

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

Reto Kromer • AV Preservation by reto.ch

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1

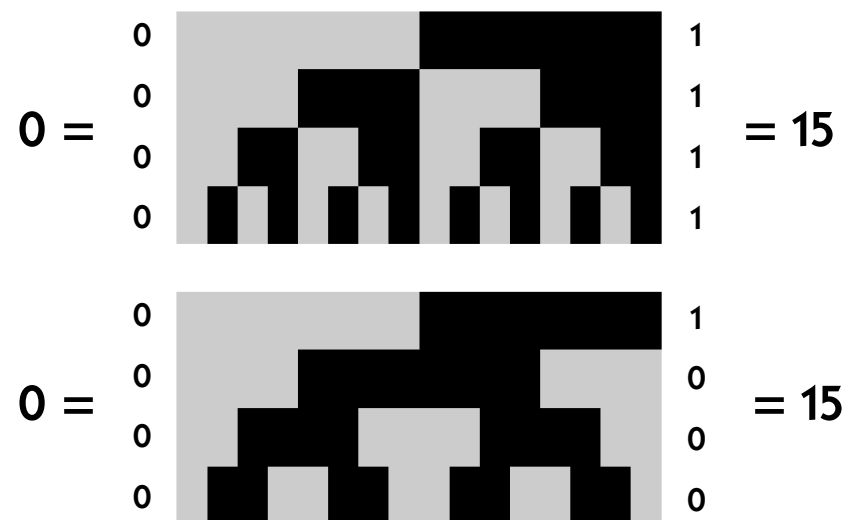
Summary

- Frank Gray (1887–1969)
- Bryce E. Bayer (1929–2012)
- Let's experiment!

