Image Super-Resolution App

Image Super-resolution App – Full Technical Documentation

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Project Overview

The Image Super-Resolution App is a deep learning–powered web application that enhances low-resolution images using EDSR (Enhanced Deep Super-Resolution Network). The application is built with Streamlit and is designed for both local execution and cloud deployment (Streamlit Community Cloud).
This project demonstrates:

- Practical deployment of deep learning models
- Handling real-world deployment constraints (CPU, memory limits)
- End-to-end ML application lifecycle

Motivation

Low-resolution images are common in:

1. Old photographs
2. Compressed images from the web
3. Surveillance and medical imaging

Traditional interpolation methods (bicubic, bilinear) fail to recover fine details. Deep learning–based super-resolution models like EDSR learn complex mappings to reconstruct high-frequency details, producing visually superior results.
This project aims to:

a. Provide an interactive, user-friendly interface for super-resolution
b. Demonstrate practical ML deployment, not just model training

Features

1. Upload PNG / JPG / JPEG images
2. Choose upscale factor (2× or 4×)
3. Real-time super-resolution inference
4. Before/After comparison slider
5. Download super-resolved image

Tech Stack

1. Frontend
Streamlit – UI framework
streamlit-image-comparison – Before/After slider

2. Backend / ML
PyTorch – Deep learning framework
torchsr – Super-resolution model zoo
EDSR – Pretrained super-resolution model

3. Image Processing
Pillow (PIL) – Image I/O
torchvision.transforms – Tensor conversion

4. Deployment
Localhost – Development & testing
Streamlit Community Cloud – Demo

Project Structure

```
project_root/
│
├──── temp                  #stores temp images
├──── app.py                # Main Streamlit application
├──── requirements.txt      # Python dependencies
└──── README.md             # Basic project overview (optional)
```

Requirements & Dependencies

- Torch
- Torchvision
- Torchsr
- streamlitstreamlit-image-comparison
- Pillow

Python version: python 3.9.x – 3.10.x recommended, newer version creates extreme incompatibilities

Model Architecture (EDSR)

EDSR (Enhanced Deep Super-Resolution Network) is a CNN-based architecture optimized for super-resolution tasks.

Characteristics:
Removes batch normalization layers (improves performance)
Uses residual blocks
Optimized for perceptual quality

Pretrained Models Used:
EDSR ×2
EDSR ×4
EDSR ×8 (Can be used, but removed due to high resource demand as it is deployed on a free cloud server)

Models are loaded using:
from torchsr.models import edsr

Application Workflow

1: Model Initialization
Models are loaded once using @st.cache_resource
Automatically selects CPU or GPU
2: Image Upload
User uploads an image
Image is converted to RGB
3: Upscale Factor Selection
User selects 2× or 4×
4: Inference
Image converted to tensor
Passed through selected EDSR model
Output tensor converted back to image
5: Visualization
Original image displayed
Before/After slider rendered
6: Download
Super-resolved image downloadable as PNG

Cloud Deployment Constraints

Problem:
Streamlit Community Cloud:
- CPU-only
- Limited RAM (~1 GB)
- No GPU acceleration

Observation:
- 2× super-resolution works reliably
- 4× super-resolution may crash for large images due to high memory usage

Possible solution(yet to be implemented):
1. Switch to a better server
2. Use a warning:

```
MAX_PIXELS_4X = 512 * 512
if scale == 4:
w, h = img.size
if w * h > MAX_PIXELS_4X:
st.warning("Image resized for 4× stability on cloud")
img = img.resize((512, 512))
```

Performance Considerations

Problems:
a. Memory usage grows quadratically with upscale factor
b. 4× output contains 16× more pixels than input
c. Inference time increases significantly on CPU

Optimizations applied:
1. Single-thread execution
2. Model caching
3. Explicit memory cleanup

