# REAL TIME COLLISION WARNING SYSTEM IN THE CONTEXT OF VEHICLE-TO-VEHICLE DATA EXCHANGE BASED ON DRIVINGS BEHAVIOURS ANALYSIS

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I dedicate this Ph.D. thesis to my beloved parents and my wife whose dreams for me have resulted in this achievement and without their loving upbringing and nurturing; I would not have been where I am today and what I am today.

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# ABSTRACT

Worldwide injuries in vehicle accidents have been on the rise in recent years, mainly due to driver error regardless of technological innovations and advancements for vehicle safety. Consequently, there is a need for a reliable-real time warning system that can alert drivers of a potential collision. Vehicle-to-Vehicle (V2V) is an extensive area of ongoing research and development which has started to revolutionize the driving experience. Driving behaviour is a subject of extensive research which gains special attention due to the relationship between speeding behaviour and crashes as drivers who engage in frequent and extreme speeding behaviour are overinvolved in crashes. National Highway Traffic Safety Administration (NHTSA) set guidelines on how different vehicle automation levels may reduce vehicle crashes and how the use of on-board short-range sensors coupled with V2V technologies can help facilitate communication among vehicles. Based on the previous works, it can be seen that the assessment of drivers' behaviours using their trajectory data is a fresh and open research field. Most studies related to driving behaviours in terms of acceleration-deceleration are evaluated at the laboratory scale using experimental results from actual vehicles. Towards this end, a five-stage methodology for a new collision warning system in the context of V2V based on driving behaviours has been designed. Real-time V2V hardware for data collection purposes was developed. Driving behaviour was analyzed in different timeframes prior obtained from actual driving behaviour in an urban environment collected from OBD-II adapter and GPS data logger of an instrumented vehicle. By measuring the in-vehicle accelerations, it is possible to categorize the driving behaviour into four main classes based on real-time experiments: safe drivers, normal, aggressive, and dangerous drivers. When the vehicle is in a risk situation, the system based on NRF24L01+PA/LNA, GPS, and OBD-II will pass a signal to the driver using a dedicated LCD and LED light signal. The driver can instantly decide to make the vehicle in a safe mood, effectively avoid the happening of vehicle accidents. The proposed solution provides two main functions:

(1) the detection of the dangerous vehicles involved in the road, and (2) the display of a message informing the driver if it is safe or unsafe to pass. System performance was evaluated to ensure that it achieved the primary objective of improving road safety in the extreme behaviour of the driver in question either the safest (or the least aggressive) and the most unsafe (or the most aggressive). The proposed methodology has retained some advantages for other literature studies because of the simultaneous use of speed, acceleration, and vehicle location. The V2V based on driving behaviour experiments shows the effectiveness of the selected approach predicts behaviour with an accuracy of over 87% in sixty-four real-time scenarios presented its capability to detect behaviour and provide a warning to nearby drivers. The system failed detection only in few times when the receiving vehicle missed data due to high speed during the test as well as the distances between the moving vehicles, the data was not received correctly since the power transmitted, the frequency range of the signals, the antenna relative positions, and the number of in-range vehicles are of interest for the V2V test scenarios. The latter result supports the conclusion that warnings that efficiently and quickly transmit their information may be better when driver are under stress or time pressure.

# ABSTRAK

Kecelakaan kenderaan di seluruh dunia telah meningkat dalam beberapa tahun kebelakangan ini, terutamanya disebabkan oleh kesalahan pemandu tanpa mengira inovasi teknologi dan kemajuan untuk keselamatan kenderaan. Oleh itu, terdapat keperluan untuk sistem amaran masa nyata yang boleh dipercayai yang dapat memberi amaran kepada pemandu mengenai kemungkinan berlakunya perlanggaran. *Vehicle-to-Vehicle* (V2V) adalah bidang penyelidikan dan penbangunan yang sedang bermula merevolusikan pengalaman memandu. Tingkah laku memandu adalah subjek kajian yang meluas dan mendapat perhatian khusus kerana hubungan antara tingkah laku memandu laju dan kemalangan kerana pemandu yang kerap dan melampau memandu laju banyak terlibat dalam kemalangan. *National Highway Traffic Safety Administration* (NHTSA) menetapkan garis panduan bagaimana tahap automasi kenderaan yang berbeza dapat mengurangkan kemalangan kenderaan dan bagaimana penggunaan sensor jarak dekat dalam kenderaan yang digabungkan dengan teknologi V2V dapat membantu memudahkan komunikasi di antara kenderaan. Berdasarkan penyelidikan sebelumnya, dapat dilihat bahawa penilaian tingkah laku pemandu menggunakan data lintasan mereka adalah bidang penyelidikan yang baharu dan terbuka. Sebilangan besar kajian yang berkaitan dengan tingkah laku memandu dari segi pecutan-perlambatan dinilai pada skala makmal menggunakan hasil eksperimen dari kenderaan sebenar. Mutahir ini, metodologi lima peringkat untuk sistem amaran perlanggaran baru dalam kontek V2V berdasarkan tingkah laku memandu telah dirancang. Perkakasan V2V masa nyata untuk tujuan pengumpulan data telah dibangunkan. Tingkah laku memandu dianalisis dalam jangka masa yang berbeza sebelum diperoleh dari tingkah laku memandu sebenar di persekitaran bandar yang dikumpulkan dari penyesuai OBD-II dan pencatat data GPS kenderaan yang diinstrumen. Dengan mengukur pecutan dalam kenderaan, adalah mungkin untuk mengkategorikan tingkah laku memandu menjadi empat kelas utama berdasarkan eksperimen masa nyata: pemandu selamat, pemandu normal, agresif, dan berbahaya.

Apabila kenderaan berada dalam keadaan berisiko, sistem berdasarkan NRF24L01 + PA / LNA, GPS, dan OBD-II akan menyampaikan isyarat kepada pemandu menggunakan isyarat di LCD dan LED khusus. Pemandu dengan serta-merta dapat membuat keputusan untuk menjadikan kenderaan dalam keadaan selamat dan berkesan mengelakkan berlakunya kemalangan kenderaan. Penyelesaian yang dicadangkan menyediakan dua fungsi utama: (1) pengesanan kenderaan berbahaya yang terlibat di jalan raya, dan (2) paparan mesej yang memberitahu pemandu jika selamat atau tidak selamat untuk dilalui. Prestasi sistem dinilai untuk memastikan bahawa ia mencapai objektif utama untuk meningkatkan keselamatan jalan raya dalam tingkah laku pemandu yang melampau sama ada yang paling selamat (atau paling tidak agresif) dan yang paling tidak selamat (atau yang paling agresif). Metodologi yang dicadangkan telah mengekalkan beberapa kelebihan untuk kajian literatur lain kerana penggunaan kecepatan, pecutan, dan lokasi kenderaan secara serentak. V2V berdasarkan eksperimen tingkah laku memandu menunjukkan keberkesanan pendekatan yang dipilih meramalkan tingkah laku dengan ketepatan lebih dari 87% dalam enam puluh empat senario masa nyata yang menunjukkan kemampuannya untuk mengesan tingkah laku dan memberi amaran kepada pemandu yang berdekatan. Sistem gagal dikesan hanya dalam beberapa kali ketika kenderaan penerima kehilangan data kerana kelajuan tinggi semasa ujian serta jarak antara kenderaan bergerak, data tidak diterima dengan betul kerana kuasa yang dihantar, julat frekuensi isyarat, kedudukan relatif antena, dan jumlah kenderaan dalam jarak tertentu untuk senario ujian V2V. Hasil kajian terakhir menyokong kesimpulan bahawa maklumat amaran yang disampaikan adalah cekap dan cepat pada ketika pemandu dibawah tekanan atau tekanan waktu.

