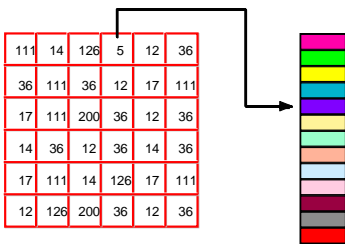


## Lecture 9

### Color Quantization

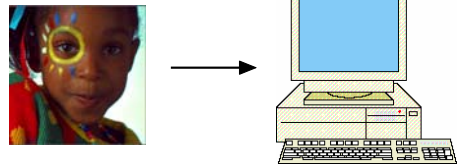
24bit Color to 8bit Color  
 Image Independent Quantization  
 Image Dependent Quantization  
 Perceptual vs Linear Quantization  
 Quantization of Image Sequences



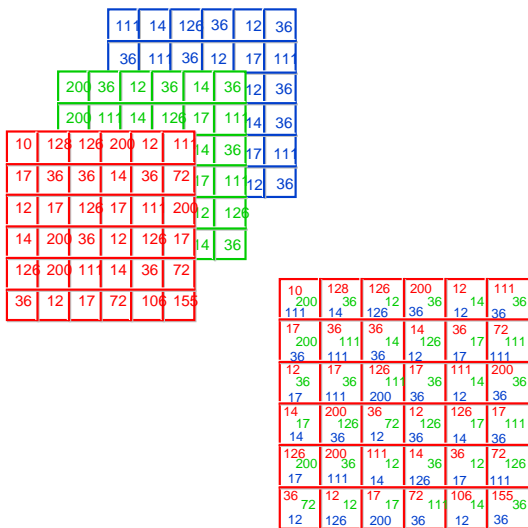
## Color Quantization

Human visual perception is used to design and constrain industrial and engineering applications.

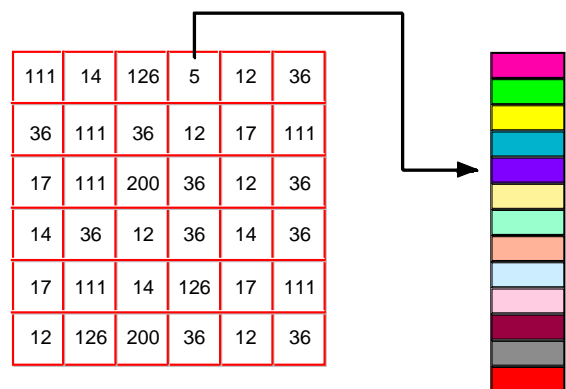
- The problem of color quantization for color images.
- Engineering solution.
- Psychophysical data and observations.
- Incorporating perceptual constraints into the color quantization process.
- Quantization of image sequences.



## Rgb Image



## Indexed Image



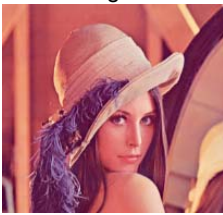
## Color Image Quantization

**Color Quantization** = Reducing the number of different colors in a color image.

Reproduce the original as best as possible

Quantized image should look “good” and look “similar” to the original.

Original

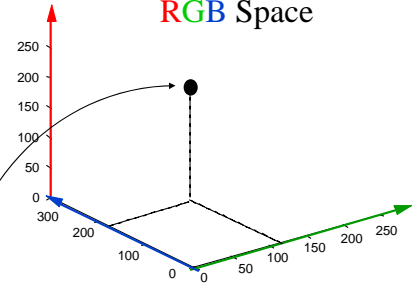


Quantized



## Color Representation

### RGB Space

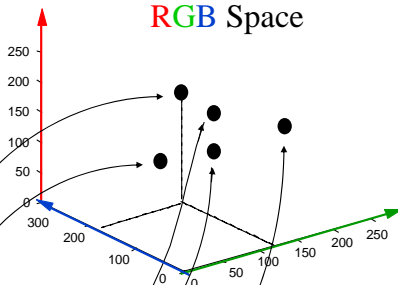


10	180	126	200
111	200	117	12
17	36	36	14
12	200	111	36
36	111	36	12
17	111	200	36
14	17	200	36
14	17	126	72
14	36	12	36

