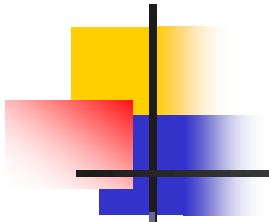

Image Restoration and Super-Resolution

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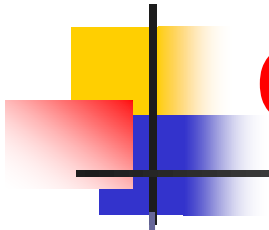


Overview

- Image Restoration
- Different approaches for Image Restoration
- Image Super-Resolution (SR)
- Super-Resolution using motion as a cue
- Learning based Super-Resolution- Use of Wavelet Transform (WT) and Discrete Cosine Transform (DCT)
- Our recent Works on Restoration and Super-Resolution

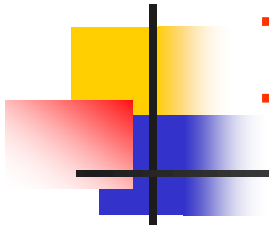
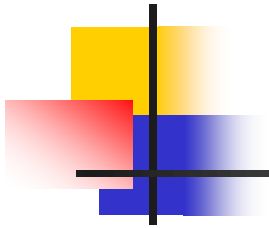
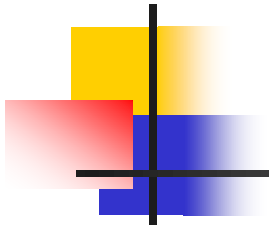


Image Restoration

- Goal of image restoration is to improve the quality of the image from it's degraded version
- Different from image enhancement
- Enhancements are heuristic procedures designed to manipulate an image and are image dependent. No strong mathematical reasoning exists.

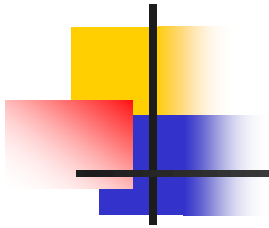


- Restoration techniques are based on modeling the degradation which takes place during image capture.
- Degradation may be due to camera defocus blur, motion blur that may occur when there is relative motion between camera and the object, atmospheric turbulence, sensor noise, etc



- Restoration- to apply inverse process on the degradation to obtain the estimate of the original

- Contrast stretching is an enhancement technique while removal of blur by deconvolution is a restoration process.



- Restoration applications:
- Medical imaging-X ray images noisy-better diagnosis
- Film industry- old film prints- scratches
- Law enforcement- license plates motion blurred (numbers not clear in the image)
- Remote sensing

