

Machine Learning Techniques for Gesture Recognition

Carlos Antonio Caceres

Thesis submitted to the faculty of the 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, Chair
John P. Bird
Craig A. Woolsey

September 9th, 2014
Blacksburg, VA

Keywords: Gesture Recognition, Smart Prosthetic, Hidden Markov Model, Support
Vector Machines, Dynamic Time Warping

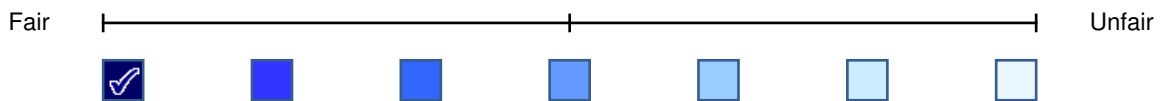
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Copyright Holder:	N. Shapiro
Publication Status:	Published
Publisher:	The alchemist
Place of Publication:	
Publication Year:	2009
Description of Work:	Published Research Paper
Date of Evaluation:	August 25, 2014
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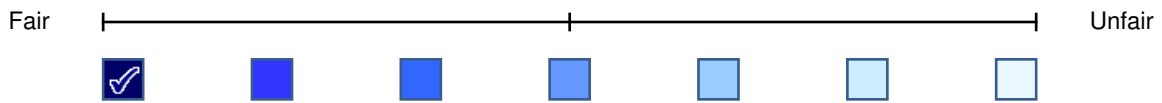
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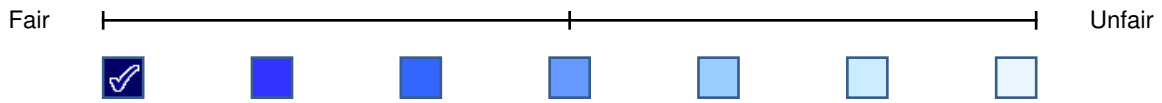
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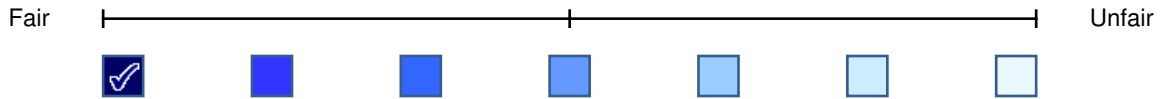
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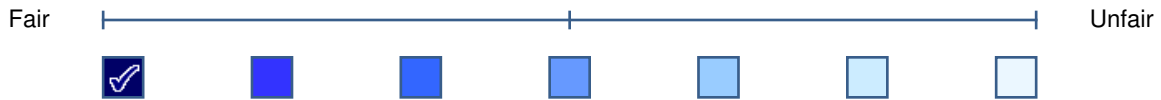
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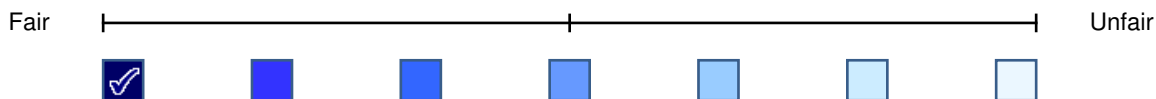
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Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	Soft computing based feature selection for environmental sound classification
Copyright Holder:	A. Shakoor, T. May, and N. Van Schijndel,
Publication Status:	Published
Publisher:	Blekinge Institute of Technology
Place of Publication:	
Publication Year:	2010
Description of Work:	Published Research Paper.
Date of Evaluation:	August 25, 2014
Date of Intended Use:	September 9, 2014

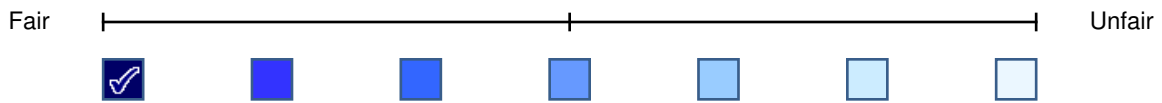
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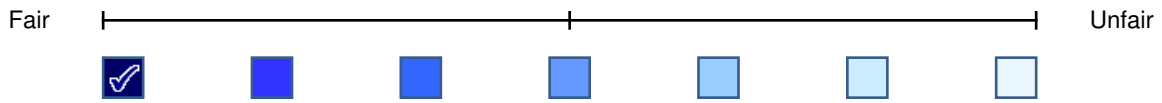
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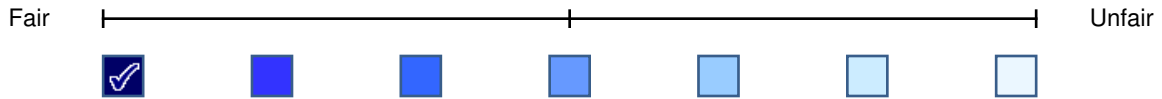
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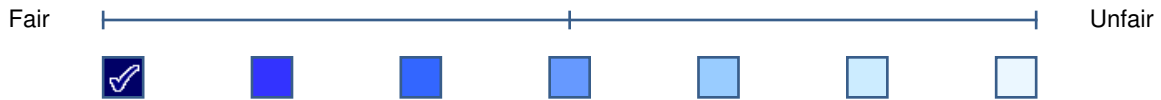
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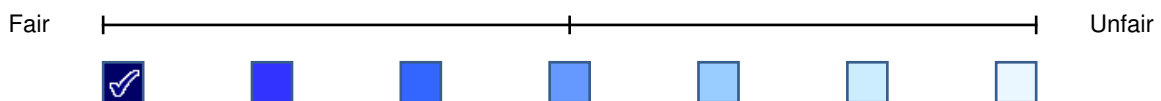
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Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	The Movement Error Rate for Evaluation of Machine Learning Methods for sEMG-based Hand Movement Classification
Copyright Holder:	A. Gijsberts, M. Atzori, C. Castellini, H. Muller, and B. Caputo
Publication Status:	Published
Publisher:	IEEE
Place of Publication:	
Publication Year:	2014
Description of Work:	Published Research Paper.
Date of Evaluation:	August 25, 2014
Date of Intended Use:	September 9, 2014

