# CCAAR PROJECTS / PUBLICATIONS

| Title and Authors | Description / Abstract | Publication / Link |
|---|---|---|
| 2011<br>Cloud Computing Concept for Intelligent Transportation Systems<br><br>by:<br>Pawel Jaworski, Tim Edwards, Jonathan Moore, Keith Burnham | Proposal of a cloud computing based urban traffic control system, aiming to increase road throughput and optimise traffic control for increased safety and reduced fuel emissions | Proceedings of 14th International IEEE Conference on Intelligent Transportation Systems<br><br>doi: 10.1109/ITSC.2011.6083087 |
| 2012<br>Microscopic Traffic Simulation Tool for Intelligent Transportation Systems<br><br>by:<br>Pawel Jaworski, Tim Edwards, Keith Burnham, Olivier Haas | Describes a microscopic traffic simulation tool for assessing the performance of intelligent transportation system traffic and vehicle control systems | Proceedings of the 15th International IEEE Conference on Intelligent Transportation Systems<br><br>doi: 10.1109/ITSC.2012.6338659 |
| 2015<br>Autonomous Vehicle Security<br><br>by:<br>Madeline Cheah, Siraj Shaikh | Examination of possible threats to autonomous vehicles, and a review of the state-of-the-art controls and countermeasures | IET Engineering & Technology Reference 1(1)<br><br>doi: 10.1049/etr.2014.0056 |
| 2016<br>Combining third party components securely in automotive systems<br><br>by:<br>Madeline Cheah, Siraj Shaikh, Jeremy Bryans, Hoang Nga Nguyen | Introduces a methodology for users to introduce or strengthen security of composed systems without requiring full knowledge of commercially sensitive sub-components | Proceedings of 10th IFIP International Conference on Information Security Theory and Practice<br><br>doi: 10.1007/978-3-319-45931-8_18 |

| Title and Authors | Description / Abstract | Publication / Link |
|---|---|---|
| 2016<br>Do we really know which vehicle attributes are important for customers?<br><br>by:<br>Milena Kukova, Cyriel Diels, Patrick Jordan, Maria Franco-Jorge, Jamie Anderson, Husni Kharouf | Reports preliminary findings from two studies designed to better understand vehicle attributes and how they influence customer purchase decisions and satisfaction | Proceedings of the 10th International Conference on Design and Emotion<br><br>doi: 10.5281/zenodo.2635727 |
| 2017<br>Towards a Testbed for Automotive Cybersecurity<br><br>by:<br>Daniel Fowler, Madeline Cheah, Siraj Shaikh, Jeremy Bryans | Proposes a testbed built over a Controller Area Network simulator | Proceedings of 10th IEEE International Conference on Software Testing, Verification and Validation: Industry Track<br><br>doi: 10.1109/ICST.2017.62 |
| 2017<br>Threat Intelligence for Bluetooth-enabled systems with automotive applications: An empirical study<br><br>by:<br>Madeline Cheah, Jeremy Bryans, Daniel Fowler, Siraj Shaikh | This paper presents a survey of vehicles and vehicular aftermarket devices with Bluetooth connectivty from a threat intelligence perspective, to gain insight into conditions during real-world driving | Proceedings of the 47th IEEE International Conference on Dependable Systems and Networks Workshops<br><br>doi: 10.1109/DSN-W.2017.22 |
| 2017<br>Towards a systematic security evaluation of the automotive Bluetooth interface<br><br>by:<br>Madeline Cheah, Siraj Shaikh, Olivier Haas, Alastair Ruddle | Presents a framework for systematic method of security testing for automotive Bluetooth interfaces, with implementation of a proof-of-concept tool to carry out the testing | Journal of Vehicular Communications 9(July)<br><br>doi: 10.1016/j.vehcom.2017.02.008 |

