Image Super-Resolution Using Deep Convolutional Networks

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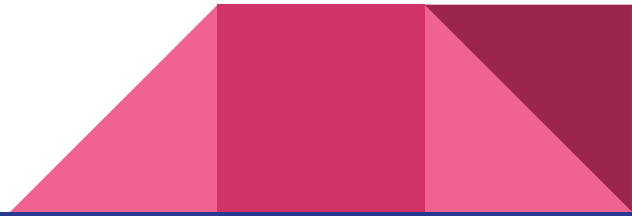


1. Problem statement

- Aim is to Convert Single Low Resolution Image to High Resolution Image.
- Classic problem in Computer Vision.
- Not a Well defined problem because solution is not Unique.
- One Solution : Constraint the Solution space by using prior Information.

1.Problem Statement

Low Resolution Image

Original / PSNR

Y

Mapping F(Y)

Goal is to Create end to end Mapping Between Y and X

High Resolution Image

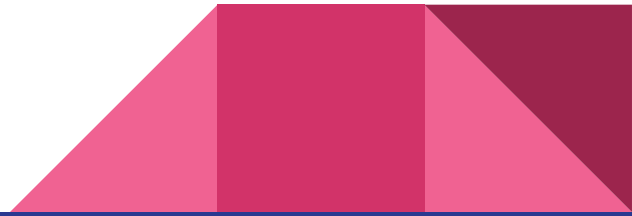
SRCNN / 27.95 dB

X

Source : Images from paper

2. Related Work

- External example based methods - Learn mapping between Low and High resolution Images using external datasets.
- Internal example based methods use Self similarity property.
- Using Self similarity approach generate patches from the Input image.
- Different mapping functions used in above methods are kernel Regression, Random forest etc..

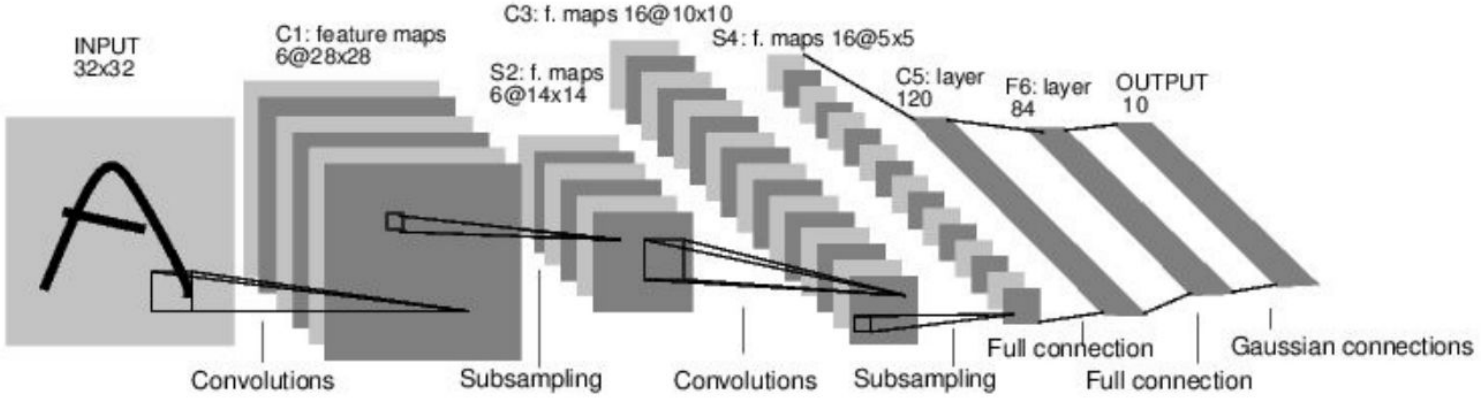


3.Concepts required

a) Convolution Neural Networks (CNNs)

- CNNs, like neural networks, are made up of neurons with learnable weights and biases.
- Each neuron receives several inputs, takes a weighted sum over them, pass it through an activation function and responds with an output.
- CNNs have wide applications in image and video recognition, recommender systems and natural language processing.

