From the Sensor to the File, or: less might be more

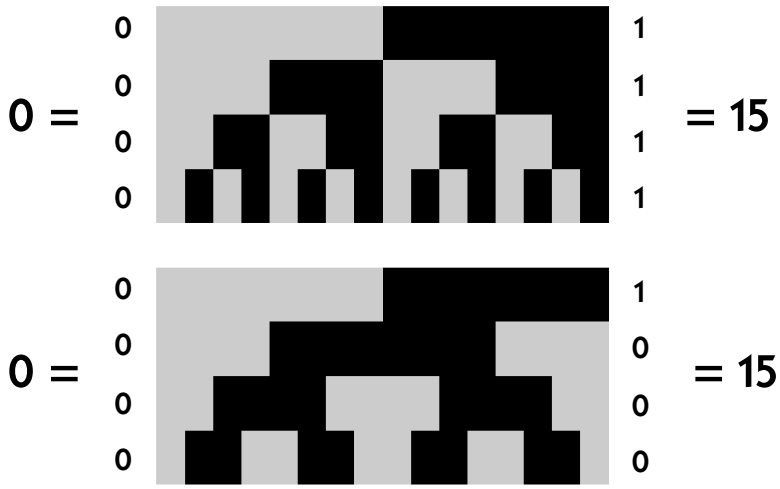
Reto Kromer • AV Preservation by reto.ch

The Reel Thing XLVI
AMIA Conference
Baltimore, Maryland, USA
13–16 November 2019

Summary

- Frank Gray (1887–1969)
- Bryce E. Bayer (1929–2012)
- [...]

Frank Gray

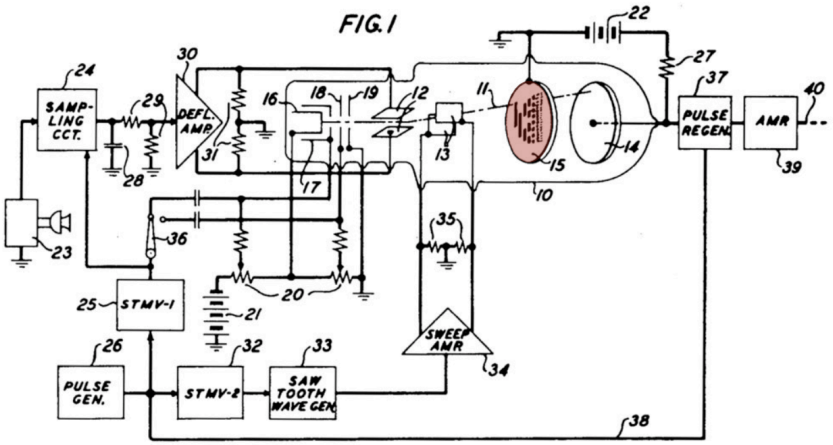


March 17, 1953 F. GRAY 2,632,058

PULSE CODE COMMUNICATION

Filed Nov. 13, 1947 4 Sheets-Sheet 1

FIG. 1



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Bryce E. Bayer

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Uncomfortable Truths

- sensors are colour blind
- Bayer sensors do not generate full RGB

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United States Patent [19] **Bayer**

[11] **3,971,065**

[45] **July 20, 1976**

[54] **COLOR IMAGING ARRAY**

[75] Inventor: **Bryce E. Bayer**, Rochester, N.Y.

[73] Assignee: **Eastman Kodak Company**, Rochester, N.Y.

[22] Filed: **Mar. 5, 1975**

[21] Appl. No.: **555,477**

[52] **U.S. Cl.** ..... **358/41**; 350/162 SF; 350/317; 358/44

[51] **Int. Cl.²** **H04N 9/24**

[58] **Field of Search** ..... 358/44, 45, 46, 47, 358/48; 350/317, 162 SF; 315/169 TV

[56] **References Cited**

UNITED STATES PATENTS

2,446,791	8/1948	Schroeder	358/44
2,508,267	5/1950	Kasperowicz	358/44
2,884,483	4/1959	Ehrenhaft et al.	358/44
3,725,572	4/1973	Kurokawa et al.	358/46

Primary Examiner—George H. Libman
Attorney, Agent, or Firm—George E. Grosser

[57] **ABSTRACT**

A sensing array for color imaging includes individual luminance- and chrominance-sensitive elements that are so intermixed that each type of element (i.e., according to sensitivity characteristics) occurs in a repeated pattern with luminance elements dominating the array. Preferably, luminance elements occur at every other element position to provide a relatively high frequency sampling pattern which is uniform in two perpendicular directions (e.g., horizontal and vertical). The chrominance patterns are interlaid therewith and fill the remaining element positions to provide relatively lower frequencies of sampling.

