



Exponent[®]
Engineering & Scientific Consulting

Carmine Senatore, Ph.D.

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Professional Profile

Dr. Senatore's specialized expertise in the area of vehicle engineering includes advanced driver assistance systems (ADAS), vehicle-to-vehicle communications (V2V), automated vehicle technologies, and on-road and off-road vehicle dynamics. Dr. Senatore is an ISO26262 functional safety certified engineer and has participated in Design Failure Mode and Effect Analysis (DFMEA) and Failure Modes Effects and Diagnostic Analysis (FMEDA) for automotive systems. His experience in accident investigations encompass the reconstruction of crashes involving passenger cars and heavy trucks, event data recorder (EDR) and engine control module (ECM) data analysis, automotive testing and simulations of vehicle crashes using the Human Vehicle Environment (HVE) software package. He has published on the topic of the use of ADAS sensor data to reconstruct vehicle crashes, and has conducted experiments to assist in the development of analysis techniques required to analyze such data.

Dr. Senatore's current interests in connected and automated vehicles include accelerated validation, collaborative perception, and the future of EDRs from an accident reconstruction and failure analysis perspective. Dr. Senatore has leveraged his experience in accident investigations to consult with clients on vehicle telematics, conduct reviews of Federal and State vehicle regulations as they apply to automotive products, and analyze vehicle requirements in their development process. His broader project experience includes the development of algorithms for automated vehicles and ADAS perception systems including the development of a patent-pending software algorithm for improving object detection leveraging camera data across multiple vehicles.

Dr. Senatore obtained his Ph.D. in Engineering Mechanics at Virginia Polytechnic Institute and State University. Prior to joining Exponent, Dr. Senatore was a research scientist at MIT, where he collaborated with national agencies, research institutions, and private companies to study how vehicles and robotic systems interact with unstructured environments. In that capacity he developed strategic and tactical tools to support mobility studies for the NASA Mars Science Laboratory (MSL) and Mars Exploration Rover (MER) missions.

Academic Credentials & Professional Honors

Ph.D., Engineering Mechanics, Virginia Polytechnic Institute and State University, 2010

B.S., Mechanical Engineering, Politecnico di Milano, Italy, 2004

Licenses and Certifications

ISO 26262 Functional Safety Engineer

Prior Experience

Research Scientist, MIT, 2013-2014

Postdoctoral Associate, MIT, 2010-2012

Research Assistant, Virginia Tech, 2008-2010

Professional Affiliations

American Society of Mechanical Engineers — ASME

Society of Automotive Engineers — SAE

Languages

Italian

Patents

US Application No 15/997,750 filed on 6/5/2018: Sensor system for multiple perspective sensor data sets. Inventor: Bin Cheng, Gaurav Bansal, Ryan Matthew Yee, Ellick Ming Huen Chan, Carmine Senatore.

Publications

Yee R, Chan E, Senatore C, Cheng B, Bansal G. Collaborative Perception for Automated Vehicles Leveraging Vehicle-To-Vehicle Communications. Proceedings of the 2018 IEEE Intelligent Vehicles Symposium, June 2018.

Harrington R, Senatore C, Scanlon J, Yee R, "The Role of Infrastructure in an Automated Vehicle Future", The Bridge - National Academy of Engineering, Volume 48 Issue 2, June 15, 2018.

Lange R, Kelly S, Senatore C, Wilson J, Yee R, Harrington R, "Data requirements for post-crash analyses of collisions involving collision avoidance technology equipped, automated, and connected vehicles", ESV 17-0338, June 2017.

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James Slonaker, D. Carrington Motley, Qiong Zhang, Stephen Townsend, Carmine Senatore, Karl Iagnemma, and Ken Kamrin, "General scaling relations for locomotion in granular media", Phys. Rev. E 95, 052901 - Published 10 May 2017 <https://journals.aps.org/pre/abstract/10.1103/PhysRevE.95.052901>

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Zolock, J., Senatore, C., Yee, R., Larson, R. et al., "The Use of Stationary Object Radar Sensor Data from Advanced Driver Assistance Systems (ADAS) in Accident Reconstruction," SAE Technical Paper 2016-01-1465, 2016, doi:10.4271/2016-01-1465.

J. B. Johnson, A. V. Kulchitsky, P. Duvoy, K. Iagnemma, C. Senatore, R. E. Arvidson, J. Moore, Discrete element method simulations of Mars Exploration Rover wheel performance, *Journal of Terramechanics*, Volume 62, December 2015, Pages 31-40

J.Y. Wong, C. Senatore, P. Jayakumar, K. Iagnemma, Predicting mobility performance of a small, lightweight track system using the computer-aided method NTVPM, *Journal of Terramechanics*, Volume 61, October 2015, Pages 23-32.

S. Ozaki, K. Hinata, C. Senatore, K. Iagnemma, Finite element analysis of periodic ripple formation under rigid wheels, *Journal of Terramechanics*, Volume 61, October 2015, Pages 11-22

Yee RM, Senatore C. Advanced driver assistance systems and connected vehicles: Current technology and future trends. *Michigan Defense Trial Counsel E-Letter* 2015; 5(3).

Senatore C, Stein N, Zhou F, Bennett K, Arvidson R, Trease B, Lindemann R, Bellutta P, Heverly P, Iagnemma K. Modeling and validation of mobility characteristics of the Mars Science Laboratory Curiosity rover. *International Symposium of Artificial Intelligence, Robotics and Automation in Space (i-SAIRAS)*, Montreal, Canada, June 2014.

