Real-time Self-driving Car Experience:
M&S and Self-driving Standards Synergy

Mark C. Davis
Wood Duck Research, Inc.
129 Wood Duck Loop
Mooresville, NC 28117
davismc@ieee.org

Daniel P. Burns
Home Ports Solutions, LLC.
125 East 44th Street
Savannah, GA 31405
daniel.p.burns@homeportssolutions.net

Jennifer H. Nolan & Dan M. Davis
Catholic Polytechnic University
1028 N Lake Ave MC 207
Pasadena, CA 91104
{ jnolan & ddavis } @catholicpolytechnic.org

Judith L. Jacobus
Education Counselor/Therapist
1564 Merion Way.
Seal Beach, CA 90740
stately07@dslextreme.com

Keywords:
Self-driving Automobiles, Simulation & Operational Standards, AI, Emerging Metrics, Figures of Merit

ABSTRACT: *The extensibility of the methodologies, insights and standards of the Modeling and Simulation community have a lot to offer to the burgeoning "self-driving automobile"(SDA) or Advanced Driver Assistant System (ADAS) efforts and, concomitantly, a lot to learn from the emerging body of data collected by the SDA users. Currently, the two communities, while fully aware of the others, are falling prey to the well documented "siloing" tradition of academic departments. They may be seen as slowing progress in both communities and, even worse, the very real prospect of a catastrophic cataclysm in one or both disciplines. New technologies are emerging to quantify and record data from many sources, as well as analytic techniques to rapidly recognize and analyze petabytes of information daily. This paper briefly surveys the current status of both efforts, indentifies the intersection of interests, and suggests the existence of data of common interests. The need for standards for the interchange of critical data has long been recognized in the M & S community. The authors suggest ways in which these lessons learned may say time, effort and lives in the SDA community's drive to early adoption. They record the historical events that sometimes set advancing technologies back decades, if not causing a permanent abandonment of otherwise promising technologies. The authors adduce both recorded records and personal experience in both M&S and SDA implementations and uses. They use that experience to proffer several views of possible futures for uses of M&S in SDA's and vice-versa. They introduce some coordinating techniques from the Systems Engineering (SE) discipline as a viable vehicle for improving both community efforts. SE strives to ensure consistency and coverage across the salient disciplines to better understand and evolve these disparate concepts. Future actions and research are envisioned for the communities at-large to consider autonomous robotics and valid simulations on the battlefield.*

1. Introduction

This paper reports on a series of observations that call of more extensibility of the Modeling and Simulation Standards (M&SS) community procedures, expertise and experience. One issue that seems to stands in the way is ubiquitous, immutable and eternal: groups tend to focus inwardly and shut out others. This is often called "siloing" in academic environments. There are many times that this is more irritating than actually meaningful.

However, significant advances in inter-disciplinary research have been successful. This is especially true when lives are at stake, *e.g.* combat or driving an automobile. In the issues called out in this paper, it is our major contention that the M&SS offers to the burgeoning "self-driving automobile" (SDA) or "Advanced Driver Assistance Systems" (ADAS) efforts a significant body of learning. Below, this paper will used the shorter "SDA" as an acronym to represent both. Also, the M&S community and the defense communities may have even more to learn from the emerging body of data collected by the SDA users. This, the authors argue, is the time to avoid siloing, lest that slow progress in both communities and, even worse, facilitate the very real prospect of a catastrophic cataclysm in both areas of concern. They are both major cause of loss of life among the young people of today's society.

New technologies are emerging to quantify and record vast amounts of digitized data, which makes it ripe for analytic techniques to rapidly recognize and analyze the basic issues and anomalous behaviors to be avoided or minimized. To begin, it is necessary to assess the current status of M&SS and SDA's, then indentifies the intersection of interests. Then the need for standards for the interchange of critical data is reviewed. This alone may say time, effort and lives in the SDA community and its drive to early adoption by large segments of the populous. The authors are so bold as to envision research needed by both of the communities Also, the paper addresses the impact of Autonomous Combat Vehicles (ACV's) in combat and valid simulations on the battlefield. The paper reports that incipient volume of SDA records the operational events that are already being amassed by that discipline.