In a presently preferred implementation, a mosaic of selectively transmissive filters is superposed in registration with a solid state imaging array having a broad range of light sensitivity, the distribution of filter types in the mosaic being in accordance with the above-described patterns.

11 Claims, 10 Drawing Figures

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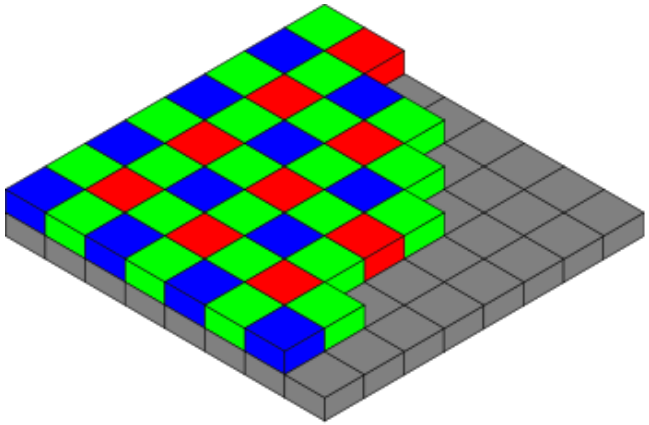
Bayer



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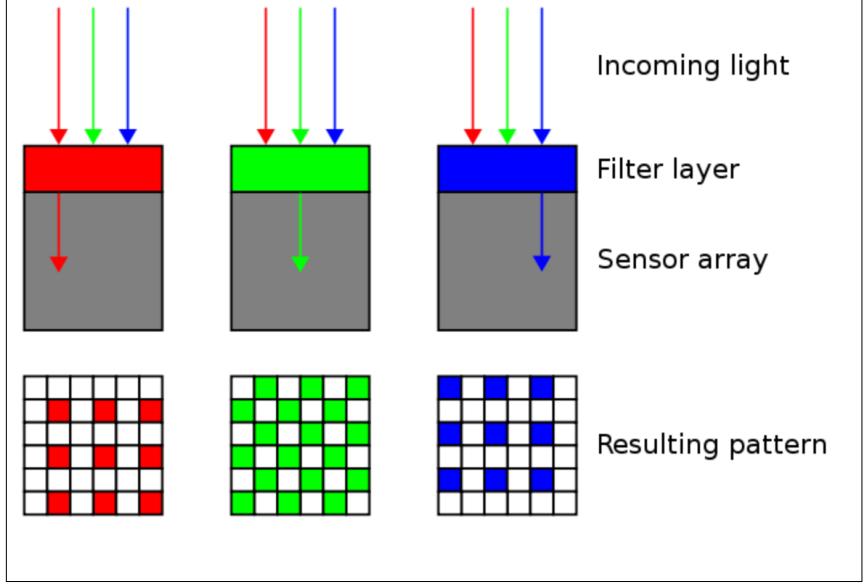