RGB Image

## Color Representation

### RGB Space

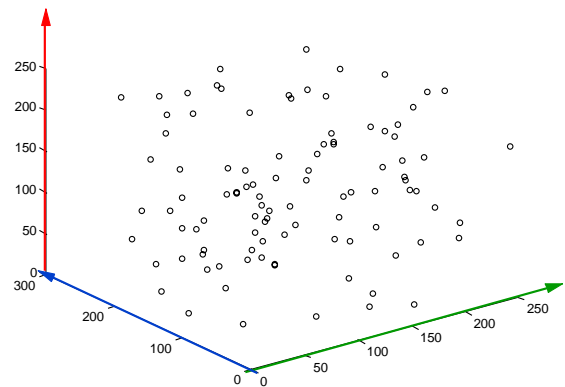


10	180	126	200
111	200	117	12
17	36	36	14
12	200	111	36
36	111	36	12
17	111	200	36
14	17	200	36
14	17	126	72
14	36	12	36

RGB Image

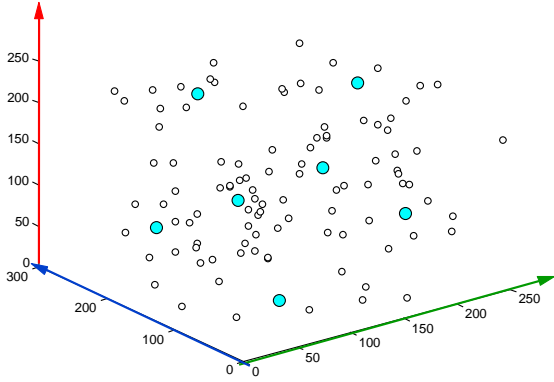
## Color Representation

### RGB Space



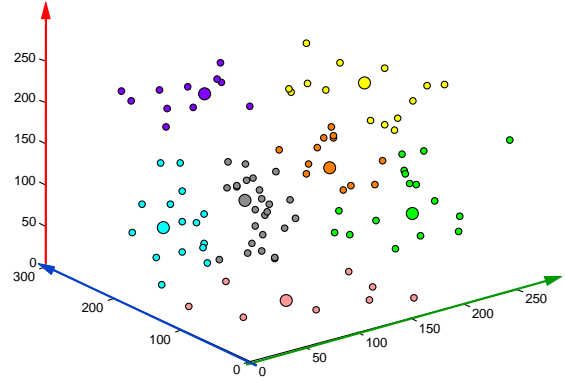
### Color Representation

### RGB Space



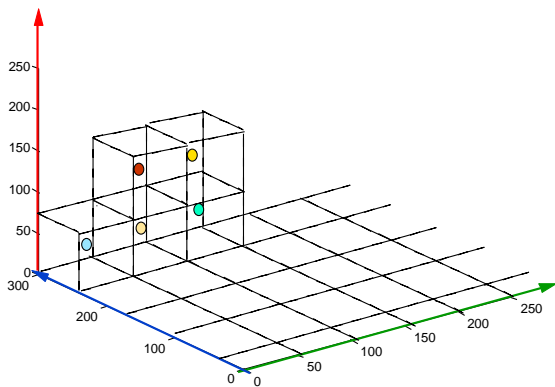
