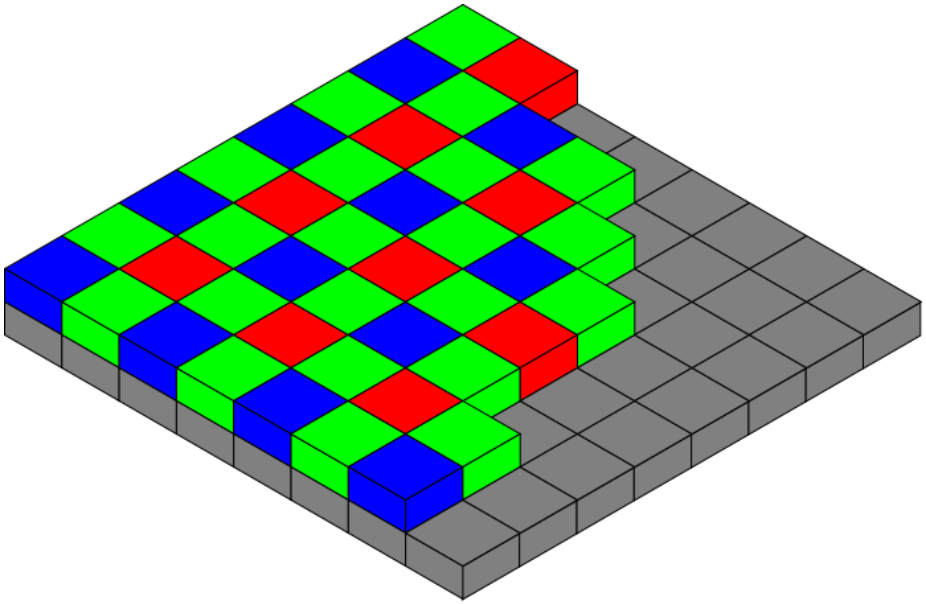
Bayer Filter and Demosaicing

Bayer Filter Mosaic

- Color filter array (CFA) for arranging RGB color filters on a square grid of photo sensors.
- Filter pattern is 50% green, 25% red and 25% blue,
  - hence also called **RGBG, GRGB** or **RGGB**
- Allows digital cameras to capture information for all 3 channels using a single 2D arrangement of sensors
  - Each sensor element captures either red, green or blue channel
  - Missing values are reconstructed using demosaicing

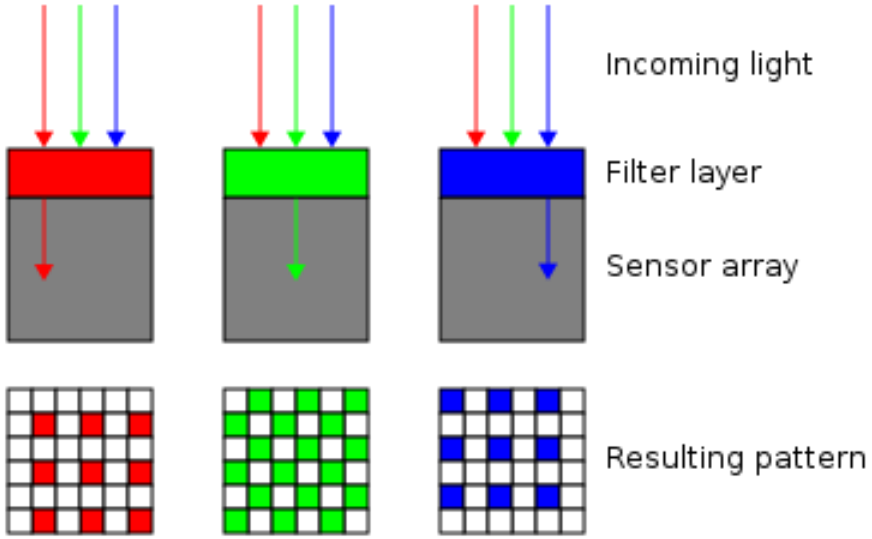
Bayer Filter Mosaic (cont'd)

Bayer arrangement of color filters on the pixel array of an image sensor



Gray boxes indicate individual sensor elements and the overlaid RGB boxes indicate the channel whose information each sensor element captures.

Profile/cross-section of sensor



Colored boxes in the resulting pattern indicate pixels where respective color information is captured; color information at white boxes needs to be reconstructed

Demosaicing

- Reconstruct a full color image from the incomplete color samples ("Bayer Pattern") output from an image sensor overlaid with a CFA
- Many methods exist
  - Simple methods interpolate the color value of the pixels of the same color in the neighborhood

Demosaicing Rules

- The channel masks are moved over the Bayer pattern image like a sliding window but with no overlap
- Locations where the mask is 1 (shaded)
  - value is directly copied from the Bayer image.
- Locations where the mask is 0 (unshaded)
  - value is the average of neighboring existing pixels
  - no. of neighboring pixels to average may be 2 (above/below or right/left) or 4 (all diagonal corners)
  - if a row/column in the mask is entirely empty, values are copied from neighboring non empty row/column

Demosaicing Example

- Let this be the 8x8 Bayer Pattern Image:

	0	1	2	3	4	5	6	7
0	102	230	199	147	166	175	124	164
1	19	241	99	15	187	47	111	97
2	61	125	62	60	165	94	114	207
3	31	125	103	90	115	160	78	136
4	47	86	25	209	139	199	130	89
5	61	230	34	4	76	21	130	239
6	106	94	240	11	190	237	208	223
7	13	28	244	43	48	198	203	140

- Let these be the 4x4 channel masks:

1	0	1	0
0	1	0	1
1	0	1	0
0	1	0	1

Green

0	0	0	0
1	0	1	0
0	0	0	0
1	0	1	0

Blue

0	1	0	1
0	0	0	0
0	1	0	1
0	0	0	0

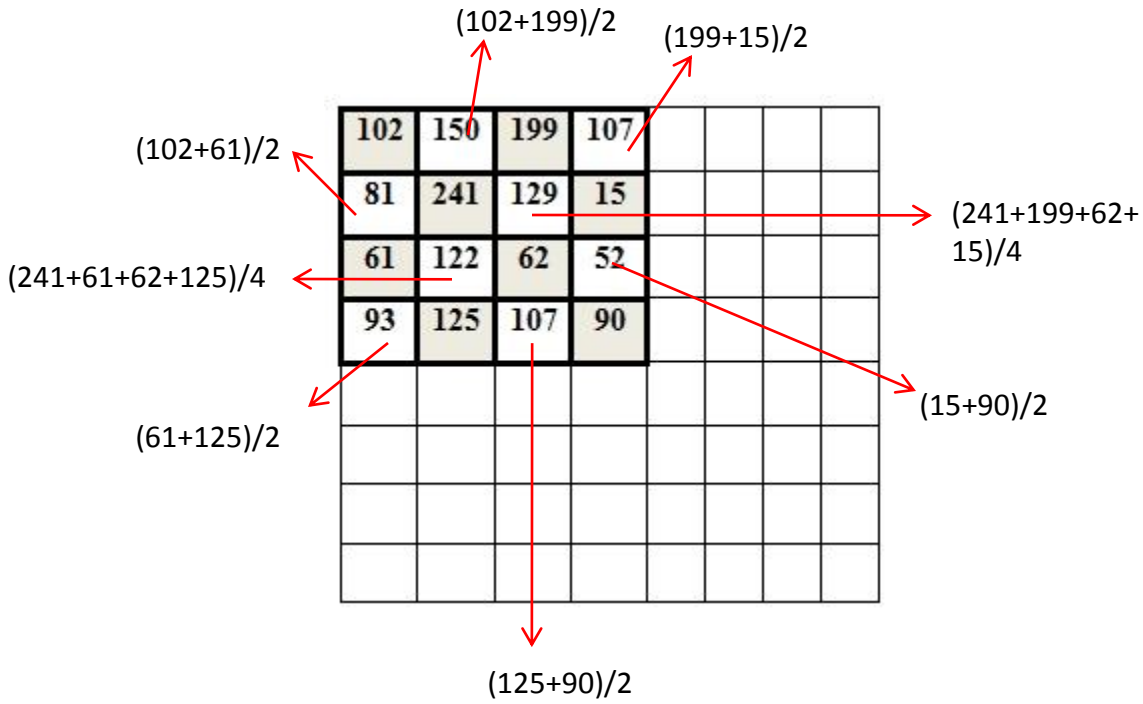
Red

Demosaicing Example: Reconstructing Green Channel

Mask position within the image

102	230	199	147	166	175	124	164
19	241	99	15	187	47	111	97
61	125	62	60	165	94	114	207
31	125	103	90	115	160	78	136
47	86	25	209	139	199	130	89
61	230	34	4	76	21	130	239
106	94	240	11	190	237	208	223
13	28	244	43	48	198	203	140

Reconstructed Pixel Values



Demosaicing Example: Reconstructing Green Channel (cont'd)

Mask positions within the image

102	230	199	147	166	175	124	164
19	241	99	15	187	47	111	97
61	125	62	60	165	94	114	207
31	125	103	90	115	160	78	136
47	86	25	209	139	199	130	89
61	230	34	4	76	21	130	239
106	94	240	11	190	237	208	223
13	28	244	43	48	198	203	140

102	230	199	147	166	175	124	164
19	241	99	15	187	47	111	97
61	125	62	60	165	94	114	207
31	125	103	90	115	160	78	136
47	86	25	209	139	199	130	89
61	230	34	4	76	21	130	239
106	94	240	11	190	237	208	223
13	28	244	43	48	198	203	140

102	230	199	147	166	175	124	164
19	241	99	15	187	47	111	97
61	125	62	60	165	94	114	207
31	125	103	90	115	160	78	136
47	86	25	209	139	199	130	89
61	230	34	4	76	21	130	239
106	94	240	11	190	237	208	223
13	28	244	43	48	198	203	140

Reconstructed Pixel Values

102	150	199	107	166	145	124	110
81	241	129	15	165	47	95	97
61	122	62	52	165	121	114	116
93	125	107	90	115	160	148	136

102	150	199	107	166	145	124	110
81	241	129	15	165	47	95	97
61	122	62	52	165	121	114	116
93	125	107	90	115	160	148	136
47	36	25	14				
76	230	124	4				
106	151	240	23				
67	28	35	43				

102	150	199	107	166	145	124	110
81	241	129	15	165	47	95	97
61	122	62	52	165	121	114	116
93	125	107	90	115	160	148	136
47	36	25	14	139	134	130	184
76	230	124	4	164	21	149	239
106	151	240	23	190	154	208	189
67	28	35	43	194	198	169	140

Demosaicing Example: Reconstructing Red Channel

Mask position within the image

102	230	199	147	166	175	124	164
19	241	99	15	187	47	111	97
61	125	62	60	165	94	114	207
31	125	103	90	115	160	78	136
47	86	25	209	139	199	130	89
61	230	34	4	76	21	130	239
106	94	240	11	190	237	208	223
13	28	244	43	48	198	203	140

Reconstructed Pixel Values