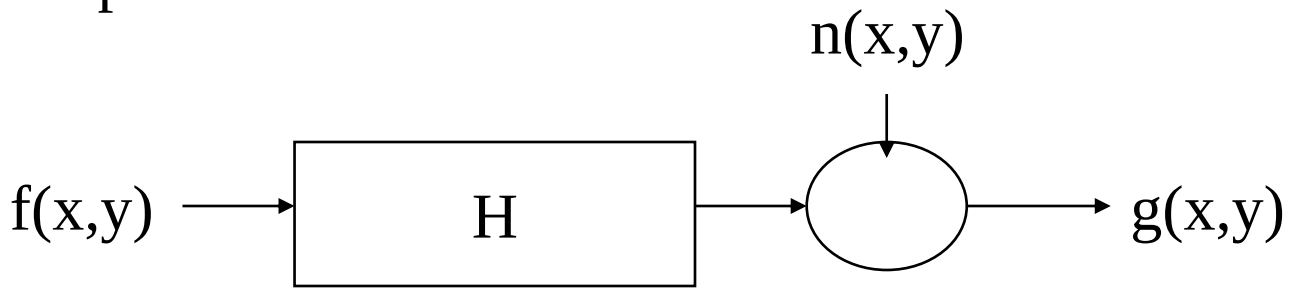
Restoration model

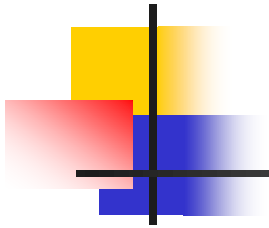
$$g(x,y) = f(x,y) * h(x,y) + n(x,y)$$

$$OR$$

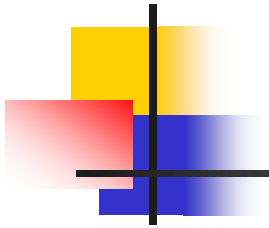
$$G(u,v) = F(u,v)H(u,v) + N(u,v)$$

• The objective of restoration is to obtain an estimate of f(x,y) given some knowledge of the H and N. This is an inverse problem





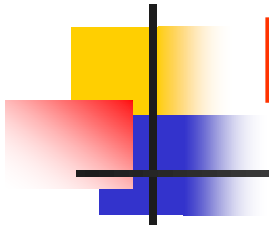
- Restoration and blind deconvolution are different
- Restoration – degradation is known- PSF (H) and noise statistics are known or assumed depending on application
- Blind deconvolution – estimate both the original signal as well as the degradation function when partial knowledge on degradation is known.



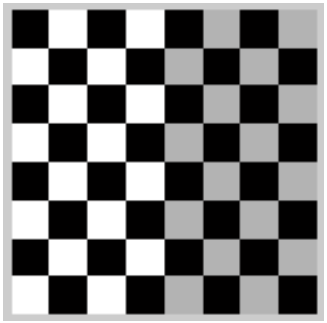
Restoration and Super-Resolution - Comparison

- Restoration – The model do not consider the aliasing. The restored image is of same size as the degraded image
- Super-resolution – Aliasing is taken care by suitably modeling the aliasing due to under sampling. The size of the super-resolved image is bigger than the degraded one. Difficult problem to solve.

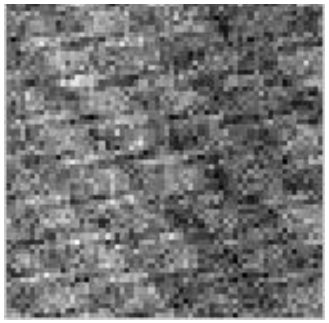
Different Approaches: Restoration



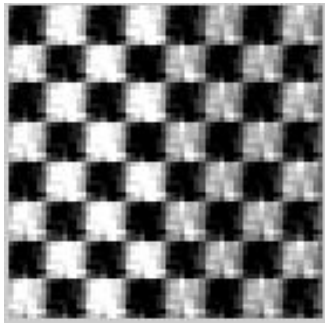
- Inverse Filtering
- Weiner Filtering
- Constrained optimization
- Unconstrained approaches.



Original Image



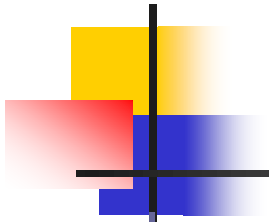
Blurred and noisy image
(degraded image)



Restored image using
Weiner filter

Image Super-Resolution (SR)

- Resolution: Smallest measurable detail in a visual presentation. Tells about the fineness of detail that can be distinguished in an image
- Spatial Resolution: spacing of pixels in an image measured in pixels per inch (ppi)
- High Spatial Resolution: Pixel density is high. (Larger no of pixels in an image)