### Color Representation

### RGB Space

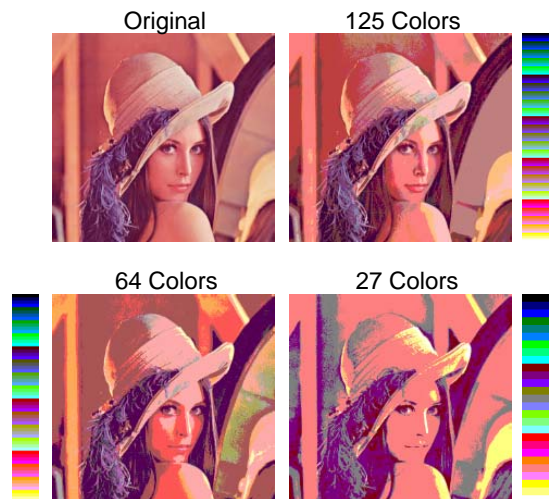


### Image Independent Quantization

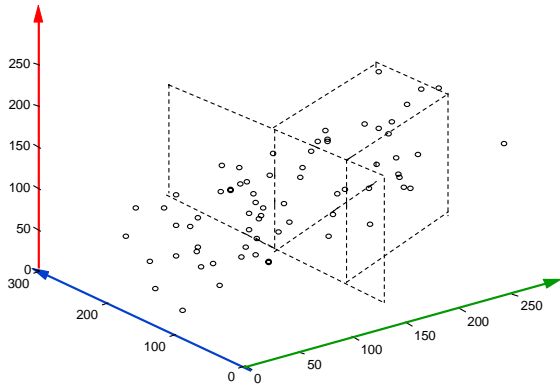
### RGB Space



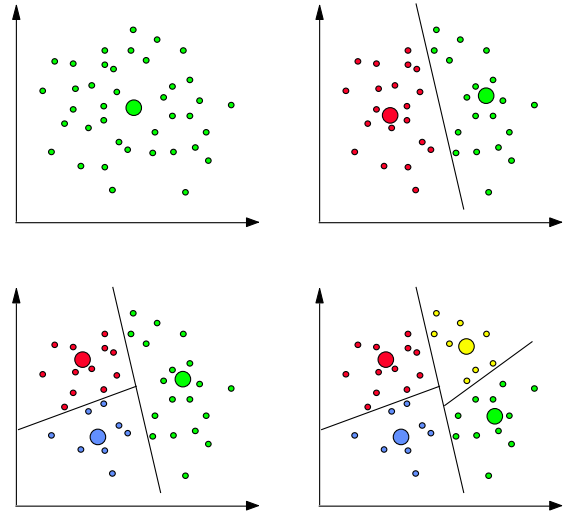
### Image Independent Quantization



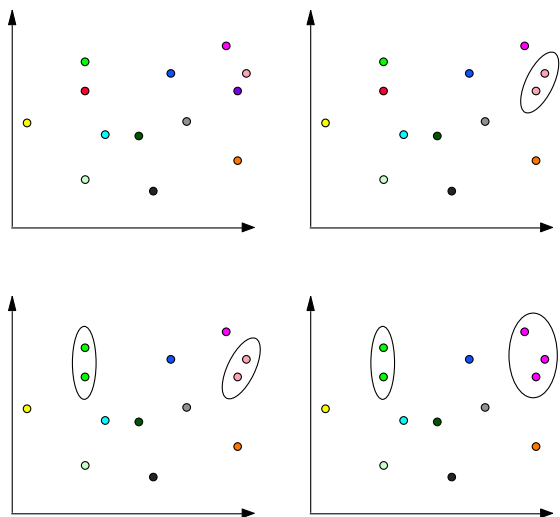
### Image Dependent Quantization



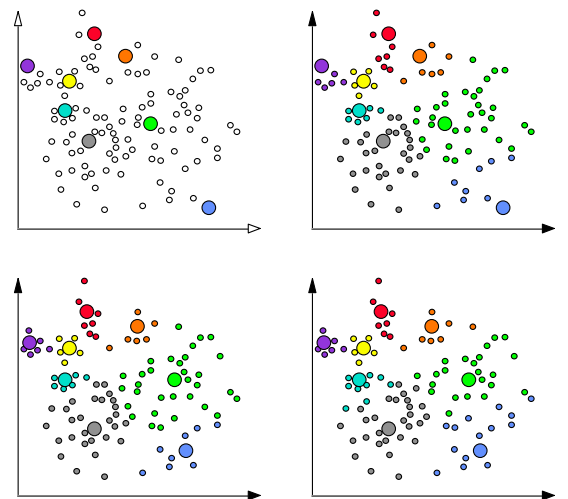
### Top-Down Quantization (Split)