A failure to do so may be detrimental to both communities, as experience has shown that improper collaborations will sometimes set advancing technologies back decades. The authors adduce both recorded records and personal experience in both M&SS and SDA. They use their experiences to proffer several views of possible futures for uses of M&SS in SDA's and vice-versa. The paper sets forth coordinating techniques from the Systems Engineering (SE) discipline as a viable vehicle for improving this perilous situation. SE strives to ensure consistency and coverage in multi-disciplinary efforts, be they research or production programs. Future actions and research across both areas will be articulated.

This paper will speak to various aspects of the interaction between real-time data being generated by "self-driving autos" and the Modeling and Simulation standards communities. The first item(s) will be a review of the significant backgrounds for both communities, to set the stage for later discussion. Commonality of interests will be a major focus. There then will follow a set of analyses of the potential interactions between the two communities, as the SDA's and the ACV's become more and more prevalent. The Simulation Standards community will have the two environments with whom they will have to contend, producing effective standards to ensure both the efficacy of the simulations and the real time feed-back of insights they can inculcate back into the communities based on their closeness to the practitioners of the respective professions. Another issue will be the cross-organizational collaboration with other standards agencies, *e.g*. SAE International (the current title for the Society of Automotive Engineers).

1.1 Background

The history of self-driving cars is amazingly long. [1] It seems that people were working on self-driving almost as soon as automobiles were invented. That may be a reflection of the observation that major transportation modes prior to automobiles were various uses of horses for motive power. In all of those cases, the person controlling the direction, speed and course taken could reliably turn those duties over to the horse with some reasonable anticipation that the horse would get them both back to home or wherever the horse was regularly fed. A couple of methods that were seen as precursors of today's efforts could more legitimately be called remotely driven automobile [2]. These early attempts bring to mind some important concepts in standardization. The first is the desirability of a careful analysis if when standards should be developed and instantiated. Too early may find the standards being overcome by events, as the technology takes a sudden turn, leaving the standards community having invested time, effort and credibility only to find their participation valueless or worse, embarrassing. Too late in articulating and proposing standards leaves the researchers, implementers and users without direction or goals they would otherwise profit from having had earlier. An ancillary effect of delay would be the production of competing standards. The second is the necessity of early operational consensus on terminology.

1.1 Self Driving Automobile Basics

Considering a century of automobiles is now behind us and the authors have a combined quarter of a millennium of driving experience, there is good cause to accept the following as basic requirements of an SDA:

- Route identification, optimization and modification
- Speed control and power consumption monitoring
- Collision avoidance and safety enhancement
- Lane selection and turn execution

The reader is invited to consider these functions and their analog in live, constructive and virtual combat. This may be especially critical if one remembers and heeds the old military adage: "No battle plan survives first contact with the enemy!". Additionally, the above requirements must be executed with an appropriate balance of three criteria:

1. Safety
2. Time to arrival
3. Comfort the result of acceleration

One form or level of self-driving all drivers have had for decades is the automatic speed control mechanisms. These have become more reliable, more easily set and, of late, more responsive to collision avoidance by automatically slowing down when a car in the same lane is going slower than the set speed of the speed control. One author set the time of first practicable speed control as around 1950 [3]. The concomitant advent of limited-access "freeways" made these devices practicable. Since the '50s, the devices have given an increasingly useful relief to drivers, but the steady improvement in control does create a need for differentiating various levels of self-driving sophistication.