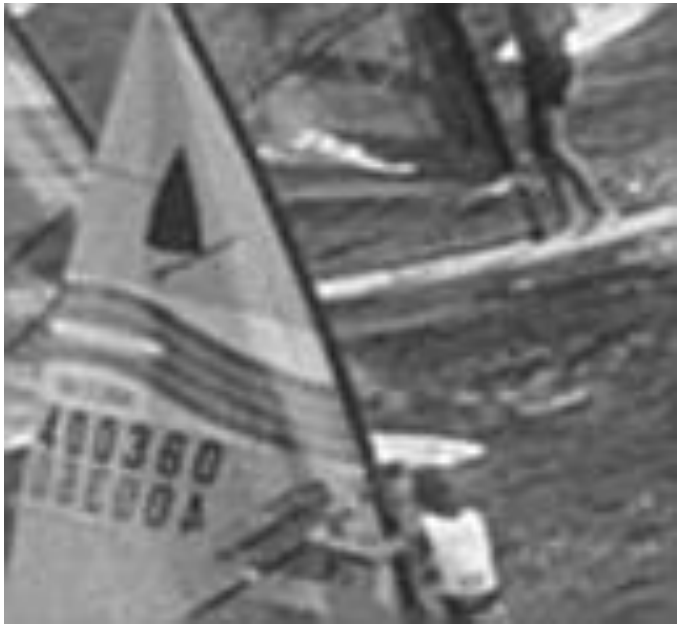
- HR Applications : Medical Imaging,
  remote sensing, robot vision, industrial inspection, etc

- Super-Resolution (SR): Obtain high resolution
  from several low resolution observations
  of the same scene. (minimizes aliasing
  and blurring).

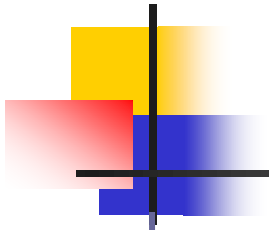
- Example on SR:

Deepu and Chaudhuri

Observations



Super-Resolved



- Why SR ?

  1. Cost 2. Shot noise

- Conventional Interpolation Methods :

  Nearest Neighbor or zero order hold

  or pixel replica, Bilinear, Bicubic

- Disadvantage : Single image used.

  Do not consider the aliasing or blurring.