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| | | |
|---|---|---|
| ADAS | – | Advanced Driver Assistance Systems |
| AIRS | – | Adaptively Intelligent Routing System |
| AIRS | – | Adaptively Intelligent Routing System |
| AVTs | – | Automated Vehicles Technologies |
| BSMs | – | Basic Safety Messages |
| C2C | – | Car-to-Car |
| CA | – | Collision avoidance |
| CAMs | – | Cooperative Awareness Messages |
| CAN | – | Controller Area Network |
| CAS | – | Collision Avoidance System |
| C-ITS | – | Cooperative-Intelligent Transportation System |
| D2D | – | Device-to-Device |
| DBQ | – | Driver Behaviour Questionnaire |
| DDoS | – | Distributed Denial-of-Service |
| DGPS | – | Differential Global Positioning System |
| DLC | – | Data Link Connector |
| DoS | – | Denial-of-Service |
| DSRC | – | Dedicated Short Range Communications |
| DTC | – | Diagnostic Trouble Code |
| ECU | – | Electronic Control Unit |
| ETSI | – | European Telecommunications Standards Institute |
| FCD | – | Floating Car Data |
| GHGs | – | Greenhouse Gas Emissions |
| GNSS | – | Global Navigation Satellite System |
| GPRS | – | General Packet Radio Service |
| GPS | – | Global Positioning System |
| HetVNETs | – | Heterogeneous Vehicular NETworks |

| | | |
|---|---|---|
| HEVs | – | Hybrid Electric Vehicles |
| IEEE | – | Institute of Electrical and Electronics Engineers |
| IMU | – | Inertial Measurement Unit |
| IoV | – | Internet of Vehicles |
| ISM | – | The Industrial, Scientific, and Medical |
| ITS | – | Intelligent Transportation System |
| km | – | Kilometer |
| km/h | – | Kilometer per hour |
| LiDAR | – | Light Detection and Ranging |
| LNA | – | Low-Noise Amplifier |
| LTE | – | Long-Term Evolution |
| NDOS | – | Node Operation System |
| NHTSA | – | National Highway Traffic Safety Administration |
| NS | – | Network Simulator |
| OBD | – | On-Board Diagnostics |
| OBU | – | On-Board-Units |
| PA | – | Power Amplifier |
| PDR | – | Packet Delivery Rate |
| PHY/MAC | – | Physical/Medium Access Control |
| PKL | – | Packet Loss |
| PSO | – | Particle Swarm Optimization |
| QoS | – | Quality of Service |
| RF | – | Radio Frequency |
| RSU | – | Road Side Unit |
| RTS/CTS | – | Request to Send / Clear to Send |
| SCs | – | Secondary Crashes |
| SDN | – | Software Defined Networking |
| SES | – | Sampling-based Estimation Scheme |
| SNR | – | Signal-to-Noise Ratio |
| SPI | – | Serial Peripheral Interface |
| TDMA | – | Time-Division Multiple Access |
| ToA | – | Time of Arrival |
| V2V | – | Vehicle-to-Vehicle |

| | | |
|---|---|---|
| V2X | – | Vehicle-to-Everything |
| VANETs | – | Vehicular Ad Hoc Networks |
| VDSA | – | Vehicular Dynamic Spectrum Access |
| VLC | – | Visible Light Communication |
| VRA | – | Vertical Relative Angle |
| VSimRTI | – | V2X Simulation Runtime Infrastructure |
| VSNs | – | Virtualized Network Services |
| WAVE | – | Wireless Access for Vehicular Environments |
| WoS | – | Web of Science |

# REFERENCES


[1] J. Lianghai, M. Liu, A. Weinand, and H. D. Schotten, "Direct vehicle-to-vehicle communication with infrastructure assistance in 5G network," in *2017 16th Annual Mediterranean Ad Hoc Networking Workshop (Med-Hoc-Net)*, 2017, pp. 1-5.

[2] L. Zhenyu, P. Lin, Z. Konglin, and Z. Lin, "Design and evaluation of V2X communication system for vehicle and pedestrian safety," *The Journal of China Universities of Posts and Telecommunications,* vol. 22, no. 6, pp. 18-26, December 2015.

[3] H. Yang, Z. Wang, and K. Xie, "Impact of connected vehicles on mitigating secondary crash risk," *International Journal of Transportation Science and Technology,* vol. 6, no. 3, pp. 196-207, 2017.

[4] National Safety Council. (2020). *Type of Crash*. Available: https://injuryfacts.nsc.org/motor-vehicle/overview/type-of-crash/

[5] T. Zinchenko, "Reliability Assessment of Vehicle-to-Vehicle Communication," Ph.D thesis, Technical University of Braunschweig, 2015.

[6] C. Liao, J. Chang, I. Lee, and K. K. Venkatasubramanian, "A trust model for vehicular network-based incident reports," presented at the 2013 IEEE 5th International Symposium on Wireless Vehicular Communications (WiVeC), 2-3 June 2013.

[7] A. J. Suzuki and K. Mizui, "Bidirectional Vehicle-to-Vehicle Communication and Ranging Systems with Spread Spectrum Techniques Using Laser Radar and Visible Light," *IEICE Transactions on Fundamentals of Electronics Communications and Computer Sciences,* vol. E100A, no. 5, pp. 1206-1214, May 2017.

[8] J. Radak, B. Ducourthial, V. Cherfaoui, and S. Bonnet, "Detecting Road Events Using Distributed Data Fusion: Experimental Evaluation for the Icy Roads Case," *IEEE Transactions on Intelligent Transportation Systems,* vol. 17, no. 1, pp. 184-194, 2016.

[9] M. Obst, L. Hobert, and P. Reisdorf, "Multi-sensor data fusion for checking plausibility of V2V communications by vision-based multiple-object tracking," in *2014 IEEE Vehicular Networking Conference (VNC)*, 2014, pp. 143-150.

[10] S. Eckelmann, T. Trautmann, H. Ußler, B. Reichelt, and O. Michler, "V2V-Communication, LiDAR System and Positioning Sensors for Future Fusion Algorithms in Connected Vehicles," *Transportation Research Procedia,* vol. 27, pp. 69-76, 2017.

[11] L. Dorn, *Driver behaviour and training*. Routledge, 2017.

[12] M. G. Jasinski and F. Baldo, "A Method to Identify Aggressive Driver Behaviour Based on Enriched GPS Data Analysis," presented at the GEOProcessing 2017 : The Ninth International Conference on Advanced Geographic Information Systems, Applications, and Services, 2017

[13] Q. Chen, B. Bellows, M. P. Wittie, S. Patterson, and Q. Yang, "MOVESET: MOdular VEhicle SEnsor Technology," in *2016 IEEE Vehicular Networking Conference*, O. Altintas, E. Ekici, M. Tsai, M. Sepulcre, B. Bloessl, and Y. L. Wei, Eds. (IEEE Vehicular Networking Conference, 2016.

