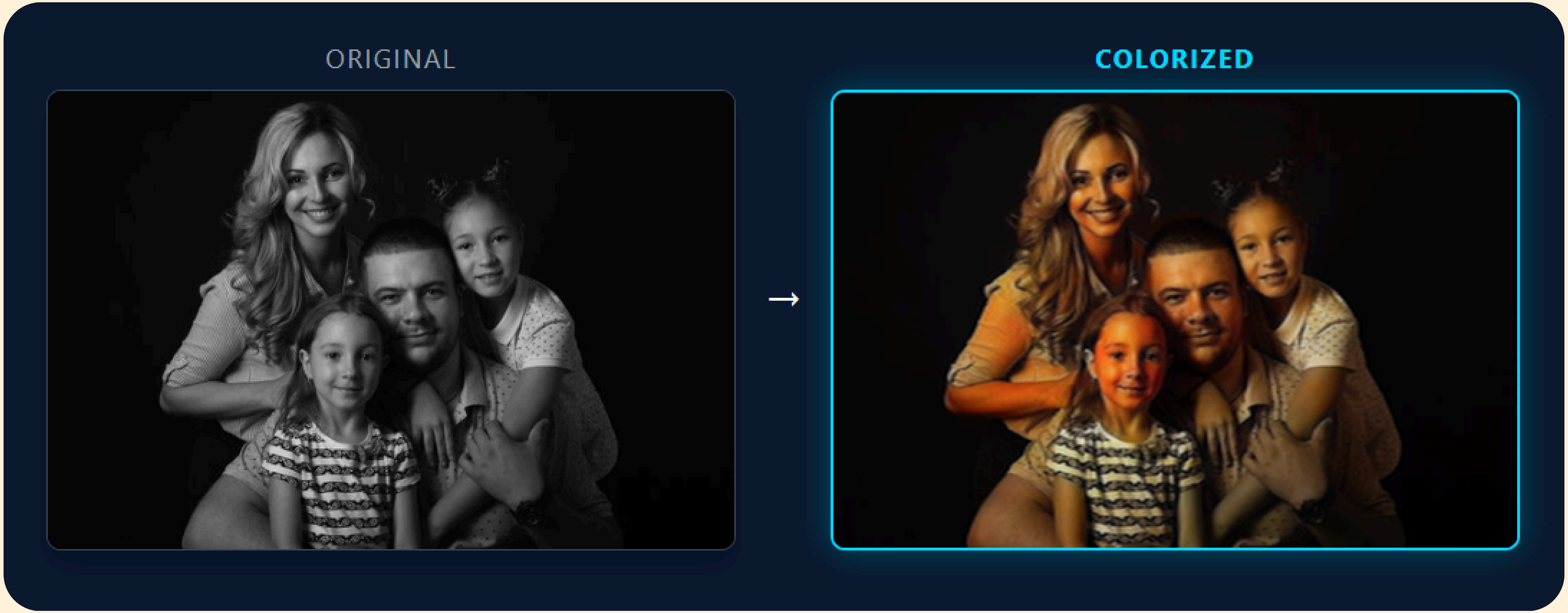
→

COLORIZED

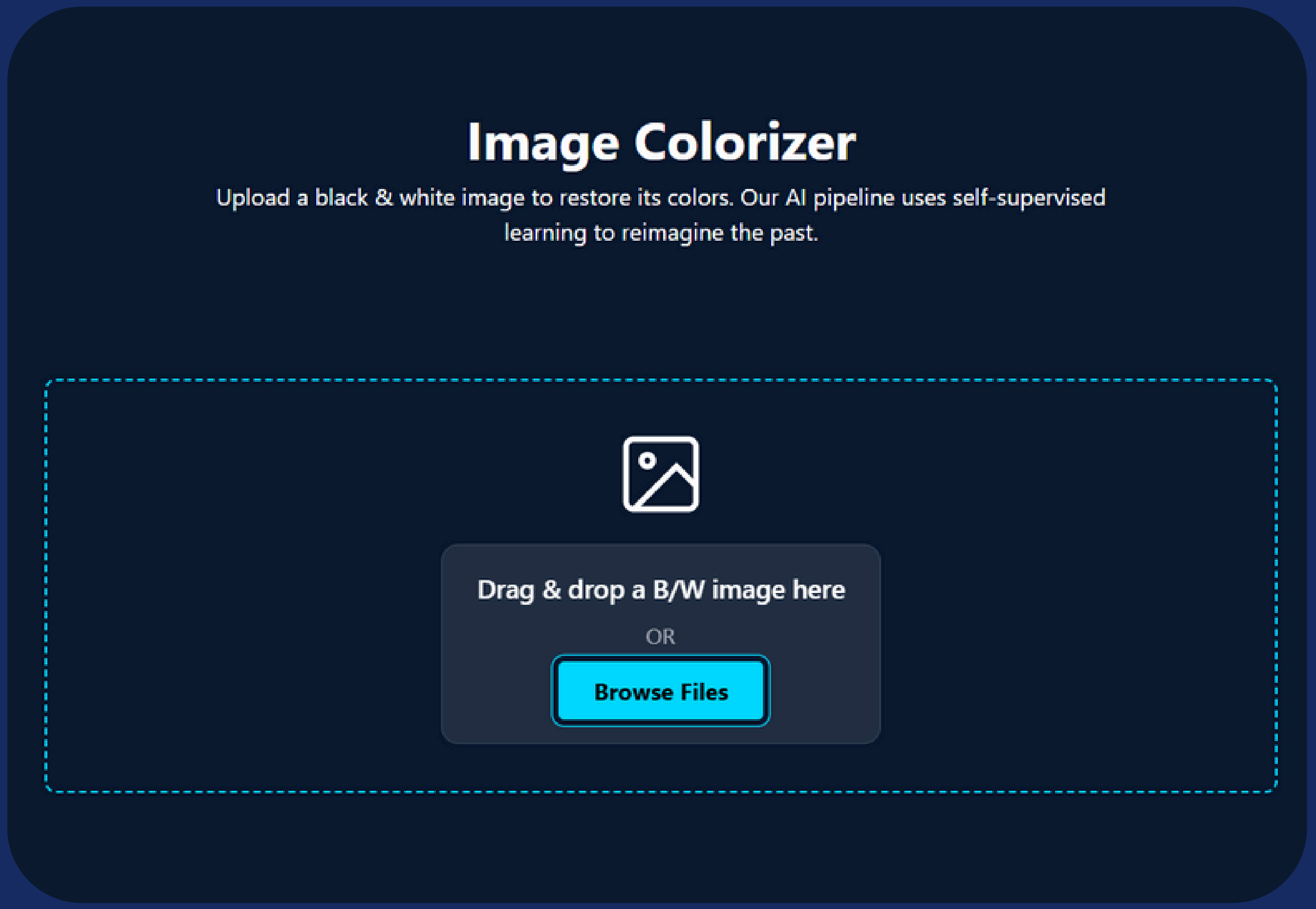
Satellite & Aerial Imagery Enhancement (Gov + Industry)