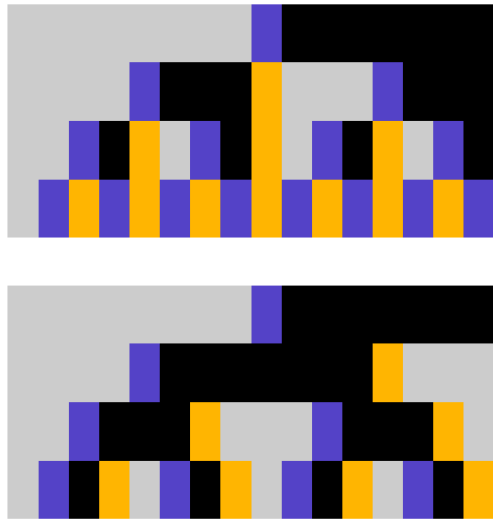
2

Frank Gray

3



4



5

March 17, 1953

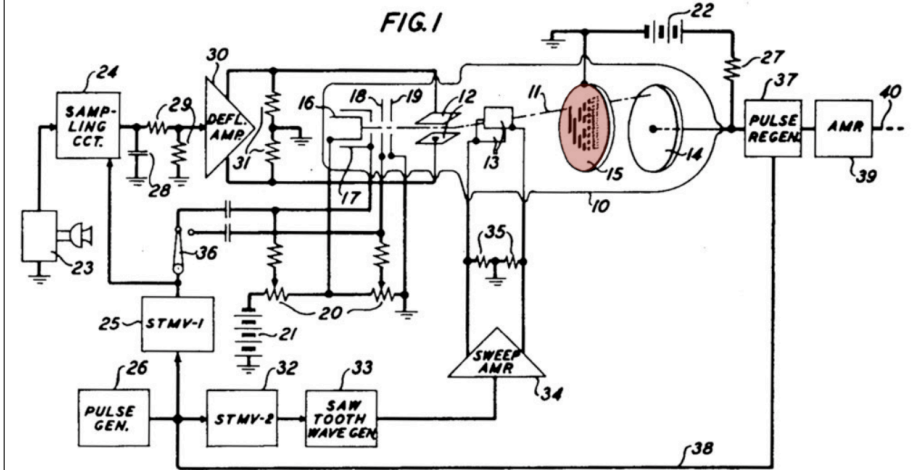
F. GRAY

2,632,058

PULSE CODE COMMUNICATION

Filed Nov. 13, 1947

4 Sheets-Sheet 1



6

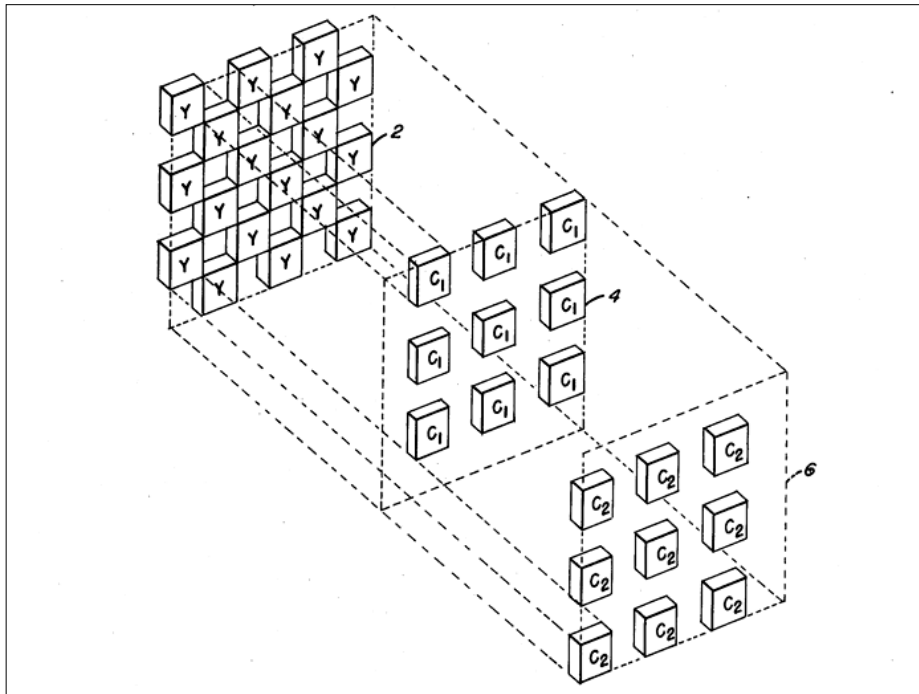
Bryce E. Bayer

Uncomfortable Truths

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

7

8



9

Let's experiment!

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

10

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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
--demaosaic={BLI|BCI|LR|VNG|SI|PG|AMZE|HQLI|AHD|DLMMSEE}
demaosaic 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

```

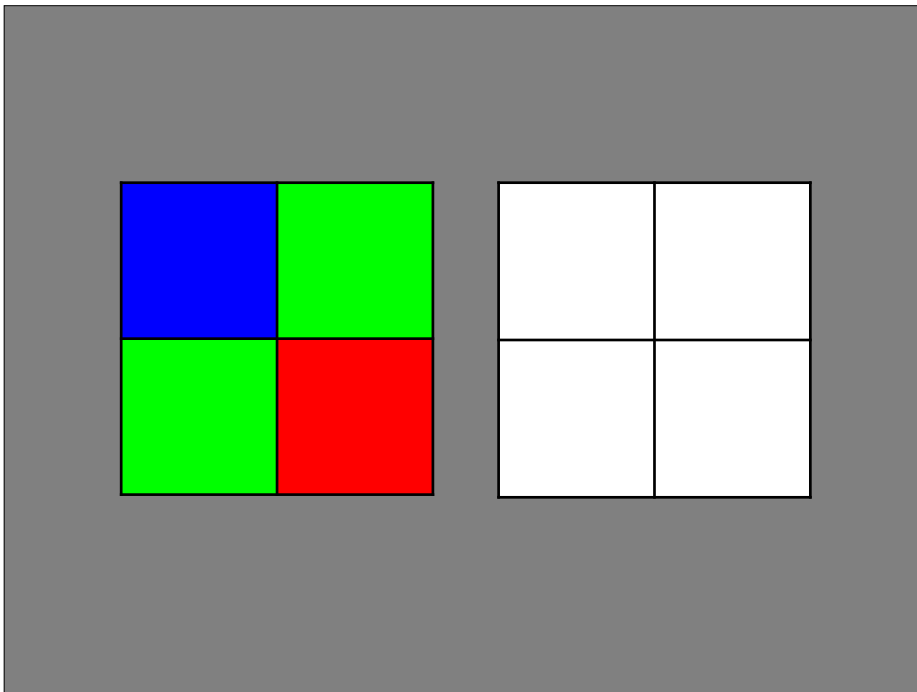
13

