# IRIS: Intelligent Roadway Image Segmentation using an Adaptive Region of Interest

***Ryan Charles Brown***

Thesis submitted to the faculty of Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

**Master of Science**

**In**

**Mechanical Engineering**

**Alfred L. Wicks**

**Kathleen Meehan**

**John P. Bird**

6/16/2014

Blacksburg, Virginia

**<u>Keywords:</u>**

**Unmanned Ground Vehicles, Robotic Perception, Roadway Perception, Image Segmentation, Lane Modeling**

# Fair Use Evaluation Documentation

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| | |
|---|---|
| **Name:** | Ryan Brown |
| **Job Title:** | Graduate Research Assistant |
| **Institution:** | Virginia Tech |
| **Title of Work Used:** | ALV |
| **Copyright Holder:** | |
| **Publication Status:** | Published |
| **Publisher:** | DARPA |
| **Place of Publication:** | Google+ |
| **Publication Year:** | 2013 |
| **Description of Work:** | Image of the DARPA ALV (Autonomous Land Vehicle) |
| **Date of Evaluation:** | January 31, 2014 |
| **Date of Intended Use:** | January 31, 2014 |

## Describe the **Purpose** and Character of Your Intended Use:

[+] Use is one-time, or is only occasional or spontaneous

Fair — Unfair

**Describe the** **Nature** **of Your Intended Use of the Copyrighted Work:**

[+] Work to be used is primarily of a factual nature (non-fiction, collection of facts, etc.)
[+] Work to be used has been previously PUBLISHED

Fair — Unfair

**Describe the** **Amount** **of Your Intended Use in Relation to the Copyrighted Work as a Whole:**

[+] If the entire work is to be used (which would NOT favor the use being fair), it is clear that no less than the entire work will achieve the stated purpose of the use (e.g. use of a photograph, a short poem, an article, etc.)

Fair — Unfair

**Describe the** **Effect** **of Your Intended Use on the Potential Market or Value of the Copyrighted Work:**

[+] The work is NOT currently under commercial exploitation (out of print, no licensing available, etc.)
[+] Proper attribution will be given with the intended use

Fair — Unfair

**The Average** <u>**"Fairness Level,"**</u> **Based on Your Rating of Each of the 4 Factors, Is:**

[see tool disclaimer for important clarifying information]:

Fair Unfair

Based on the information and justification I have provided above, I, Ryan Brown, am asserting this use is **FAIR** under Section 107 of the U.S. Copyright Code.

Signature: ______________________________

Date of Signature: ______________________________

***Disclaimer:** *This document is intended to help you* collect, organize & archive the information you might need to support your fair use evaluation. *It is not a source of legal advice or assistance. The results are only as good as the input you have provided by are intended to suggest next steps, and not to provide a final judgment. It is recommended that* you share this evaluation with a copyright specialist before proceeding with your intended use.

# Fair Use Evaluation Documentation

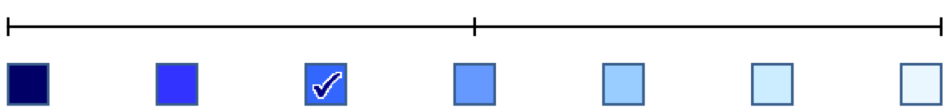
Compiled using the **Fair Use Evaluator** [cc] 2008 Michael Brewer & the Office for Information Technology Policy, http://librarycopyright.net/fairuse/

| | |
|---|---|
| **Name:** | Ryan Brown |
| **Job Title:** | Graduate Research Assistant |
| **Institution:** | Virginia Tech |
| **Title of Work Used:** | Figure 1 |
| **Copyright Holder:** | Y. Wang et. al. |
| **Publication Status:** | Published |
| **Publisher:** | Elsevier B.V. |
| **Place of Publication:** | |
| **Publication Year:** | 2004 |
| **Description of Work:** | Figure describing the model of a roadway lane that is used in the algorithm further developed in the work. |
| **Date of Evaluation:** | January 22, 2014 |
| **Date of Intended Use:** | January 22, 2014 |

**Describe the Purpose and Character of Your Intended Use:**

[+] Use is transformative, i.e. it uses the existing work in a new way (creates an index to the work) or for a new purpose (parody, pastiche, instructional materials, etc.) Transformative works are favored because the purpose of U.S. Copyright Law is to encourage the development and dissemination of new knowledge to benefit the public and thereby advance learning.