Different approaches to Solve Super-resolution Problem

- Motion
- Zoom
- Blur
- Photometry
- Learning based techniques

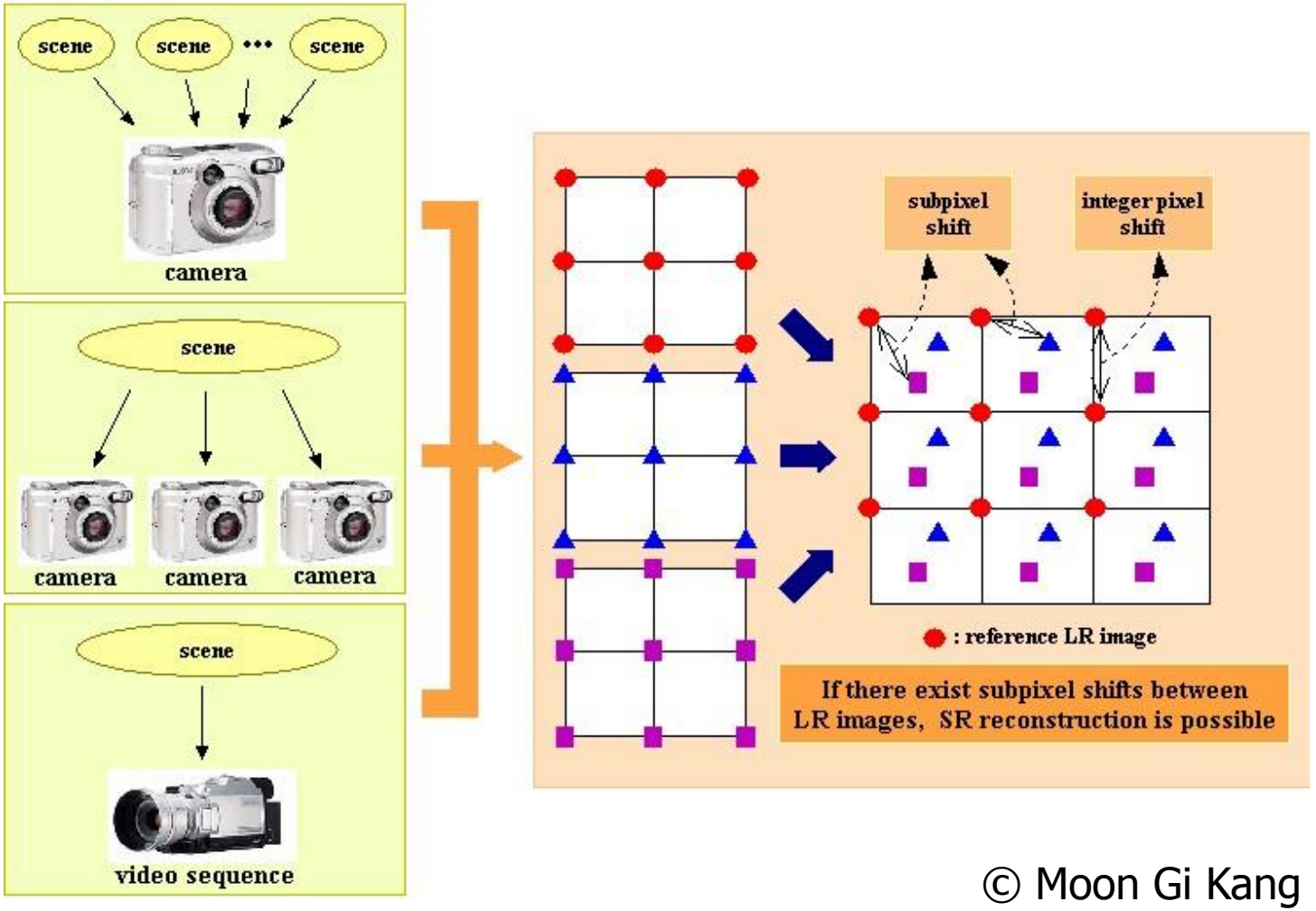
MPEG sequence

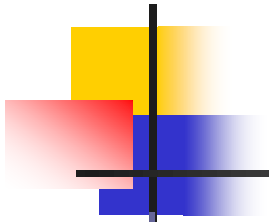
A key frame

Super-Resolved

Use of Motion Cue
Dipti and Chaudhuri

The Idea!





Learning based Super-Resolution

USE OF DISCRETE WAVELET TRANSFORM (DWT) AND DISCRETE COSINE TRANSFORM (DCT)

Prakash Gajjar, PhD student

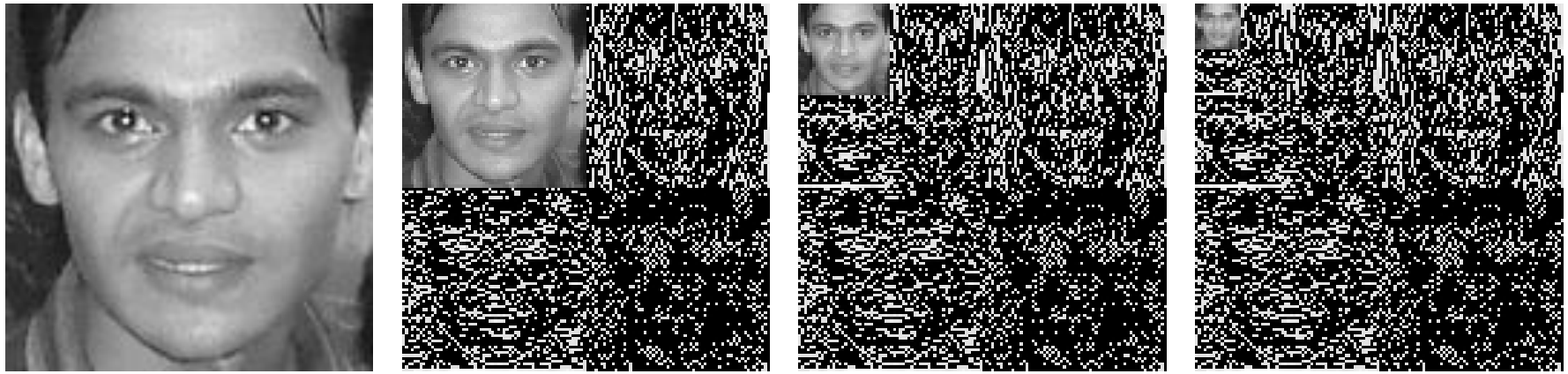
Problem Definition

- Given a low resolution image and a set of high resolution training images learn the high frequencies from the training data set and obtain SR.

