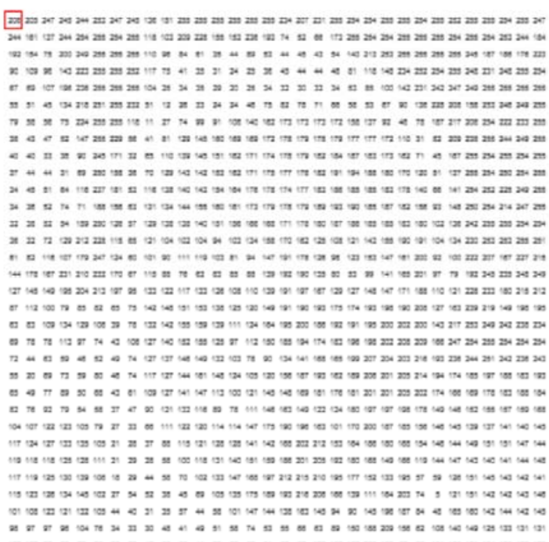
# Bilinear Interpolation and Convolution Kernels

- Often in image processing use Convolutions
- Basically create a matrix operation
- Ie a matrix that multiplies values in the image matrix
- Then apply to all parts of the image
- Eg is the bilinear interpolation or sharpen
- Now apply matrix centered on a pixel to values near it

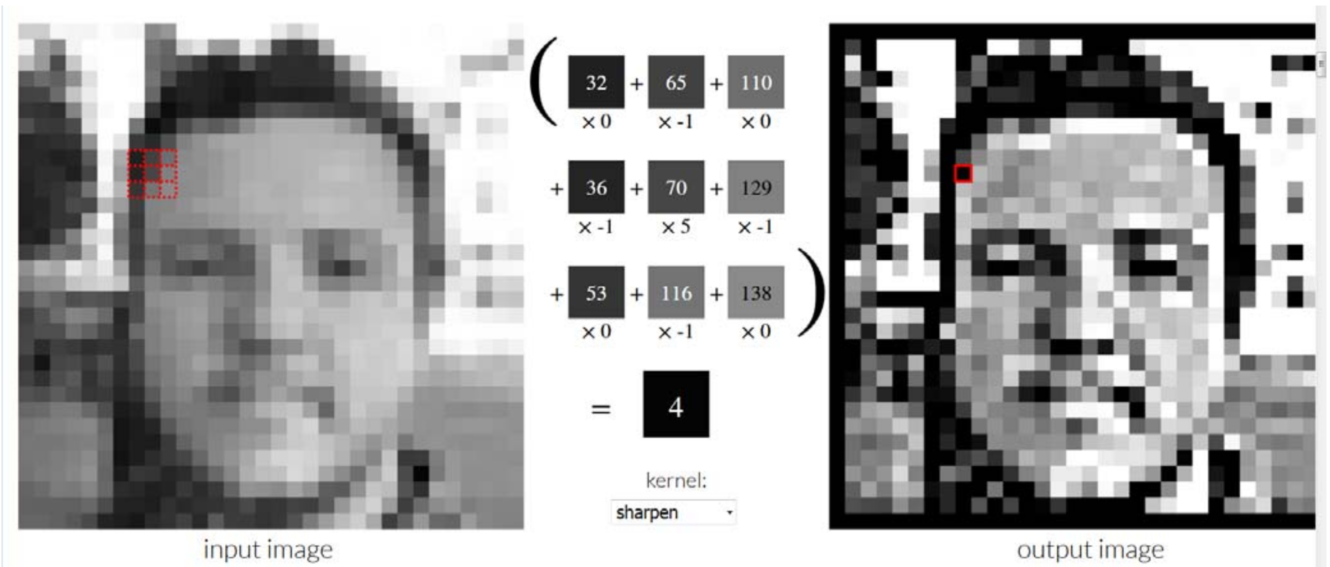
| | | |
|---|---|---|
| 0 | -1 | 0 |
| -1 | 5 | -1 |
| 0 | -1 | 0 |