[14] F. Yu and S. Biswas, "Self-Configuring TDMA Protocols for Enhancing Vehicle Safety With DSRC Based Vehicle-to-Vehicle Communications," *IEEE Journal on Selected Areas in Communications,* vol. 25, no. 8, pp. 1526-1537, 2007.

[15] M. Sepulcre, J. Gozalvez, and B. Coll-Perales, "Why 6 Mbps is Not (Always) the Optimum Data Rate for Beaconing in Vehicular Networks," *IEEE Transactions on Mobile Computing,* vol. 16, no. 12, pp. 3568-3579, 2017.

[16] B. Soret, M. G. Sarret, I. Z. Kovacs, F. J. Martin-Vega, G. Berardinelli, and N. H. Mahmood, "Radio Resource Management for V2V Discovery," in *2017 IEEE 85th Vehicular Technology Conference (VTC Spring)*, 2017.

[17] J. Ahrems, "Appraisal of Feasibility of Using Vehicle-to-Vehicle Communications for Safe Passage of Unsignalled Road Intersection under Varying Conditions," *IFAC Proceedings Volumes,* vol. 46, no. 28, pp. 84-89, 2013.

[18] B. Glas, O. Sander, V. Stuckert, K. D. Muller-Glaser, and J. Becker, "Car-to-Car Communication Security on Reconfigurable Hardware," in *2009 IEEE Vehicular Technology Conference*(IEEE Vehicular Technology Conference, 2009, pp. 2155-2159.

[19] M. A. Lebre, F. Le Mouel, and E. Menard, "Resilient, Decentralized V2V Online Stop-free Strategy in a Complex Roundabout," in *2016 IEEE 83rd Vehicular Technology Conference*(IEEE Vehicular Technology Conference Proceedings, 2016.

[20] H. Tchouankem, "Characterization of Intersection Topologies in Urban Areas for Vehicle-to-Vehicle Communication," in *2016 IEEE 84th Vehicular Technology Conference (VTC-Fall)*, 2016, pp. 1-5.

[21] F. Cardoso, A. Serrador, and T. Canas, "Algorithms for Road Safety Based on GPS and Communications Systems WAVE," *Procedia Technology,* vol. 17, pp. 640-649, 2014.

[22] A. M. Orozco, S. Cespedes, R. Michoud, and G. Llano, "Design and simulation of a collision notification application with geocast routing for car-to-car communications," *European Transport Research Review,* vol. 7, no. 4, Dec 2015, Art. no. 36.

[23] N. Varga, L. Bokor, A. Takács, J. Kovács, and L. Virág, "An architecture proposal for V2X communication-centric traffic light controller systems," in *2017 15th International Conference on ITS Telecommunications (ITST)*, 2017, pp. 1-7.

[24] B. Zardosht, S. S. Beauchemin, and M. A. Bauer, "A predictive accident-duration based decision-making module for rerouting in environments with V2V communication," *Journal of Traffic and Transportation Engineering (English Edition),* vol. 4, no. 6, pp. 535-544, December 2017.

[25] C. Olaverri-Monreal, P. Gomes, R. Fernandes, F. Vieira, and M. Ferreira, "The See-Through System: A VANET-Enabled Assistant for Overtaking Maneuvers," in *2010 IEEE Intelligent Vehicles Symposium*(IEEE Intelligent Vehicles Symposium, 2010, pp. 123-128.

[26] M. El-Said, V. Bhuse, and A. Arendsen, "An Empirical Study to Investigate the Effect of Air Density Changes on the DSRC Performance," *Procedia Computer Science,* vol. 114, pp. 523-530, 2017.

[27] A. Memon, F. K. Shaikh, and E. Felemban, "Experimental evaluation of vehicle-to-vehicle based data transfer," in *2015 International Conference on Information and Communication Technology Research (ICTRC)*, 2015, pp. 274-277.

[28] W. Alghamdi, E. Shakshuki, and T. R.Sheltami, "Context-Aware Driver Assistance System," *Procedia Computer Science,* vol. 10, pp. 785-794, 2012.

[29] F. Jiménez, J. E. Naranjo, J. J. Anaya, F. García, A. Ponz, and J. M. Armingol, "Advanced Driver Assistance System for Road Environments to Improve Safety and Efficiency," *Transportation Research Procedia,* vol. 14, pp. 2245-2254, // 2016.

[30] V. Milanés, L. Alonso, J. Villagrá, J. Godoy, T. de Pedro, and J. P. Oria, "Traffic jam driving with NMV avoidance," *Mechanical Systems and Signal Processing,* vol. 31, pp. 332-344, Augest 2012.

[31] J. R. Ward, G. Agamennoni, S. Worrall, A. Bender, and E. Nebot, "Extending Time to Collision for probabilistic reasoning in general traffic scenarios," *Transportation Research Part C: Emerging Technologies,* vol. 51, pp. 66-82, 2015.

[32] N. Motamedidehkordi, M. Margreiter, and T. Benz, "Shockwave Suppression by Vehicle-to-Vehicle Communication," *Transportation Research Procedia,* vol. 15, pp. 471-482, 2016.

[33] P. Gora and I. Rub, "Traffic models for self-driving connected cars," in *Transport Research Arena Tra2016*, vol. 14, L. Rafalski and A. Zofka, Eds. (Transportation Research Procedia, 2016, pp. 2207-2216.

[34] J.-N. Russo, T. Sproesser, F. Drouhin, and M. Basset, "Risks Level Assessments for Automotive Application," *IFAC-PapersOnLine,* vol. 49, no. 15, pp. 163-168, 2016.

[35] Y. Ma, Z. Zhang, S. Chen, Y. Yu, and K. J. I. A. Tang, "A comparative study of aggressive driving behavior recognition algorithms based on vehicle motion data," vol. 7, pp. 8028-8038, 2018.

[36] J. H. Ogle, "Quantitative assessment of driver speeding behavior using instrumented vehicles," Ph.D thesis, Civil Engineering, Georgia Institute of Technology, 2005.

[37] E. G. Mantouka, E. N. Barmpounakis, and E. I. Vlahogianni, "Identifying driving safety profiles from smartphone data using unsupervised learning," *Safety Science,* vol. 119, pp. 84-90, 2019.

[38] O. Bagdadi and A. Várhelyi, "Jerky driving—An indicator of accident proneness?," *Accident Analysis & Prevention,* vol. 43, no. 4, pp. 1359-1363, Jul. 2011.

[39] A. Tang and A. Yip, "Collision avoidance timing analysis of DSRC-based vehicles," *Accident Analysis & Prevention,* vol. 42, no. 1, pp. 182-195, January 2010.

[40] S. H. Lee, S. Lee, and M. H. Kim, "Development of a Driving Behavior-Based Collision Warning System Using a Neural Network," *International Journal of Automotive Technology,* journal article vol. 19, no. 5, pp. 837-844, Oct. 2018.

[41] N. Pothirasan and M. P. Rajasekaran, "Automatic vehicle to vehicle communication and vehicle to infrastructure communication using NRF24L01 module," in *2016 International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT)*, 2016, pp. 400-405.