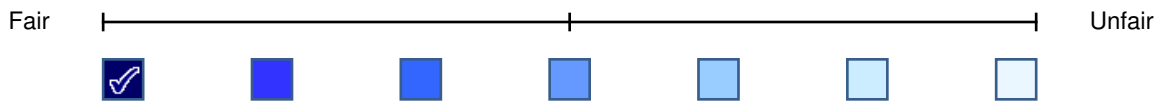
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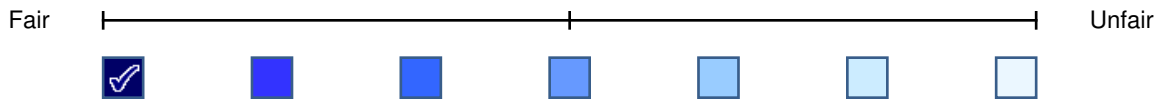
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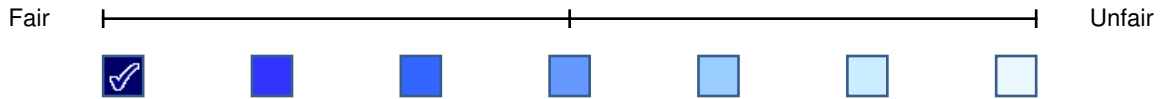
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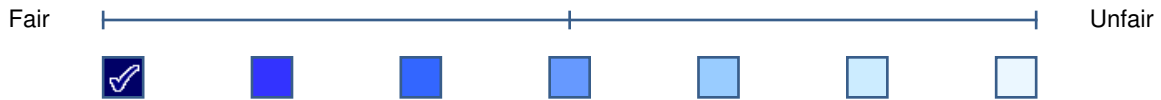
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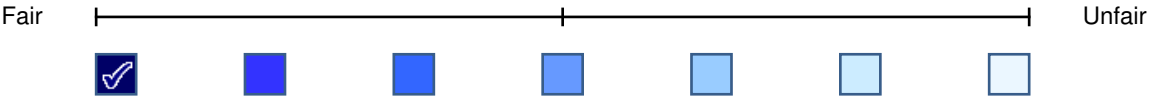
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Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	The Sign Language Alphabet
Copyright Holder:	HowStuffWorks
Publication Status:	Unpublished
Publisher:	
Place of Publication:	
Publication Year:	2007
Description of Work:	Webpage image describing American Sign Language
Date of Evaluation:	August 25, 2014
Date of Intended Use:	September 9, 2014