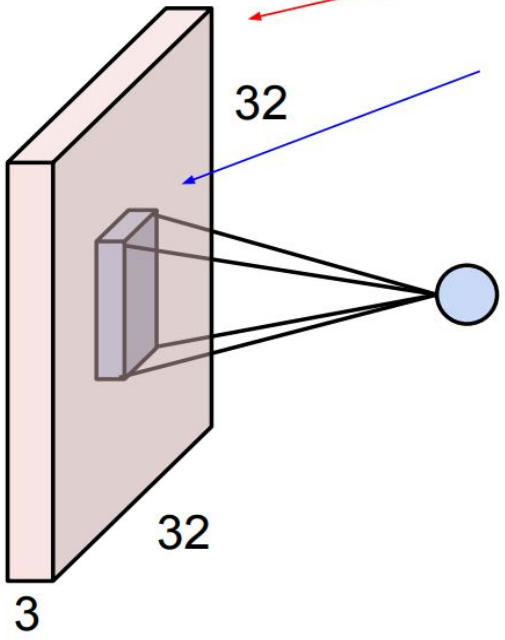
Convolutional Neural Networks



[LeNet-5, LeCun 1980]

*Source: from Andrej Karpathy course.

Convolution Layer



32x32x3 image

5x5x3 filter w

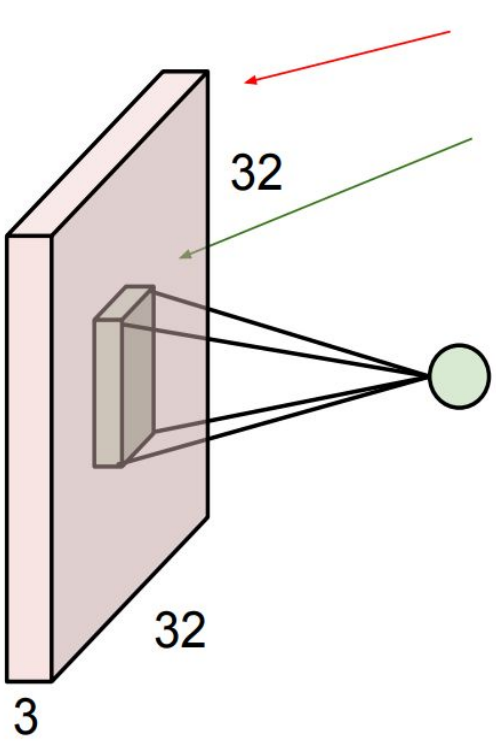
1 number:
the result of taking a dot product between the filter and a small 5x5x3 chunk of the image (i.e. 5*5*3 = 75-dimensional dot product + bias)

$$w^T x + b$$

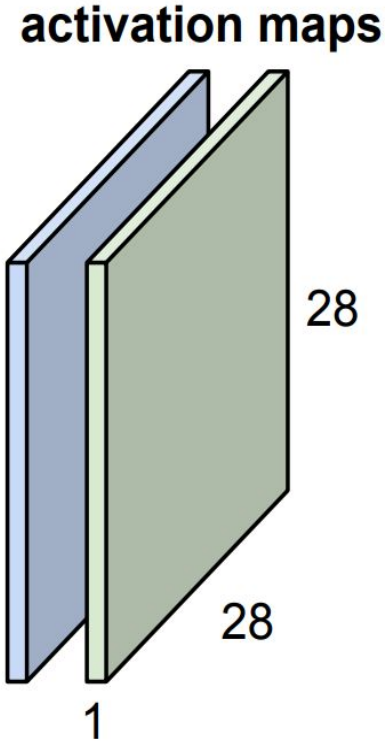
*Source: from Andrej Karpathy course.

