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A Review of Situation Awareness in the Connected Cars Environment

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Abstract:

Over the next 30 years, technological innovation will make automobile travel more convenient. Internet of Cars will perform an increasing number of driving tasks without human input and will lure customers away from traditional public transportation. This paper deals with the in-depth review related to the role of Situation Awareness (SAW) in the Internet of Cars concept. Here we introduce novel approaches to develop a comprehensive model to address situation awareness (SAW), which will be helpful to learn how to develop the best strategy and by this way improve traffic safety and efficiency in the technological environment.

Keywords — **Situation Awareness, Internet of Cars, traffic safety.**

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I. INTRODUCTION

The concept of smart city came in response to provide for the aspirations of a citizen. The objective of the smart cities is to provide a decent quality life and clean and sustainable environment by the application of the smart solutions. One of the fundamental thirst of the smart cities is to improve quality of life by developing “smart mobility” [1]. The main component of a smart city is intelligent infrastructure, which can be achieved by Internet of Things (IoT), which represents the physical infrastructure as an integration of sensors [1].

At present we have more than a billion cars on the roads and it increases still, road safety has become a major challenging factor within the transportation industry. Statistics indicate that road accidents produce about 1.3 millions of fatalities per year [2]. As of now it is clear that novel alternatives within the transportation industry are very necessary. Smart cars as a outcome of Intelligent Transportation Systems forms a considerable portion of IoT, that evolve to Vehicular Ad-hoc NETworks (VANETs) which sowed seeds to a new paradigm called the Internet of Cars (IoC).

II. COMMUNCATION IN VANETs

Vehicular Ad-hoc NETworks (VANETs) forms the platform for communication for IoC, and met with strong rise in research activities in recent years. They help to ensure transportation e□ciency, improve safety, and to mitigate the impacts of tra□c congestion [3]. In VANETs, vehicles are deemed mobile sensor platforms [4] that are able to collect data from their surrounding, conclude and then, transmit relevant information to the interested entities [5]. VANETs depend on wireless communication channels between the car to other nearby entities. The communication links maybe Vehicle-to-Vehicle (V2V), Vehicle-to-RSU (V2R), Vehicle-to-Infrastructure (V2I), Vehicle-to-Human

(V2H), and Vehicle-to-Sensor (V2S). The potentiality of VANETs has been acknowledged with the establishment of ambitious research programs such as WAVE, C2C-CC, CVIS, NoW, VSC [6]. Clearly, VANETs pave the way for the cars to become connected devices, and to operate in a data-rich environment.

III. SITUATION AWARENESS

As the number of sensors installed on cars increase, and their connectivity improves, they become a swarm of mobile sensors and information sources that consistently generate and receive huge amounts of data and information. Connected cars should take advantage of this big data to provide drivers with proper situation awareness. Therefore, it is crucial to develop a comprehensive and well-organized framework to extract, manage, and interpret the available data and information to consequently achieve proper Situation AWareness (SAW). The importance of SAW on the road is highlighted by Salmon et al as, “SAW has received far less attention in a road transport context. This is despite the fact that failures related to poor SAW, such as inattention, have been identified as key casual factors in road tra c crashes” [7].

IV. SAFETY APPLICATIONS

Among the applications visualised for the IoC, which are safety, convenience, and comfort [8], the safety applications are discussed here. Safety applications allow vehicles to be aware of the surrounding environment, and if necessary, avoid incidents by taking proper actions on time. Based on their level of interference, safety applications are either passive or active [9]. Passive applications automatically take physical actions and are mainly used in the autonomous driver-less vehicles. However, active applications only provide driving assistance to drivers using proper Human-Computer Interaction (HCI) units, and are generally implemented by the Advanced Driver Assistance Systems (ADAS). The later types of safety applications are Collision (Avoidance) Warning Systems [10, 11, 12, 13], Intersection Safety Management [14, 15, 16], Object Detection [17, 18, 19, 20], Lane Departure Warning Systems, and Blind Spot Mitigation [21, 22, 23] are deemed the major safety applications of the Internet of Cars [24].