### Bottom-Up Quantization (Merge)



### LBG Quantization (Iterative) (Linde Buzo Gray 1980)



## Image Dependent Quantization

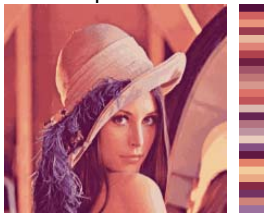
Original



Independent



Dependent



## Observation I

Distances and quantization errors measured in RGB space, do not relate to human perception.

- Weber's Law - we are more sensitive to changes in darker regions than in lighter regions.
- We are more sensitive to intensity changes than to hue shifts.  
(Loughren 53', Hacking 53', McAdan 81')

## Perceptual vs Linear Quantization

Original



Perceptual



Intensity



## RGB vs YIQ Quantization

Original



RGB Quantization



YIQ Quantization

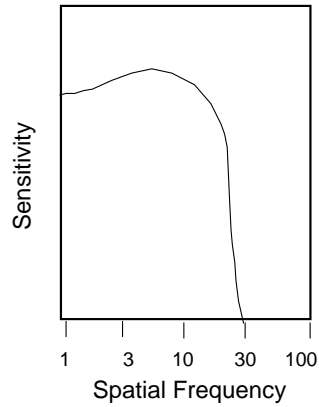


## Observation II

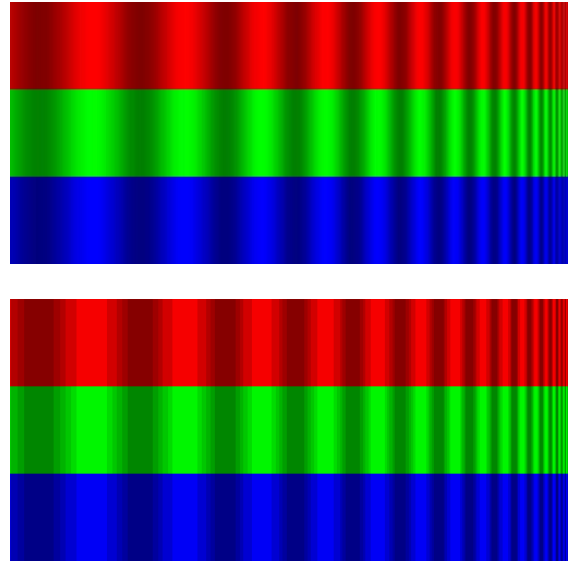
Quantization errors are spatially dependent.

We are more sensitive to errors at lower spatial frequencies.

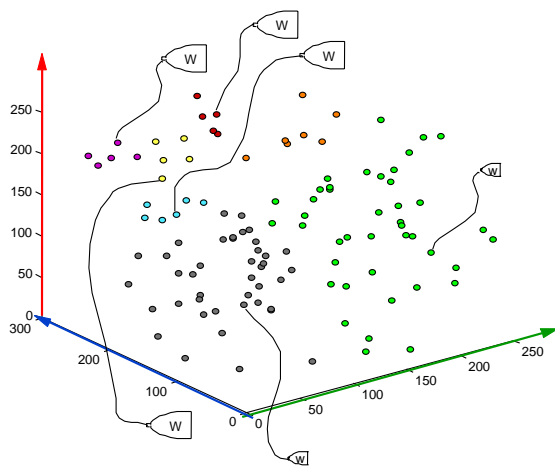
(Legge and Foley 80', Schade 56', Campbell and Robson 68')