Senatore C, Iagnemma K. Analysis of stress distributions under lightweight wheeled vehicles. *Journal of Terramechanics* 2014 Feb; 51:1-17. ISSN 0022-4898, <http://dx.doi.org/10.1016/j.jterra.2013.10.003>.

Senatore C, Wulfmeier M, Vlahinich I, Andrade J, Iagnemma K. Design and implementation of a particle image velocimetry method for analysis of running gear-soil interaction. *Journal of Terramechanics* 2013 Oct-Dec; 50(5-6):311-326. ISSN 0022-4898, <http://dx.doi.org/10.1016/j.jterra.2013.09.004>.

Zhou F, Arvidson R, Bennet K, Trease B, Lindemann R, Iagnemma K, Senatore C, Bellutta P. Simulations of Mars Rover Traverses. *Journal of Field Robotics* 2014; 31(1). <http://dx.doi.org/10.1002/rob.21483>.

Senatore C, Jayakumar P, Iagnemma K. Experimental study of lightweight tracked vehicle performance on dry granular materials. 7th Americas Regional Conference of the ISTVS, Tampa, FL, November 4-7, 2013.

Smith W, Melanz D, Senatore C, Iagnemma K, Peng H. Comparison of DEM and traditional modeling methods for simulating steady-state wheel-terrain interaction for small vehicles. 7th Americas Regional Conference of the ISTVS, Tampa, FL, November 4-7, 2013.

Jayakumar P, Melanz D, Maclennan J, Senatore C, Iagnemma K. Stochastic modeling and uncertainty cascade of soil bearing and shearing characteristics for light-weight vehicle applications. 7th Americas Regional Conference of the ISTVS, Tampa, FL, November 4-7, 2013.

Senatore C, Jayakumar P, Maclennan J, Iagnemma K. Investigation of stress and failure in granular soils for lightweight robotic vehicle applications. *Proceedings, Ground Vehicle Systems Engineering and Technology Symposium*, Troy, MI, August 2012. Best conference paper award.

Senatore C, Iagnemma K. Direct shear behavior of dry, granular soils for low normal stress with application to lightweight robotic vehicle modelling. *Proceedings, International Symposium of the International Society of Terrain-Vehicle Systems*, Blacksburg, VA, 2011.

Senatore C, Sandu C. Torque distribution influence on tractive efficiency and mobility of off-road wheeled vehicles. *Journal of Terramechanics* 2011 Oct; 48(5):372-383.

Senatore C, Sandu C. Off-road tire modeling and the multi-pass effect for vehicle dynamics simulation.

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Iagnemma K, Senatore C, Trease B, Arvidson R, Shaw A, Zhou F, Van Dyke, L, Lindemann R. Terramechanics modeling of Mars Surface Exploration rovers for simulation and parameter estimation. Proceedings, ASME International Design Engineering Technical Conference, 2011.

Trease B, Arvidson R, Lindemann R, Bennett K, Zhou F, Iagnemma K, Senatore C, Van Dyke L. Dynamic modeling and soil mechanics for path planning of Mars Exploration Rovers. Proceedings, ASME International Design Engineering Technical Conference, 2011.

Senatore C, Sandu C. Off-road vehicle mobility and energy efficiency Prediction, 9th Asia-Pacific Conference of the ISTVS, Sapporo, Japan, September 2010.

Senatore C, Ross SD. Detection and characterization of transport barriers in complex flows via ridge extraction of the finite time Lyapunov exponent field. International Journal of Numerical Methods in Engineering 2010 Dec, 10.1002/nme.3101.

Ross SD, Tanaka ML, Senatore C. Detecting dynamical boundaries from kinematic data in biomechanics. Chaos: An Interdisciplinary Journal of Nonlinear Science 2010; 20:017507.

Senatore C, Sandu C. Exit angle influence on energy efficiency of off-road tires. 11th European Regional Conference of the ISTVS, Bremen, Germany, October 2009.

Senatore C, Ross SD. Fuel-efficient navigation in complex flows. Proceedings, 2008 American Control Conference, pp.12441248, 2008.

Presentations

Senatore C. "Automated Vehicles: Current Landscape and Future Directions". 13th International Conference on Multibody Systems, Nonlinear Dynamics, and Control (MSNDC), Special Session Keynote Presentation, Cleveland, OH, August 8 2017

Senatore C. "Future EDR for Automated Vehicles", SAE 2016 FROM ADAS TO AUTOMATED DRIVING SYMPOSIUM, Munich, Germany, November 30, 2016

Senatore C. "Sensor Redundancy and Next-Gen Event Data Recorders From a Failure Analysis Perspective", SAE Government Industry Meeting, Washington D.C., January 21, 2016

Senatore C, Iagnemma K. "Terramechanics and mobility research". Invited Talk, Tank Automotive Research Development and Engineering Center (TARDEC), Warren, MI, June 13, 2013.

Senatore C, Iagnemma K. Terramechanics and mobility research. Invited Talk, Tank Automotive Research Development and Engineering Center (TARDEC), Warren, MI, June 13, 2013.

Peer Reviewer

Journal of Terrmechanics

Journal of Field Robotics

Society of Automotive Engineers Technical Publications