| Title and Authors | Description / Abstract | Publication / Link |
|---|---|---|
| 2017<br>Designing for comfort in shared and automated vehicles (SAV): a conceptual framework<br><br>by:<br>Cyriel Diels, Tugra Erol, Milena Kukova, Joscha Wasser, Maciej Cieslak, William Payre, Abhijai Miglani, Neil Mansfield, S.G. Hodder, Jelte Bos | Discusses major comfort factors in the context of SAV and highlight both similarities and differences between transport modes | Proceedings of 1st International Comfort Congress<br><br>https://dspace.lboro.ac.uk/2134/25572 |
| 2017<br>Formalising Systematic Security Evaluations using Attack Trees for Automotive Applications<br><br>by:<br>Madeline Cheah, Hoang Nga Nguyen, Jeremy Bryans, Siraj Shaikh | Presents a method for systematically generating tests based on formalised attack trees | Proceedings of 11th IFIP International Conference on Information Security Theory and Practice<br><br>doi: 10.1007/978-3-319-93524-9_7 |
| 2017<br>Driverless Pods: From Technology Demonstrators to Desirable Mobility Solutions<br><br>by:<br>Cyriel Diels, Joscha Wasser, Anthony Baxendale, Michael Tovey | Introduces a conceptual comfort framework for the design of last mile mobility solutions, with analysis and comparison of current concepts in the context of passenger comfort experience | Proceedings of 8th International Conference on Applied Human Factors and Ergonomics<br><br>doi: 10.1007/978-3-319-60441-1_53 |
| 2018<br>Building an automotive security assurance case using systematic security evaluations<br><br>by:<br>Madeline Cheah, Siraj Shaikh, Jeremy Bryans, Paul Wooderson | Builds on earlier work by using systematic security evaluations to enumerate undesirable behaviours, enabling the assignment of severity ratings in a (semi-) automated manner | Computers & Security 77(August)<br><br>doi: 10.1016/j.cose.2018.04.008 |

| Title and Authors | Description / Abstract | Publication / Link |
|---|---|---|
| 2018<br>Fuzz Testing for Automotive Cybersecurity<br><br>by:<br>Daniel Fowler, Jeremy Bryans, Siraj Shaikh, Paul Wooderson | This paper demonstrates how fuzz testing has a part to play as one of many security tests that a vehicle's systems could undergo before being made ready for series production. | Proceedings of 48th Annual IEEE/IFIP International Conference on Dependable Systems and Networks Workshops<br><br>doi: 10.1109/DSN-W.2018.00070 |
| 2018<br>Development and Verification of a Distributed Electro-Thermal Li-Ion Cell Model<br><br>by:<br>Richard Stocker, Neophytos Lophitis, Asim Mumtaz | Presents an ID distributed electro-thermal Li-ion model that gives accurate representations of cell thermal and electrical characteristics in response to current application | Proceedings of the 44th Annual Conference of the IEEE Industrial Electronics Society<br><br>doi: 10.1109/IECON.2018.8591633 |
| 2018<br><br>Ergonomic Evaluation of a Driveless Pod Design<br><br>By:<br><br>Joscha Wasser, Cyriel Diels, Anthony Baxendale, Michael Tovey | A driverless last mile mobility vehicle design, developed based on a theoretical comfort model and user feedback from focus groups, was evaluated with the aid of an ergonomic buck. The evaluation focused on the physical interaction with the interior, analysis of movements within the vehicle cabin, overall cabin dimensions and usability. The trial also demonstrated that a wheelchair user can access the vehicle whilst three seated passengers are present and will have sufficient space in the interior | Proceedings of the Human Factors and Ergonomics Society Annual Meeting 62<br>DOI:10.1177/1541931218621317 |
| 2019<br>Human-Agent Teaming – An Evolving Interaction Paradigm: An Innovative Measure of Trust<br><br>by:<br>Samson Palmer, Dale Richards, Graham Shelton-Rayner, David Inch, Kurtulus Izzetoglu | Presents findings from an experiment that examines the human-autonomy interaction across different frameworks of authority (from manual to fully autonomous) | Proceedings of the 20th International Symposium on Aviation Psychology<br><br>doi: 10.4233/uuid:c8e9b17b-89ea-4faf-b55c-767c1ae070ef |