V. APPLICATIONS OF SAW

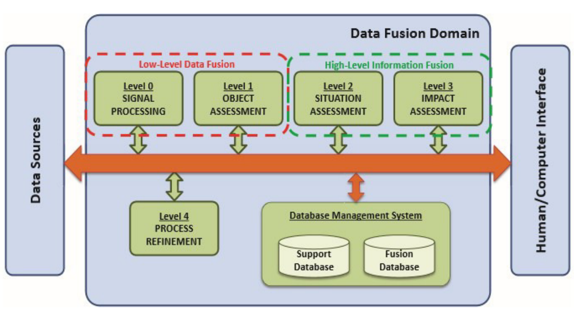
Application of SAW on the road is theoretically and methodologically studied by Salmon et al. in [25]. The authors analyze SAW from three di erent perspectives: individual (psychological), computational, and socio-technical. In the individual perspective the driver is considered as the center of the model, and the goal of situation assessment is to measure his/her behavior, reactions, and interactions in di erent situations. Through the second perspective, Salmon et al. study the computing (engineering) perspective of SAW that provides the entities of interest with appropriate information by using technological facilities. The computing perspective serves as a bridge that links the individual mental model to in-vehicle technologies and road infrastructure. Finally, the third perspective of SA is introduced as the socio-technical systems that are mainly based on the idea of distributed SAW. In these systems, all entities in an environment are assumed to have partial knowledge about their surrounding and make communication links to share their knowledge and improve their understanding about the environment. Furthermore, other entities make use of this knowledge to address their desired goal, such as avoiding collisions. Some issues such as compatibility, and knowledge scaling are some of the challenges that rise in distributed socio-technical SA systems.

A. Socio-technical side of SAW

While the individual perspective is well-studied in the literature [26, 27, 28], just a few attempts that exploit computational and socio-technical side of SAW in the Internet of Cars, can be found in the literature. For instance, Markis et al. [29] propose a survey on context-aware mobile and wireless networking by mainly discussing context uncertainty handling, acquisition, modeling, exchange, and evaluation. Specifically, Markis et al. [29] introduce an abstract classification that while clarifies the main aspects of a context aware mobile network, avoids giving sufficient knowledge about the available methods that aim to model those aspects. In fact, the analysis given in this paper is more abstract and technology-centric (rather than being specific and methodology-centric).

VI. TAXONOMY

Kakkasageri and Manvi [30] propose a general taxonomy for information management protocols in safety applications. The presented taxonomy structures information management protocols into four main branches: information gathering, aggregation, validation, and dissemination. Furthermore, the authors introduce different classes of approaches per branch, and introduce the major protocols assigned to them, accordingly. While the proposed classification is very useful in information dissemination problems in VANET, it does not pro-vide any information about how to achieve situation awareness. As defined by Mica R. Endsley [31], SAW is "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future". Alternatively, SAW is deemed the result of the High-Level Information Fusion (HLIF) that takes place in the levels 2 and 3 of the well-known JDL Model [32]. The inputs of HLIF are the levels 0 and 1, which are mostly related to Low-Level Data Fusion.



VII. MAJOR ENTITIES IN THE IOCS

Establishing the relationship between SAW, and driver inattentiveness is one of the most crucial, yet mostly unexplored problems in the IoC. As one of the major attempts made in this regard, the impact of driver inattention on road accidents has been extensively studied by Klauer et al. [26], who have analyzed the driver inattentiveness using the driving data collected in the 100-Car Naturalistic Driving Study [49]. The authors take advantage of the rich data and information provided from different sources, such as a variety of sensors and driver's personal information and driving records, and explore a number of factors involved in the near-crash/crash incidents. Furthermore, they categorize these factors into four groups of, namely, Vehicle, Environmental, Driver, and Demographic factors. Furthermore, they present a variety of conditions under which the inattentive driving behaviors are expected to increase. As an alternative approach to what Klauer et al. [26] proposed as major factors of road incidents, we merge demographics with driver, as they share similar characteristics, and add VANET as another important factor that impacts various driving situations on the road. Nevertheless, SAW on the road is deemed an important challenging task, and requires the development of comprehensive computing models to assist the drivers/passengers during driving task [25]. In the following, we study SAW in the Internet of Cars by exploring it through different perspectives.

VIII. PERCEPTION

Devlin [50] defines a situation as a "structured part of reality that is discriminated by some agent". We characterize such a structure as an aggregation of entities and the relationships between them, and build the first stage of SAW as Perception.

IX. ENTITY

Entities are the result of LLDF that is covered in levels 0 and 1 of JDL Model [32]. Therefore, they inherit all of its issues, such as unavailability and undetectability of data, failure in observing, and misinterpretation of the data [33, 34]. These issues are caused by data imperfection, correlation, inconsistency, and disparateness [35].

X. RELATIONSHIP

The basis of knowledge is composed of entities that are connected to each other through various types of relationships. John F. Sowa in [36] relates the entities through di erent types of networks that are useful to semantically represent the knowledge, and to reason about it. These networks are composed of, Definitional, Assertional, Implicational, Executable, Learning and Hybrid relationships.