Fair



Unfair

## Describe the **Nature** of Your Intended Use of the Copyrighted Work:

[+] Work to be used has been previously PUBLISHED
[+] Work to be used is primarily of a factual nature (non-fiction, collection of facts, etc.)

Fair — Unfair

☐ ☑ ☐ ☐ ☐ ☐ ☐

## Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] The portion used is not the "heart" of the work (the portion considered most central to the work as a whole)
[+] Only limited and reasonable portions will be used

Fair — Unfair

☑ ☐ ☐ ☐ ☐ ☐ ☐

## Describe the **Effect** of Your Intended Use on the Potential Market or Value of the Copyrighted Work:

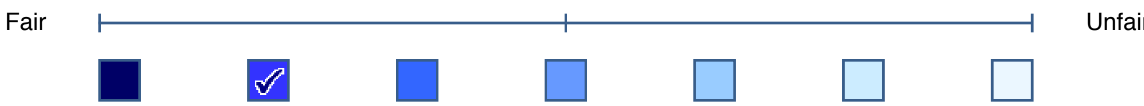
[+] Proper attribution will be given with the intended use
[+] The work is NOT currently under commercial exploitation (out of print, no licensing available, etc.)
[+] A market for the work as it will be used is absent or is negligible & use of the work will have little or no negative impact on its value or potential value

Fair — Unfair

☐ ☑ ☐ ☐ ☐ ☐ ☐

**The Average "Fairness Level," Based on Your Rating of Each of the 4 Factors, Is:**

[see tool disclaimer for important clarifying information]:




Based on the information and justification I have provided above, I, Ryan Brown, am asserting this use is **FAIR** under Section 107 of the U.S. Copyright Code.

Signature: ______________________________

Date of Signature: ______________________________

***Disclaimer:** *This document is intended to help you* collect, organize & archive the information you might need to support your fair use evaluation. *It is not a source of legal advice or assistance. The results are only as good as the input you have provided by are intended to suggest next steps, and not to provide a final judgment. It is recommended that* you share this evaluation with a copyright specialist before proceeding with your intended use.

# Fair Use Evaluation Documentation

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| | |
|---|---|
| **Name:** | Ryan Brown |
| **Job Title:** | Graduate Research Assistant |
| **Institution:** | Virginia Tech |
| **Title of Work Used:** | Logitech C615 HD Pro Webcam |
| **Copyright Holder:** | Logitech |
| **Publication Status:** | Published |
| **Publisher:** | Logitech |
| **Place of Publication:** | |
| **Publication Year:** | |
| **Description of Work:** | Image of RigWheels RMH1 |
| **Date of Evaluation:** | March 3, 2014 |
| **Date of Intended Use:** | March 3, 2014 |

**Describe the Purpose and Character of Your Intended Use:**

[+] Use is clearly defined and is restricted in scope (limited duration, not iterative, restricted access, etc.)
[+] Use is not-for-profit
[+] Use is one-time, or is only occasional or spontaneous

Fair — Unfair

## Describe the **Nature** of Your Intended Use of the Copyrighted Work:

[+] Work to be used has been previously PUBLISHED
[+] Work to be used is primarily of a factual nature (non-fiction, collection of facts, etc.)

Fair ——————————————— Unfair

☑ ☐ ☐ ☐ ☐ ☐ ☐

## Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] If the entire work is to be used (which would NOT favor the use being fair), it is clear that no less than the entire work will achieve the stated purpose of the use (e.g. use of a photograph, a short poem, an article, etc.)