```

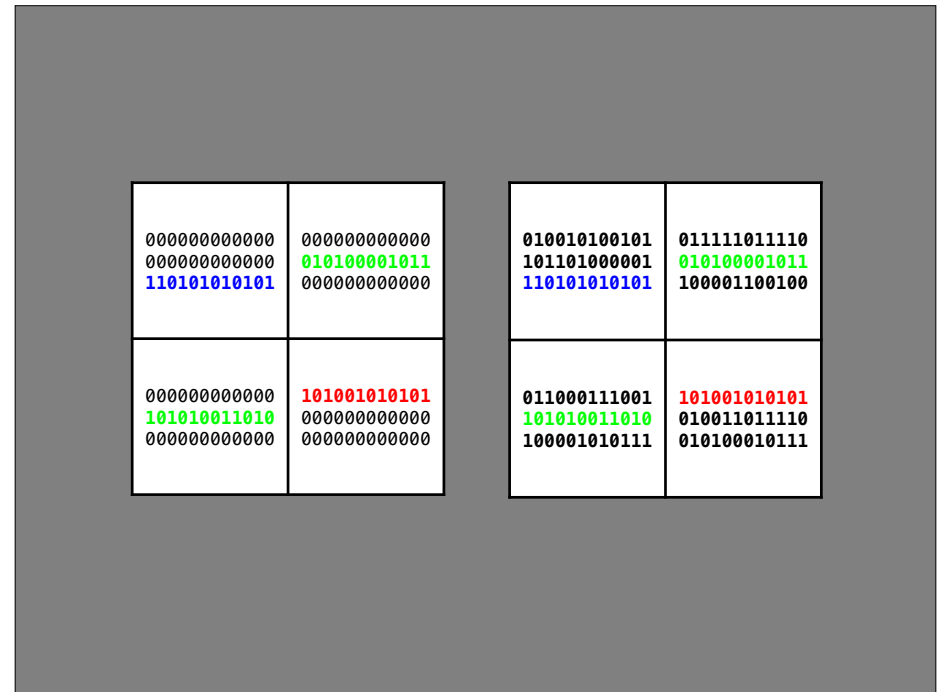
0111010100101010100010110101011110
010011010101010101010100001011101010
0111010100101010100010110101011110
000111010101010101010100001011101010
011010101001010101010001011010101111
001010101010101010000101110101010000
0111010100101010100010110101011110
010101010101010101000010111010100110
100101110101001010101000101101010101
1110010101010101010000101110101010
0111010100101010100010110101011110
0101010101010101001101010100000001
0010100010101010101001010101010101

```

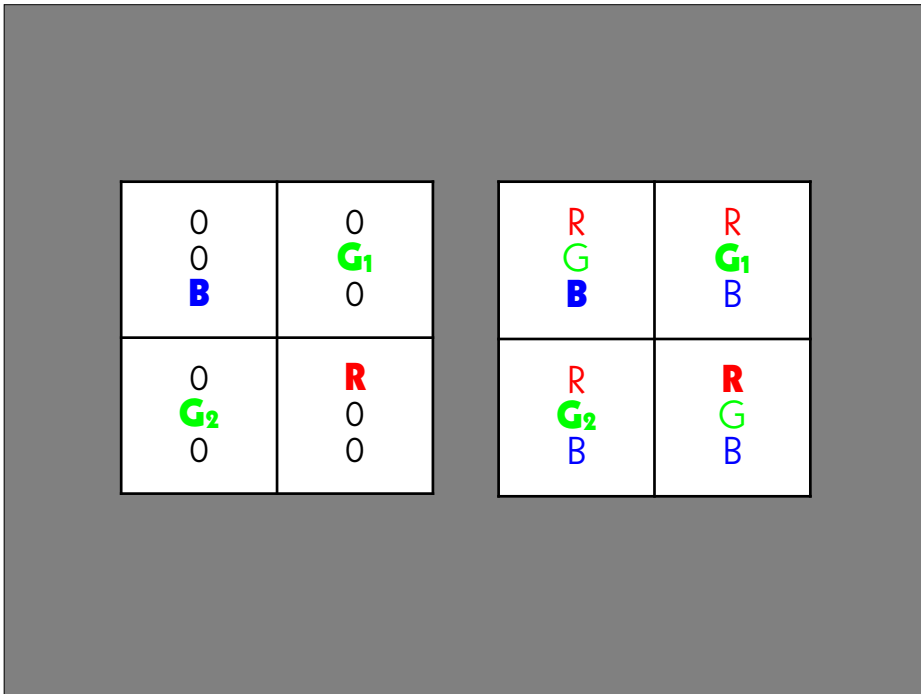
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15



16



17

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Terminal — less - man movimenc
--bayer2rgb={bgrg|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:

      +-----+-----+
      | blue | green |
bgrg = +-----+-----+
      | green | red  |
      +-----+-----+

      +-----+-----+
      | red  | green |