[42] H. Saha, S. Mandal, S. Mitra, S. Banerjee, U. J. I. J. o. C. N. Saha, and I. Security, "Comparative Performance Analysis between nRF24L01+ and XBEE ZB Module Based Wireless Ad-hoc Networks," vol. 9, pp. 36-44, 2017.

[43] C. Bernardini, M. R. Asghar, and B. Crispo, "Security and privacy in vehicular communications: Challenges and opportunities," *Vehicular Communications,* vol. 10, pp. 13-28, 2017.

[44] D. Antolino Rivas, J. M. Barceló-Ordinas, M. Guerrero Zapata, and J. D. Morillo-Pozo, "Security on VANETs: Privacy, misbehaving nodes, false information and secure data aggregation," *Journal of Network and Computer Applications,* vol. 34, no. 6, pp. 1942-1955, 2011.

[45] B. Mokhtar and M. Azab, "Survey on Security Issues in Vehicular Ad Hoc Networks," *Alexandria Engineering Journal,* vol. 54, no. 4, pp. 1115-1126, 2015.

[46] R. G. Engoulou, M. Bellaïche, S. Pierre, and A. Quintero, "VANET security surveys," *Computer Communications,* vol. 44, pp. 1-13, 2014.

[47] F. Cunha *et al.*, "Data communication in VANETs: Protocols, applications and challenges," *Ad Hoc Networks,* vol. 44, pp. 90-103, 2016.

[48] S. A. Ben Mussa, M. Manaf, and K. Z. Ghafoor, *Beaconing and Transmission Range Adaptation Approaches in Vehicular Ad Hoc Networks: Trends & Research Challenges* (2014 International Conference on Computational Science and Technology). 2014.

[49] N. Torabi and B. S. Ghahfarokhi, "Survey of medium access control schemes for inter-vehicle communications," *Computers & Electrical Engineering,* vol. 64, pp. 450-472, 2017.

[50] R. S. Bali, N. Kumar, and J. J. P. C. Rodrigues, "Clustering in vehicular ad hoc networks: Taxonomy, challenges and solutions," *Vehicular Communications,* vol. 1, no. 3, pp. 134-152, 2014.

[51] N.-E. E. Faouzi, H. Leung, and A. Kurian, "Data fusion in intelligent transportation systems: Progress and challenges – A survey," *Information Fusion,* vol. 12, no. 1, pp. 4-10, 2011.

[52] K. Zheng, Q. Zheng, P. Chatzimisios, W. Xiang, and Y. Q. Zhou, "Heterogeneous Vehicular Networking: A Survey on Architecture, Challenges, and Solutions," *IEEE Communications Surveys and Tutorials,* vol. 17, no. 4, pp. 2377-2396, 2015.

[53] H. Hasrouny, A. E. Samhat, C. Bassil, and A. Laouiti, "VANet security challenges and solutions: A survey," *Vehicular Communications,* vol. 7, pp. 7-20, 2017.

[54] S. Al-Sultan, M. M. Al-Doori, A. H. Al-Bayatti, and H. Zedan, "A comprehensive survey on vehicular Ad Hoc network," *Journal of Network and Computer Applications,* vol. 37, pp. 380-392, 2014.

[55] L. C. Hua, M. H. Anisi, P. L. Yee, and M. Alam, "Social networking-based cooperation mechanisms in vehicular ad-hoc network—a survey," *Vehicular Communications,* vol. 10, pp. 57-73, 2017.

[56] H. T. Cheng, H. Shan, and W. Zhuang, "Infotainment and road safety service support in vehicular networking: From a communication perspective," *Mechanical Systems and Signal Processing,* vol. 25, no. 6, pp. 2020-2038, 2011.

[57] I. Achour, T. Bejaoui, and S. Tabbane, *Network coding approach for vehicle-to-vehicle communication: Principles, Protocols and Benefits* (2014 22nd International Conference on Software, Telecommunications and Computer Networks). 2014.

[58] H. S. Basheer and C. Bassil, "A review of broadcasting safety data in V2V: Weaknesses and requirements," *Ad Hoc Networks,* vol. 65, pp. 13-25, 2017.

[59] M. S. Kakkasageri and S. S. Manvi, "Information management in vehicular ad hoc networks: A review," *Journal of Network and Computer Applications,* vol. 39, pp. 334-350, 2014.

[60] B. Rashid and M. H. Rehmani, "Applications of wireless sensor networks for urban areas: A survey," *Journal of Network and Computer Applications,* vol. 60, pp. 192-219, 2016.

[61] K. Lidstrom *et al.*, "A Modular CACC System Integration and Design," *IEEE Transactions on Intelligent Transportation Systems,* vol. 13, no. 3, pp. 1050-1061, 2012.

[62] F. Visintainer, L. Altomare, A. Toffetti, A. Kovacs, and A. Amditis, "Towards Manoeuver Negotiation: AutoNet2030 Project from a Car Maker Perspective," *Transportation Research Procedia,* vol. 14, pp. 2237-2244, 2016.

[63] M. García Sánchez, M. Portela Táboas, and E. Lemos Cid, "Millimeter wave radio channel characterization for 5G vehicle-to-vehicle communications," *Measurement,* vol. 95, pp. 223-229, 2017.

[64] S. Medetov, M. Bakhouya, J. Gaber, K. Zinedine, M. Wack, and P. Lorenz, "A decentralized approach for information dissemination in Vehicular Ad hoc Networks," *Journal of Network and Computer Applications,* vol. 46, pp. 154-165, 2014.

[65] H. P. Luong, M. Panda, H. L. Vu, and B. Q. Vo, "Beacon Rate Optimization for Vehicular Safety Applications in Highway Scenarios," *IEEE Transactions on Vehicular Technology,* vol. 67, no. 1, pp. 524-536, 2018.

[66] A. Saxena, H. Li, D. Goswami, and C. B. Math, *Design and Analysis of Control Strategies for Vehicle Platooning* (2016 IEEE 19th International Conference on Intelligent Transportation Systems). 2016, pp. 1805-1812.

[67] M. Ren, L. Khoukhi, H. Labiod, J. Zhang, and V. Vèque, "A mobility-based scheme for dynamic clustering in vehicular ad-hoc networks (VANETs)," *Vehicular Communications,* vol. 9, pp. 233-241, 2017.

[68] Y. Allouche and M. Segal, "Cluster-Based Beaconing Process for VANET," *Vehicular Communications,* vol. 2, no. 2, pp. 80-94, April 2015.

[69] B. Jain, G. Brar, J. Malhotra, S. Rani, and S. H. Ahmed, "A cross layer protocol for traffic management in Social Internet of Vehicles," *Future Generation Computer Systems,* 2017.

[70] B. Brik, N. Lagraa, A. Lakas, and A. Cheddad, "DDGP: Distributed Data Gathering Protocol for vehicular networks," *Vehicular Communications,* vol. 4, pp. 15-29, 2016.

[71] B. Jarupan and E. Ekici, "PROMPT: A cross-layer position-based communication protocol for delay-aware vehicular access networks," *Ad Hoc Networks,* vol. 8, no. 5, pp. 489-505, Jul 2010.

[72] A. Choudhury, T. Maszczyk, C. B. Math, H. Li, and J. Dauwels, "An Integrated Simulation Environment for Testing V2X Protocols and Applications," *Procedia Computer Science,* vol. 80, pp. 2042-2052, 2016.