| Title and Authors | Description / Abstract | Publication / Link |
|---|---|---|
| 2019<br>Enabling Security Checking of Automotive ECUs with CSP models<br><br>by:<br>John Heneghan, Siraj Shaikh, Jeremy Bryans, Madeline Cheah, Paul Wooderson | This paper presents an approach, using CSP, to support systematic security testing of ECU components, with a case study using the mechanisms that enable Over-The-Air software updates | Proceedings of 49th IEEE International Conference on Dependable Systems and Networks Workshops – Safety and Security of Intelligent Vehicles<br><br>In press |
| 2019<br>A Method for Constructing Automotive Cybersecurity Tests, A CAN Fuzz Testing Example<br><br>by:<br>Daniel Fowler, Jeremy Bryans, Madeline Cheah, Siraj Shaikh, Paul Wooderson | Production of a method to construct useful automotive security tooling and tests, in this case a Controller Area Network fuzz testing prototype | Proceedings of 2019 IEEE International Workshop on Automobile Software, Security and Safety<br><br>In press |
| 2019<br>Accurate ride comfort estimation combining accelerometer measurements, anthropometric data and neural networks<br><br>by:<br>Maciej Cieslak, Stratis Kanarachos, Mike Blundell, Cyriel Diels, Mark Burnett, Anthony Baxendale | Explores the use of neural network for accurate estimations of ride comfort, by combining anthropometric data and acceleration measurements | Neural Computing and Applications<br><br>In press |
| 2019<br>Performance Boundary Identification for the Evaluation of Automated Vehicles using Gaussian Process Classification<br><br>by:<br>Felix Batsch, Alireza Daneshkhah, Madeline Cheah, Stratis Kanarachos, Anthony Baxendale | Proposes an approach to identify the performance boundary (where corner cases are located) using Gaussian Process Classification. This is demonstrated on an exemplary traffic jam approach scenario | Proceedings of the 2019 IEEE Intelligent Transportation Systems Conference Workshop<br><br>In press |

| Title and Authors | Description / Abstract | Publication / Link |
|---|---|---|
| 2019<br>Applicability of Modern Correlation Tools for Ride Comfort Evaluation and Estimation<br><br>by:<br>Maciej Cieslak, Stratis Kanarachos, Mike Blundell, Cyriel Diels, Anthony Baxendale | A study analysing the usability of modern correlation tools, such as artificial neural networks, for objective and subject data correlation, evaluation and explores the possibility of prediction of subjective responses based on measured data | Proceedings of the 2nd International Comfort Congress<br><br>In press |
| 2019<br>DigiCAV project: Exploring a Test-Driven Approach in the Development of Connected and Autonomous Vehicles<br><br>by:<br>Ioannis Kyriakopoulos, Pawel Jaworski, Stratis Kanarachos | A concept paper introducing the Digital CAV Porving Ground project and disseminates results from the first deliverable. The aim of this project is to explore the feasibility of a simulation platform, enabling a test-driven development approach for CAV. | Proceedings of the 2019 IEEE International Conference on Connected Vehicles and Expo<br><br>In press |
| 2019<br><br>Design-of-Experiments Analysis of Li-Ion Cell Capacity Fading in High Temperature Automotive Conditions<br><br>By:<br><br>Richard Stocker, Asim Mumtaz, Neophytos Lophitis | This paper examines the evolution of performance degradation through capacity fade in Li-ion cells when subjected to 8 months of automotive drive cycles in high temperature conditions. This is done by combining a temperature controlled, highly transient cycling approach with a design-of-experiments matrix varying charge current magnitude and Depth-of-Discharge, two factors known to be influential in ageing rate.<br><br>The subsequent results are then analyzed using design-of-experiments methodology and trend analysis, comparing the rates of capacity evolution at various points in cell lifetime. What was found is that the cell ageing evolved in 3 main phases dependent on the cycling time duration rather than Ah throughput. In early life, charge current was influential, while in later life depth-of-discharge proved significant.<br>It was also clear, that the factors could not be treated in isolation, with higher order and interaction effects observed. This implies that modeling of cell ageing cannot be uniform across lifetime and must consider the different ageing phases of the cell. | 2019 Electric Vehicles International Conference (EV)<br><br>doi: 10.1109/EV.2019.8893026. |