The advent of route planning was enabled by increasing sophistication in analysis (often called "the travelling salesman" problem), computer capability and the Global Positioning System. This might be seen as a classic disruptive technology as was most famously identified and characterized by Clayton Christiansen[4]. It is noteworthy that this disruptive technology spawned a new industrial base for automobile navigation that lasted only about a decade before being displaced with virtually ubiquitous availability of the same capabilities in SmartPhones and on-board programs in the automobiles themselves. These trends may impact standards and uses, so should be taken under advisement by the standards community.

The SAE has promulgated a series of definitions in J3016 Levels of Driving Automation [5] and the current one was updated in April of 2021. The base level is basically no additional assistance from the vehicle in maintaining safe and comfortable operation. The higher levels are basically concerned with the adequate sophistication to continue to operate well in degrading conditions. In a situation that is mirrored in DoD simulations, there often seems to be and assumption that all people will react similarly in a given set of circumstances. This is not at variance with the experience of both designers of battlefield simulations and the engineers of operational equipment. One might note that J3016 does not speak to user feedback, alert functions or machine failure anomaly reaction.

1.2 Autonomous Combat Vehicles

The simulation community has significant history in user situation awareness and the need for consistent machine/user communication. Another cross disciplinary asset may be the aircraft cockpit, with its well-known use for automating operations while maintaining instantaneous human interference when called for. Whether in the civilian's driving context or the battle field's ACV's use, another dimension may be manual or artificial-managed machine behavior modification.

However, the authors assert that it is not just the ACV developers and war-fighter users who would benefit from the study of the impacts of SDA experience. Even the traditional roles of both simulation of and training for human participants in combat may find insights, otherwise not recognized, from analysis of the implementation of SDA's. It is noted that during the advent of massive parallel computing in the 1990's, many first-time practitioners of parallel processing techniques reported significant optimization of what they had previously seen as well-refined code after the parallelization effort. There were unforeseen issues that arose in that process that could then lead to more effective serial code.

The use of ACV's is expanding rapidly. UAV's, cruise missiles, autonomous naval ships, and self-diving ground vehicles are already in the field. Their use it being analyzed in many different *fora* considering simulation of their impacts, including a significant Chinese interest. [7] Simulations for training, analysis and evaluation of these vehicles is currently on-going [8], but the authors have noted a significant lack of manifest interest in the human behavior issues that are going to emerge as people long-accustomed to dealing with other humans are now faced with burgeoning autonomous systems that have an ability to modify their own behaviors automatically and at a rate that may be unfamiliar to their human collaborators.

The range of vehicles is great, with the accompanying wide range of degree of human control and potential for catastrophic damage if the electronic directions either fail or are compromised by hostile forces.

All of these computer/user interfaces may similar to the issues currently being faced, in real-time, but the drivers of SDA's The number of fielded SDA systems is hard to assess, but the authors estimate it must be in the thousands who are operating at least at the SAE J3016 Level 3. That level requires one to maintain an indicium of attention (eye focus or hand on steering wheel sensor) and often requires the driver to take over SDA functions due to change in either traffic flow or environmental conditions. One incident observed by one of the authors (M.C. Davis) was the instruction to the driver to take command which was issued by a self-driving enabled Tesla. The ostensible reason therefor was a large and dense spray of a puddle struck by a truck going at a high rate of speed. This rendered both the driver and the SDA sensor temporarily "blind." Congress has also studied these issues [10]

1.3 Observations from Early Experience with SDA's

Some data has already been collected, anecdotally by the authors and in a more rigorous manner by the entities that are fielding SDA's. The latter entities are very competitive, so they are hesitant to release their data. One of the authors heard an oral presentation at a share-holders' meeting of the Tesla corporation that stated 400,000 self-driving Teslas were on the road. It has been estimated that nearly that number are also being fielded by other developers. If these numbers are correct, something on the order of a million SDA's are on the roads already.