## Quantization errors are spatially dependent



## Weighted Quantization



## Weighted Quantization

Original



Dependent Quantization

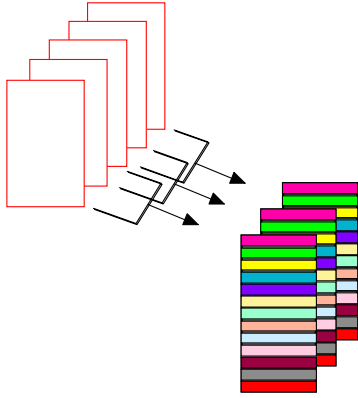


Weighted Quantization

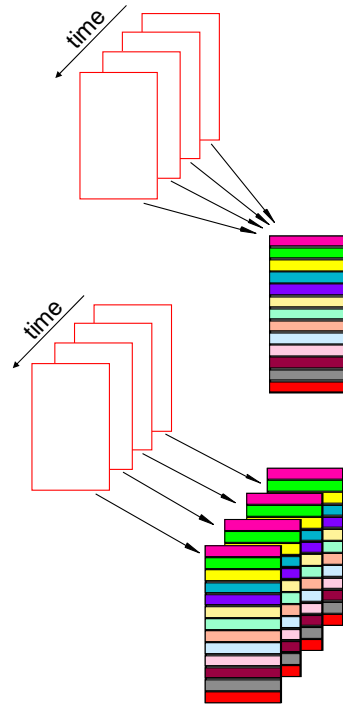


### Image Sequence Quantization

- Color Reproduction.
- Color Continuity.