| Title and Authors | Description / Abstract | Publication / Link |
|---|---|---|
| 2019<br><br>Generation of Pedestrian Pose Structures using Generative Adversarial Networks<br><br>By:<br><br>James Spooner, Madeline Cheah, Vasile Palade, Stratis Kanarachos, Alireza Daneshkhah | The safety of vulnerable road users is of paramount importance as transport moves towards fully automated driving.<br><br>The richness of real-world data required for testing autonomous vehicles is limited, and furthermore, the available data does not have a fair representation of different scenarios and rare events.<br><br>This work presents a novel approach for the generation of human pose structures, specifically the type of pose structures that would appear to be in pedestrian scenarios.<br><br>The results show that the generated pedestrian structures are indistinguishable from the ground truth pose structures when classified using a suitably trained classifier.<br><br>The paper demonstrates that the Generative Adversarial Network architecture can be used to create realistic new training samples, and, in future, new pedestrian events. | Proceedings to the 18th IEEE International Conference on Machine Learning and Applications<br><br>DOI: 10.1109/ICMLA.2019.00269. |
| 2019<br><br>Classification of a Pedestrian's Behaviour Using Dual Deep Neural Networks<br><br>By:<br><br>James Spooner, Madeline Cheah, Vasile Palade, Stratis Kanarachos, Alireza Daneshkhah | Vulnerable road user safety is of paramount importance as transport moves towards fully autonomous driving. The research question posed by this research is of how can we train a computer to be able to see and perceive a pedestrian's movement. This work presents a dual network architecture, trained in tandem, which is capable of classifying the behaviour of a pedestrian from a single image with no prior context.<br><br>The results show that the most successful network was able to achive a correct classification accuracy of 94.3% when classifying images based on their behaviour. This shows the use of a novel data fusion method for pedestrian images and human poses. Having a network with these capabilities is important for the future of transport, as it will allow vehicles to correctly erceive the intention of pedestrians crossing the street, and will ultimately lead to fewer pedestrian casualties on roads | Advances in Intelligent Systems and Computing, vol 1230. Springer<br><br>DOI: 10.1007/978-3-030-52243-8_42 |

| Title and Authors | Description / Abstract | Publication / Link |
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| 2020<br><br>A Taxonomy of Validation Strategies to Ensure the Safe Operation of Highly Automated Vehicles<br><br>By:<br><br>Felix Batsch, Stratis Kanarachos, Madeline Cheah, Roberto Ponticelli & MikeBlundell | Self-driving cars are on the horizon, making it necessary to consider safety assurance and homologation of these autonomously operating vehicles.<br><br>In this study, we systematically review literature that proposes new methods for these areas. The available methods were categorized into a novel taxonomy, dividing them into the strategies of combinatorial testing, robustness testing and search-based testing.<br><br>We analyzed the literature in regard to modeling capabilities, targeted automation subsystem, targeted driving task level and the metrics used for criticality evaluation and coverage of the scenario space.<br><br>We found that there are significant differences and shortcoming in the modeling capabilities of the existing research and that methods of each strategy usually target a specific driving task level.<br><br>Additionally the criticality assessment of scenario-based validation methods was examined, revealing the need for more comprehensive metrics to assess complex scenarios.<br><br>The developed taxonomy furthers the understanding in different scenario-based testing approaches for automated vehicles and serves as a guide for future research. | Journal of Intelligent Transportation Systems<br><br>Technology, Planning, and Operations<br><br>DOI:10.1080/15472450.2020.1738231 |