Convolution Layer

consider a second, green filter

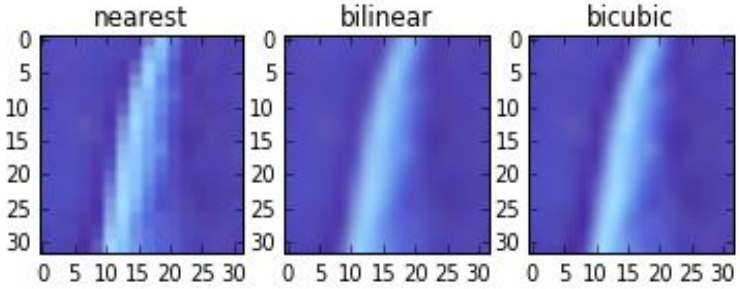


convolve (slide) over all spatial locations



*Source: from Andrej Karpathy course.

3. Bicubic Interpolation

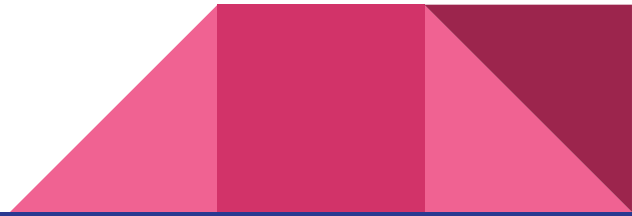


- Interpolation is a method of Constructing New data points within range of Discrete Data Points.
- Several Interpolation techniques exist like Bilinear Interpolation, Bicubic Interpolation etc..
- In proposed approach they have used Bicubic Interpolation which takes the pixel $y = ax^3+bx^2+cx+d$.
- It is observed in above diagram that edges are represented in Cubic polynomial.