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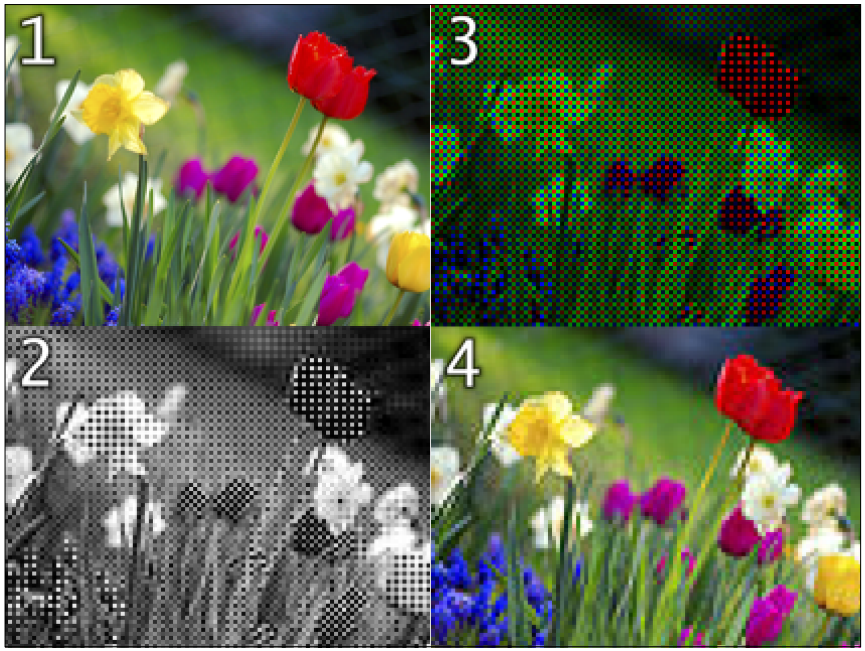

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Let's experiment!

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Terminal — less ◂ man movimenc

```
movimenc(1)                The MovIm video codec                movimenc(1)

NAME
       movimenc - MovIm encoder

SYNOPSIS
       movimenc [input_options] -i input_file [encoding_options]
       [output_options] -o output_file

       movimenc -h | -v

DESCRIPTION
       MovIm is a video codec specifically designed for both conservation and
       restoration of moving images.

       libmovim is a C library implementing MovIm. Its associated utility
       movimenc is a MovIm encoder.

       The openMovIm package includes the libmovim library and its associated
       movimenc, movimdec and movimplay utilities, as well as the openmovim
       Bash command-line interface.

OPTIONS
   GENERAL OPTIONS
:
```

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Terminal — less ◂ man movimenc

```
       --demosaic={BLI|BCI|LR|VNG|SI|PG|AMZE|HQLI|AHD|DLMMSEE}
           demosaic a Bayer-encoded input_file into an RGB output_file

           This option allows to choose between different demosaicing
           algorithms, because the results may vary a lot, depending on the
           image content.

           The following algorithms are implemented:
           - BLI = bilinear interpolation
           - BCI = bicubic interpolation
           - LR = Lanczos resampling
           - VNG = variable number of gradients
           - SI = spline interpolation
           - PG = pixel grouping
           - AMZE = aliasing minimisation and zipper elimination
           - HQLI = high-quality linear interpolation (Malvar, He and Cutler.
           IEEE 2004)
           - AHD = adaptive homogeneity-directed (Hirakawa and Parks. IEEE
           2005)
           - DLMMSEE = directional linear minimum mean square-error estimation
           (Zhang and Xiaolin. IEEE 2005)

   OTHER OPTIONS
       -h, --help
:
```

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```
01110101001010101000101101010111100
01001101010101010101000010111010100
01110101001010101000101101010111100
00011101010101010101000010111010100
01101010100101010100010110101011111
00101010101010101000010111010100000
01110101001010101000101101010111100
01010101010101010000101110101001100
10010111010100101010100010110101010
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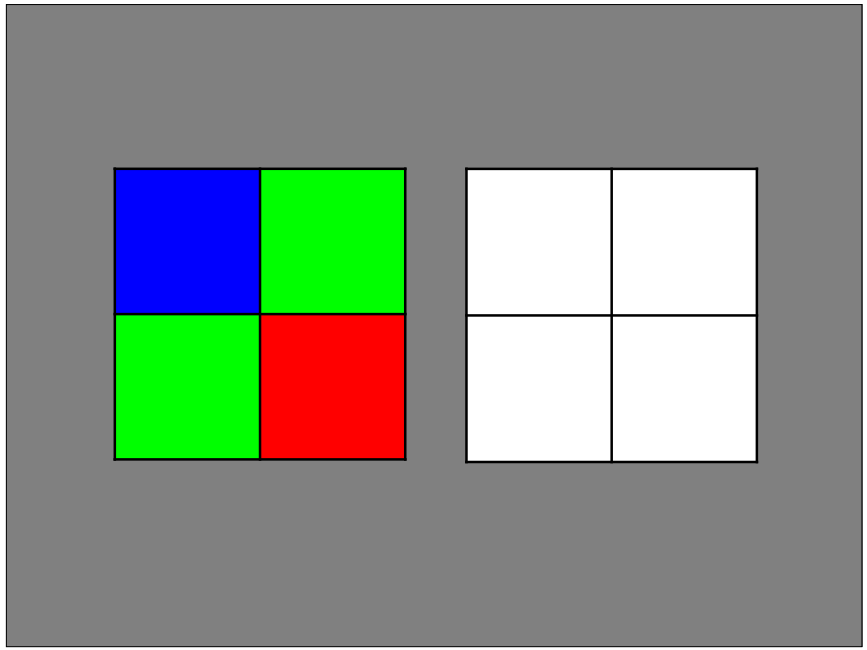

