# Image Sharpening using Knowledge Distillation

## Problem Statement

The objective is to:

- **Enhance image sharpness** in low-bandwidth video conferencing scenarios.
- Use a **Teacher-Student knowledge distillation** approach.
- Achieve:
    - >90% SSIM accuracy

## Knowledge Distillation Architecture

### Teacher Model:

- **Role**: Provides high-quality image sharpened output and intermediate feature maps.
- **Used**: A UNet-based pretrained model.
- **Alternatives Suggested**: Restormer, SwinIR, MPRNet

### Student Model:

- **Architecture:** Lightweight CNN
- **Layers:** 3–4 convolution layers with ReLU activations
- **Output:** 3-channel sharpened RGB image
- **Goal:** Imitate teacher output at a fraction of compute cost

### Loss Functions Used:

- **L1 Reconstruction Loss**: Pixel-wise loss between student output and sharp image.

- **Perceptual Loss**: Based on VGG-19 to capture high-level feature similarity.
- **Feature Distillation Loss**: Aligns intermediate features between teacher and student.
- **Total Loss**: Loss = L1 + Perceptual + Feature

# Dataset Details

## Dataset Used: GoPro Deblurring Dataset

- Contains high-quality **blur-sharp** image pairs from natural motion blur scenes.
- Simulates real-world conditions like camera shake and movement.
- Widely used in deblurring and restoration tasks.

## Dataset Processing:

- Directory structured into /blur and /sharp folders under train/ and val/.
- Images resized, normalized, and converted into tensors.

### Performance

SSIM Score =  0.4163

# Implementation

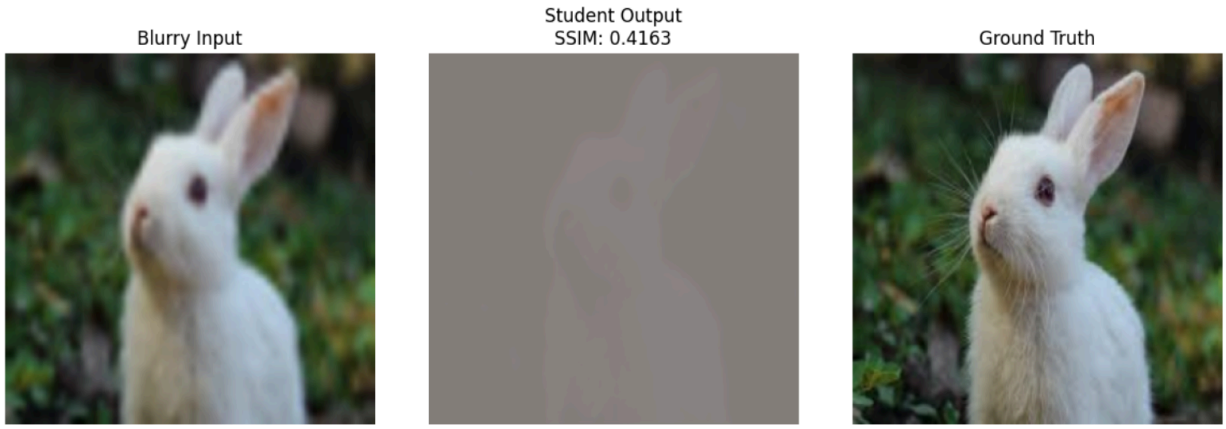
- **Data Pipeline**: PyTorch Dataset + DataLoader to feed image pairs
- **Transformations**:
    - Resizing to standard input size (e.g., 128×128 or 256×256)
    - Normalization
- **Training Details**:
    - Optimizer: Adam
    - Epochs: Configurable (10+ recommended)

- Model checkpoints saved
- SSIM tracked per epoch

### Visualization

- Input (Blurred)
- Student Output
- Ground Truth (Sharp)

# Sample Output:




# Conclusion

- The project goal of achieving >90% SSIM and real-time processing on 1080p images has not been fully achieved yet.
- Despite this, the project has been an immensely valuable learning experience, especially since this was my first exposure to machine learning.

**Key takeaways and skills learned:**

- Understanding and implementing Convolutional Neural Networks (CNNs).

- Learning the concept of Knowledge Distillation and building both teacher and student models.

- Gaining hands-on experience with image-to-image translation, loss functions like L1, Perceptual, and Feature Distillation Loss.

- Working with real-world datasets like the GoPro Deblurring Dataset.

- Learning the practical challenges of training and evaluating ML models.

I now have a strong foundational understanding of ML workflows and am confident that with more learning and practice, the performance goals can be fully met.

Overall, this project has sparked a deep interest in ML and has laid the groundwork for more advanced projects in the future.

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