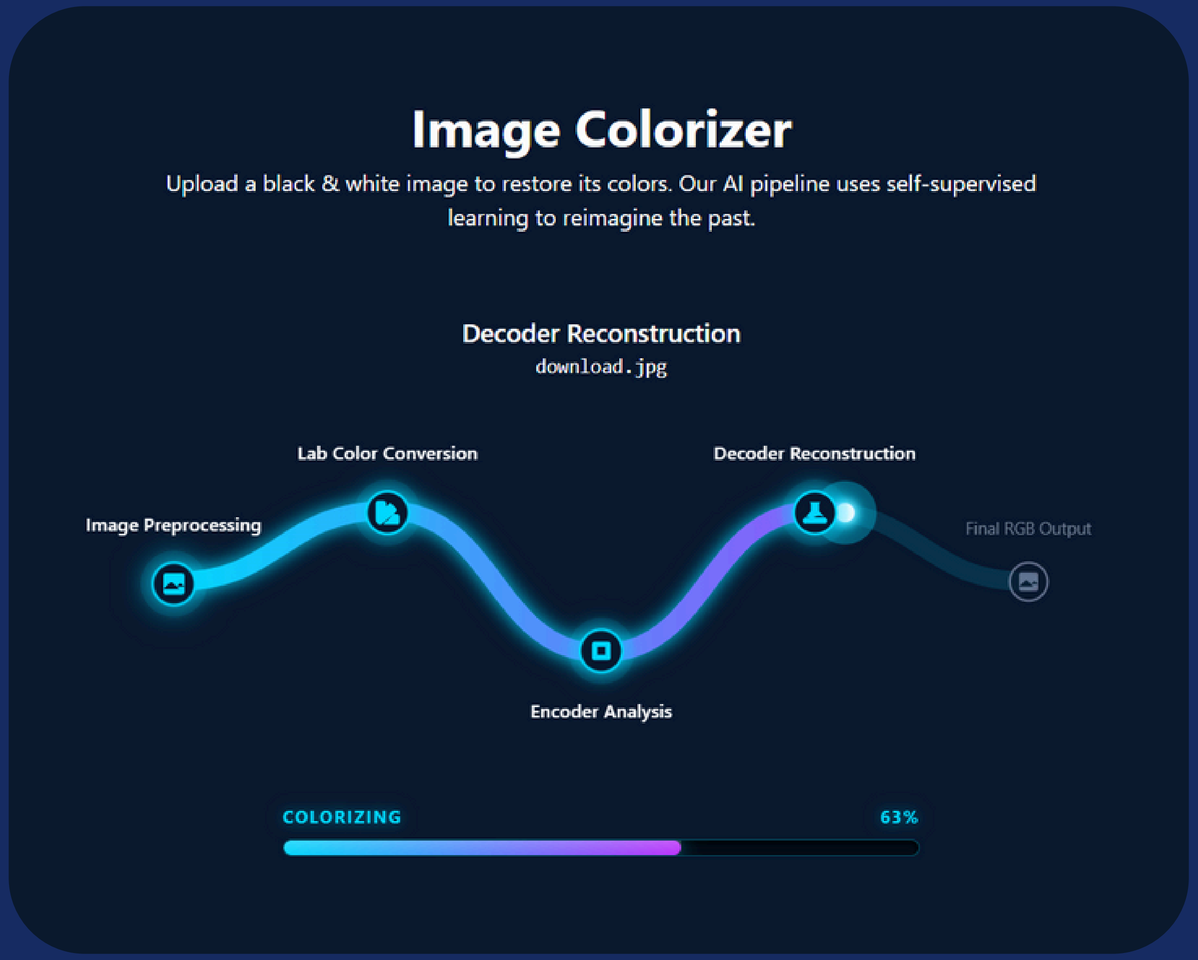


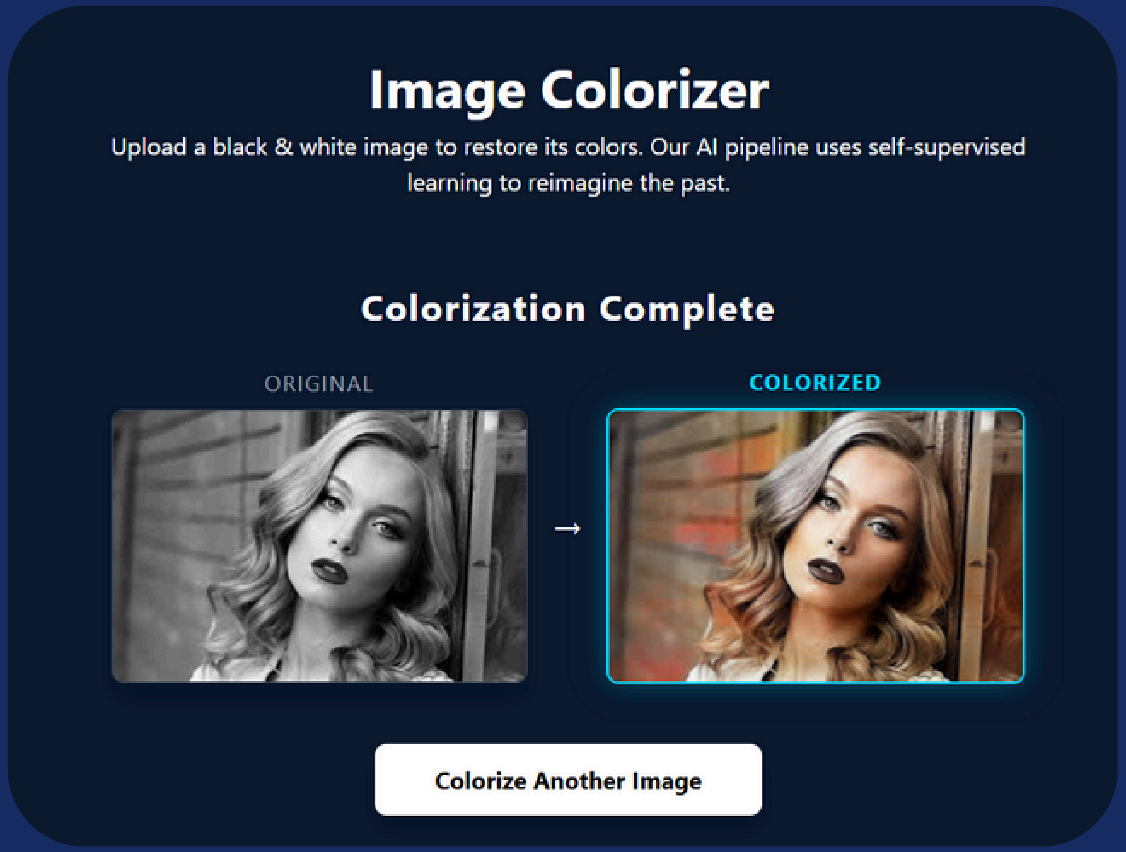
Consumer Apps (Family Photo Colorization)



User Interface







Conclusion & Future Roadmap

Key Achievements

Robust U-Net SDAE Model
Self supervised learning, effective colorization

Optimized Preprocessing
Lab color space, noise injection pipeline

Reliable Training System
Seamless checkpointing for resumption

Future Enhancements & Next Steps

Perceptual Losses
(VGG/GAN for visual realism)

B&W Movie Restoration:
with temporal consistency

High-Resolution Colorization pipeline
preserving fine details

User-Guided Color Hints
(scribbles for artistic control)

THANK YOU