Fair ——————————————— Unfair

☑ ☐ ☐ ☐ ☐ ☐ ☐

## Describe the **Effect** of Your Intended Use on the Potential Market or Value of the Copyrighted Work:

[+] Use of the work minimizes the potential for unauthorized use that could impact its value (i.e. steps are taken to ensure the content is not used outside of the stated purpose or audience)
[+] Use of the work has the potential to create or improve the market for the work

Fair ——————————————— Unfair

☐ ☑ ☐ ☐ ☐ ☐ ☐

**The Average "Fairness Level," Based on Your Rating of Each of the 4 Factors, Is:**

[see tool disclaimer for important clarifying information]:

Fair | Unfair

Based on the information and justification I have provided above, I, Ryan Brown, am asserting this use is **FAIR** under Section 107 of the U.S. Copyright Code.

Signature: ______________________________

Date of Signature: ______________________________

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# Fair Use Evaluation Documentation

Compiled using the **Fair Use Evaluator** [cc] 2008 Michael Brewer & the Office for Information Technology Policy, http://librarycopyright.net/fairuse/

| | |
|---|---|
| **Name:** | Ryan Brown |
| **Job Title:** | Graduate Research Assistant |
| **Institution:** | Virginia Tech |
| **Title of Work Used:** | Odin |
| **Copyright Holder:** | |
| **Publication Status:** | Published |
| **Publisher:** | Mechatronics Lab - VT |
| **Place of Publication:** | www.mechatronic.me.vt.edu |
| **Publication Year:** | 2013 |
| **Description of Work:** | Image of ODIN, VT entry to DARPA Urban Challenge |
| **Date of Evaluation:** | January 31, 2014 |
| **Date of Intended Use:** | January 31, 2014 |

**Describe the <u>Purpose</u> and Character of Your Intended Use:**

[+] Use is one-time, or is only occasional or spontaneous

Fair ——————————————————— Unfair

☐ ☑ ☐ ☐ ☐ ☐ ☐

Describe the **Nature** of Your Intended Use of the Copyrighted Work:

[+] Work to be used is primarily of a factual nature (non-fiction, collection of facts, etc.)
[+] Work to be used has been previously PUBLISHED

Fair —— Unfair

☐ ☑ ☐ ☐ ☐ ☐ ☐

Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] If the entire work is to be used (which would NOT favor the use being fair), it is clear that no less than the entire work will achieve the stated purpose of the use (e.g. use of a photograph, a short poem, an article, etc.)

Fair —— Unfair

☐ ☑ ☐ ☐ ☐ ☐ ☐

Describe the **Effect** of Your Intended Use on the Potential Market or Value of the Copyrighted Work:

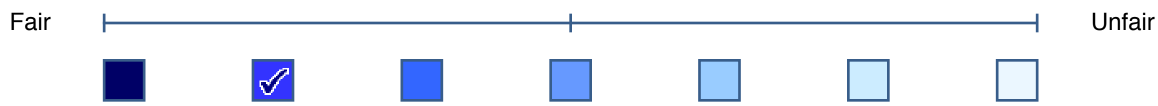
[+] The work is NOT currently under commercial exploitation (out of print, no licensing available, etc.)
[+] Proper attribution will be given with the intended use

Fair —— Unfair

☐ ☑ ☐ ☐ ☐ ☐ ☐

**The Average "Fairness Level," Based on Your Rating of Each of the 4 Factors, Is:**

[see tool disclaimer for important clarifying information]:




Based on the information and justification I have provided above, I, Ryan Brown, am asserting this use is **FAIR** under Section 107 of the U.S. Copyright Code.

Signature: ____________________________________

Date of Signature: ____________________________________

***Disclaimer:** *This document is intended to help you* collect, organize & archive the information you might need to support your fair use evaluation. *It is not a source of legal advice or assistance. The results are only as good as the input you have provided by are intended to suggest next steps, and not to provide a final judgment. It is recommended that* you share this evaluation with a copyright specialist before proceeding with your intended use.