[73] A. Grzybek, G. Danoy, P. Bouvry, and M. Seredynski, "Mitigating flash crowd effect using connected vehicle technology," *Vehicular Communications,* vol. 2, no. 4, pp. 238-250, October 2015.

[74] S. Allani, T. Yeferny, and R. Chbeir, "A scalable data dissemination protocol based on vehicles trajectories analysis," *Ad Hoc Networks,* vol. 71, pp. 31-44, 3/15/ 2018.

[75] A. Wahid, M. A. Shah, F. F. Qureshi, H. Maryam, R. Iqbal, and V. Chang, "Big data analytics for mitigating broadcast storm in Vehicular Content Centric networks," *Future Generation Computer Systems,* 2017.

[76] S. Gong, J. Shen, and L. Du, "Constrained optimization and distributed computation based car following control of a connected and autonomous vehicle platoon," *Transportation Research Part B: Methodological,* vol. 94, pp. 314-334, 2016.

[77] C. Song, J. Wu, M. Liu, and H. Zheng, "Efficient routing through discretization of overlapped road segments in VANETs," *Journal of Parallel and Distributed Computing,* vol. 102, pp. 57-70, 2017.

[78] P. Salvo, I. Turcanu, F. Cuomo, A. Baiocchi, and I. Rubin, "Heterogeneous cellular and DSRC networking for Floating Car Data collection in urban areas," *Vehicular Communications,* vol. 8, pp. 21-34, 2017.

[79] M. Y. Abualhoul, M. Marouf, O. Shagdar, and F. Nashashibi, "Platooning Control Using Visible Light Communications: A Feasibility Study," in *2013 16th International IEEE Conference on Intelligent Transportation Systems*(IEEE International Conference on Intelligent Transportation Systems-ITSC, 2013, pp. 1535-1540.

[80] M. I. Ashraf, L. Chen-Feng, M. Bennis, and W. Saad, "Towards low-latency and ultra-reliable vehicle-to-vehicle communication," in *2017 European Conference on Networks and Communications (EuCNC)*, 2017, pp. 1-5.

[81] P. Gora and I. Rüb, "Traffic Models for Self-driving Connected Cars," *Transportation Research Procedia,* vol. 14, pp. 2207-2216, 2016.

[82] M. S. Rayeni, A. Hafid, and P. K. Sahu, "Dynamic spatial partition density-based emergency message dissemination in VANETs," *Vehicular Communications,* vol. 2, no. 4, pp. 208-222, October 2015.

[83] B. Singh, H. Hasbullah, M. Y. Nayan, and B. Tahlan, *Early Detection of Incident using Vehicular Ad-hoc Network* (2014 International Conference on Computer and Information Sciences). 2014.

[84] A. Ltifi, A. Zouinkhi, and M. S. Bouhlel, "Trust-based Scheme for Alert Spreading in VANET," *Procedia Computer Science,* vol. 73, pp. 282-289, 2015.

[85] A. Petrillo, A. Salvi, S. Santini, and A. S. Valente, "Adaptive multi-agents synchronization for collaborative driving of autonomous vehicles with multiple communication delays," *Transportation Research Part C: Emerging Technologies,* vol. 86, pp. 372-392, 2018.

[86] S. Zhang, Y. Wu, and Y. T. Wang, *An Embedded Node Operating System for Real-Time Information Interaction in Vehicle-to-Vehicle Communication* (2016 IEEE 19th International Conference on Intelligent Transportation Systems). 2016, pp. 887-892.

[87] Z. Zhou, H. Yu, C. Xu, F. Xiong, Y. Jia, and G. Li, "Joint relay selection and spectrum allocation in d2d-based cooperative vehicular networks," in *2017 International Conference on Information and Communication Technology Convergence (ICTC)*, 2017, pp. 241-246.

[88] D. Jia and D. Ngoduy, "Enhanced cooperative car-following traffic model with the combination of V2V and V2I communication," *Transportation Research Part B: Methodological,* vol. 90, pp. 172-191, Augest 2016.

[89] M. Gueriau, R. Billot, N. E. El Faouzi, J. Monteil, F. Armetta, and S. Hassas, "How to assess the benefits of connected vehicles? A simulation framework for the design of cooperative traffic management strategies," *Transportation Research Part C-Emerging Technologies,* vol. 67, pp. 266-279, Jun 2016.

[90] A. Sassi, Y. Elhillali, and F. Charfi, "Evaluating Experimental Measurements of the IEEE 802.11p Communication Using ARADA LocoMate OBU Device Compared to the Theoretical Simulation Results," *Wireless Personal Communications,* vol. 97, no. 3, pp. 3861-3874, Dec 2017.

[91] Y. Agarwal, K. Jain, and O. Karabasoglu, "Smart vehicle monitoring and assistance using cloud computing in vehicular Ad Hoc networks," *International Journal of Transportation Science and Technology,* 2017.

[92] S. Naumann, F. Wolf, and R. Schönrock, "Floating Car Observer – An innovative vehicle-sensor for urban and highway scenarios," *IFAC Proceedings Volumes,* vol. 43, no. 23, pp. 19-24, 2010.

[93] Y. Agarwal, K. Jain, S. Kumar, and G. N. Bhardwaj, *TLST: Time of Arrival Based Localization and Smart Tunnel concept in VANETs* (2016 3rd International Conference on Signal Processing and Integrated Networks). 2016, pp. 779-784.

[94] B. R. Chang, H. F. Tsai, and C.-P. Young, "Intelligent data fusion system for predicting vehicle collision warning using vision/GPS sensing," *Expert Systems with Applications,* vol. 37, no. 3, pp. 2439-2450, 3/15/ 2010.

[95] M. I. Sanchez, M. Gramaglia, C. J. Bernardos, A. de la Oliva, and M. Calderon, "On the implementation, deployment and evaluation of a networking protocol for VANETs: The VARON case," *Ad Hoc Networks,* vol. 19, pp. 9-27, 2014.

[96] V. Jindal and P. Bedi, "Reducing waiting time with parallel preemptive algorithm in VANETs," *Vehicular Communications,* vol. 7, pp. 58-65, January 2017.

[97] A. Gibaud and P. Thomin, "Message forwarding based on vehicle trajectory history in Fully Distributed Traffic Information Systems," *Computer Communications,* vol. 60, pp. 40-52, 4/1/ 2015.

[98] M. Srotyr, T. Zelinka, and Z. Lokaj, "Hybrid communication solution for C-ITS and its evaluation," in *2017 Smart City Symposium Prague (SCSP)*, 2017, pp. 1-7.

[99] K. Golestan, F. Sattar, F. Karray, M. Kamel, and S. Seifzadeh, "Localization in vehicular ad hoc networks using data fusion and V2V communication," *Computer Communications,* vol. 71, pp. 61-72, 11/1/ 2015.

[100] H. Tchouankem and T. Lorenzen, "Measurement-based evaluation of interference in Vehicular Ad-Hoc Networks at urban intersections," in *2015 IEEE International Conference on Communication Workshop (ICCW)*, 2015, pp. 2381-2386.

[101] G. Yan and D. B. Rawat, "Vehicle-to-vehicle connectivity analysis for vehicular ad-hoc networks," *Ad Hoc Networks,* vol. 58, pp. 25-35, 2017.