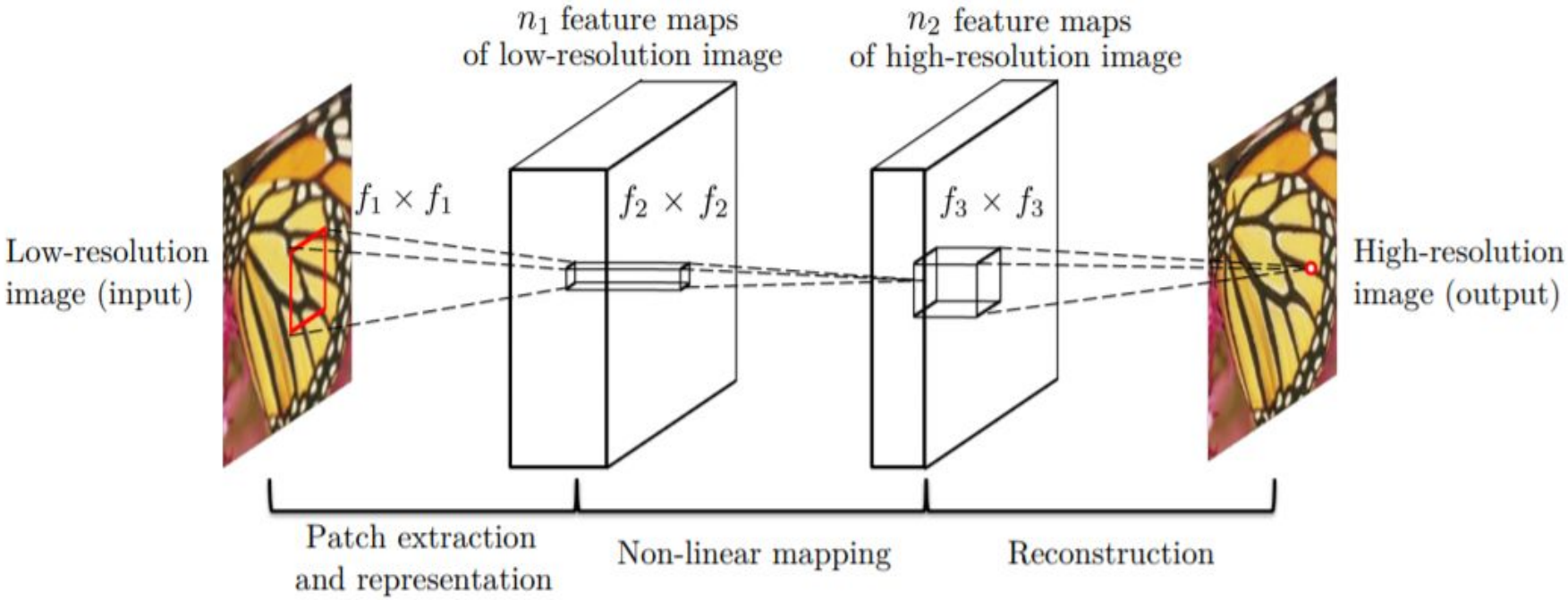
Source : Image from Google

4. Proposed Approach

- Involves Three Phases :
  - Patch Extraction and Representation.
  - Non-Linear Mapping.
  - Reconstruction.
- Initially we upscale image using Bicubic Interpolation.
- As specified before, we wish to learn mapping F between low resolution Image and High Resolution Image through above three phases.



4. Proposed Approach



Source : Image from paper.

4. Proposed Approach - (a) Patch Extraction and representation

- Convolve the image with filters and each output is referred as Basis.
- We can Understand it as Feature map which represent the Patch in low resolution image.
- How the Feature maps are generated for Low Resolution Image?

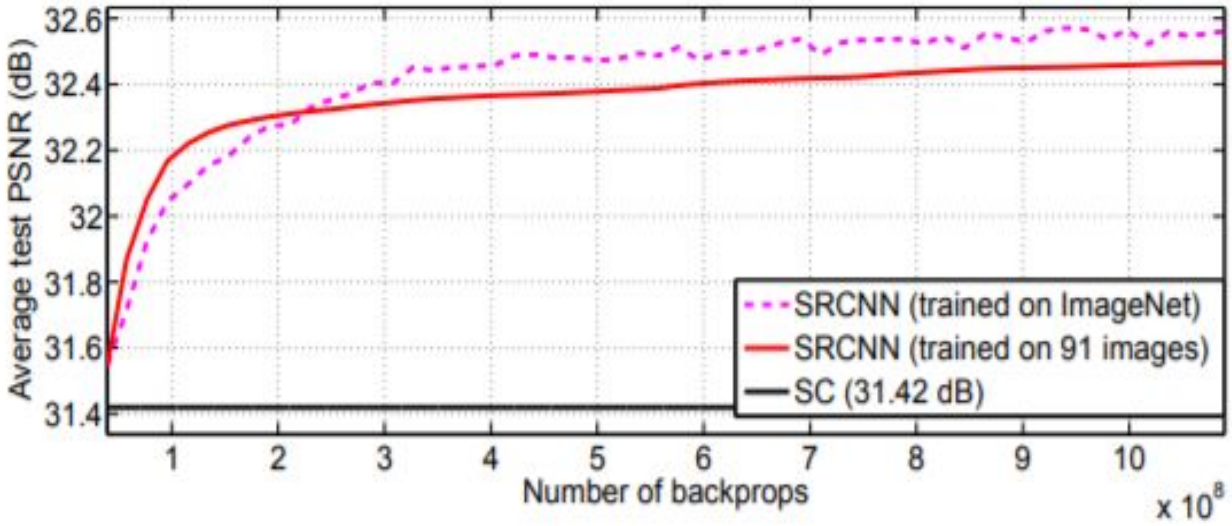
4. Proposed Approach - (b) Non Linear Mapping

- Each Feature map generated, wil be mapped to a new Feature map.
- This will be converted in later stage as a patch in High Resolution Image.
- Apply ReLU activation for each value in values generated in the Matrix.
- Values in the Weights in each Layer are updated to Minimise MSE or Maximise PSNR.

