Image Super Resolution

Group 6

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Overview

Goal:

- Produce a *predicted* high resolution image based on the low-resolution input
- Balance between the running cost and predictive performance

Outline:

- Baseline
- Advanced Algorithm (SRCNN)
- Model Evaluation

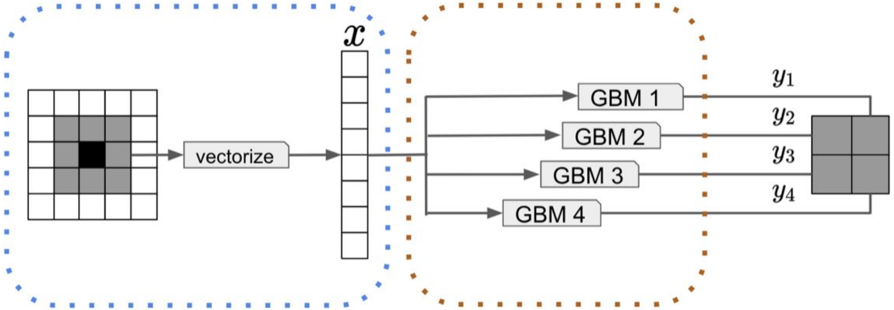
1. Baseline

Neighboring pixels with GBM

Feature Construction

Baseline Algorithm

Build low/high-resolution patch pairs, and learn the best mapping between them.



Feature Extraction

Low and High-resolution image patches ILR and IHR with sizes D×D and U×U (D=3,U=2)

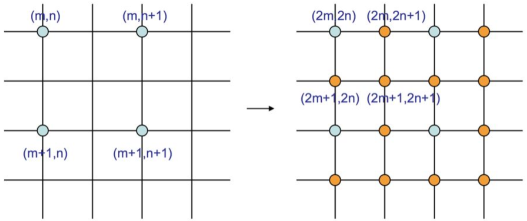
$$x = \text{vectorize}(I_{LR}) - \text{center pixel}(I_{LR}) \in \mathbb{R}^{D^2 \times 1}$$

$$y = \text{vectorize}(I_{HR}) - \text{center pixel}(I_{LR}) \in \mathbb{R}^{U^2 \times 1}$$

Prediction Algorithm

For R/G/B channel:

Predictor(x): First outside layer (8 pixels) of each pixel
Response(y): Corresponding 4 subpixels



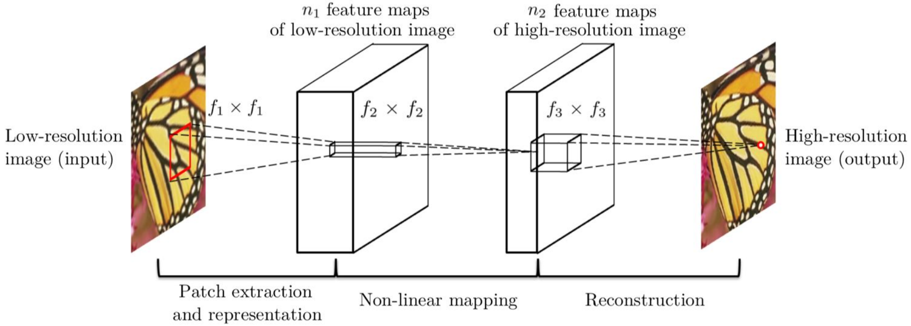
Model:

- 3 channels * 4 sub-pixels = 12 models
- Linear regression model
- Tune parameters by Gradient Boosting Machine(number of trees, depth, etc)

2. Advanced Algorithm

Super-Resolution Convolutional Neural Networks

Architecture of Super-resolution Convolutional Neural Network



Patch extraction and representation

Extract patches from the low-resolution image and represents each patch as a high-dimensional vector. These vectors comprise a set of feature maps.

$$F_1(\mathbf{Y}) = \max\left(0, W_1 * \mathbf{Y} + B_1\right),$$

Non-Linear mapping

This operation nonlinearly maps each high-dimensional vector onto another high-dimensional vector. Each mapped vector is conceptually the representation of a high-resolution patch. These vectors comprise another set of feature maps.