rggb = +-----+-----+
      | green | blue |
      +-----+-----+

      +-----+-----+
      | green | blue |
gbrg = +-----+-----+
      | red  | green |
      +-----+-----+

      +-----+-----+
      | green | red  |
grbg = +-----+-----+
      | 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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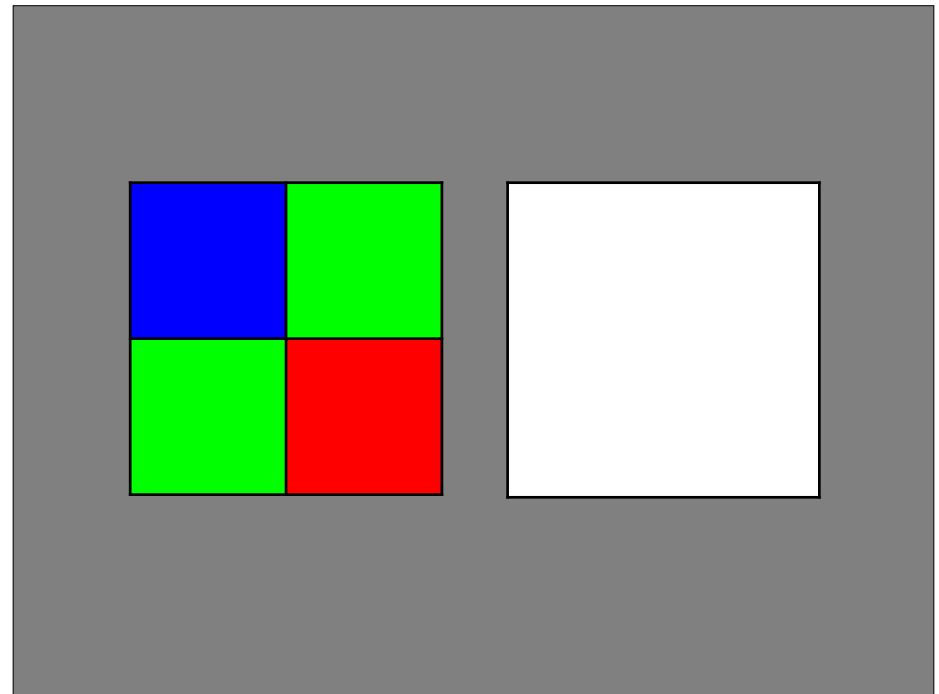
18

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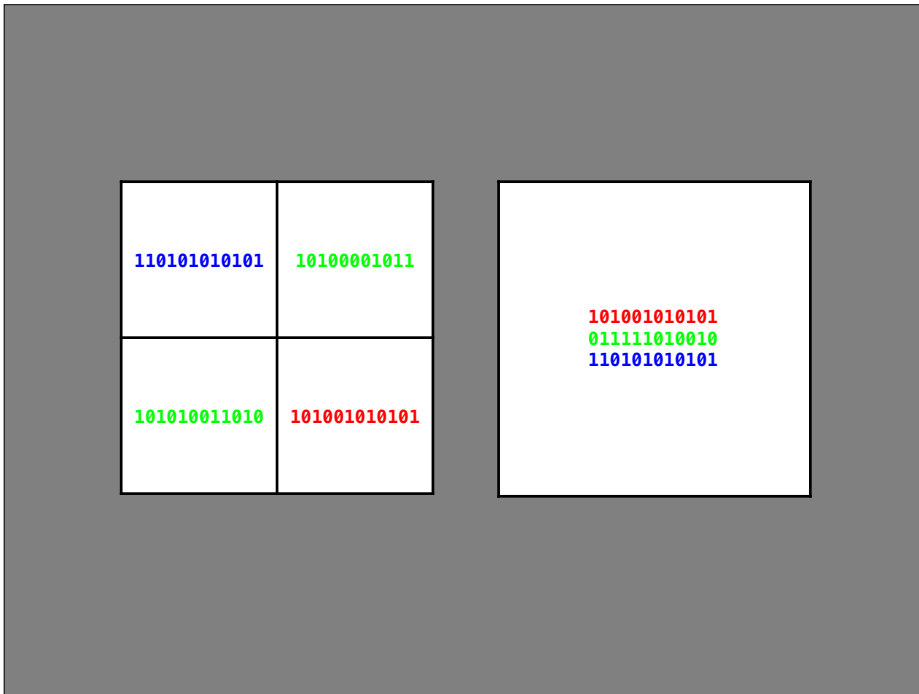
0111010100101010100010110101011110
010011010101010101010100001011101010
0111010100101010100010110101011110
0001110101010101010100001011101010
0110101001001010101000101101010111
001010101010101010000101110101010000
0111010100101010100010110101011110
010101010101010101000010111010100110
1001011101010010101010001011010101
1110010101010101010000101110101010
0111010100101010100010110101011110
010101010101010101001101010100000001
0010100010101010101001010101010101