[102] P. Karadimas and D. Matolak, "Generic stochastic modeling of vehicle-to-vehicle wireless channels," *Vehicular Communications,* vol. 1, no. 4, pp. 153-167, 2014.

[103] Y. Wang, Y. Zhang, J. Hu, and X. Pei, "An Analysis on Stochastic Broadcast Range in VANET Based on Generalized Packet Loss Model," in *2015 IEEE 18th International Conference on Intelligent Transportation Systems*, 2015, pp. 1055-1060.

[104] H. Gong, K. He, Y. Qu, and P. Wang, "Analysis and improvement of vehicle information sharing networks," *Physica A: Statistical Mechanics and its Applications,* vol. 452, pp. 106-112, 6/15/ 2016.

[105] J. Santa, R. Toledo-Moreo, M. A. Zamora-Izquierdo, B. Úbeda, and A. F. Gómez-Skarmeta, "An analysis of communication and navigation issues in collision avoidance support systems," *Transportation Research Part C: Emerging Technologies,* vol. 18, no. 3, pp. 351-366, June 2010.

[106] A. Baiocchi, "Analysis of timer-based message dissemination protocols for inter-vehicle communications," *Transportation Research Part B: Methodological,* vol. 90, pp. 105-134, 8// 2016.
[107] A. M. Said, M. Marot, A. W. Ibrahim, and H. Afifi, "Modeling interactive real-time applications in VANETs with performance evaluation," *Computer Networks,* vol. 104, pp. 66-78, 2016.
[108] M. R. Jabbarpour, A. Marefat, A. Jalooli, R. M. Noor, R. H. Khokhar, and J. Lloret, "Performance analysis of V2V dynamic anchor position-based routing protocols," *Wireless Networks,* vol. 21, no. 3, pp. 911-929, Apr 2015.
[109] H. Su, C. H. Cho, Y. H. Chu, and W. Y. Chang, *A Traffic Information Dissemination Mechanism Based on DSRC/WAVE and Its Applications* (2012 12th International Conference on Its Telecommunications). 2012, pp. 629-632.
[110] S. Carrese, E. Cipriani, L. Mannini, and M. Nigro, "Dynamic demand estimation and prediction for traffic urban networks adopting new data sources," *Transportation Research Part C: Emerging Technologies,* vol. 81, pp. 83-98, 2017.
[111] J. Liu, B. Cai, Y. Wang, and J. Wang, "A lane level positioning-based cooperative vehicle conflict resolution algorithm for unsignalized intersection collisions," *Computers & Electrical Engineering,* vol. 39, no. 5, pp. 1381-1398, 2013.
[112] T. Y. Wu, N. Guizani, and C. Y. Hsieh, "An efficient adaptive intelligent routing system for multi-intersections," *Wireless Communications & Mobile Computing,* vol. 16, no. 17, pp. 3175-3186, Dec 2016.
[113] D. Perez-Diaz de Cerio and J. L. Valenzuela, "Provisioning Vehicular Services and Communications Based on a Bluetooth Sensor Network Deployment," *Sensors,* vol. 15, no. 6, pp. 12765-12781, Jun 2015.
[114] M. Bou Farah, D. Mercier, F. Delmotte, and É. Lefèvre, "Methods using belief functions to manage imperfect information concerning events on the road in VANETs," *Transportation Research Part C: Emerging Technologies,* vol. 67, pp. 299-320, 2016.
[115] J. Toutouh and E. Alba, "Light commodity devices for building vehicular ad hoc networks: An experimental study," *Ad Hoc Networks,* vol. 37, Part 2, pp. 499-511, February 2016.
[116] Z. He and D. Zhang, "Cost-efficient traffic-aware data collection protocol in VANET," *Ad Hoc Networks,* vol. 55, pp. 28-39, February 2017.
[117] A. Sassi, F. Charfi, L. Kamoun, Y. Elhillali, and A. Rivenq, "The impact of mobility on the performance of V2X communication," in *2011 4th International Conference on Logistics*, 2011, pp. 434-438.
[118] L. Kristiana, C. Schmitt, and B. Stiller, "A filtering concept for improving the angle-based forwarding scheme in Vehicular Ad-Hoc Network communications," in *2016 22nd Asia-Pacific Conference on Communications (APCC)*, 2016, pp. 545-551.
[119] B. C. Dhas and P. P. E. Winston, "Efficient vehicular communication using random access channels in UMTS based network
" in *International Conference on Electronics and Communication Systems*, 2014.
[120] S. Pagadarai, B. A. Lessard, A. M. Wyglinski, R. Vuyyuru, and O. Altintas, "Vehicular Communication: Enhanced Networking Through Dynamic Spectrum Access," *IEEE Vehicular Technology Magazine,* vol. 8, no. 3, pp. 93-103, 2013.
[121] L. Du, L. Han, and X.-Y. Li, "Distributed coordinated in-vehicle online routing using mixed-strategy congestion game," *Transportation Research Part B: Methodological,* vol. 67, 2014.
[122] B. Baron *et al.*, "Virtualizing vehicular node resources: Feasibility study of virtual machine migration," *Vehicular Communications,* vol. 4, pp. 39-46, 2016.
[123] F. Bounini, D. Gingras, H. Pollart, and D. Gruyer, "Real time cooperative localization for autonomous vehicles," in *2016 IEEE 19th International Conference on Intelligent Transportation Systems (ITSC)*, 2016, pp. 1186-1191.

[124] G. M. Hoang, B. Denis, J. Härri, and D. T. M. Slock, "Robust data fusion for cooperative vehicular localization in tunnels," in *2017 IEEE Intelligent Vehicles Symposium (IV)*, 2017, pp. 1372-1377.

[125] A. Bazzi, B. M. Masini, A. Zanella, and A. Calisti, "Visible light communications as a complementary technology for the internet of vehicles," *Computer Communications,* vol. 93, pp. 39-51, 11/1/ 2016.

[126] Z. Zhou, C. Gao, C. Xu, Y. Zhang, and D. Zhang, "Reliable Content Dissemination in Internet of Vehicles Using Social Big Data," in *IEEE Global Communications Conference*, 2017, pp. 1-6.

[127] D. B. Rawat, C. Bajracharya, and G. Yan, "Towards intelligent transportation Cyber-Physical Systems: Real-time computing and communications perspectives," in *SoutheastCon 2015*, 2015, pp. 1-6.

[128] M. Barradi, A. S. Hafid, and S. Aljahdali, "Highway Multihop Broadcast Protocols for Vehicular Networks," in *IEEE International Conference on Communications*, 2012.

[129] T. Petrov, M. Dado, K. E. Ambrosch, and P. Holecko, *Experimental Topology for V2V Communication Based on Internet of Things* (2016 Elektro 11th International Conference). 2016, pp. 72-76.

[130] Z. Wu, J. Yang, and L. Huang, "Study on the Collision Avoidance Strategy at Unsignalized Intersection based on PreScan Simulation," *Procedia - Social and Behavioral Sciences,* vol. 96, pp. 1315-1321, 11/6/ 2013.

[131] O. Shagdar and P. Muhlethaler, "Study on Merging Control Supported by IEEE 802.11p Systems for Highway Environments'," in *IFIP Wireless Days*, 2013.