# Fair Use Evaluation Documentation

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| | |
|---|---|
| **Name:** | Ryan Brown |
| **Job Title:** | Graduate Research Assistant |
| **Institution:** | Virginia Tech |
| **Title of Work Used:** | Pinhole Camera Model |
| **Copyright Holder:** | J. Forsyth |
| **Publication Status:** | Published |
| **Publisher:** | Prentice Hall |
| **Place of Publication:** | Boston |
| **Publication Year:** | 2011 |
| **Description of Work:** | Image showing the pinhole camera model. |
| **Date of Evaluation:** | February 3, 2014 |
| **Date of Intended Use:** | February 3, 2014 |

**Describe the** **Purpose** **and Character of Your Intended Use:**

[+] Use is clearly defined and is restricted in scope (limited duration, not iterative, restricted access, etc.)

Fair —— Unfair

## Describe the **Nature** of Your Intended Use of the Copyrighted Work:

[+] Work to be used has been previously PUBLISHED
[+] Work to be used is primarily of a factual nature (non-fiction, collection of facts, etc.)

Fair ——————————————————————— Unfair

## Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] If the entire work is to be used (which would NOT favor the use being fair), it is clear that no less than the entire work will achieve the stated purpose of the use (e.g. use of a photograph, a short poem, an article, etc.)

Fair ——————————————————————— Unfair

## Describe the **Effect** of Your Intended Use on the Potential Market or Value of the Copyrighted Work:

[+] Use of the work minimizes the potential for unauthorized use that could impact its value (i.e. steps are taken to ensure the content is not used outside of the stated purpose or audience)
[+] Proper attribution will be given with the intended use

Fair ——————————————————————— Unfair

**The Average "Fairness Level," Based on Your Rating of Each of the 4 Factors, Is:**

[see tool disclaimer for important clarifying information]:

Fair — Unfair

Based on the information and justification I have provided above, I, Ryan Brown, am **UNDECIDED** whether this use if fair under Section 107 of the U.S. Copyright Code.

Signature: ______________________________

Date of Signature: ______________________________

***Disclaimer:** This document is intended to help you* collect, organize & archive the information you might need to support your fair use evaluation. *It is not a source of legal advice or assistance. The results are only as good as the input you have provided by are intended to suggest next steps, and not to provide a final judgment. It is recommended that* you share this evaluation with a copyright specialist before proceeding with your intended use.

# Fair Use Evaluation Documentation

Compiled using the **Fair Use Evaluator** [cc] 2008 Michael Brewer & the Office for Information Technology Policy, http://librarycopyright.net/fairuse/

| | |
|---|---|
| **Name:** | Ryan Brown |
| **Job Title:** | Graduate Research Assistant |
| **Institution:** | Virginia Tech |
| **Title of Work Used:** | Projective Camera Geometry |
| **Copyright Holder:** | UNKNOWN |
| **Publication Status:** | Unknown |
| **Publisher:** | |
| **Place of Publication:** | |
| **Publication Year:** | |
| **Description of Work:** | |
| **Date of Evaluation:** | February 5, 2014 |
| **Date of Intended Use:** | February 5, 2014 |

## Describe the Purpose and Character of Your Intended Use:

[+] Use is clearly defined and is restricted in scope (limited duration, not iterative, restricted access, etc.)
[+] Use is one-time, or is only occasional or spontaneous
[+] Use is for "criticism, comment, news reporting, teaching, (including multiple print copies for classroom use), scholarship or research"

Fair Unfair

## Describe the **Nature** of Your Intended Use of the Copyrighted Work:

[+] Work to be used contains limited new knowledge, content, or creative expression (in relation to previously copyrighted works)
[+] Work to be used is primarily of a factual nature (non-fiction, collection of facts, etc.)

Fair | Unfair

☐ ☑ ☐ ☐ ☐ ☐ ☐

## Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] If the entire work is to be used (which would NOT favor the use being fair), it is clear that no less than the entire work will achieve the stated purpose of the use (e.g. use of a photograph, a short poem, an article, etc.)
[+] The amount used falls within widely recognized fair use guidelines* vetted by key stakeholder groups [reference guidelines]

Fair | Unfair

☑ ☐ ☐ ☐ ☐ ☐ ☐

## Describe the **Effect** of Your Intended Use on the Potential Market or Value of the Copyrighted Work:

[+] A market for the work as it will be used is absent or is negligible & use of the work will have little or no negative impact on its value or potential value
[+] The copyright holder cannot be identified or cannot be found after a reasonable search, or, once found does not respond (one way or another) to requests for permission to use the work