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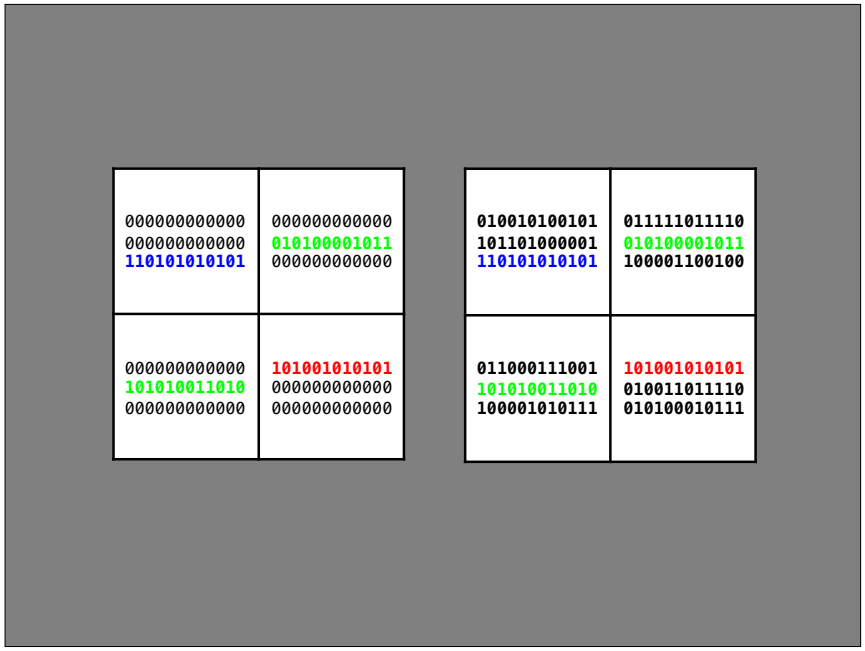
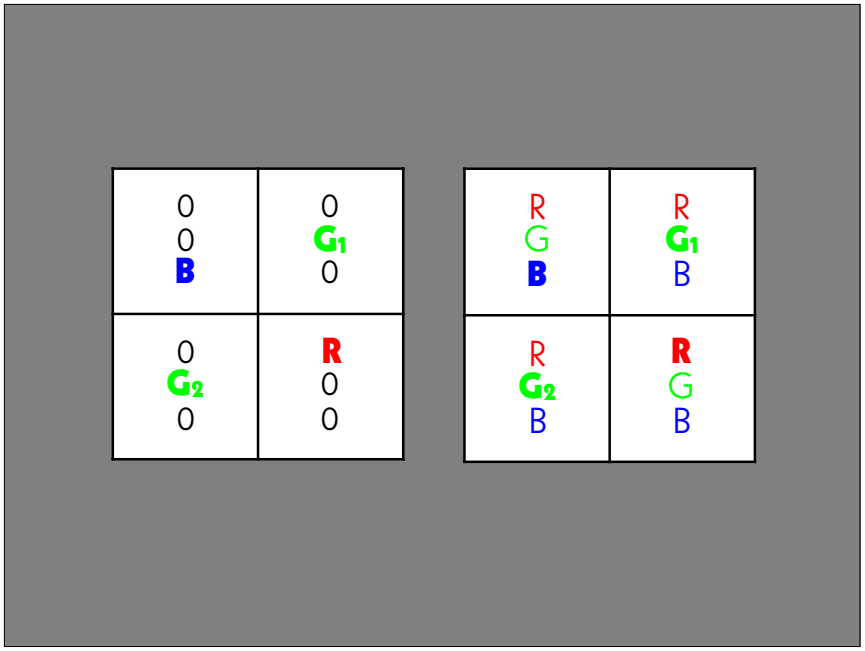
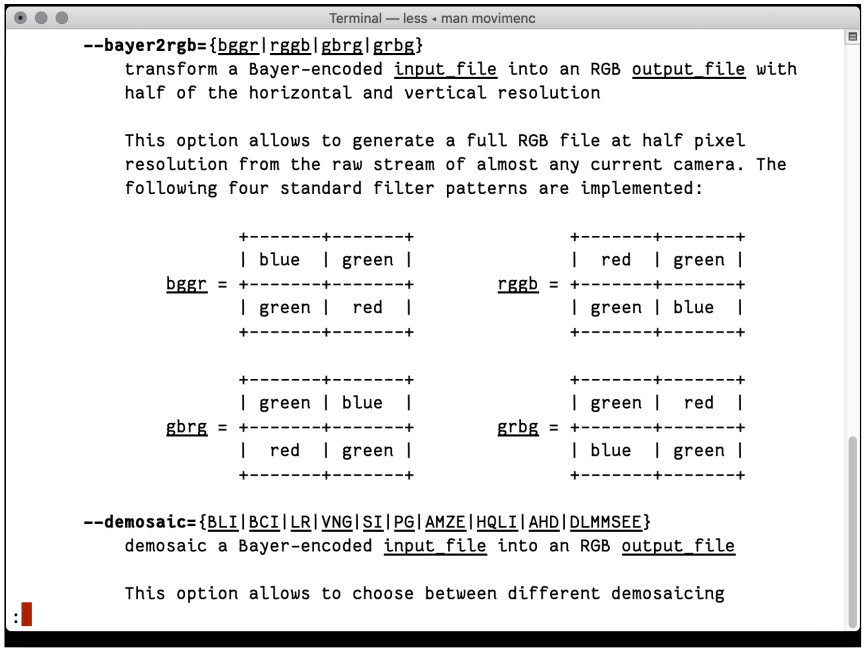