Based on the heat of the rhetoric on-line, the authors feel safe in assuming that the differences in approach of the various companies covers quite a range of both hardware and software. Most have a wide range of sensors for lane control and collision avoidance. One notable hold-out has been Elon Musk and Tesla. They began relying on cameras in the visible light spectra, with an initial input of radars and ultra-sonic sensors. That lower frequency sensor was then deprecated. Then recently, Tesla announced that they may now add a radar sensor. [11] While some commentators took that as an admission of abandonment of the "camera only" policy, members of the simulation standards community have the experience with the ebbing and flowing of technology that may be of use to the emerging SDA standards. An underlying approach of trial and error may result in success and failures not anticipated during the process. One of the insights from the work of Professor Christensen [5] was that the experts in the technology being disrupted often fail due to the constraints of both their technical vision and their currently profitable business model. The innovators are not bound by either of these hobbles. It is a widely held principle within Tesla that: "The best part is no part.".

One of the issues facing all of the developers is the placement of the sensors on the vehicle. This must be done with care to insure the effectiveness the safety devices. However, there are also issues of protection for damage, reduction of wind resistance, maintenance and moderation of noise from disruption of air flow. Additionally, in a subjective dimension not often found in military simulations: style and attractiveness must be considered. Many of these considerations will impact current development efforts and future decisions.

The image on the right, Figure 4, is from a hyperbolic (in the authors' opinion) article [11] that was taking a position in opposition to the Tesla approach. The resolution of that issue, concerning the appropriate sensor mix, and the optimal way to achieve the most effective system is beyond the scope of this paper. However the likelihood that the absence of a professional evaluation of SDA progress and preferred paths might retard rather than enhance theses processes be rationally inferred. The timing of acceptance or rejection of any approach has been shown to be critical in the past. [13]

Some more moderate reviews have been made of the sensor selection issue. [14] Time will tell what will be the optimal array that meets all of the criteria. Full awareness of mistakes of the past will be useful in avoiding potential problems.

One issue that has been observed is the other subjective impacts of this new technology. Questions could be raised about the personal and societal effects of the availability of self-driving calls. These may also fall within the ambit of the standards and System Engineering professionals. One such issue is that of anxiety of the passengers. A human driver analog would be the anxiety of the passenger if they are uncomfortable with the skills/attitudes of the driver. Most of those in our culture are familiar both with the unsettling realization of the driver that their passengers are "hitting the brakes" on their own, but empty, floor-boards. Conversely, riding with someone who consistently tailgates the car in front of them can un-nerve the passengers. The analogous reaction of the rider in an SDA has as yet to be studied, but early adopters of self-driving vehicles have reported both sides of this issue: i.e. being frightened when the vehicle took an unexpected maneuver in some instances, but getting frustrated with the over-cautiousness of the system, especially when the passenger is in a hurry

Tesla's stated goals are about changing transportation to save the planet. There position is such that it introduces different metrics including cost control. More sensors may be cool but not required to solve problem at hand. Tesla has introduced a new term: Full Self Driving (FSD). They characterize it as an attempt to respond to a problem for humans with a program designed for humans. The offered rationale is that humans only use sight to drive, so the goal is to enable Tesla to do FSD with only visible light cameras. The authors do not take a position on the viability of this assertion for the purposes of this paper, but it is cited here to establish the current issues of concern for the industry.

The authors believe that battlefield usage of AI will be different in the cases of when the opponent is an ACV's entity, as opposed to a human one. They foresee different goals, different constraints, and different sensors all of which will require, to some degree, different algorithms. FSD and Tesla robotics are solving human problems. In combat venues there will both AI/human and AI/AI contexts, which suggests there will be an entirely new set of problems.

2. Discussion of Potential SDA/M&S Standards Interactions

Having pointed out several common interests, while noting some differences, this section will delve more deeply into where the authors see opportunities for productive interactions. Many of the disciplines and goals of the cognizant standards community overlap. Within the narrow group of professionals in the SISO organization, the authors do not personally know of any who have said that they attend other conferences of standards personnel. Much of the SISO work has been oriented to interoperability hardware and software parameters. The authors believe they have shown a number of overlaps in interests, backgrounds and goals to merit examining the coordination of disparate groups.