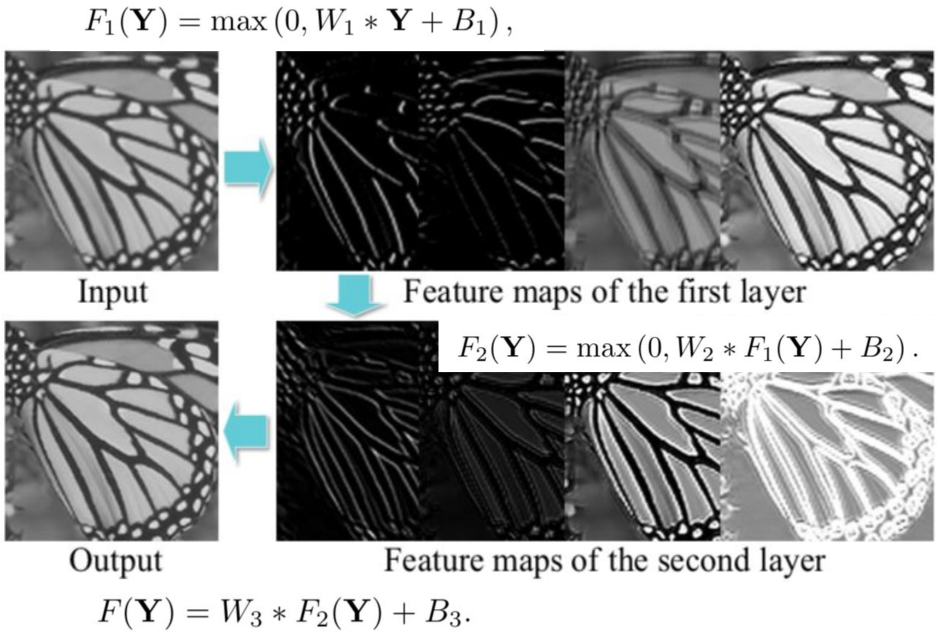
$$F_2(\mathbf{Y}) = \max\left(0, W_2 * F_1(\mathbf{Y}) + B_2\right).$$

Reconstruction

This operation aggregates the above high-resolution patch-wise representations to generate the final high-resolution image. This image is expected to be similar to the ground truth X.

$$F(\mathbf{Y}) = W_3 * F_2(\mathbf{Y}) + B_3.$$

Example feature maps of different layers



Recall of Terminology

Feature:Piece of **information** that describes a part of image or whole image. These features could be corners, edges, lines, color, etc.

- Feature maps of the first layer: **Structures** (e.g., edges at different directions)
- Feature maps of the second layer: **Intensities**

Model Training and Performance Trade off

Learning algorithm: a set of instructions that tries to model the **target function** using training dataset.

In this case,

Learning the end-to-end mapping function ***F*** requires the estimation of network parameters Θ = {*W1, W2, W3, B1, B2, B3*}. This is achieved through minimizing the loss between the **reconstructed images** F(Y;Θ) and the **corresponding ground truth high- resolution images** X.

Given a set of high-resolution images {Xi} and their corresponding low-resolution images {Yi}, we use **Mean Squared Error (MSE)** as the *loss function*:

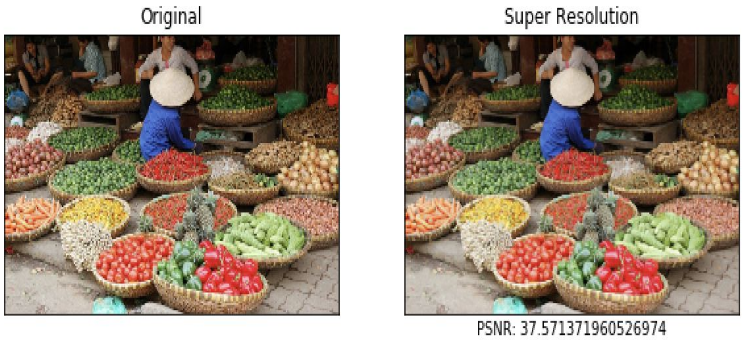
$$L(\Theta) = \frac{1}{n}\sum_{i=1}^{n} ||F(\mathbf{Y}_i;\Theta) - \mathbf{X}_i||^2,$$