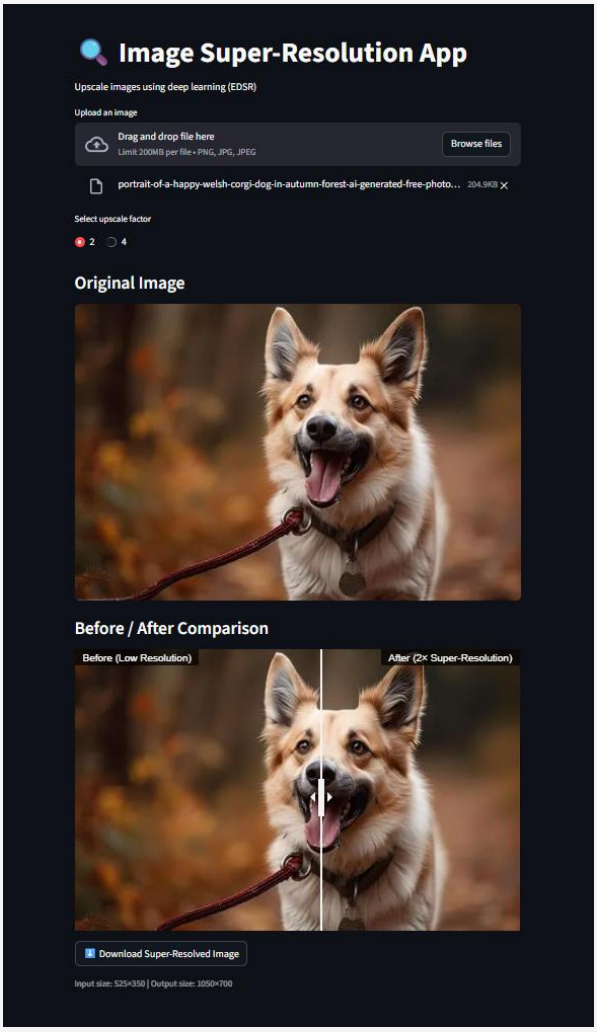
Deployment

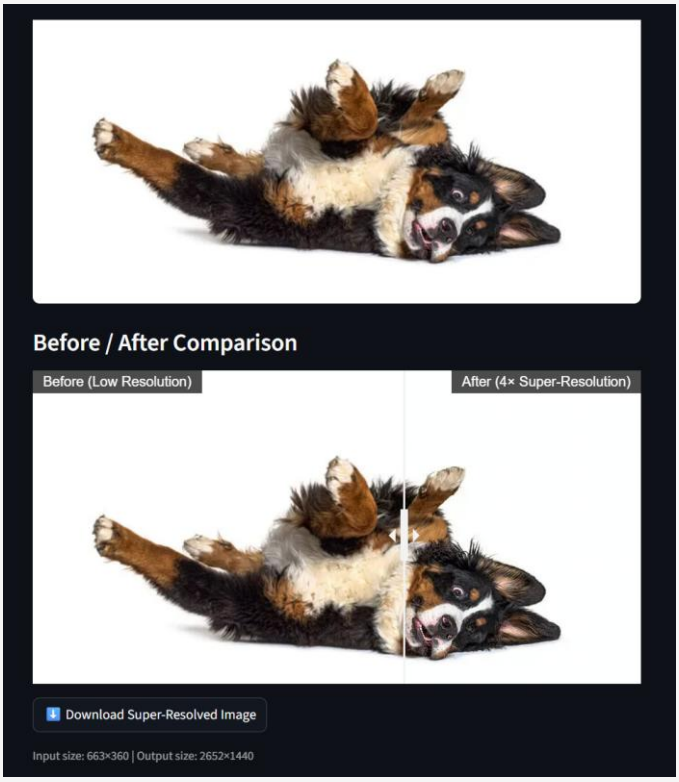
Local Deployment @Localhost
Run Locally at project Folder:

pip install -r requirements.txt
streamlit run app.py

Server Deployment:
1.Push project to GitHub repository
2. Go to https://share.streamlit.io
3. Connect GitHub account
4. Select repository
5. Set app.py as entry point
6. Deploy

Link:
https://image-super-resolution-app-ibmbu2m5hlc2g2szjqtafd.streamlit.app/





Future Improvements

Tile-based inference for large images
GPU deployment (Hugging Face / AWS)
Image format optimization
Model selection UI
Better Looking UI
Integration with API for better future scalability

○ Support for ESRGAN / Real-ESRGAN:

The trial for ESRGAN / Real-ESRGAN has already been initiated but soon it is found that, while implementing we expericenced same error every time :

ModuleNotFoundError: No module named 'torchvision.transforms.functional_tensor'

Its is found that :
"functional_tensor submodule was deprecated and removed in newer versions of Torchvision, starting from version 0.15.
This module was previously used for tensor-specific image transformations but has been replaced by the functional module."

Same Issue like mine can be found at:
https://github.com/pytorch/vision/pull/7269
https://discuss.pytorch.org/t/no-module-named-torchvision-transforms-functional-tensor/206390