Another factor that may be in the offing in SDAs is their anticipated focus on consumer acceptance. Computer scientists and simulation professionals are not often observed being concerned with consumers' emotional reaction to the human/computer interface. Similarly and perhaps more ardently, the military personnel more often rely on the force of command presence to assure adoption of new weapons and tactics. To some large degree, the standards and metrics available for assessing and assuring these adoptions are utilized to the best advantage to the societies producing them.

One very useful discipline in manifesting coordination and collaboration is the Systems Engineering group. Some of the authors on this paper have previously introduced this capability to the M&S community in the ModSim World Conference [15]. This paper focused on the use of various tools that are the heart of Systems Engineering analyses. Using newly emerging virtual conversational human/computer interfaces as an example, the paper suggested uses for future development efforts. The same, this paper asserts, is true for the SDA/Autonomous Combat Vehicle issues. That would include the attention that needs to be paid to both the adoption of SDAs by the public and the enhancement of morale and trust in new weapon systems by the war-fighters.

In the case of the consumers who are interested in deciding to purchase or otherwise use (*e.g.* a self-driving Uber or Lyft vehicle) SDAs, it might address two basic inducers of stress during use. On one hand, a user may become frustrated if the SDA is not driving fast enough to meet their desire to make scheduled arrival time. The next may be made uncomfortable that, even if the sensors and algorithms are demonstrably safe, they may be made uncomfortable by the SDA being more aggressive than the rider would choose. If the entire focus is on safety, there are a range of speeds that could be safe, yet many of these selections could evoke and completely different level of stresses in the user/rider.

To make the stress inducers demonstrate more face validity, the reader is called upon to consider their own experience. Riding alone in a car gives one a sense of being in control of the situation. Driving on the edge of the safety envelope is not particularly stress-inducing, as one knows the degree one is willing to press the limits of vehicle safety. However, when riding, rather than driving, the stress elevation is exacerbated due to the uncertainty of the intentions and skills of the driver. Earlier studies have shown that, even if credible studies have shown that the automatic operation of a aircraft is safer under computer control, the public would not be comfortable with no human control. One would not be too speculative to assume that similarly exacerbating reactions will be observed in both SDA's and ACV's.

To address these issues effectively, it arguably, would require more than just establishing some "liaison agreements/committees". A truly multi-disciplinary team, one with both the technical skills and the social graces to work with members of a parallel, yet different, community would be needed. The aforementioned Systems Engineering professionals would be useful assets in setting up such a liaison effort. One would be well-advised to consider these capabilities early on in the process. Concomitant efforts in both the SDA and M&S communities would make the process more likely to succeed. It is envisioned that the process would entail three major efforts:

1. The identification of a range of necessary and useful standards
2. Coordination of standards across various communities
3. Recognizing when differences are mandated

This observation has been seen in blogs: a self-driving beta tester was driving on a four lane street at night. A darkly dressed pedestrian stepped off of the curb into the path of the SDA. The person was crossing in the middle of the block with no nearby intersection or crosswalk. The driver did not see the pedestrian, so had no warning of an impending disaster. The car did "see" the pedestrian and radically maneuvered and was able to avoid the pedestrian. However, the driver was significantly un-nerved. There seem to be no provision for ameliorating the stress on the monitoring driver.

Such unexpected behavior will be frequent occurrences with ACVs. It is very important planning and administering the training of operators. It will also be desirable to build trust by the operators in the vehicles in order to prepare the operators in such a way that such incidents can be anticipated, understood and safely internalized. Recent finding have found that traumatic stress from combat can usually be mitigated by a careful blend of keeping the exposed person awake for a period of time and making counselors immediately available. The user interface must provide enough historical detail for the operator to understand how the vehicle behaved. In the example above replaying the visualization data of the street and the pedestrian would be sufficient. In other cases, the operator may need more detailed information about the "pedestrian" and what may have affected the decision. While the design of such interfaces may not be trivial or inexpensive, it will merit specifying the operator review requirements, which will become an important part of the vehicle specification.