A. ***Definitional Relationships:*** Definitonal relationships represent a hierarchy of entities located on a spectrum with two ends of abstraction (generalization), and specification. The Description Logics [37] and KL-ONE language [38] are able to model definitional relationships. Some relationships is assumed to be true by definition.

B. ***Implicational Relationships:*** Implicational relationships are commonly modeled using Probabilistic Graphical Models (PGMs) [39]. PGMs well-known derivations are Bayesian Networks (BNs), Dynamic Bayesian Networks (DBNs) [39], and Fuzzy Bayesian Networks (FBNs) [40].

C. ***Executable Relationships:*** The structures that model an interaction between a set of entities, collaborating to reach a certain goal, implement means of executable relationships. through a predefined program, and to break apart or get combined in substructures. Data-Flow Graphs [41] and Petri Nets (PNs) [42] are two most well-known formalisms incorporating executable relationships. Two di erent variations of PNs are object and plan PNs, which are useful for objects and events recognition [43], respectively.

D. ***Learning Relationships:*** These types of relationships take advantage of their built-in memory to intelligently respond to new information, and modify their internal state accordingly. Besides, relationships as well as entities are valued based on a weight that indicates how much they influence the outcome. Moreover, some learning networks change their structure to adapt to new context and perform more e ciently. ANN [44] and all of its variations reside in this category.

E. ***Hybrid Relationships:*** A combination of various types of relationships introduced so far, is called a hybrid relationship. One of the most common tools is Unified Modeling Language (UML) [45] that is widely used in software engineering. A combination of definitional, assertional, and executable networks can be simply defined using UML. Multi-Entity Bayesian Networks (MEBN) [46] are also deemed another framework that models hybrid relationships. MEBN aim to improve the conventional implicational relationships in BN by incorporating means of introducing definitional, assertional, and executable relationships powered by Ontologies and First-order Logic (FOL).

XI. CONCLUSION

In this paper, we highlighted the role of Situation Awareness (SAW) in the Internet of Cars concept, by proposing an in-depth review on the di erent SAW components, and explaining how di erent relevant methods can model the main aspects of each component. The paradigm of Internet of Cars is fast becoming reality, and it is crucial to know the ups and downs of di erent methods in SAW. Therefore, we discussed di erent approaches that show various capabilities in handling major aspects of SAW components. The paper can help in recognizing the solid directions of SAW research, and their applicability in the Internet of Cars.

REFERENCES

[1] The Smart/Connected City and Its Implications for Connected Transportation. Technical report, U.S. Department of Transportation John A Volpe National Transportation Systems Center, October 2014.
[2] http://www.asirt.org/.
[3] K. Golestan, A. Jundi, L. Nassar, F. Sattar, F. Karray, M. Kamel, and S. Boumaiza. Vehicular Ad-hoc Networks(VANETs): Capabilities, Challenges in Information Gathering and Data Fusion. In Autonomous and Intelligent Systems, Lecture Notes in Computer Science, pages 34–41. Springer Berlin Heidelberg, 2012.
[4] Mario Gerla, Eun-Kyu Lee, Giovanni Pau, and Uichin Lee. Internet of Vehicles: From Intelligent Grid to Autonomous Cars and Vehicular Clouds. In IEEE World Forum on Internet of Things, March 2014.
[5] Ning Lu, Nan Cheng, Ning Zhang, Xuemin Shen, and J.W. Mark. Connected Vehicles: Solutions and Challenges. Internet of Things Journal, IEEE, 1(4):289–299, Aug 2014.
[6] G. Karagiannis, O. Altintas, E. Ekici, G. Heijenk, B. Jarupan, K. Lin, and T. Weil. Vehicular networking: A survey and tutorial on requirements, architectures, challenges, standards and solutions. Communications Surveys Tutorials, IEEE, 13(4):584–616, Fourth 2011.
[7] Paul M. Salmon, Neville A. Stanton, and Kristie L. Young. Situation awareness on the road: review, theoretical and methodological issues, and future directions. Theoretical Issues in Ergonomics Science, 13(4):472–492, 2011.

[8] F. Sattar, F. Karray, M. Kamel, L. Nassar, and K. Golestan. Recent Advances on Context-Awareness and Data/Information Fusion in ITS. International Journal of Intelligent Transportation Systems Research, pages 1–19, 2014.

[9] Rolf Isermann, Roman Mannale, and Ken Schmitt. Collision-avoidance systems PRORETA: Situation analysis and intervention control. Control Engineering Practice, 20(11):1236–1246, 2012. Special Section: Wiener-Hammerstein System Identification Benchmark.

