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

**Keywords:**

Unmanned Ground Vehicles, Robotic Perception, Roadway Perception, Image Segmentation, Lane Modeling
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
Describe the **Nature** of Your Intended Use of the Copyrighted Work:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work to be used is primarily of a factual nature (non-fiction, collection of facts, etc.)</td>
<td></td>
</tr>
<tr>
<td>Work to be used has been previously PUBLISHED</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.)</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>The work is NOT currently under commercial exploitation (out of print, no licensing available, etc.)</td>
<td></td>
</tr>
<tr>
<td>Proper attribution will be given with the intended use</td>
<td></td>
</tr>
</tbody>
</table>
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: ________________________________

*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.
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.

<table>
<thead>
<tr>
<th>Description of Work:</th>
<th>Figure describing the model of a roadway lane that is used in the algorithm further developed in the work.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of Evaluation:</td>
<td>January 22, 2014</td>
</tr>
<tr>
<td>Date of Intended Use:</td>
<td>January 22, 2014</td>
</tr>
</tbody>
</table>

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.
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
--- | ---
[ ] | 
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[ ] | 

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
--- | ---
[ ] | 
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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
--- | ---
[ ] | 
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Page 2
The Average "Fairness Level," Based on Your Rating of Each of the 4 Factors, Is:

[see tool disclaimer for important clarifying information]:

<table>
<thead>
<tr>
<th>Fair</th>
<th>✓</th>
<th>Unfair</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>Fair</th>
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</tr>
</thead>
<tbody>
<tr>
<td>✔</td>
<td></td>
</tr>
</tbody>
</table>

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

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

<table>
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<th>Fair</th>
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</thead>
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<tr>
<td>✔</td>
<td></td>
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</tbody>
</table>

| 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.) |

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

<table>
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<tr>
<th>Fair</th>
<th>Unfair</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔</td>
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</tr>
</tbody>
</table>

| 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 |

Page 2
The Average "Fairness Level," Based on Your Rating of Each of the 4 Factors, Is:

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<table>
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<tr>
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<tbody>
<tr>
<td>✓</td>
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<td></td>
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</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Fair</th>
<th></th>
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<th></th>
<th></th>
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</tr>
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<td><img src="true" alt="Fair" /></td>
<td><img src="false" alt="Unfair" /></td>
<td><img src="false" alt="Unfair" /></td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Fair</th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th>Unfair</th>
</tr>
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</table>

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.)

<table>
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<tr>
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<th></th>
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<th></th>
<th></th>
<th></th>
<th>Unfair</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>Fair</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Unfair</th>
</tr>
</thead>
</table>
The Average "Fairness Level," Based on Your Rating of Each of the 4

Factors, Is:

[see tool disclaimer for important clarifying information]:

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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.)
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.)

<table>
<thead>
<tr>
<th>Fair</th>
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<th></th>
<th></th>
<th>Unfair</th>
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</thead>
<tbody>
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<td>☑️</td>
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<td>☐️</td>
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<td>☐️</td>
<td>☐️</td>
</tr>
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</table>

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.)

<table>
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<td>☐️</td>
<td>☐️</td>
<td>☐️</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
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<th>Fair</th>
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<th></th>
<th></th>
<th></th>
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</table>
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: __________________________

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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.)

---

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]

---

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
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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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

[ ][ ][ ][ ][ ][ ]
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:

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| 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

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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.

This is a file from the Wikimedia Commons. Information from its description page there is shown below.

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Summary

**Description**  **English:** A bayer pattern on a sensor in isometric perspective/projection  
**Polski:** Wzór bayer będący mozaiką kolorowych filtrów na kwadratowej siatce czujników fotograficznych matrycy CCD

**Date**  28 December 2006

**Source**  Own work

This vector image was created with Inkscape.

**Author**  en:User:Cburnett

**Permission**  **GFDL & GPL**

(Reusing this file)

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You are free:

- **to share** – to copy, distribute and transmit the work
- **to remix** – to adapt the work

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- **attribution** – You must attribute the work in the manner specified by the author or licensor (but not in any way that suggests that they endorse you or your use of the work).
- **share alike** – If you alter, transform, or build upon this work, you may distribute the resulting work only under the same or similar license to this one.

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You may select the license of your choice.

File history

Click on a date/time to view the file as it appeared at that time.
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
  - حساب (تصوير)
- Usage on as.wikipedia.org
  - বিকিপিডিয়া:অনুবাদ/তড়িৎ আবু ইলেকট্রনিক প্রকৌশল
- Usage on bn.wikipedia.org
  - তড়িৎ ও ইলেকট্রনিক প্রকৌশল
- Usage on ca.wikipedia.org
  - Filtre mosaïque de Bayer
  - Representación per subpixels
  - Cámara digital
  - Filtre RGBW
  - Usuari:Mcapdevila/Projecció isomètrica
  - Sensor CMOS
  - Mosaic filtro de color
  - Reconhecimento 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
  - ದೃಶ್ಯಮಾಣೆ

- Usage on ml.wikipedia.org
  - ഓഫീസ് ക്യൂട്ട

- Usage on my.wikipedia.org
  - ສ່ຽວ dmačה

- 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
  - Digikamera
- Bildsensor
- Bayerfilter
  - Usage on ta.wikipedia.org
    - மேல் மூலம்

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