Items to be considered in this matter:

- Training
- Understanding capabilities of vehicles
- Overcoming "I can do it better" and "I can react faster" caused by point of view
- Building trust by the operator

3. Analysis

The authors now will look at several issues raised above. Much of their analysis is based on the evidence adduced above, but is also colored by their experiences in the service and in education. The reader is encouraged to contact the authors with any analyses or comments they think are at variance with the authors'. That which is advanced here are a set of theses to be discussed, not a set of findings to be proven.

3.1 Anticipating Future Trends

A critical issue in all of these matters is anticipating where the technology is expected to go and what might be alternative paths that could be chosen. Divergent thinking techniques like "brain-storming" should be engaged if possible. The SE community also has a developed set of tools to assist in this task. Multi-disciplinary is not just a phrase; for Systems Engineers, it is a commitment.

The SDA and M&S communities should keep lines of communications open and be alert for unexpected advances and potential threats in each other's efforts. These sorts projects often proceed with spurts and progress, but also plateaus and even set-backs. Siloing is a common enemy of passing the word to other's disciplines.

3.2 Feedback to the Developer Communities

The authors have significant experience with M&S, military operations standards for both, but they have little experience with SDA projects, with its constraints driven by an interest in protecting industrial secrets. It has been observed that the M&S community has good relations with the standards personnel, often attending each others' conventions. It is unknown how much this is mirrored in the SDA organizations.

It is also unknown how much contact the developers have with the ultimate users of the products. This may drive a concerted effort to expand an outreach to each of those groups. This may suggest another coordinated effort to interface regularly with AVC trainers and trainees as well as programmers and users of SDA's.

3.3 New Technology Contributions

There are far too many evolving technologies and techniques to cover in depth here, but the list below shows problems and potential responses:

3.4 Metrics and Standards

As is often said: "If you can't give me a number, don't even talk to me." Without a well defined figure of merit, most Artificial Intelligence can make no progress, or worse, convey an erroneous impression. This is where the standards communities are so well equipped to insist upon clearly defined roles and goals. From these, standards can arise and progress be made. The earlier one gets involved, the quicker the users and developers will have input into the direction of the product. Also this will help the "buy-in" from the users when the product is fielded.

4. Conclusions

Both SDA's and ACV's need standards and have developed communities to direct and enable their efforts. All of these communities are faced with new and expanded major issues. There are rational arguments in favor of increased collaboration between the standards communities from each discipline and their own user bases. Also, a collaboration between the two standards communities from the each individual disciplines would be potentially mutually beneficial. The commonality of the standards groups would make them an asset in the process of avoiding siloing, with it resultant effect of errors in planning and implementation. As a higher level issue, both groups could be the leaders in making their visions more acceptable by the users by focusing new technological advances that can identify, quantify and analyze human behavior as has not been feasible up to this time.

5. Acknowledgements

The authors wish to thank all of the simulation professionals with whom they have worked over the last three decades. This discipline is blessed with a fine group of creative and productive career scientists. We should also note that much of the work cited was supported by grants from the Office of Naval Research's STEM Program (ONR N00014-16-1-2820) and by research assistants supported by the National Science Foundation Research Experience for Undergraduates program (NSF 1560426). Nevertheless, the positions taken in the paper are the authors' own and do not represent in any way the views of the Department of Defense or the US Government.

6. References

[1] Badue, C., Guideline, R., Carneiro, R. V., Azevedo, P., Cardoso, V. B., Forechi, A., ... & De Souza, A. F. (2021). Self-driving cars: A survey. Expert Systems with Applications, 165, 113816.