[10] Anouck Ren´ee Girard, J Borges de Sousa, James A Misener, and J Karl Hedrick. A control architecture for integrated cooperative cruise control and collision warning systems. In Decision and Control, 2001. Proceedings of the 40th IEEE Conference on, volume 2, pages 1491–1496. IEEE, 2001.

[11] J-i Meguro, Taishi Murata, J-i Takiguchi, Yoshiharu Amano, and Takumi Hashizume. Gps multipath mitigation for urban area using omnidirectional infrared camera. Intelligent Transportation Systems, IEEE Transactions on, 10(1):22–30, 2009.

[12] Jihua Huang and Han-Shue Tan. Error analysis and performance evaluation of a future-trajectory-based cooperative collision warning system. Intelligent Transportation Systems, IEEE Transactions on, 10(1):175–180, 2009.

[13] Aris Polychronopoulos, Manolis Tsogas, Angelos J Amditis, and Luisa Andreone. Sensor fusion for predicting vehicles' path for collision avoidance systems. Intelligent Transportation Systems, IEEE Transactions on, 8(3):549–562, 2007.

[14] Paul Mathias. The intelligent cooperative intersection as part of urban tra□c control systems. In 12th World Congress on Intelligent Transport Systems, pages 2796–2804, 2005.

[15] SE Shladover. E□ects of Tra□c Density on Communication Requirements for Cooperative Intersection Collision Avoidance Systems (CICAS), Mar. 2005, Richmond, CA: California PATH. Partners for Advanced Transit and Highways (PATH), 2005.

[16] Minoru Tamura, Seiki Takahashi, Shinji Yasuhara, Masachika Kojima, and Kouki Minegishi. Development of intersection safety support systems using vehicle-tovehicle communication. In 12th World Congress on Intelligent Transport Systems, pages 3966–3972, 2005.

[17] Junping Zhang, Ben Tan, Fei Sha, and Li He. Predicting pedestrian counts in crowded scenes with rich and high-dimensional features. Intelligent Transportation Systems, IEEE Transactions on, 12(4):1037–1046, 2011.

[18] Pongtep Angkititrakul, Ryuta Terashima, and Toshihiro Wakita. On the use of stochastic driver behavior model in lane departure warning. Intelligent Transportation Systems, IEEE Transactions on, 12(1):174–183, 2011.

[19] Madhav V Chitturi, Juan C Medina, and Rahim Ray F Benekohal. E□ect of shadows and time of day on performance of video detection systems at signalized intersections. Transportation research part C: emerging technologies, 18(2):176–186, 2010.

[20] Sayanan Sivaraman and Mohan Manubhai Trivedi. A general active-learning framework for on-road vehicle recognition and tracking. Intelligent Transportation Systems, IEEE Transactions on, 11(2):267–276, 2010.

[21] Hsu-Yung Cheng, Bor-Shenn Jeng, Pei-Ting Tseng, and K-C Fan. Lane detection with moving vehicles in the tra□c scenes. Intelligent Transportation Systems, IEEE Transactions on, 7(4):571–582, 2006.

[22] Pau-Lo Hsu, Hsu-Yuan Cheng, Bol-Yi Tsuei, and Wen-Jing Huang. The adaptive lane-departure warning system. In SICE 2002. Proceedings of the 41st SICE Annual Conference, volume 5, pages 2867–2872. IEEE, 2002.

[23] Tarak Gandhi and Mohan M Trivedi. Vehicle surround capture: Survey of techniques and a novel omni-video-based approach for dynamic panoramic surround maps. Intelligent Transportation Systems, IEEE Transactions on, 7(3):293–308, 2006.

[24] Junping Zhang, Fei-Yue Wang, Kunfeng Wang, Wei-Hua Lin, Xin Xu, and Cheng Chen. Data-Driven Intelligent Transportation Systems: A Survey. Intelligent Transportation Systems, IEEE Transactions on, 12(4):1624–1639, dec. 2011.

[25] Paul M. Salmon, Neville A. Stanton, and Kristie L. Young. Situation awareness on the road: review, theoretical and methodological issues, and future directions. Theoretical Issues in Ergonomics Science, 13(4):472–492, 2011.

[26] 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. Technical Report DOT HS 810 594, U.S. Department of Transportation, April 2006.

[27] Kristie Young, John D Lee, and Michael A Regan. Driver distraction: Theory, e□ects, and mitigation. CRC Press, 2008.