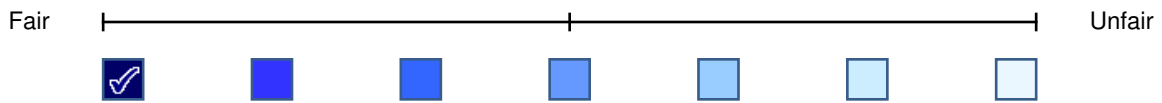
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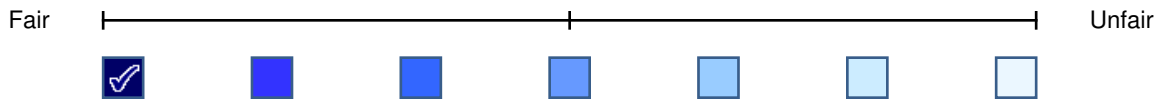
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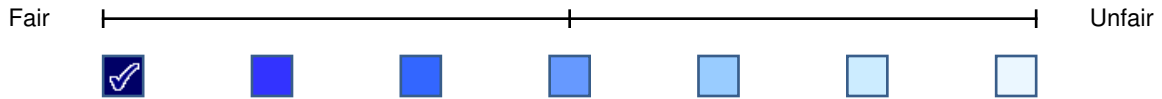
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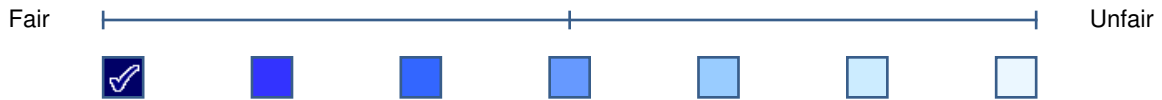
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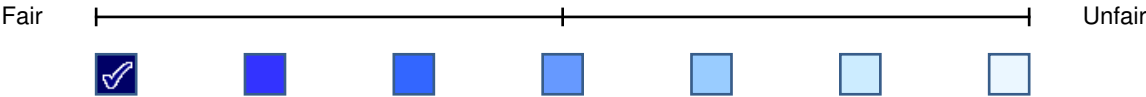
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Name:	Carlos Caceres
Job Title:	Graduate Research Assistant
Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	A decomposition algorithm for surface electrode-array electromyogram
Copyright Holder:	G. A. Garcia, R. Okuno, and K. Azakawa
Publication Status:	Published
Publisher:	IEEE
Place of Publication:	
Publication Year:	2005
Description of Work:	Published Research Paper
Date of Evaluation:	August 25, 2014
Date of Intended Use:	September 9, 2014

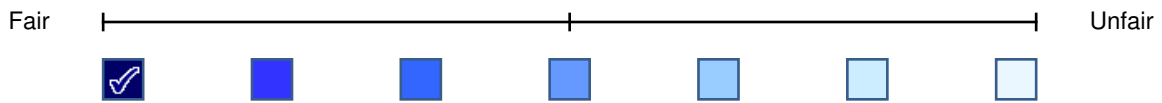
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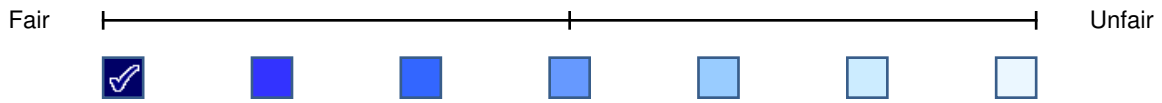
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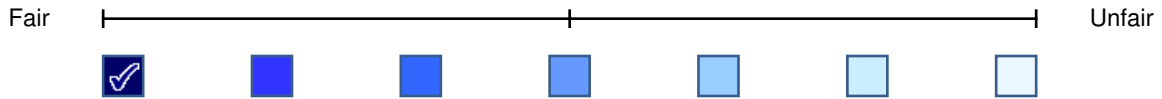
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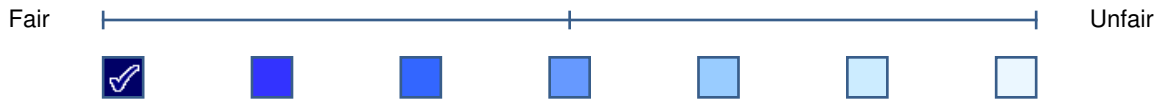
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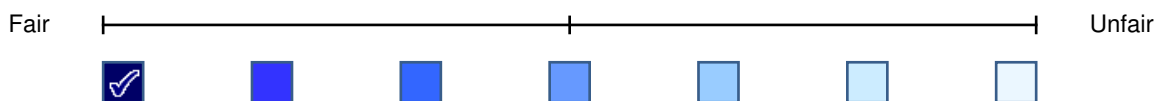
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Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	An Investigation of Electromyographic (EMG) Control of Dextrous Hand Prostheses for Transradial Amputees
Copyright Holder:	A. Hussein Ali
Publication Status:	Published
Publisher:	IEEE
Place of Publication:	
Publication Year:	2013
Description of Work:	Published Research Paper.
Date of Evaluation:	August 25, 2014
Date of Intended Use:	September 9, 2014