[2] The Atlantic (2016). Your Grandmother's Driverless Car. Retrieved on 18 Dec 22 (published in 2016) from the internet using the URL: https://www.theatlantic.com/technology/archive/2016/06/beep-beep/489029/.

[3] Holloway, E. R. (1966). An Automatic Speed Controller for Automobiles. (Doctoral dissertation, Georgia Institute of Technology).

[4] Christensen, C. M. (2013). The innovator's dilemma: when new technologies cause great firms to fail. Harvard Business Review Press. Cambridge, Massachusetts, USA.

[5] SAE (2022). J3016 – Levels of Driving Automation. SAE International. Warrendale, Pennsylvania. USA. Retrieved from on 18Dec22: https://www.sae.org/binaries/content/assets/cm/content/blog/sae-j3016-visual-chart_5.3.21.pdf

[6] SAE (2019). SAE Standards News: J3016 automated-driving graphic update. SAE International. Retrieved from the internet on 18Dec22: https://www.sae.org/news/2019/01/sae-updates-j3016-automated-driving-graphic

[7] Fan, J. R., Li, D. G., Li, R. P., & Wang, Y. (2020). Analysis on MAV/UAV cooperative combat based on complex network. Defense Technology, 16(1), 150-157; Beijing, China.

[8] Cox, J., DeRosier, S., Howell, A., Jones, J., & Thompson, B. (2022). Developing Requirements to Validate Autonomous Ground Vehicle Simulations.

[9] US Army Training and Doctrine Command (TRADOC). (2017). US Army Robotics and Autonomous Systems Strategy. Ft. Eustis Virginia, USA.

[10] Feickert, A., Elsea, J., Kapp, L., & Harris, L. (2018, November). US ground forces robotics and autonomous systems (RAS) and artificial intelligence (AI): Considerations for Congress. LIBRARY OF CONGRESS WASHINGTON DC.

[11] Electrek, (2022), Tesla says it is adding radar in its cars next month amid self-driving suite concerns. Retrieved on 12 Dec 22 from: https://electrek.co/2022/12/06/tesla-radar-car-next-month-self-driving-suite-concerns/

[12] ArsTechnica, (2022). People who paid Tesla $3,000 for full self-driving might be out of luck. Retrieved 17 Dec 2022: https://arstechnica.com/cars/2018/04/why-selling-full-self-driving-before-its-ready-could-backfire-for-tesla/

[13] Kim, H. C. (2015). Acceptability engineering: the study of user acceptance of innovative technologies. Journal of applied research and technology, 13(2), 230-237.

[14] Ignatious, H. A., & Khan, M. (2022). An overview of sensors in Autonomous Vehicles. Procedia Computer Science, 198, 736-741.

[15] Burns, D.P., Davis, D.M., & Nordhagen, J. N. (2018). Systems Engineering: Optimizing Creation of Virtual Conversational Human. In the Proceedings of the *ModSim World Conference*. Norfolk, Virginia

[16] Benjamin D. Nye, Dan M. Davis, Sanad Z. Rizvi, Kayla Carr, William Swartout, Raj Thacker & Kenneth Shaw (2020). Feasibility and Usability of MentorPal, a Framework for rapid Development of virtual Mentors. *Journal of Research on Technology in Education*.

[17] Haag, A., Goronzy, S., Schaich, P., & Williams, J. (2004). Emotion recognition using bio-sensors: First steps towards an automatic system. In Affective Dialogue Systems: Tutorial and Research Workshop, ADS 2004, Kloster Irsee, Germany, June 14-16, 2004. Proceedings (pp. 36-48). Springer Berlin Heidelberg.

[18] Ellouze, M., Mechti, S., Krichen, M., Ravi, V., & Belguith, L. H. (2022). A deep learning approach for detecting the behavior of people having personality disorders towards COVID-19 from Twitter. International Journal of Computational Science and Engineering, 25(4), 353-366.