```

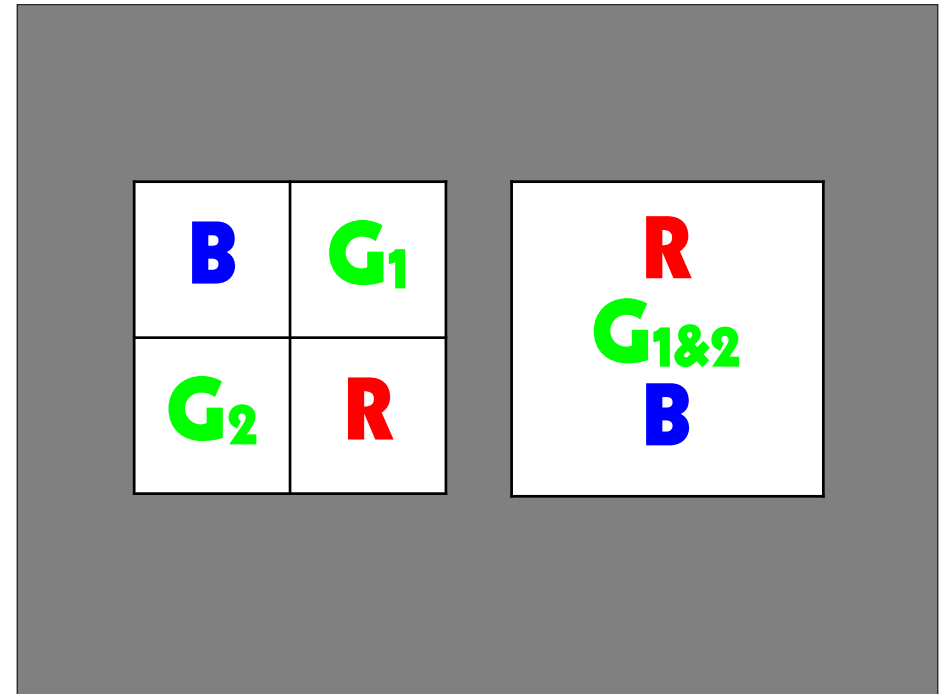
19



20



21



22

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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
  
```

23

```

Terminal — less · man openmovim
OPTIONS
GENERAL OPTIONS
  Select a mode:

  -e, --encode
    encoding mode: use movimenc to encode an input_file to an
    output_file

  -d, --decode
    decoding mode: use movimdec to decode an input_file to an
    output_file

  -p, --play
    playing mode: use movimplay to play an input_file

  -a, --analyse, --analyze
    analysing mode: use movimdec to analyse the validity of an
    input_file and write a report to an output_file if specified or to
    the Terminal otherwise

  -m, --metadata
    metadata mode: use movimdec to extract the technical metadata of an
    input_file (without analysing its validity) and write a report to
    an output_file if specified or to the Terminal otherwise
  
```

24

```
Terminal — less + man openmovim

-e, --encode
encoding mode: use movimenc to encode an input_file to an
output_file

-d, --decode
decoding mode: use movimdec to decode an input_file to an
output_file

-p, --play
playing mode: use movimplay to play an input_file

-a, --analyse, --analyze
analysing mode: use movimdec to analyse the validity of an
input_file and write a report to an output_file if specified or to
the Terminal otherwise

-m, --metadata
metadata mode: use movimdec to extract the technical metadata of an
input_file (without analysing its validity) and write a report to
an output_file if specified or to the Terminal otherwise

-s, --scan
scan mode: use movimenc to encode the input_file (i.e. the stream
coming from a sensor) into an output_file
```

25

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 $\frac{1}{3}$ of the data are real

digital reduction to RGB

- $\frac{3}{4}$ the amount of the generated data
- the file has $\frac{1}{2}$ of the sensor resolution
- all data are real

26

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27

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28