000000000000 000000000000
000000000000 010100001011
110101010101 000000000000
010010100101 011111011110
101101000001 010100001011
110101010101 100001100100
000000000000 101001010101
101010011010 000000000000
000000000000 000000000000
011000111001 101001010101
101010011010 010011011110
100001010111 010100010111

17


0 0
0 G1
B 0
0 R
G2 0
0 0
R R
G G1
B B
R R
G2 G
B B

18


Terminal — less ◂ man movimenc
--bayer2rgb={bggr|rggb|gbrg|grbg}
transform a Bayer-encoded input_file into an RGB output_file with
half of the horizontal and vertical resolution
This option allows to generate a full RGB file at half pixel
resolution from the raw stream of almost any current camera. The
following four standard filter patterns are implemented:
bggr = | blue | green | / | green | red |
rggb = | red | green | / | green | blue |
gbrg = | green | blue | / | red | green |
grbg = | green | red | / | blue | green |
--demosaic={BLI|BCI|LR|VNG|SI|PG|AMZE|HQLI|AHD|DLMMSEE}
demosaic a Bayer-encoded input_file into an RGB output_file
This option allows to choose between different demosaicing
:

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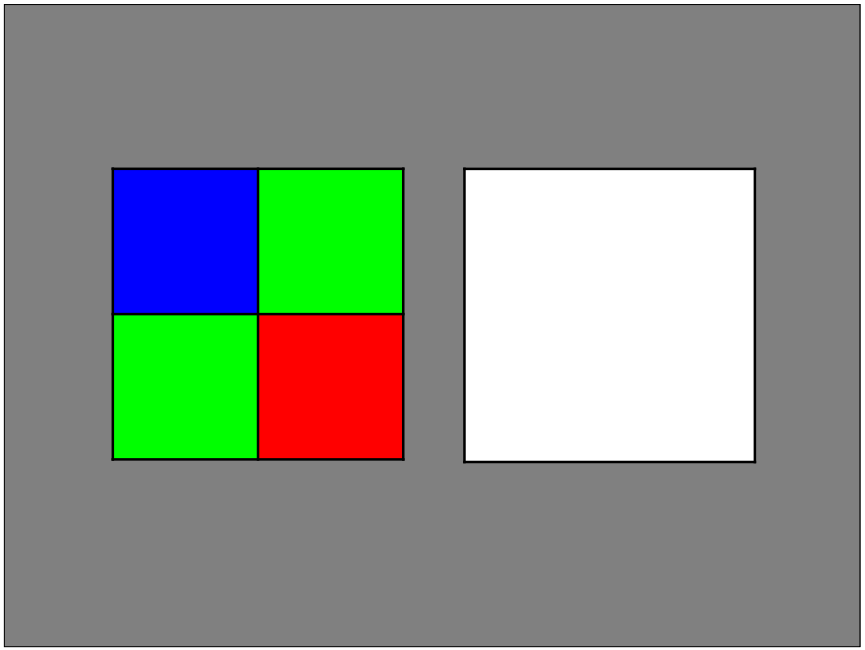

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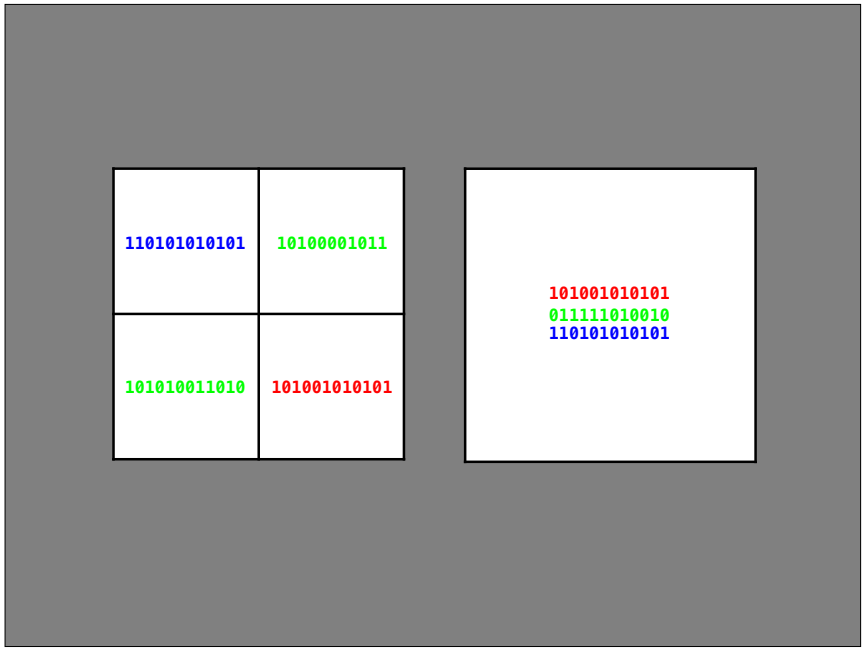

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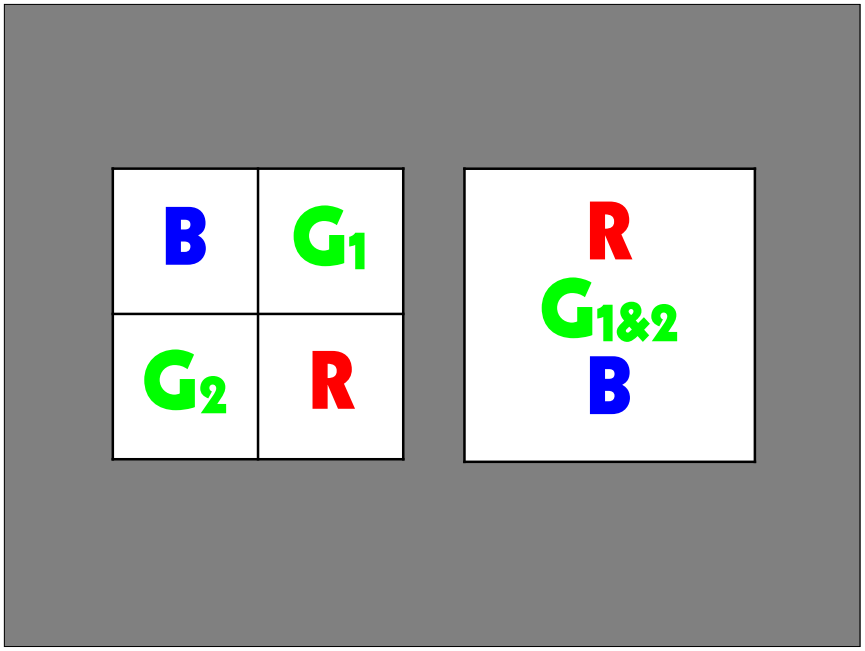