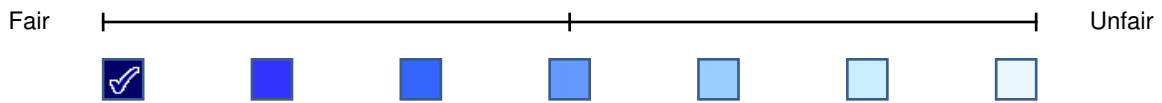
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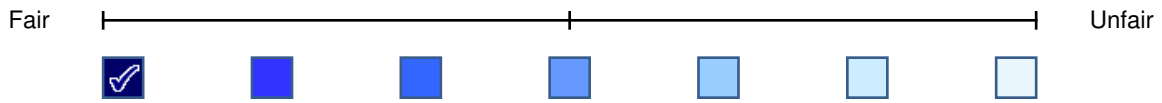
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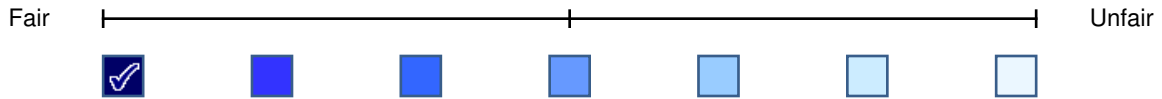
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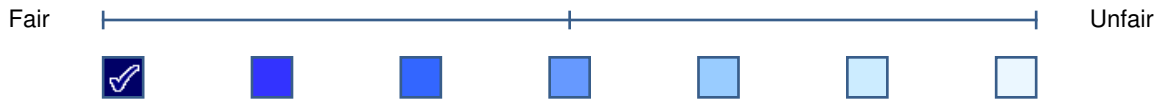
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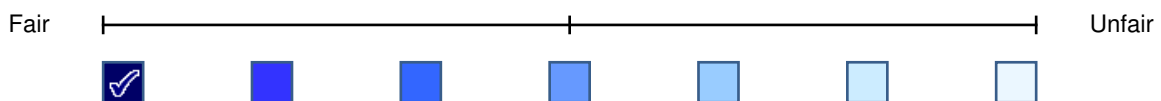
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Name:	Carlos Caceres
Job Title:	Graduate Research Assistant
Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	Building the Ninapro database: A resource for the biorobotics community
Copyright Holder:	M. Atzori, A. Gijsberts, S. Heynen, A. M. Hager, O. Deriaz, P. van der Smagt, C. Castellini, B. Caputo, and H. Muller
Publication Status:	Published
Publisher:	IEEE
Place of Publication:	
Publication Year:	2012
Description of Work:	Published Research Paper.
Date of Evaluation:	August 25, 2014
Date of Intended Use:	September 9, 2014

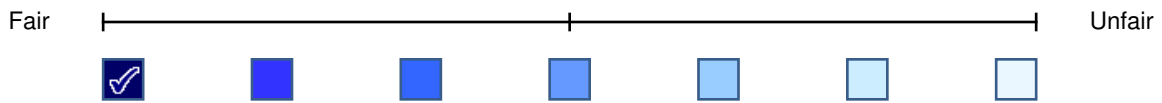
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[+] Use is not-for-profit
[+] Use is for "criticism, comment, news reporting, teaching, (including multiple print copies for classroom use), scholarship or research"



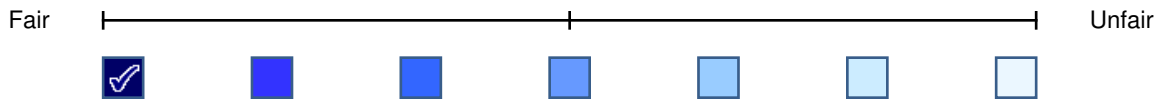
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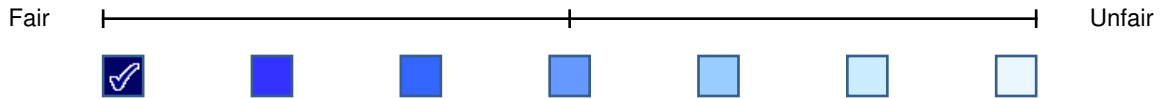
Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

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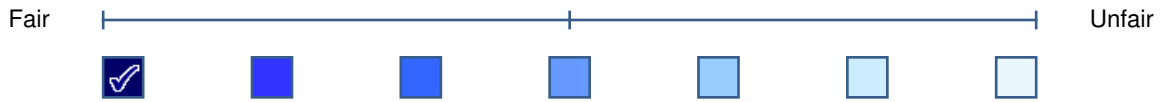
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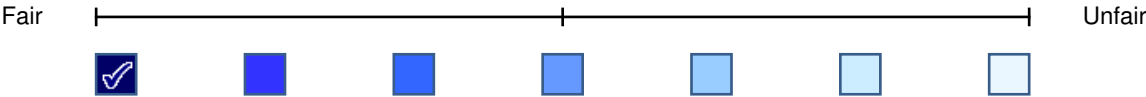
Fair Use Evaluation Documentation

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Name:	Carlos Caceres
Job Title:	Graduate Research Assistant
Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	Dynamic Time Warping
Copyright Holder:	M. Müller
Publication Status:	Published
Publisher:	Information Retrieval for Music and Motion
Place of Publication:	Berlin
Publication Year:	2007
Description of Work:	Published Research Paper.
Date of Evaluation:	August 25, 2014
Date of Intended Use:	September 9, 2014

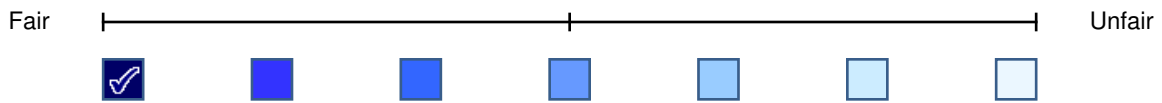
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[+] Use is not-for-profit
[+] Use is for "criticism, comment, news reporting, teaching, (including multiple print copies for classroom use), scholarship or research"