- Multiply then sum for a replacement value



# Convolution Kernel Results

- Example is a sharping kernel
- Left is input image showing location of kernel multiply
- Right is output applied to whole image
- Really good interactive page to see this at http://setosa.io/ev/image-kernels/



## Bilinear Interpolation and Kernels

- Bilinear interpolation as a kernel

$$K_B = K_R = \frac{1}{4}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

$$K_G = \frac{1}{4}\begin{bmatrix} 0 & 1 & 0 \\ 1 & 4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

- When applied to an raw image get interpolation but also artifacts


**Fig. 2.3** **a** Original image, **b** Demosaiced image by bilinear interpolation

# Demosaicing Artifacts

- Consider an image with a sharp vertical gray edge
- Chang et all showed how this creates false color at the edges
- Look at the R,G,B channels
- Each color suffers different errors due to different patterns
- Two types of error
- Zipper effect
- False color
- Note angle of edge changes these effects

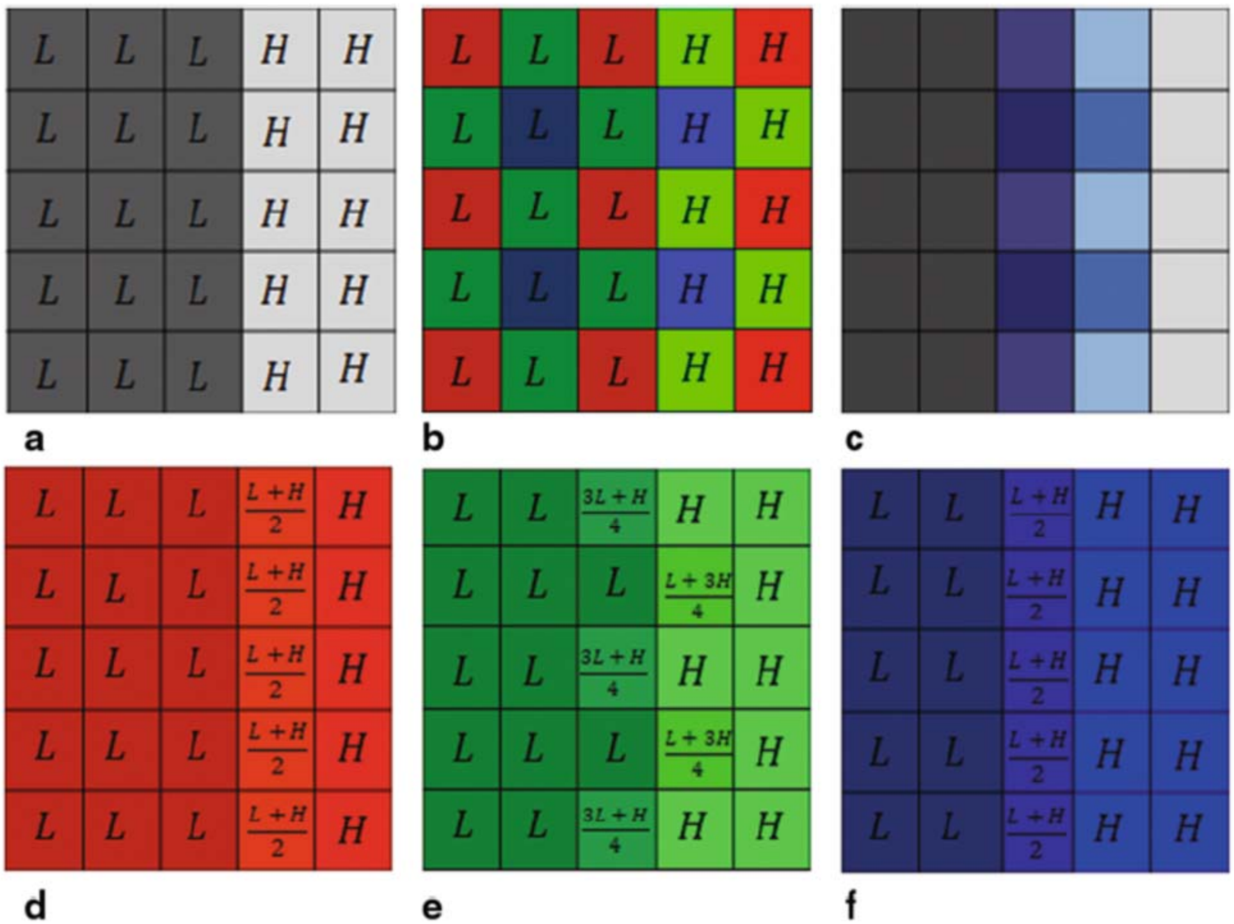



**Fig. 2.4** **a** Synthesized gray image, **b** CFA samples of **a**, **c** Bilinear interpolation result, **d** Bilinear interpolated red plane, **e** Bilinear interpolated green plane, **f** Bilinear interpolated blue plane

## Zipper Effect

- Zipper effect: abrupt/unexpected intensity change at edges