[132] F. A. Teixeira, V. F. e Silva, J. L. Leoni, D. F. Macedo, and J. M. S. Nogueira, "Vehicular networks using the IEEE 802.11p standard: An experimental analysis," *Vehicular Communications,* vol. 1, no. 2, pp. 91-96, 2014.

[133] T. Acarman, C. Yaman, Y. Peksen, and A. U. Peker, "Intersection Based Routing in Urban VANETs," in *IEEE 18th International Conference on Intelligent Transportation Systems*, 2015, pp. 1087-1092.

[134] A. Olia, H. Abdelgawad, B. Abdulhai, and S. N. Razavi, "Assessing the Potential Impacts ofConnected Vehicles: Mobility, Environmental, and Safety Perspectives," *Journal of Intelligent Transportation Systems,* vol. 20, no. 3, pp. 229-243, 2016.

[135] M. Amadeo, C. Campolo, and A. Molinaro, "Enhancing IEEE 802.11p/WAVE to provide infotainment applications in VANETs," *Ad Hoc Networks,* vol. 10, no. 2, pp. 253-269, 2012.

[136] A. Mukhopadhyay, S. Raghunath, and M. Kruti, "Feasibility and performance evaluation of VANET techniques to enhance real-time emergency healthcare services," in *2016 International Conference on Advances in Computing, Communications and Informatics (ICACCI)*, 2016, pp. 2597-2603.

[137] Y. Lu, Q. Cui, Y. Hou, Z. Gao, and B. Zhang, "Graph-based time-critical cooperative data exchange in V2V via network coding strategy," in *2017 IEEE 18th International Workshop on Signal Processing Advances in Wireless Communications (SPAWC)*, 2017, pp. 1-5.

[138] S. Szigeti, C. Csiszár, and D. Földes, "Information Management of Demand-responsive Mobility Service Based on Autonomous Vehicles," *Procedia Engineering,* vol. 187, pp. 483-491, 2017.

[139] C. Y. Qu, D. A. Ulybyshev, B. K. Bhargava, R. Ranchal, and L. T. Lilien, "Secure Dissemination of Video Data in Vehicle-to-Vehicle Systems," in *2015 IEEE 34th Symposium on Reliable Distributed Systems Workshop*(Symposium on Reliable Distributed Systems Proceedings, 2015, pp. 47-51.

[140] C. A. Kerrache, N. Lagraa, C. T. Calafate, and A. Lakas, "TFDD: A trust-based framework for reliable data delivery and DoS defense in VANETs," *Vehicular Communications,* vol. 9, pp. 254-267, 2017.

[141] S. Sousa *et al.*, "A New Approach on Communications Architectures for Intelligent Transportation Systems," *Procedia Computer Science,* vol. 110, pp. 320-327, 2017.

[142] A. J. Ghandour, K. Fawaz, H. Artail, M. Di Felice, and L. Bononi, "Improving vehicular safety message delivery through the implementation of a cognitive vehicular network," *Ad Hoc Networks,* vol. 11, no. 8, pp. 2408-2422, 2013.

[143] C. A. Kerrache, N. Lagraa, C. T. Calafate, J.-C. Cano, and P. Manzoni, "T-VNets: A novel trust architecture for vehicular networks using the standardized messaging services of ETSI ITS," *Computer Communications,* vol. 93, pp. 68-83, 11/1/ 2016.

[144] A. Baiocchi, F. Cuomo, M. De Felice, and G. Fusco, "Vehicular Ad-Hoc Networks sampling protocols for traffic monitoring and incident detection in Intelligent Transportation Systems," *Transportation Research Part C: Emerging Technologies,* vol. 56, pp. 177-194, July 2015.

[145] Z. Li and M. Shahidehpour, "Deployment of cybersecurity for managing traffic efficiency and safety in smart cities," *The Electricity Journal,* vol. 30, no. 4, pp. 52-61, May 2017.

[146] N. Salameh, G. Challita, S. Mousset, A. Bensrhair, and S. Ramaswamy, "Collaborative positioning and embedded multi-sensors fusion cooperation in advanced driver assistance system," *Transportation Research Part C-Emerging Technologies,* vol. 29, pp. 197-213, Apr 2013.

[147] M. Hübner, T. Lück, and E. Schnieder, "Cooperative Control of Multi-Vehicle-Formations in Road Traffic by means of Consensus Algorithm and Petri Nets," *IFAC Proceedings Volumes,* vol. 42, no. 15, pp. 328-333, 2009.

[148] M. Aramrattana, T. Larsson, J. Jansson, and A. Nåbo, "A simulation framework for cooperative intelligent transport systems testing and evaluation," *Transportation Research Part F: Traffic Psychology and Behaviour,* 2017.

[149] S. K. Choi, "An ontological model to support communications of situation-aware vehicles," *Transportation Research Part C: Emerging Technologies,* vol. 53, pp. 112-133, 2015.

[150] B. HomChaudhuri, R. Lin, and P. Pisu, "Hierarchical control strategies for energy management of connected hybrid electric vehicles in urban roads," *Transportation Research Part C: Emerging Technologies,* vol. 62, pp. 70-86, 2016.

[151] L. Lucien, C. Lang, N. Marilleau, and L. Philippe, "Multiagent Hybrid Architecture for Collaborative Exchanges between Communicating Vehicles in an Urban Context," *Procedia Computer Science,* vol. 83, pp. 695-699, 2016.

[152] W. Balzano, A. Murano, and F. Vitale, "V2V-EN – Vehicle-2-Vehicle Elastic Network," *Procedia Computer Science,* vol. 98, pp. 497-502, 2016.

[153] A. B. Ellison, S. P. Greaves, and M. C. J. Bliemer, "Driver behaviour profiles for road safety analysis," *Accident Analysis & Prevention,* vol. 76, pp. 118-132, 2015.

[154] L. M. Martinussen, M. Møller, and C. G. Prato, "Assessing the relationship between the Driver Behavior Questionnaire and the Driver Skill Inventory: Revealing sub-groups of drivers," *Transportation Research Part F: Traffic Psychology and Behaviour,* vol. 26, pp. 82-91, 2014.

[155] D. Farooq *et al.*, "Analyzing the importance of driver behavior criteria related to road safety for different driving cultures," *International journal of environmental research public health,* vol. 17, no. 6, p. 1893, 2020.

[156] C. Z. Na Lin, Masayoshi Tomizuka, Pan Song, Zexing Zhang and Gang Li, "An overview on study of identification of driver behavior characteristics for automotive control," *Mathematical Problems in Engineering,* p. 15, 17 March 2014.

[157] L. Ball, "Aggressive driving behaviour : a forensic psychological perspective," Ph.D thesis, University of Nottingham, 2018.

[158] C. M. Martinez, M. Heucke, F. Wang, B. Gao, and D. Cao, "Driving Style Recognition for Intelligent Vehicle Control and Advanced Driver Assistance: A Survey," *IEEE Transactions on Intelligent Transportation Systems,* vol. 19, no. 3, pp. 666-676, 2018.

[159] A. Wahab, T. G. Wen, and N. Kamaruddin, "Understanding driver behavior using multi-dimensional CMAC," in *2007 6th International Conference on Information, Communications & Signal Processing*, 2007, pp. 1-5: IEEE.