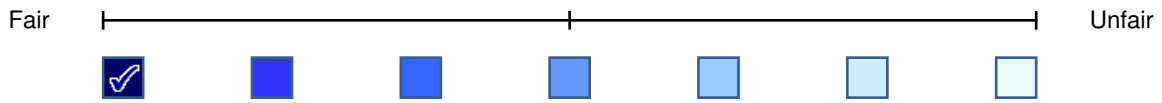
Describe the **Nature** of Your Intended Use of the Copyrighted Work:

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



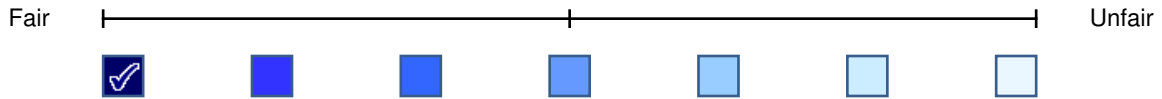
Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] Only limited and reasonable portions will be used



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

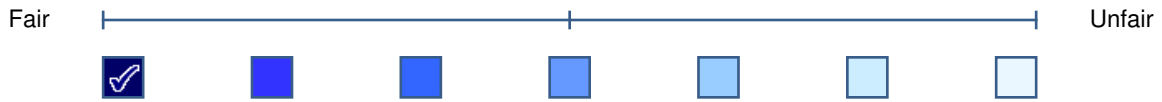
[+] Use of the work has the potential to create or improve the market for the work
[+] Proper attribution will be given with the intended use



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

Factors, Is:

[see tool disclaimer for important clarifying information]:



Other Important Criteria: This fair use form applies to figures 8 and 9 of this thesis.

Use of the work is limited to images which help illustrate the specific concepts in Master's Thesis. Said thesis will not be used for any type of financial gains and thus will not take away from the original work.

Based on the information and justification I have provided above, I, Carlos Caceres, 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.*

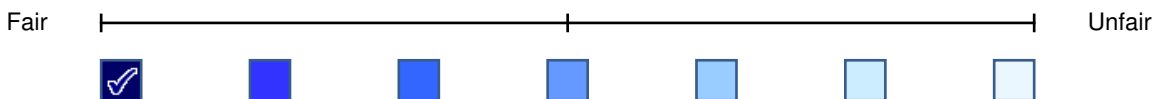
Fair Use Evaluation Documentation

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

Name:	Carlos Caceres
Job Title:	Graduate Research Assistant
Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	Evaluating the feasibility of EMG and bend sensors for classifying hand gestures
Copyright Holder:	S. A. R. Tidwell S. Karlaputi, R. Akl, K. Kavi and D. Struble
Publication Status:	Published
Publisher:	Proceedings of the International Conference on Multimedia and Human Computer Interaction
Place of Publication:	
Publication Year:	2013
Description of Work:	Webpage image describing American Sign Language
Date of Evaluation:	August 25, 2014
Date of Intended Use:	September 9, 2014

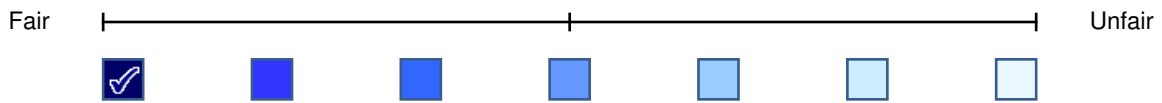
Describe the **Purpose** and Character of Your Intended Use:

[+] Use is not-for-profit
[+] Use is for "criticism, comment, news reporting, teaching, (including multiple print copies for classroom use), scholarship or research"



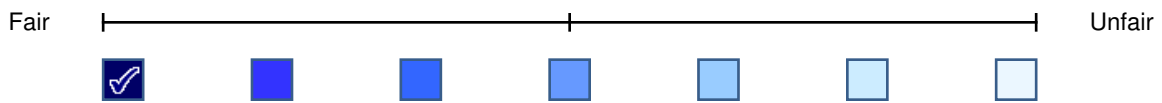
Describe the **Nature** of Your Intended Use of the Copyrighted Work:

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



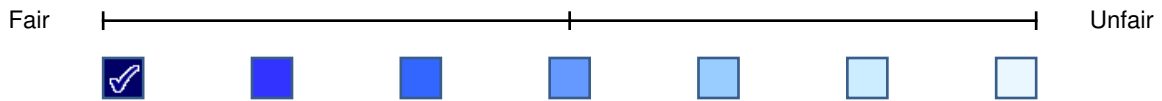
Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] Only limited and reasonable portions will be used



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

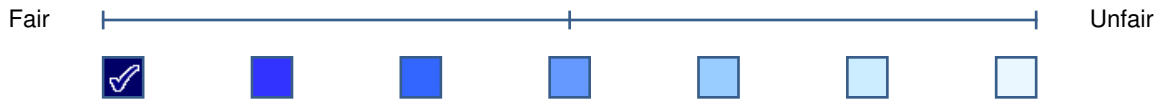
[+] Use of the work has the potential to create or improve the market for the work
[+] Proper attribution will be given with the intended use



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

Factors, Is:

[see tool disclaimer for important clarifying information]:



Other Important Criteria: This fair use form applies to figure 2 of this thesis.