| Title and Authors | Description / Abstract | Publication / Link |
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| 2020<br>Generation of Pedestrian Crossing Scenarios Using Ped-Cross Generative Adversarial Network<br><br>by:<br>James Spooner, Vasile Palade, Madeline Cheah, Stratis Kanarachos, Alireza Daneshkhah | The safety of vulnerable road users is of paramount importance as transport moves towards fully automated driving. The richness of real-world data required for testing autonomous vehicles is limited and furthermore, available data do not present a fair representation of different scenarios and rare events.<br><br>Before deploying autonomous vehicles publicly, their abilities must reach a safety threshold, not least with regards to vulnerable road users, such as pedestrians.<br><br>In this paper, we present a novel Generative Adversarial Networks named the Ped-Cross GAN. Ped-Cross GAN is able to generate crossing sequences of pedestrians in the form of human pose sequences.<br><br>The Ped-Cross GAN is trained with the Pedestrian Scenario dataset. The novel Pedestrian Scenario dataset, derived from existing datasets, enables training on richer pedestrian scenarios. We demonstrate an example of its use through training and testing the Ped-Cross GAN.<br><br>The results show that the Ped-Cross GAN is able to generate new crossing scenarios that are of the same distribution from those contained in the Pedestrian Scenario dataset.<br><br>Having a method with these capabilities is important for the future of transport, as it will allow for the adequate testing of Connected and Autonomous Vehicles on how they correctly perceive the intention of pedestrians crossing the street, ultimately leading to fewer pedestrian casualties on our roads | https://www.mdpi.com/2076-3417/11/2/471 |

| Title and Authors | Description / Abstract | Publication / Link |
|---|---|---|
| 2020<br><br>Universal Li-Ion Cell Electro-Thermal Model<br><br>By:<br><br>Richard Stocker, Asim Mumtaz, Paramjeet, Michele Braglia, Neophytos Lophitis | This paper describes and verifies a Li-ion cell electro-thermal model and the associated data analysis process.<br><br>It is designed to be adaptable and give accurate results across all variations of operating conditions and cell design based only on time domain voltage, current and temperature measurements.<br><br>The creation of this model required an analysis process ensuring consistency in expressing the underlying cell behavior.<br><br>This informed a flexible modelling structure adaptable both to cell performance variations and the limitations of the available test data.<br><br>The model has been created with a combined thermal and electrical approach enabling 1D nodal distribution adaptable to both cylindrical and prismatic cells.<br><br>These features combine with an intelligent parameter identification process identifying model structure and parameterization across the usage range, adaptable to any Nickel-Manganese-Cobalt Li-Ion cell.<br><br>It is designed to retain physical meaning and representation to each circuit element across the temperature operating range.<br><br>The model is verified in several different operating conditions through representative automotive cycling on an 18650 cell and a BEV2 format prismatic cell, representing the extremes of automotive cell design.<br><br>The consistency of the model parameters with real phenomena is also analyzed and validated against Electrochemical Impedance Spectroscopy data. | IEEE Transactions on Transportation Electrification<br><br>DOI: 10.1109/TTE.2020.2986606 |

| Title and Authors | Description / Abstract | Publication / Link |
|---|---|---|
| 2020<br><br>Assessing Variable Levels of Delegated Control – A Novel Measure of Trust<br><br>By:<br><br>Samson Palmer, Dale Richards, Graham Shelton-Rayner, Kurtulus Izzetoglu, David Inch | Autonomous cars are set to drastically change the driving environment. The promise of a safer and more efficient driving experience has led to a<br><br>significant rise in research surrounding human interaction with autonomous systems,<br><br>however we must investigate ways to effectively integrate these systems and develop the partnership between human and autonomous system. In particular,<br><br>understanding the nature of human-automation trust will ensure safe and efficient<br><br>integration of these systems, and therefore investing in new measures of trust is key to the development of the human-automation partnership. This paper discusses findings of an experiment that examines the nature of human-automation<br><br>interaction and the neural correlates associated with trust. Participants were asked to interact with unmanned vehicle control stations of varying levels of control and integrity, whilst prefrontal cortical activity was monitored using functional<br><br>Near Infrared spectroscopy. The findings of this study suggest that the anterior prefrontal cortex (aPFC) is associated with uncertainty of the decisionmaking<br><br>abilities of an autonomous system, whilst the ventrolateral prefrontal cortex (vlPFC) has been implicated in the development of distrust as a result of poor decision making. The findings present a new opportunity to develop a reliable<br><br>measure of human-automation trust that could inform future system design and<br><br>facilitate a safer and more effective human automation partnership. | HCI International 2020 – Late Breaking Papers: Cognition, Learning and Games<br><br>DOI: 10.1007/978-3-030-60128-7_16 |