- Covers neighboring pixels
- Appears as an on-off pattern near edges
- Caused by improver averaging of neighbor color near edge
- Interpolation along an edge better than across the edge
- Across edge creates high frequency components
- If image interpolation is orthogonal to edge boundry
- Then color is unrelated to the object
- Hence many other demosaicing algorithms are edge sensitive
- Also green pattern is diagonal
- Zipper most often when edges not aligned to diagonal directions

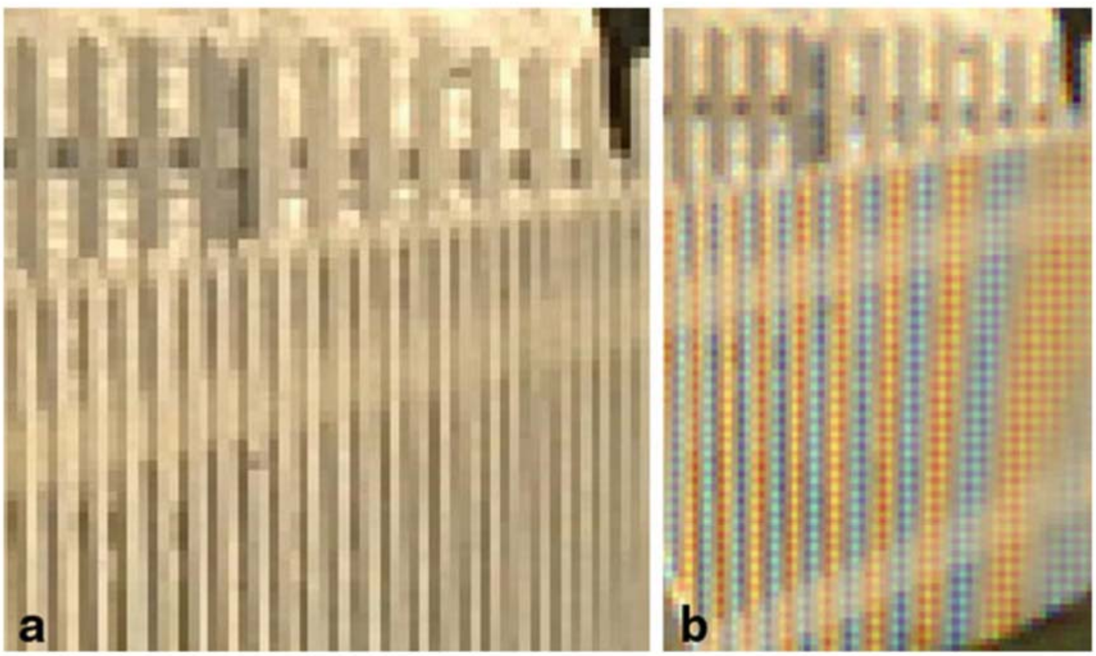



**Fig. 2.5** Zipper effect. **a** Fence bars in the original image, **b** Fence bars in the bilinear interpolated image

## False Color

- False color – spurious colors not present in original image
- Sudden hue changes from different errors in different color planes
- Creates large intensity changes in different color planes
- Many algorithms use spectral correlation between planes to correct
- Keep hue or color change slowly
- Both Zipper and False color called misguidance color artifacts
- Caused by wrong interpolation directions
- Even with correct direction of edge still get interpolation artifacts
- Due to interpolation limitation
- Interpolation artifacts less noticeable
- than misguidance color artifacts