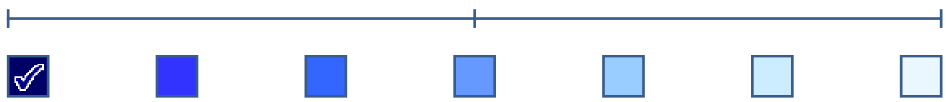
Fair | Unfair

☑ ☐ ☐ ☐ ☐ ☐ ☐

**The Average "Fairness Level," Based on Your Rating of Each of the 4 Factors, Is:**

[see tool disclaimer for important clarifying information]:

Fair



Unfair

Based on the information and justification I have provided above, I, Ryan Brown, am asserting this use is **FAIR** under Section 107 of the U.S. Copyright Code.

Signature: ______________________________

Date of Signature: ______________________________

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# Fair Use Evaluation Documentation



| | |
|---|---|
| **Name:** | Ryan Brown |
| **Job Title:** | Graduate Research Assistant |
| **Institution:** | Virginia Tech |
| **Title of Work Used:** | RigMount RMH1 |
| **Copyright Holder:** | RigWheels |
| **Publication Status:** | Published |
| **Publisher:** | RigWheels |
| **Place of Publication:** | |
| **Publication Year:** | |
| **Description of Work:** | Image of RigWheels RMH1 |
| **Date of Evaluation:** | March 3, 2014 |
| **Date of Intended Use:** | March 3, 2014 |

**Describe the Purpose and Character of Your Intended Use:**

[+] Use is clearly defined and is restricted in scope (limited duration, not iterative, restricted access, etc.)
[+] Use is not-for-profit
[+] Use is one-time, or is only occasional or spontaneous

Fair — Unfair

## Describe the **Nature** of Your Intended Use of the Copyrighted Work:

[+] Work to be used has been previously PUBLISHED
[+] Work to be used is primarily of a factual nature (non-fiction, collection of facts, etc.)

Fair — Unfair

☑ ☐ ☐ ☐ ☐ ☐ ☐

## Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] If the entire work is to be used (which would NOT favor the use being fair), it is clear that no less than the entire work will achieve the stated purpose of the use (e.g. use of a photograph, a short poem, an article, etc.)

Fair — Unfair

☑ ☐ ☐ ☐ ☐ ☐ ☐

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[+] Use of the work has the potential to create or improve the market for the work

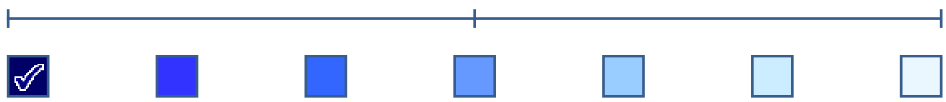
Fair — Unfair

☐ ☑ ☐ ☐ ☐ ☐ ☐

**The Average** **"Fairness Level,"** **Based on Your Rating of Each of the 4 Factors, Is:**

[see tool disclaimer for important clarifying information]:

Fair



Unfair

Based on the information and justification I have provided above, I, Ryan Brown, am asserting this use is **FAIR** under Section 107 of the U.S. Copyright Code.