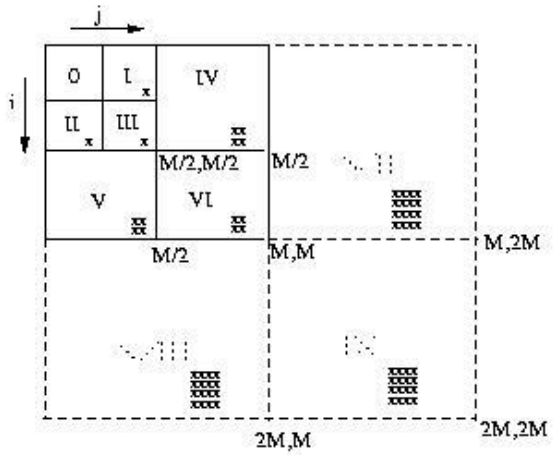
Approach

- Learn the wavelet coefficients at finer scales of the unknown high resolution image from high resolution training set.

An image and its Wavelet Transform (DB4)



Learning:



Test image

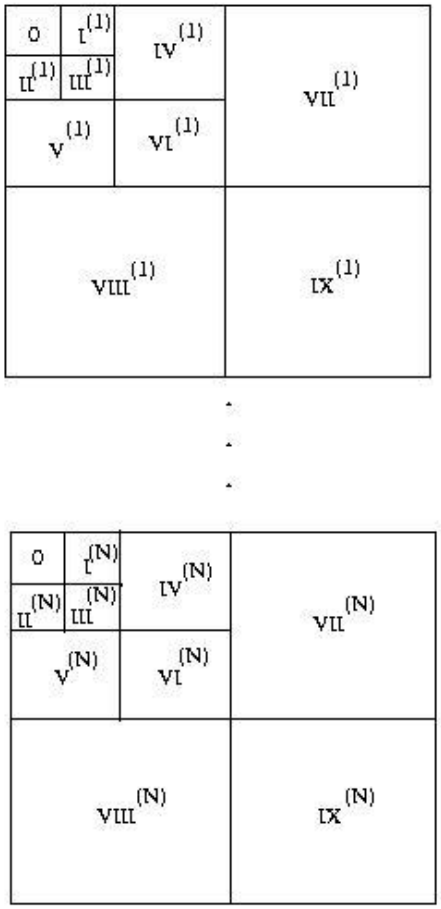


image 1

image N

Training images

Results

Low resolution image