Original


Bilinear Interpolation

# Median Demosaicing

- General idea – use the green plane first
- Reason more G than other colors hence less aliased
- Aliased – sampling error
- Human eyes more green sensitive
- Hence getting G right most important
- Median method uses this spectral correlation
- Two similar methods: Freeman

Freeman, W., "Median Filter For Reconstructing Missing Color Samples", US Patent 4,724,395, Cambridge, 1988.

- Cok

Cok, D., "Signal processing method and apparatus for producing interpolated chrominance values in a sampled color image signal", U.S. Patent No.: 4,642,678, Eastman Kodak Company, Feb. 10, 1987.

- Algorithm has 4 steps:
- First do bilinear interpolation
- Then difference between each color plane is computed using

$$D_{rg}(x,y) = f_r(x,y) - f_g(x,y)$$

$$D_{gb}(x,y) = f_g(x,y) - f_b(x,y)$$

$$D_{rb}(x,y) = f_r(x,y) - f_b(x,y)$$

- f denotes the pixel value at location x, y from indicate color plane.
- Next, median filter is applied to computed difference Drg, Dgb Drb.
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# Freeman Median Demosaicing

- Purpose of the median filter
  - suppress any large discrepancies between color planes
  - based on information from the surrounding pixels
- Last stage is the correction step
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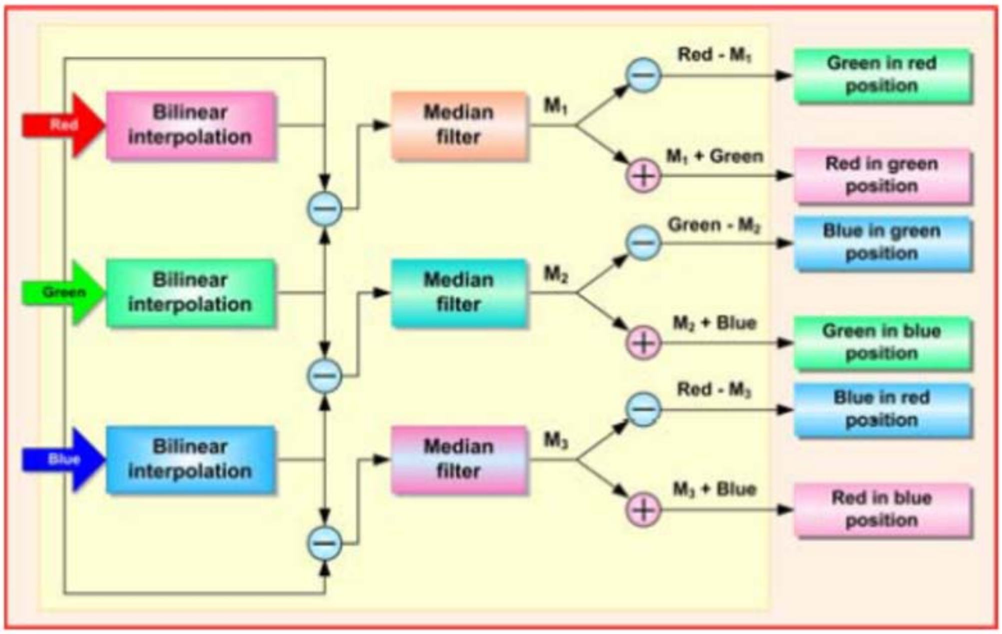


Fig. 2: Diagram of Freeman interpolation

# Freeman Method

- Look at image sequence
- A original
- B green plane
- C R/G ratio
- D R-G different


**Fig. 2.7** Compare ratio image and difference image. **a** Original image, **b** Green plane, **c** $R/G$ ratio image, **d** $R - G$ difference image