[28] Guy H Walker, Neville A Stanton, Paul M Salmon, and Daniel P Jenkins. A review of sociotechnical systems theory: a classic concept for new command and control paradigms. Theoretical Issues in Ergonomics Science, 9(6):479–499, 2008.

[29] P. Makris, D.N. Skoutas, and C. Skianis. A survey on context-aware mobile and wireless networking: On networking and computing environments' integration. Communications Surveys Tutorials, IEEE, 15(1):362–386, First 2013.

[30] M.S. Kakkasageri and S.S. Manvi. Information management in vehicular ad hoc networks: A review. Journal of Network and Computer Applications, 39:334 – 350, 2014.

[31] Mica R Endsley. Design and evaluation for situation awareness enhancement. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting, volume 32, pages 97–101. SAGE Publications, 1988.

[32] Alan N. Steinberg and Christopher L. Bowman. Rethinking the JDL Data Fusion Levels. In NSSDF Conference Proceedings, pages 1–6. JHAPL, June 2004.

[33] Mica R Endsley and Daniel J Garland. Pilot situation awareness training in general aviation. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting, volume 44, pages 357–360. SAGE Publications, 2000.

[34] Mica R Endsley. Situation awareness and human error: Designing to support human performance. In Proceedings of the High Consequence Systems Surety Conference, pages 2–9. Lawrence Eribaum Associates, 1999.

[35] Bahador Khaleghi, Alaa Khamis, Fakhreddine O. Karray, and Saiedeh N. Razavi. Multisensor data fusion: A review of the state-of-the-art. Information Fusion, 14(1):28–44, 2013.

[36] John F. Sowa. Knowledge representation: logical, philosophical, and computational foundations. Computer Science Series. Brooks/Cole, 2000.

[37] Franz Baader and Werner Nutt. Basic Description Logics. In Description logic handbook, pages 43–95, 2003.

[38] Ronald J Brachman and James G Schmolze. An Overview of the KL-ONE Knowledge Representation System. Cognitive science, 9(2):171–216, 1985.

[39] Daphne Koller and Nir Friedman. Probabilistic Graphical Models: Principles and Techniques. MIT press, 2009.

[40] Heping Pan and Lin Liu. Fuzzy Bayesian Metworks—A General Formalism for Representation, Inference and Learning with Hybrid Bayesian Networks. International Journal of Pattern Recognition and Artificial Intelligence, 14(07):941–962, 2000.

[41] M Douglas McIlroy, JM Buxton, Peter Naur, and Brian Randell. Mass-produced software components. In Proceedings of the 1st International Conference on Software Engineering, Garmisch Pattenkirchen, Germany, pages 88–98. sn, 1968.

[42] James L Peterson. Petri net theory and the modeling of systems. 1981.

[43] Gal Lavee, Artyom Borzin, Ehud Rivlin, and Michael Rudzsky. Building Petri Nets from Video Event Ontologies. In George Bebis, Richard Boyle, Bahram Parvin, Darko Koracin, Nikos Paragios, Syeda-Mahmood Tanveer, Tao Ju, Zicheng Liu, Sabine Coquillart, Carolina Cruz-Neira, Torsten Mu¨ller, and Tom Malzbender, editors, Advances in Visual Computing, volume 4841 of Lecture

Notes in Computer Science, pages 442–451. Springer Berlin Heidelberg, 2007.

[44] B Yegnanarayana. Artificial neural networks. PHI Learning Pvt. Ltd., 2009.

[45] James Rumbaugh, Ivar Jacobson, and Grady Booch. Unified Modeling Language Reference Manual, The. Pearson Higher Education, 2004.

[46] Kathryn B. Laskey. MEBN: A language for first-order Bayesian knowledge bases. Artif. Intell., 172(2-3):140–178, 2008.

[47] Thomas A Dingus, SG Klauer, VL Neale, A Petersen, SE Lee, JD Sudweeks, MA Perez, J Hankey, DJ Ramsey, S Gupta, et al. The 100-car naturalistic driving study, Phase II-results of the 100-car field experiment. Technical report, 2006.

[48] Keith Devlin. Logic and information. Cambridge University Press, 1995.

[49] R.N. Carvalho, R. Haberlin, P.C.G. Costa, K.B. Laskey, and K.C. Chang. Modeling a probabilistic ontology for Maritime Domain Awareness. In Information Fusion (FUSION), 2011 Proceedings of the 14th International Conference on, pages 1–8, july 2011.

[50] D. Caveney and W.B. Dunbar. Cooperative driving: Beyond V2V as an ADAS sensor. In Intelligent Vehicles Symposium (IV), 2012 IEEE, pages 529–534, June 2012.