4. Proposed Approach - (c) Reconstruction & Back Propagation

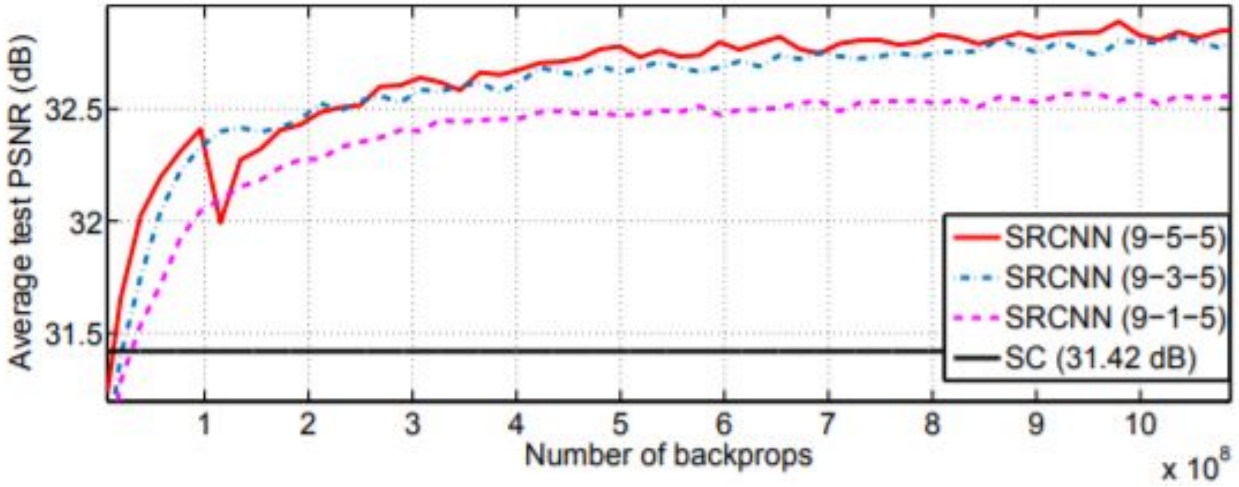
- In Reconstruction Phase, the transformed values are updated back into C Channel Image chosen Initially.
- The weight values updation Based on the standard Backpropagation algorithm used in Neural Networks.
- One Backprop means the weights updated after each Feed Forward Operation.
- Number of Backprops affect the convergence to Local Minimum or Global Minimum as Neural Networks is not a Convex Optimisation.

5. Model and Performance Analysis - Varying Number of Samples.



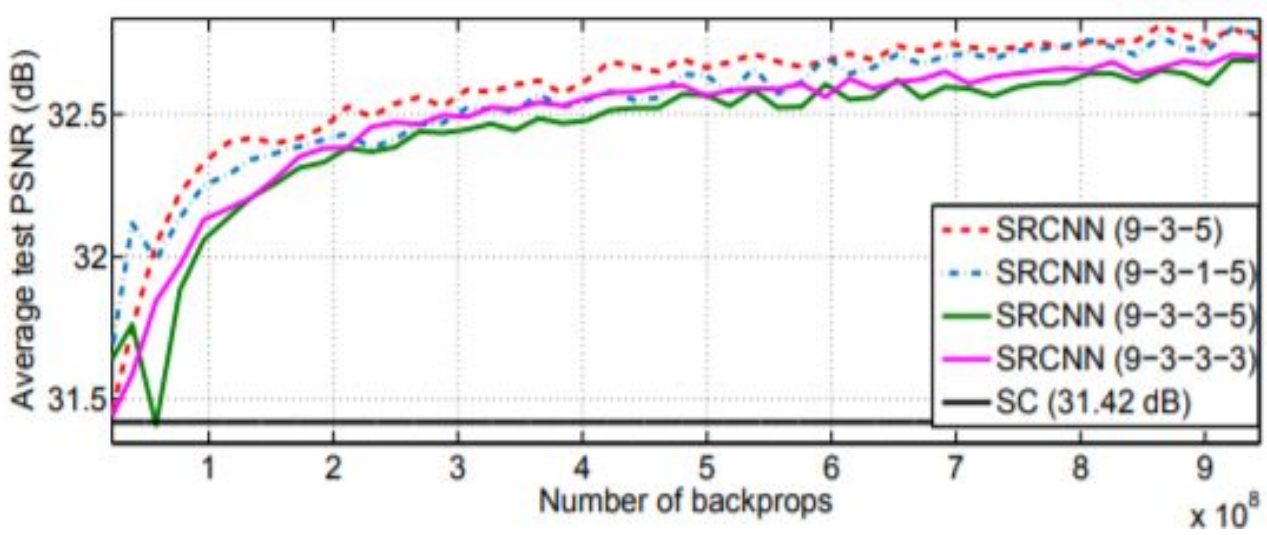
It is Observed that Training data even with 91 Images is as Comparable to 5 Million Images in ImageNet data.