[19] Richardson, J. H. (2019). The development of a driver alertness monitoring system. In Fatigue and Driving (pp. 219-229). Routledge.

[20] Batbaatar, E., Li, M., & Ryu, K. H. (2019). Semantic-emotion neural network for emotion recognition from text. IEEE access, 7, 111866-111878.

Author Biographies

DAN M. DAVIS is a Research Associate Professor at Catholic Polytechnic University (CPU) and is also active as a consultant at the Institute for Creative Technologies, University of Southern California (USC). He is currently focusing on large-scale DoD simulations and virtual human implementations. Prior to retirement, he was the Director of the JESPP project at USC for more than a decade. As the Assistant Director of Advanced Computing Research at Caltech, he ran Synthetic Forces Express, bringing HPC to DoD simulations. He has also served as a Director at the Maui High Performance Computing Center and in computer research roles at the Jet Propulsion Laboratory and Martin Marietta. He was the Chairman of the Coalition of Academic Supercomputing Centers and has taught at the undergraduate and graduate levels. As early as 1971, Dan was writing programs in FORTRAN on one of Seymour Cray's CDC 6500's. While in the Marine Corps, he saw duty in Vietnam as a Cryptologist and retired in 2002 as a Commander, U.S.N. He received B.A. and J.D. degrees from the University of Colorado in Boulder.

JENNIFER H. NOLAN, PH. D. is the President of Catholic Polytechnic University and Professor of Psychology in their College of Arts and Sciences. Her earlier work specialized in memory, dementias, stroke and insulin resistance. She is a brain plasticity specialist and certified Cogmed provider. Previously, she was the C.O.O. and co-founder of a stroke and brain injury rehabilitation center. Dr. Nolan has taught university courses at the University of California Irvine, Loyola Marymount University, and Glendale Community College. She has conducted local and nationwide clinical trials, and published in both scientific journals and popular magazines. She received a BA in Psychology from Loyola Marymount University, Los Angeles and a Ph.D. in Psychology from the Dept. of Cognitive Science at the University of California, Irvine.

MARK C. DAVIS, PH.D. is the Chief Technical Officer at Wood Duck Research, Inc, and is semi retired after careers in the US Navy and as a computer design engineer for both IBM and Lenovo. Rising to the level of Distinguished Engineer at Lenovo, he was responsible for the design of laptop computer cross-disciplinary technology, including PC architecture, embedded systems, open source and virtualization. Previous work was with IBM in the areas of software development and architecture involving security, storage and virtualization. Dr. Davis has been granted well over fifty patents that were filed during his service at both companies. He is a graduate of the Duke University NROTC program and was commissioned as an Ensign, attended nuclear power school, and served as a Submarine Officer for twelve years, including one duty tour as a classroom instructor. He left the active duty as a Lieutenant Commander to pursue a PhD. Mark holds a BSEE degree from Duke

University and a PhD in Computer Science from the University of North Carolina, Chapel Hill, where his advisor was Professor Fredrick P. Books.

JUDITH L. JACOBUS is retired from conducting speech therapy as a Speech and Language Specialist for more than two decades. Her experiences were in public schools settings in Orange County. California. She also previously taught for 12 years as a classroom teacher in multi-cultural communities there. Judith currently volunteers her professional skills for a local police department, so has extensive experience with dysfunctional adults and children in a variety of both every-day and traumatic situations. Her participation in amateur theatrics has more fully familiarized her with the characteristics of human behavior as they are projected via verbal, facial and body-language cues. This experience has also exposed her to the skill and art of the selection of appropriate persons for specific on-screen roles. Judith holds a lifetime Special Education Credential in Speech and Hearing Therapy, K-12 from the State of California. She earned a B. A. Degree in Speech Communications from the California State University Long Beach and an M. A. Degree in Teaching and Teacher Leadership from the Grand Canyon University in Glendale, Arizona.