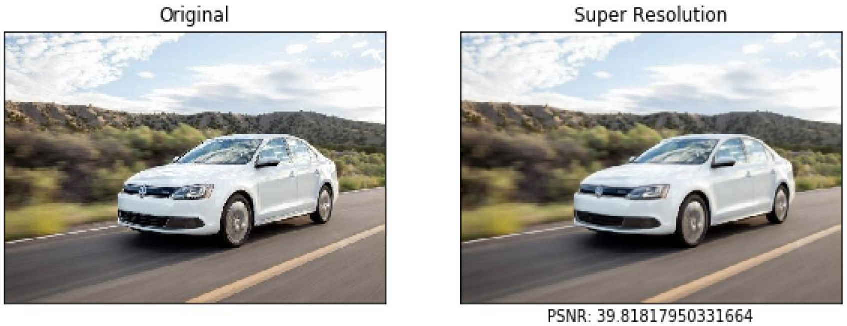
Performance	Filter Numbers	Filter Size	Number of Layers
Accuracy	+	+	No apparent
Computational Efficiency	-	-	-
Setting	n1=64, n2=32	f1 =9, f2 =1, f3 =5	3

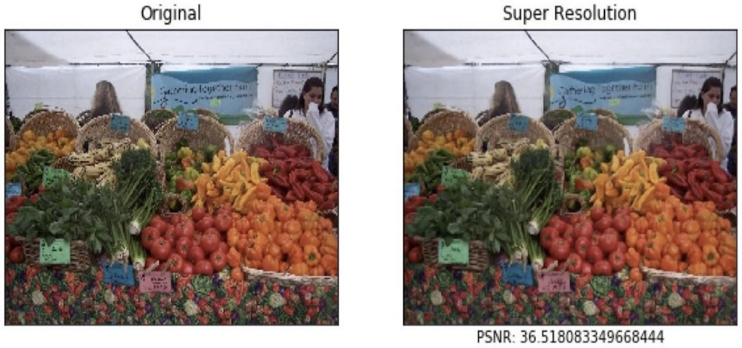
3. Model Evaluation

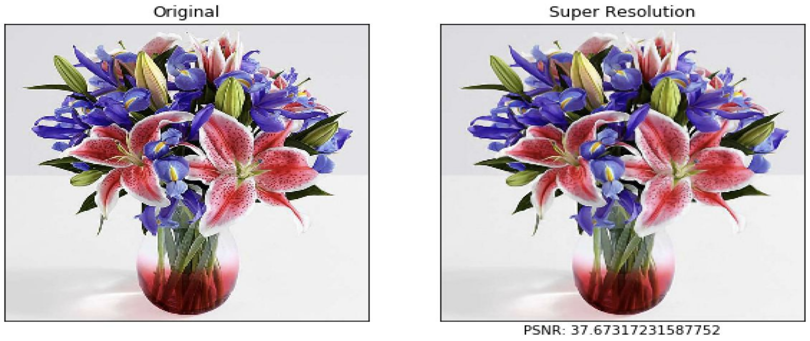
Baseline & SRCNN

Super Resolution by SRCNN









Performance Improvement

	Baseline	SRCNN
Average PSNR	25.0	**31.2**
Running Time (1500 images)	20min	**10min**

Model Comparison

Criteria	Baseline	SRCNN
Complexity	**Easy to implement**	Hard to understand
SR Speed	Time Consuming	**Fast**
Accuracy	Low Accuracy	**High**
Data Requirement	**Small Dataset**	Data hungry

Conclusion

- SRCNN performs remarkably in the perspective of **Accuracy** and Super resolution **Speed**.
- **Computational expensive** to train.
- **Hard to comprehend** without strong theoretical foundation.

THANKS!

- Reference

Image Super-Resolution Using Deep Convolutional Networks

http://mmlab.ie.cuhk.edu.hk/projects/SRCNN.html