| Title and Authors | Description / Abstract | Publication / Link |
|---|---|---|
| 2021<br>Scenario Optimisation and Sensitivity Analysis for Safe Automated Driving Using Gaussian Processes<br><br>by:<br>Felix Batsch, Alireza Daneshkhah, Vasile Palade, Madeline Cheah | Assuring the safety of automated vehicles is essential for their timely introduction and acceptance by policymakers and the public.<br><br>To assess their safe design and robust decision making in response to all possible scenarios, new methods that use a scenario-based testing approach are needed, as testing on public roads in normal traffic would require driving millions of kilometres.<br><br>We make use of the scenario-based testing approach and propose a method to model simulated scenarios using Gaussian Process based models to predict untested scenario outcomes. This enables us to efficiently determine the performance boundary, where the safe and unsafe scenarios can be evidently distinguished from each other.<br><br>We present an iterative method that optimises the parameter space of a logical scenario towards the most critical scenarios on this performance boundary.<br><br>Additionally, we conduct a novel probabilistic sensitivity analysis by efficiently computing several variance-based sensitivity indices using the Gaussian Process models and evaluate the relative importance of the scenario input parameters on the scenario outcome.<br><br>We critically evaluate and investigate the usefulness of the proposed Gaussian Process based approach as a very efficient surrogate model, which can model the logical scenarios effectively in the presence of uncertainty. The proposed approach is applied on an exemplary logical scenario and shows viability in finding concrete critical scenarios. The reported results, derived from the proposed approach, could pave the way to more efficient testing of automated vehicles and instruct further physical tests on the determined critical scenarios | https://www.mdpi.com/2076-3417/11/2/775 |

| Title and Authors | Description / Abstract | Publication / Link |
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| 2022<br><br>Requirements for the Automated Generation of Attack Trees to Support Automotive Cybersecurity Assurance<br><br>By:<br><br>Kacper Sowka, Luis-Pedro Cobos, Alastair Ruddle, Paul Wooderson | As the need for automotive assurance continues to grow, it becomes necessary to develop approaches which can provide assurance cases in a systematic and efficient manner.<br><br>In the case of cybersecurity, this problem is exacerbated by the increasing complexity of vehicular onboard systems, their inherent obscurity due to their heterogenous architecture, emergent behaviors, and the disparate motivations and resources of potential threat agents.<br><br>Furthermore, the advancement of connected autonomous vehicles (CAV) may allow external attackers to leverage the naïve trust ECUs have for adjacent devices to compromise the safety and security of the vehicle. To that end, there is an increased interest in automatically producing threat models such as attack trees, which usually rely on intensive expert driven construction or rudimentary formally defined processes, to identify potential threats to a vehicle.<br><br>Therefore, this paper will explore the ways in which such an automated scheme could be applied for a practicable identification and analysis of potential attack paths.<br><br>Although ISO/SAE 21434 recommends the development of an assurance case for cybersecurity, the precise nature of a cybersecurity case is not explicitly defined within the standard.<br><br>Therefore, this paper also explores the combination of threat modelling techniques with assurance case techniques adapted from accepted practice in vehicle safety for functional safety (per ISO 26262) while taking into consideration the relevant standards. | WCX SAE World Congress Experience 2022<br><br>https://www.sae.org/publications/technical-papers/content/2022-01-0124/<br><br>doi:10.4271/2022-01-0124 |