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Terminal — less ◂ man movimenc

```
          - DLMMSEE = directional linear minimum mean square-error estimation
          (Zhang and Xiaolin. IEEE 2005)

   OTHER OPTIONS
       -h, --help
           display a help message

       -v, --version
           display the running version

SEE ALSO
       movimdec(1) and movimplay(1); libmovim(1) and movim(1); openmovim(1).

COPYRIGHT
       Copyright (c) 2014-2019 by Reto Kromer

LICENSE
       The openMovIm package is released under a 3-Clause BSD License.

DISCLAIMER
       The openMovIm package is provided "as is" without warranty or support
       of any kind.

2019-08-03                https://avpres.net/MovIm/                movimenc(1)
(END)
```

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Terminal — less ◂ man openmovim

```
openmovim(1)                The MovIm video codec                openmovim(1)

NAME
       openmovim - Command-line interface to encode, decode, play and analyse
       moving images using 'libmovim'

SYNOPSIS
       openmovim (-e | -d | -p | -a | -m | -s) -i input_file [-o output_file]

       openmovim (-c | -u) -i input_file [-o output_file]

       openmovim -h | -v

DESCRIPTION
       MovIm is a video codec specifically designed for both conservation and
       restoration of moving images.

       libmovim is a C library implementing MovIm and movimenc, movimdec and
       movimplay are its associated utilities.

       openmovim is a Bash command-line interface to libmovim allowing to
       encode, decode, play and analyse virtually any moving images.

       The openMovIm package includes the libmovim library and its associated
:
```

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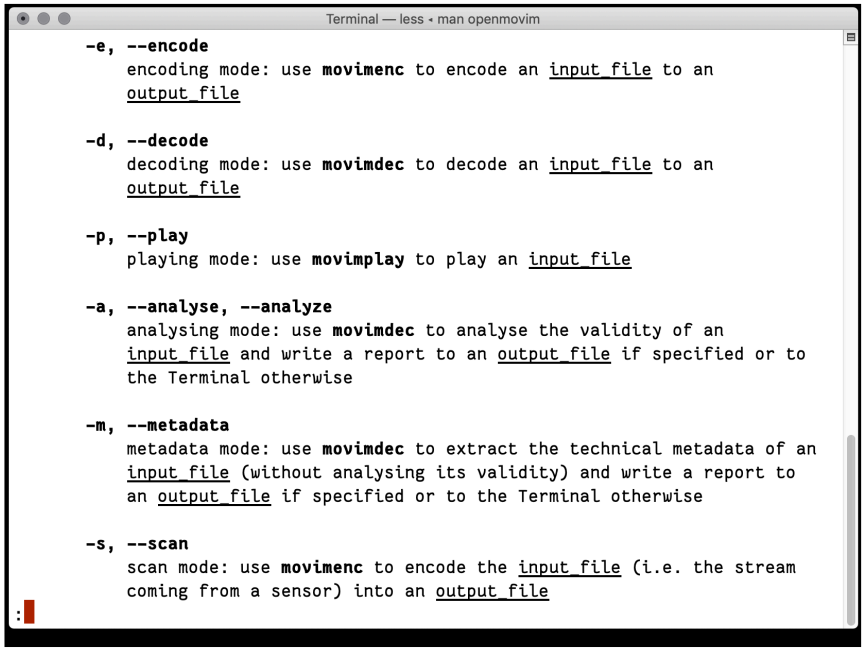

Two ways to use Bayer data

digital blow-up to RGB

- 3 times the amount of the generated data
- the file has the full sensor resolution
- only ⅓ of the data are real

digital reduction to RGB

- ¾ the amount of the generated data
- the file has ½ of the sensor resolution
- all data are real

Acknowledgements

- Tommy Aschenbach
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