Signature: ______________________________

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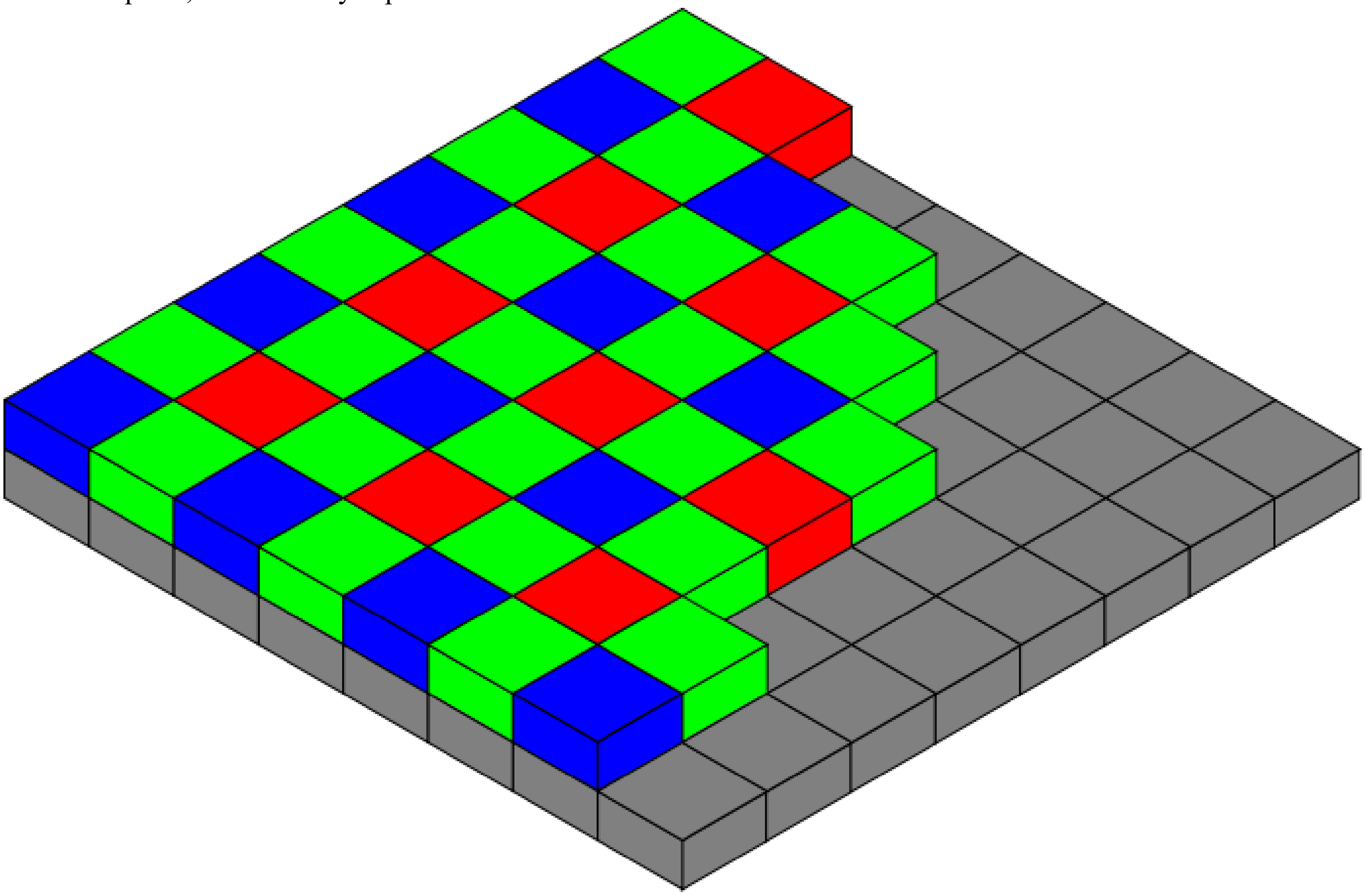
# File:Bayer pattern on sensor.svg

From Wikipedia, the free encyclopedia



Bayer_pattern_on_sensor.svg (SVG file, nominally 700 × 455 pixels, file size: 30 KB)

This image rendered as PNG in other sizes: 200px, 500px, 1000px, 2000px.