5. Model and Performance Analysis - Varying Filter Size in F2



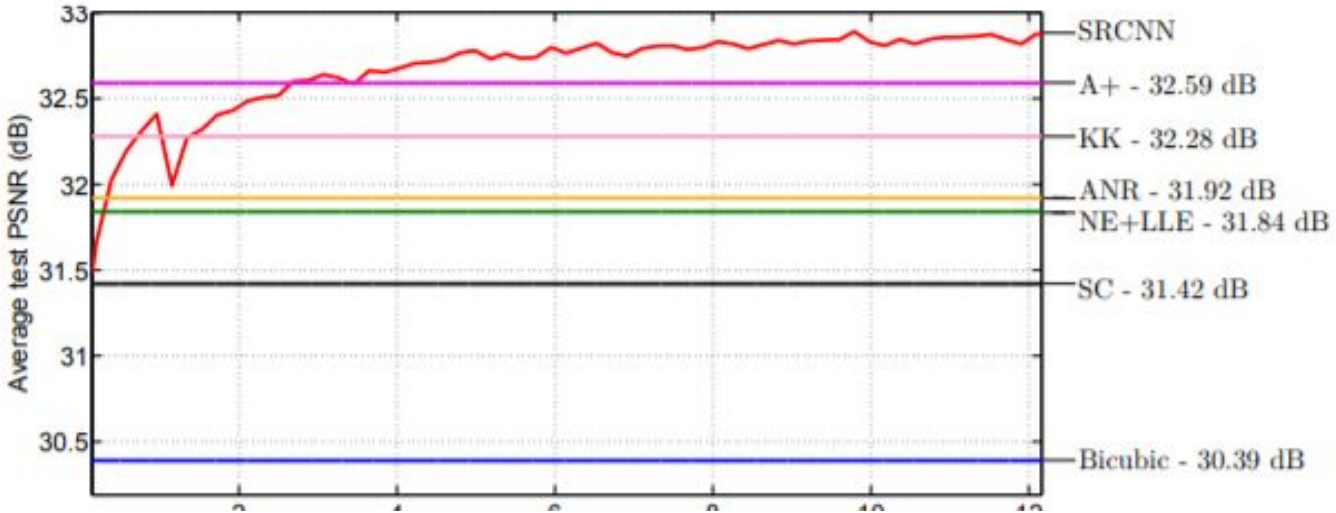
As there is Increase in Filter Size, there is Improvement in Average Test PSNR.

5. Model and Performance Analysis - Varying Number of Layers



As we Increase Number of Layers, it is not Guaranteed to Increase Performance.

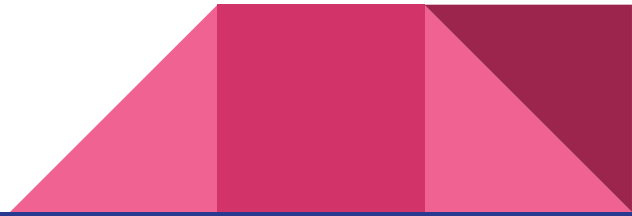
5. Model and Performance Analysis - With State of Art Algorithms



Proposed method- SRCNN achieved a better performance than previous State of Art Algorithms.

6. Conclusion

- Official Implementation - link here (Matlab code)
- Proposed a Convolution Neural network which learns end to end mapping between Low resolution Image and High resolution Image.
- Pre-processing - Bicubic Interpolation.
- Activation Function - ReLU
- Proposed approach showed better average PSNR ratio than state of art methods.
- Authors Improved SRCNN in Later years and named it is FSRCNN.