[160] O. Raz, H. Fleishman, and I. Mulchadsky, "System and method for vehicle driver behavior analysis and evaluation," ed: Google Patents, 2008.
[161] E. M. Carboni and V. Bogorny, "Inferring Drivers Behavior through Trajectory Analysis," Cham, 2015, pp. 837-848: Springer International Publishing.
[162] A. B. Ellison, M. C. Bliemer, S. P. J. A. A. Greaves, and Prevention, "Evaluating changes in driver behaviour: a risk profiling approach," vol. 75, pp. 298-309, 2015.
[163] F. Tango and M. Botta, "Real-Time Detection System of Driver Distraction Using Machine Learning," *IEEE Transactions on Intelligent Transportation Systems,* vol. 14, no. 2, pp. 894-905, 2013.
[164] A. Aksjonov, P. Nedoma, V. Vodovozov, E. Petlenkov, and M. Herrmann, "A Novel Driver Performance Model Based on Machine Learning," *IFAC-Papers On Line,* vol. 51, no. 9, pp. 267-272, 2018.
[165] X. Zheng *et al.*, "Big Data for Social Transportation," *IEEE Transactions on Intelligent Transportation Systems,* vol. 17, no. 3, pp. 620-630, 2016.
[166] D. Crundall, "Hazard prediction discriminates between novice and experienced drivers," *Accident Analysis & Prevention,* vol. 86, pp. 47-58, 2016.
[167] T. Petzoldt, T. Weiß, T. Franke, J. F. Krems, and M. Bannert, "Can driver education be improved by computer based training of cognitive skills?," *Accident Analysis & Prevention,* vol. 50, pp. 1185-1192, 2013.
[168] M. Plöchl and J. Edelmann, "Driver models in automobile dynamics application," *Vehicle System Dynamics,* vol. 45, no. 7-8, pp. 699-741, 2007.
[169] J. X. Wenshuo Wang, and Huiyan Chen, "Modeling and recognizing driver behavior based on driving data: A survey," *Mathematical Problems in Engineering,* February 2014.
[170] J. Engelbrecht, M. J. Booysen, and G.-J. Van Rooyen, "Recognition of driving manoeuvres using smartphone-based inertial and GPS measurement," *Proceedings of the 1st International Conference on the Use of Mobile ICT in Africa,* 2014.
[171] M. Niezgoda, T. Kamiński, and M. Kruszewski, "Measuring driver behaviour-indicators for traffic safety," *Journal of KONES Powertrain and Transport,* vol. 19, pp. 503-511, 2012.
[172] D. L. Van Rooy, J. Rotton, and T. M. Burns, "Convergent, discriminant, and predictive validity of aggressive driving inventories: they drive as they live," vol. 32, no. 2, pp. 89-98, 2006.
[173] C. Miyajima *et al.*, "Driver Modeling Based on Driving Behavior and Its Evaluation in Driver Identification," *Proceedings of the IEEE,* vol. 95, no. 2, pp. 427-437, 2007.
[174] A. S. Zeeman and M. J. Booysen, "Combining speed and acceleration to detect reckless driving in the informal public transport industry," in *16th International IEEE Conference on Intelligent Transportation Systems (ITSC 2013)*, 2013, pp. 756-761.
[175] S. Mehar and S. M. Senouci, "An optimization location scheme for electric charging stations," in *2013 International Conference on Smart Communications in Network Technologies (SaCoNeT)*, 2013, vol. 01, pp. 1-5.
[176] J. Xu, K. Yang, Y. Shao, and G. Lu, "An Experimental Study on Lateral Acceleration of Cars in Different Environments in Sichuan, Southwest China," *Discrete Dynamics in Nature and Society,* vol. 2015, p. 494130, 2015.
[177] A. Aljaafreh, N. Alshabatat, and M. S. N. Al-Din, "Driving style recognition using fuzzy logic," in *IEEE International Conference on Vehicular Electronics and Safety*, 2012, pp. 460-463.
[178] T. Imkamon, P. Saensom, P. Tangamchit, and P. Pongpaibool, "Detection of hazardous driving behavior using fuzzy logic," in *2008 5th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology*, 2008, vol. 2, pp. 657-660.
[179] W. Hailin, L. Hanhui, and S. Zhumei, "Fatigue Driving Detection System Design Based on Driving Behavior," in *2010 International Conference on Optoelectronics and Image Processing*, 2010, vol. 1, pp. 549-552.

[180] L. Eboli, G. Mazzulla, and G. Pungillo, "Combining speed and acceleration to define car users' safe or unsafe driving behaviour," *Transportation Research Part C: Emerging Technologies,* vol. 68, pp. 113-125, 2016.

[181] S.-H. Chen, J.-S. Pan, and K. Lu, "Driving behavior analysis based on vehicle OBD information and adaboost algorithms," in *Proceedings of the international multiconference of engineers and computer scientists*, 2015, vol. 1, pp. 18-20.

[182] T. Ezaki, T. Date, and H. Inoue, "An Analysis Platform for the Information Security of In-Vehicle Networks Connected with External Networks," Cham, 2015, pp. 301-315: Springer International Publishing.

[183] J. Zaldivar, C. T. Calafate, J. C. Cano, and P. Manzoni, "Providing accident detection in vehicular networks through OBD-II devices and Android-based smartphones," in *2011 IEEE 36th Conference on Local Computer Networks*, 2011, pp. 813-819.

[184] M. Wu, S. Zhang, and Y. Dong, "A Novel Model-Based Driving Behavior Recognition System Using Motion Sensors," vol. 16, no. 10, p. 1746, 2016.

[185] C. G. Q. M, J. O. López, and A. C. C. Pinilla, "Driver behavior classification model based on an intelligent driving diagnosis system," in *2012 15th International IEEE Conference on Intelligent Transportation Systems*, 2012, pp. 894-899.

[186] Z. Szalay *et al.*, "ICT in road vehicles — Reliable vehicle sensor information from OBD versus CAN," in *2015 International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS)*, 2015, pp. 469-476.

[187] Freematics. (2017). *Freematics ESP32 OBD Kit*. Available: https://freematics.com/store/index.php?route=product/product&product_id=87

[188] Adafruit. (2017). *Adafruit ultimate gps breakout - 66 channel w/10 hz updates*. Available: https://www.adafruit.com/product/746

[189] S. Latif *et al.*, "Multicriteria Based Next Forwarder Selection for Data Dissemination in Vehicular Ad Hoc Networks Using Analytical Network Process," *Mathematical Problems in Engineering,* p. 18, 2017.

[190] M. Rohani, "Bus driving behaviour and fuel consumption," Ph.D thesis, Faculty of Engineering, Science & Mathematics University of Southampton, 2012.

[191] T. Sato, M. Akamatsu, T. Shibata, S. Matsumoto, N. Hatakeyama, and K. Hayama, "Predicting Driver Behavior Using Field Experiment Data and Driving Simulator Experiment Data: Assessing Impact of Elimination of Stop Regulation at Railway Crossings," *International Journal of Vehicular Technology,* vol. 2013, p. 912860, 2013/03/31 2013.

[192] S. G. Klauer, T. A. Dingus, V. L. Neale, J. D. Sudweeks, and D. J. Ramsey, "The impact of driver inattention on near-crash/crash risk: An analysis using the 100-car naturalistic driving study data," Apr. 2006.