Use of the work is limited to images which help illustrate the specific concepts in Master's Thesis. Said thesis will not be used for any type of financial gains and thus will not take away from the original work.

Based on the information and justification I have provided above, I, Carlos Caceres, 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.*

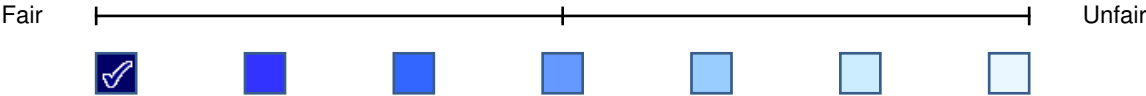
Fair Use Evaluation Documentation

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

Name:	Carlos Caceres
Job Title:	Graduate Research Assistant
Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	Forearm Surface EMG Signals Recognition and Musculoskeletal System Dynamics Identification Using Intelligent Computational Methods
Copyright Holder:	A. Zeghibib
Publication Status:	Published
Publisher:	
Place of Publication:	
Publication Year:	2007
Description of Work:	Published Book. Unknown Publisher.
Date of Evaluation:	August 25, 2014
Date of Intended Use:	September 9, 2014

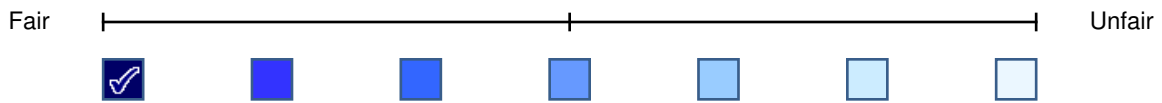
Describe the **Purpose** and Character of Your Intended Use:

[+] Use is not-for-profit
[+] Use is for "criticism, comment, news reporting, teaching, (including multiple print copies for classroom use), scholarship or research"



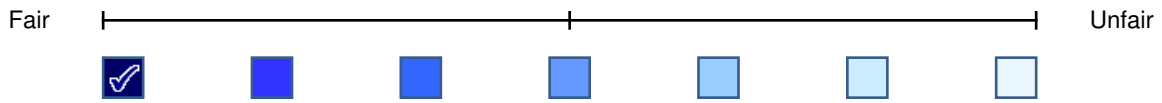
Describe the **Nature** of Your Intended Use of the Copyrighted Work:

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



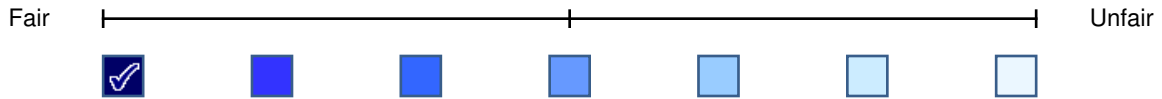
Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] Only limited and reasonable portions will be used



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

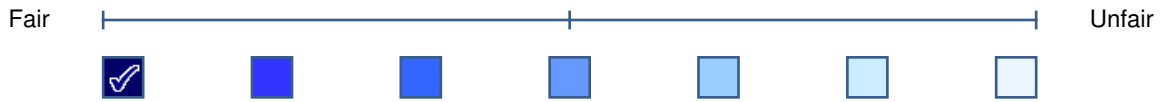
[+] Use of the work has the potential to create or improve the market for the work
[+] Proper attribution will be given with the intended use



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

Factors, Is:

[\[see tool disclaimer for important clarifying information\]:](#)



Other Important Criteria: This fair use form applies to figure 6 of this thesis.

Use of the work is limited to images which help illustrate the specific concepts in Master's Thesis. Said thesis will not be used for any type of financial gains and thus will not take away from the original work.

Based on the information and justification I have provided above, I, Carlos Caceres, 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.*

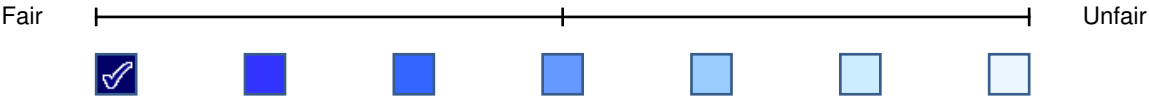
Fair Use Evaluation Documentation

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

Name:	Carlos Caceres
Job Title:	Graduate Research Assistant
Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	Gesture Recognition for Musician Computer Interaction
Copyright Holder:	N. E. Gillian
Publication Status:	Published
Publisher:	Queen's University Belfast
Place of Publication:	Ireland
Publication Year:	2011
Description of Work:	Published Research Paper.
Date of Evaluation:	August 25, 2014
Date of Intended Use:	September 9, 2014