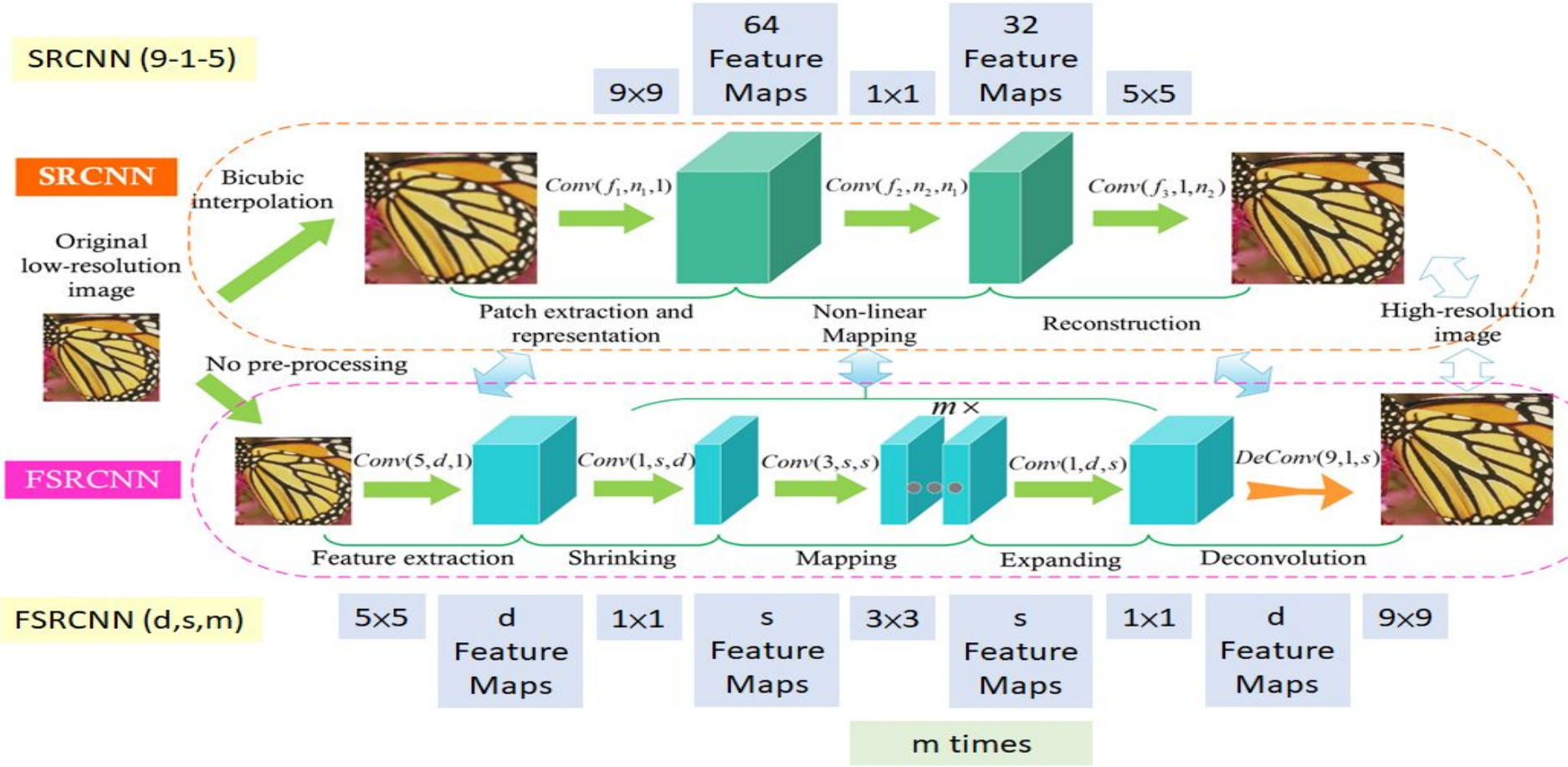


Image : FSRCNN Paper.

Thank You