Bilinear interpolation

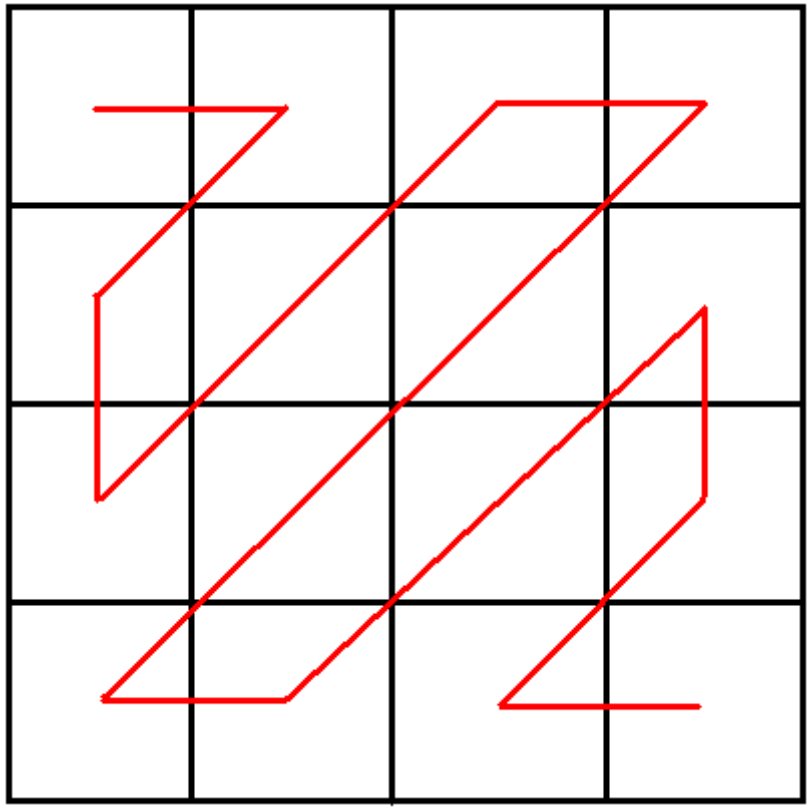
Super-resolved image

Learning using DCT

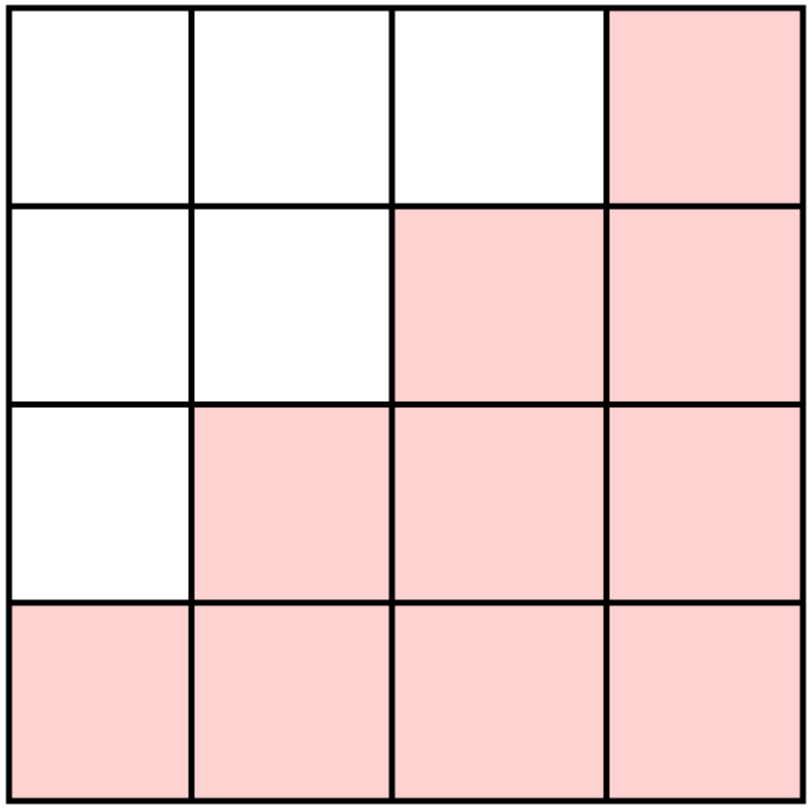
- Objective: Given a set consisting of pair of LR and HR images of a camera obtain high resolution image for an LR image captured using the same camera.
- Motivation: HR Video with a very low memory.