## Summary

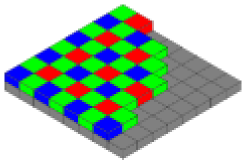
| | |
|---|---|
| **Description** | **English:** A bayer pattern on a sensor in isometric perspective/projection<br>**Polski:** Wzór bayer będący mozaiką kolorowych filtrów na kwadratowej siatce czujników fotograficznych matrycy CCD |
| **Date** | 28 December 2006 |
| **Source** | Own work<br>This vector image was created with Inkscape. |
| **Author** | en:User:Cburnett |
| **Permission (Reusing this file)** | GFDL & GPL |

# Licensing:



# File history

Click on a date/time to view the file as it appeared at that time.

| | Date/Time | Thumbnail | Dimensions | User | Comment |
|---|---|---|---|---|---|
| current | 06:46, 27 December 2006 |  | 700 × 455 (30 KB) | Cburnett | {{Information \|Description='''en:''' A bayer pattern on a sensor \|Source=Own work with Inkscape \|Date=December 28, 2006 \|Author=en:User:Cburnett \|Permission=GFDL \|other_versions= }} |

# File usage

The following pages on the English Wikipedia link to this file (pages on other projects are not listed):

- Bayer filter
- Charge-coupled device
- Color filter array
- Demosaicing
- Digital camera
- Electrical engineering
- RGB color model
- User:Cburnett
- User:Cburnett/GFDL images

# Global file usage

The following other wikis use this file:

- Usage on ar.wikipedia.org
  - حساس (تصوير)
- Usage on as.wikipedia.org
  - ৱিকিপিডিয়া:অনুবাদ/তড়িৎ আৰু ইলেকট্রনিক প্রকৌশল
- Usage on bn.wikipedia.org
  - তড়িৎ ও ইলেকট্রনিক প্রকৌশল
- Usage on ca.wikipedia.org
  - Filtre mosaic de Bayer
  - Representació per subpíxels
  - Càmera digital
  - Filtre RGBW
  - Usuari:Mcapdevila/Projecció isomètrica
  - Sensor CMOS
  - Mosaic filtre de color
  - Reconeixement de color
- Usage on cs.wikipedia.org
  - Bayerova maska
- Usage on de.wikipedia.org
  - Demosaicing
- Usage on en.wikibooks.org
  - Adventist Youth Honors Answer Book/Arts and Crafts/Digital Photography
  - A-level Computing/AQA/Computer Components, The Stored Program Concept and the Internet/Hardware Devices/Input devices

  - A-level Computing/AQA/Print version/Unit 2
  - GCSE Computing/Computing hardware/Input and output devices
- Usage on es.wikipedia.org
  - Proyección isométrica
  - Sensor CMOS
  - Mosaico de Bayer
  - Cámara digital
  - Filtro RGBW
  - Mosaico filtro de color
  - Reconocimiento de color
- Usage on fa.wikipedia.org
  - عکاسی
- Usage on fr.wikipedia.org
  - Matrice de Bayer
- Usage on fr.wikibooks.org
  - Photographie/Thèmes/Répétitions, réseaux et trames
  - Utilisateur:Jean-Jacques MILAN/03 perspective
- Usage on hi.wikipedia.org
  - डिजिटल कैमरा
- Usage on ia.wikipedia.org
  - Ingenieria electric
- Usage on it.wikipedia.org
  - Demosaicizzazione
  - Schema Bayer
- Usage on ja.wikipedia.org
  - 電気工学
- Usage on kn.wikipedia.org
  - ಡಿಜಿಟಲ್ ಕ್ಯಾಮೆರಾ
- Usage on ml.wikipedia.org
  - ബ്രൈസ് ബേയർ
- Usage on my.wikipedia.org
  - □□□□□□□□□□□□□□□□□□□□□□
- Usage on nl.wikipedia.org
  - Bayerfilter
- Usage on pt.wikipedia.org
  - Fotografia
  - Sensor de imagem
- Usage on ro.wikipedia.org
  - Demozaicare
  - Matrice de filtre de culoare
- Usage on ru.wikipedia.org
  - Фильтр Байера
  - Обсуждение:Перспектива
  - Цветной кинематограф
- Usage on sr.wikipedia.org
  - CCD senzor
  - Дигитални фото-апарат
- Usage on sv.wikipedia.org
  - Digitalkamera

  - Bildsensor
  - Bayerfilter
- Usage on ta.wikipedia.org
  - இருமப் படமி

View more global usage of this file.

Retrieved from "http://en.wikipedia.org/wiki/File:Bayer_pattern_on_sensor.svg"