

# **ALGORITHM TO ENABLE INTELLIGENT RAIL BREAK DETECTION**

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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

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Description of item under review for fair use: Figure 1 Human-lives lost due to rail accidents Walker, TJ, et al, 'On the Stock Market's Reaction to Major Railroad Accidents', 2012, online Available: [http://www-rohan.sdsu.edu/~kpukthua/publications/23\\_Railroad\(Journal%20of%20the%20Transportation%20Research%20Forum06\).pdf](http://www-rohan.sdsu.edu/~kpukthua/publications/23_Railroad(Journal%20of%20the%20Transportation%20Research%20Forum06).pdf)

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Description of item under review for fair use: Figure 2 Financial losses incurred due to rail accidents Source: Walker, TJ, et al, 'On the Stock Market's Reaction to Major Railroad Accidents', 2012, online Available: [http://www-rohan.sdsu.edu/~kpukthua/publications/23\\_Railroad\(Journal%20of%20the%20Transportation%20Research%20Forum06\).pdf](http://www-rohan.sdsu.edu/~kpukthua/publications/23_Railroad(Journal%20of%20the%20Transportation%20Research%20Forum06).pdf)

Report generated on: 01-15-2014 at : 06:30:37

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#### Factor 2

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Name: Sreyoshi Bhaduri

Description of item under review for fair use: Figure 3 Causes of rail road accidents in 2012 Source: FRA, 'Accident trends and summary statistics', 2013, online Available: <http://safetydata.fra.dot.gov/OfficeofSafety/default.aspx>

Report generated on: 01-15-2014 at : 06:32:24

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#### Factor 3

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Description of item under review for fair use: Figure 4 Depicting an accident caused by train derailment caused by track break [3] Source: 2011 Manchester NY, 08/25/1911, online. Available: <http://www.lvrr.com/derailments-and-wrecks/?nggpage=3>

Report generated on: 01-15-2014 at : 06:33:58

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#### Factor 2

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Description of item under review for fair use: Figure 5 Consequences of Rail Break Detection [6] Source: 2006, ' Risk Analysis of Derailment Induced by Rail Breaks', Jianmin Zhao et al, IEEE1-4244-0008-2/06

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Description of item under review for fair use: Figure 6 Showing the working of an SVM binary classifier model [10]  
Source: Jason Weston, 'Support Vector Machines Tutorial', NEC Labs America Princeton online Available:  
[http://www.cs.columbia.edu/~kathy/cs4701/documents/jason\\_svm\\_tutorial.pdf](http://www.cs.columbia.edu/~kathy/cs4701/documents/jason_svm_tutorial.pdf)

Report generated on: 01-15-2014 at : 06:37:18

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Description of item under review for fair use: Figure 8 Algorithm development data evidence [15] Source: 2011 Brad Hopkins, 'A Rail Surface Based Defect Detection and Prediction Algorithm', PhD thesis dissertation VirginiaTech

Report generated on: 01-15-2014 at : 06:38:55

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#### Factor 2

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Description of item under review for fair use: Figure 9 SVM classifier working for linearly separable data [16] Source: 2013, Andrew Zisserman, 'Machine learning tutorials', University of Oxford. Online Available: <http://www.robots.ox.ac.uk/~az/lectures/ml/>

Report generated on: 01-15-2014 at : 06:40:13

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#### Factor 2

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Description of item under review for fair use: Figure 10 Data points representing linearly not separable data [16]  
Source: 2013, Andrew Zisserman, 'Machine learning tutorials', University of Oxford. Online Available:  
<http://www.robots.ox.ac.uk/~az/lectures/ml/>

Report generated on: 01-15-2014 at : 06:41:12

### **Based on the information you provided:**

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#### **Factor 2**

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#### **Factor 3**

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Description of item under review for fair use: Figure 11 Showing transformation of feature space to higher dimension [16] Source: 2013, Andrew Zisserman, 'Machine learning tutorials', University of Oxford. Online Available: <http://www.robots.ox.ac.uk/~az/lectures/ml/>

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### Based on the information you provided:

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Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

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Description of item under review for fair use: Figure 18: VTI Monitor as used by ENSCO. Photo by ENSCO [17]  
Source: 2013, Maldonado Rafael, Saied Taheri, Sreyoshi Bhaduri 'Autonomous Broken Rail Detection', presentation to FRA

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Description of item under review for fair use: Figure 19: V/TI monitor equipment location. Photo by ENSCO [17]  
Source: 2013, Maldonado Rafael, Saied Taheri, Sreyoshi Bhaduri 'Autonomous Broken Rail Detection', presentation to FRA

Report generated on: 01-15-2014 at : 06:44:27

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Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

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Description of item under review for fair use: Figure 20 Axle sensor mounting [17] Source: 2013, Maldonado Rafael, Saied Taheri, Sreyoshi Bhaduri 'Autonomous Broken Rail Detection', presentation to FRA

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Description of item under review for fair use: Figure 21: Intensity Factor readings for generated vertical acceleration data available from rail model [15] Source: 2011 Brad Hopkins, 'A Rail Surface Based Defect Detection and Prediction Algorithm', PhD thesis dissertation VirginiaTech

Report generated on: 01-15-2014 at : 06:46:06

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#### **Factor 3**

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