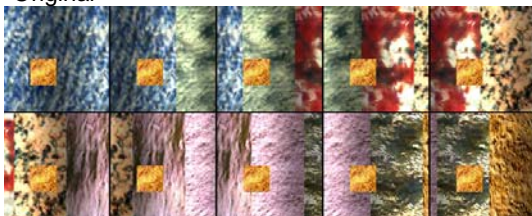


### Image Sequence Quantization

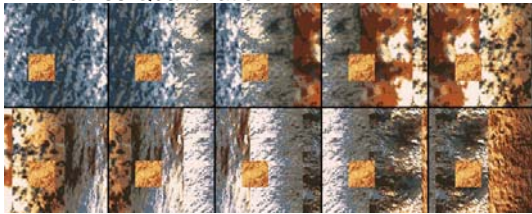


### Image Sequence Quantization

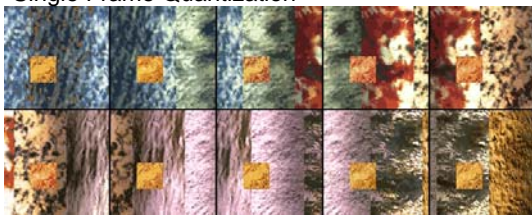
Original



All Frames Quantization

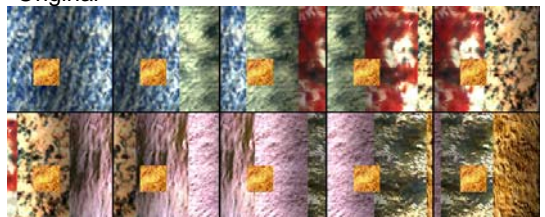


Single Frame Quantization

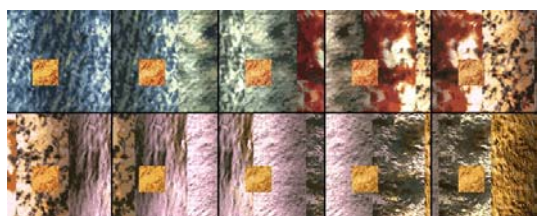


### Image Sequence Quantization

Original



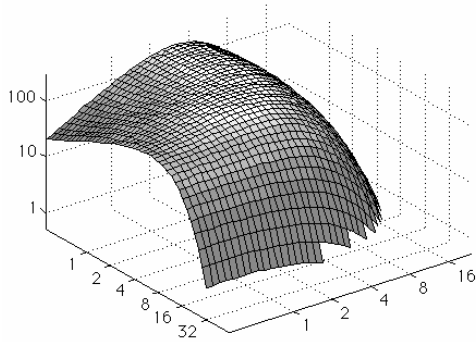
3 Frame Quantization



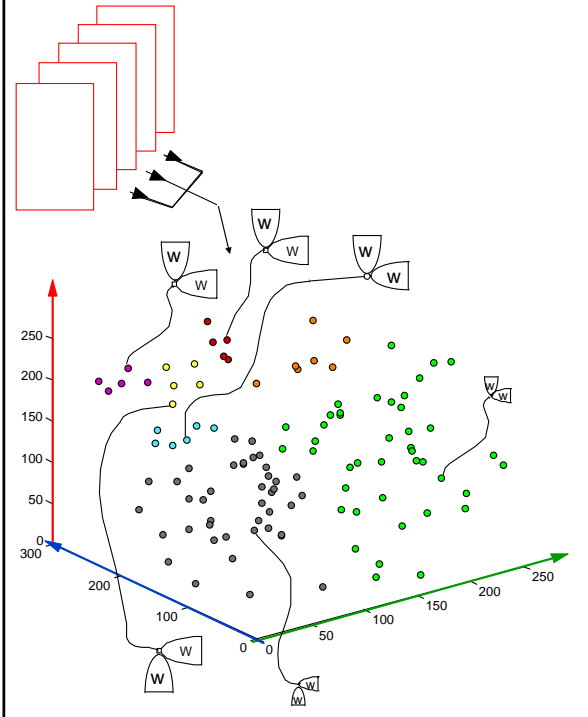
## Observation III

Quantization errors are spatially and temporally dependent.

- We are more sensitive to errors at lower spatial frequencies and lower temporal frequencies.



## Weighted Quantization



## Weighted Quantization



Weight per pixel color is multiplicative:

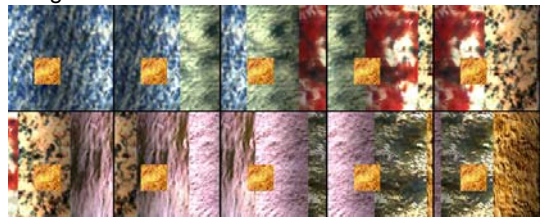
**Spatial-weighting:** depends on local spatial business around pixel (high business -> low weight)

**Time-frame weighting:** 1:2:1 for frame  $i-1, i, i+1$  (current frame -> high weight)

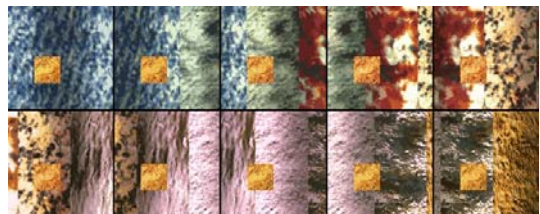
**Time-frequency weighting:** depends on temporal frequency of pixels (high temporal frequency -> low weights)

## Weighted Quantization

Original

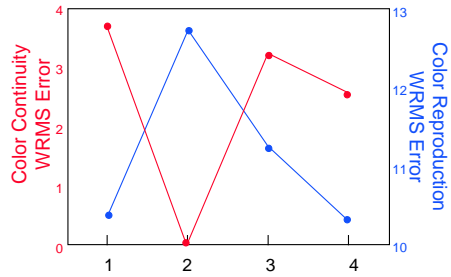


Weighted Quantization



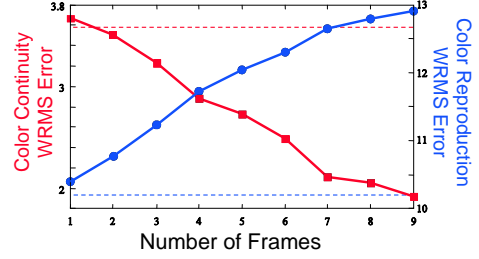


## Quantization Methods



1. Single frame quantization
2. All frames quantization
3. Three frames quantization
4. Weighted quantization

## Quantization Methods



--- Weighted Quantization

## Improving Quantization

Original



Quantization (2 bins)



Dithered