Sample training pairs of images

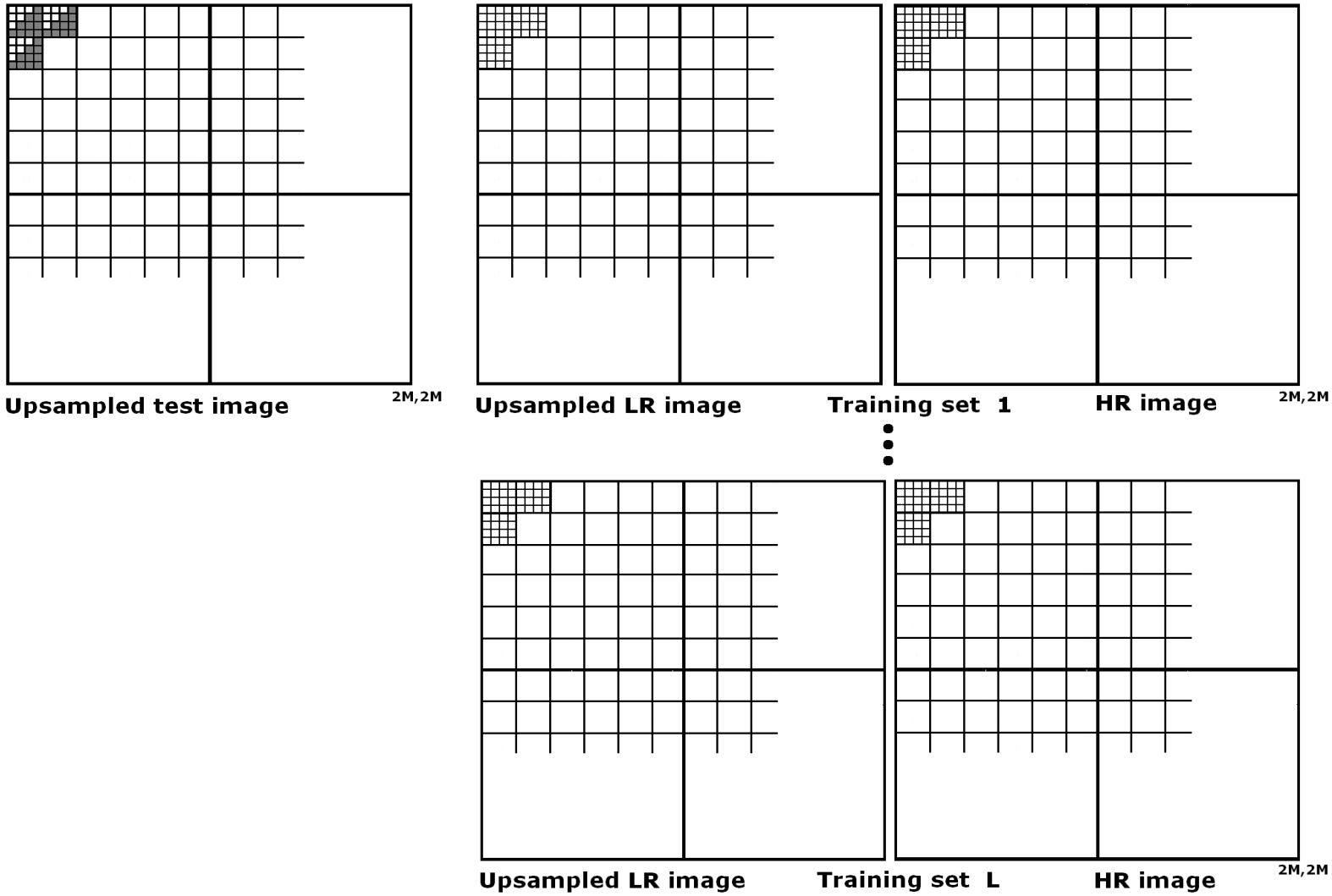
A 4x4 DCT block



DCT coefficients related to high frequency details in a block



DCT based Learning from LR-HR pairs:



DA-IICT

Results

Observation

Bicubic Interpolation

MSE=0.003784

DCT based Super-resolved

MSE=0.003245

Conclusions

- A learning based technique for super-resolution using a single low resolution image is described
- Advantage: 1. No cue used 2. Single LR observation used
- Learning represents the next challenging frontier for computer vision.

Our recent works in SR and Restoration

- Super-resolution in real time- Graph cuts optimization- Swati Sharma (M.tech student)
- Particle Swarm Optimization for SR (B.tech student)
- SR based on histograms of different filters as priors (B.Tech students).
- Learning based methods for restoration–Kishor (PhD student)
- Super-resolution of multi-spectral images in remote sensing (B.tech student)

THANK YOU