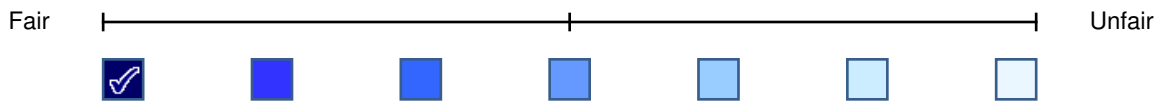
Describe the **Purpose** and Character of Your Intended Use:

[+] Use is not-for-profit
[+] Use is for "criticism, comment, news reporting, teaching, (including multiple print copies for classroom use), scholarship or research"



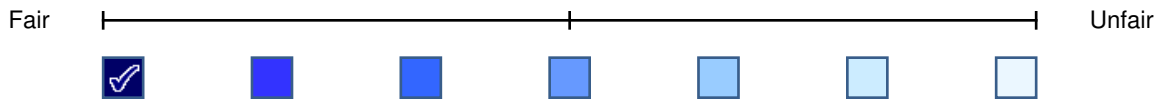
Describe the **Nature** of Your Intended Use of the Copyrighted Work:

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



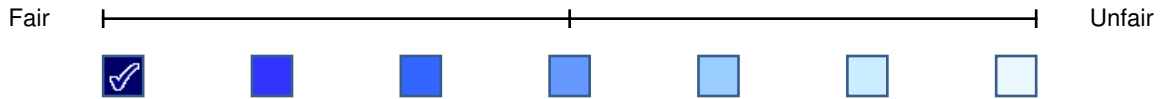
Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] Only limited and reasonable portions will be used



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

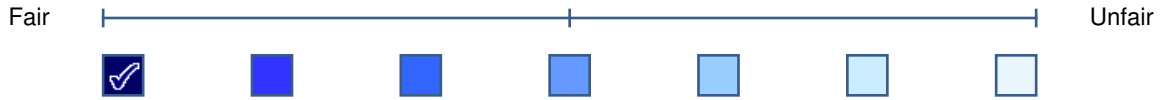
[+] Use of the work has the potential to create or improve the market for the work
[+] Proper attribution will be given with the intended use



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

Factors, Is:

[see tool disclaimer for important clarifying information]:



Other Important Criteria: This fair use form applies to figures 7, 10, 11, and 18 of this thesis.

Use of the work is limited to images which help illustrate the specific concepts in Master's Thesis. Said thesis will not be used for any type of financial gains and thus will not take away from the original work.

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

Signature: _____

Date of Signature: _____

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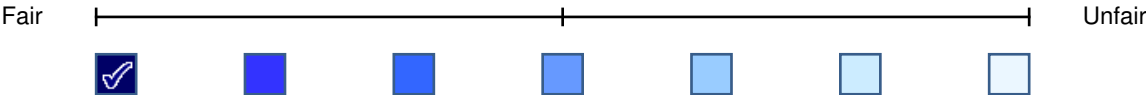
Fair Use Evaluation Documentation

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

Name:	Carlos Caceres
Job Title:	Graduate Research Assistant
Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	Hand Gesture Recognition Research Based on Surface EMG Sensors and 2D-accelerometers
Copyright Holder:	C. Xiang, Z. Xu, Z. Zhang-Yan, Y. Ji-Hai, V. Lantz, W. Kong-Qiao, X. Chen, X. Zhang, Z.-Y. Zhao, J.-H. Yang, and K.-Q. Wang
Publication Status:	Published
Publisher:	Wearable Computers
Place of Publication:	
Publication Year:	2007
Description of Work:	Published Research Paper
Date of Evaluation:	August 25, 2014
Date of Intended Use:	September 9, 2014

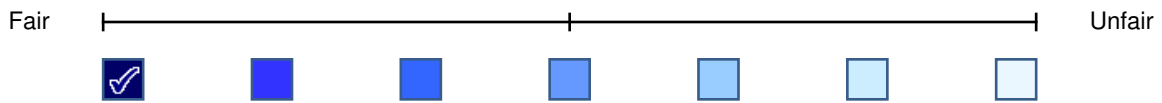
Describe the **Purpose** and Character of Your Intended Use:

[+] Use is not-for-profit
[+] Use is for "criticism, comment, news reporting, teaching, (including multiple print copies for classroom use), scholarship or research"



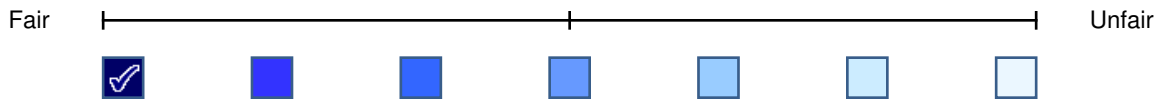
Describe the **Nature** of Your Intended Use of the Copyrighted Work:

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



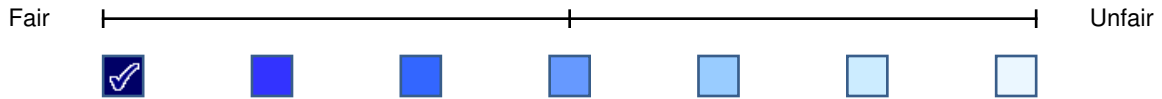
Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] Only limited and reasonable portions will be used



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

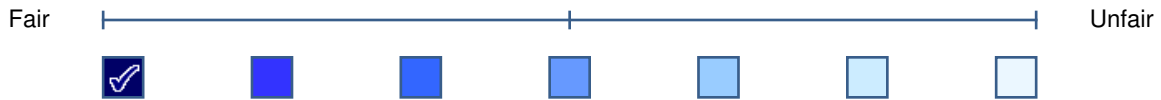
[+] Use of the work has the potential to create or improve the market for the work
[+] Proper attribution will be given with the intended use



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

Factors, Is:

[\[see tool disclaimer for important clarifying information\]:](#)



Other Important Criteria: This fair use form applies to figure 15 of this thesis.

Use of the work is limited to images which help illustrate the specific concepts in Master's Thesis. Said thesis will not be used for any type of financial gains and thus will not take away from the original work.

Based on the information and justification I have provided above, I, Carlos Caceres, 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.*

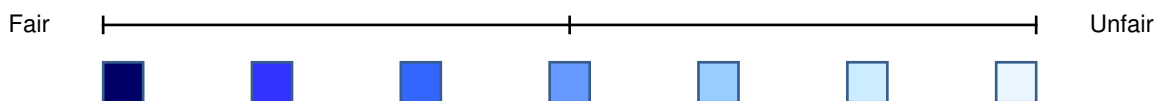
Fair Use Evaluation Documentation

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

Name:	Carlos Caceres
Job Title:	Graduate Research Assistant
Institution:	Virginia Polytechnic Institute and State University
Title of Work Used:	Amputation Rehabilitation and Prosthetic Restoration. From Surgery to Community Reintegration
Copyright Holder:	Alberto Esquenazi
Publication Status:	Published
Publisher:	Moss Rehab Regional Amputee Rehabilitation Centre
Place of Publication:	Philadelphia, USA
Publication Year:	2004
Description of Work:	Published Research Paper
Date of Evaluation:	October 3, 2014
Date of Intended Use:	October 3, 2014

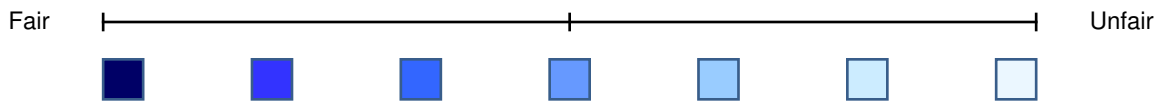
Describe the **Purpose** and Character of Your Intended Use:

[+] Use is for "criticism, comment, news reporting, teaching, (including multiple print copies for classroom use), scholarship or research"
[+] Use is not-for-profit



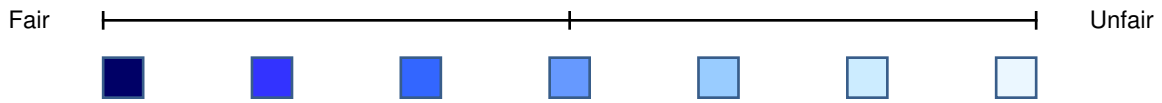
Describe the **Nature** of Your Intended Use of the Copyrighted Work:

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



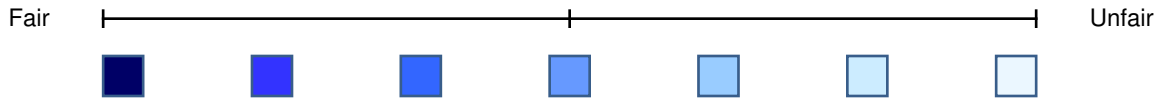
Describe the **Amount** of Your Intended Use in Relation to the Copyrighted Work as a Whole:

[+] Only limited and reasonable portions will be used



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

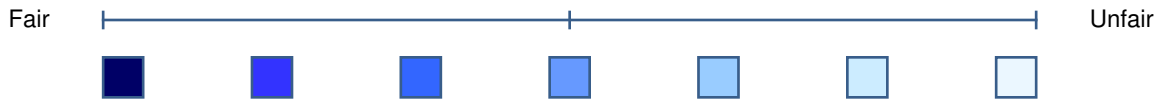
[+] Use of the work has the potential to create or improve the market for the work
[+] Proper attribution will be given with the intended use



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

Factors, Is:

[\[see tool disclaimer for important clarifying information\]:](#)



Other Important Criteria:

This fair use form applies to figure 3 of this thesis.



Based on the information and justification I have provided above, I, Carlos Caceres, 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.*