On Future Development of Autonomous Systems: A Report of the Plenary Panel at IEEE ICAS'21

Yingxu Wang, *Fellow, IEEE,* University of Calgary, AB, Canada (yingxu@ucalgary.ca)
Ioannis Pitas, *Fellow, IEEE,* Aristotle University of Thessaloniki (AUTH), Greece (pitas@csd.auth.gr)
Konstantinos N. Plataniotis, *Fellow, IEEE,* University of Toronto, ON, Canada (kostas@ece.utoronto.ca)
Carlo S. Regazzoni, *SM, IEEE,* University of Genova, Italy (carlo.regazzoni@unige.it)
Brian M. Sadler, *Life Fellow, IEEE,* The US Army Research Laboratory, USA (brian.m.sadler6.civ@mail.mil)
Amit Roy-Chowdhury, *Fellow, IEEE,* University of California, Riverside, CA, USA (amitrc@ece.ucr.edu)
Ming Hou, *SM, IEEE*, Defence Research and Development Canada, Toronto, Canada (ming.hou@drdc-rddc.gc.ca)
Arash Mohammadi, *SM, IEEE,* Univ. of Concordia, Montreal, QC, Canada (arash.mohammadi@concordia.ca)
Lucio Marcenaro, *SM, IEEE,* University of Genova, Italy (lucio.marcenaro@unige.it)
Farokh Atashzar, *MIEEE,* New York University, NY, USA (sfa7@nyu.edu)
Saif alZahir, *SM IEEE,* Univ. of Concordia, Montreal, QC, Canada (saifz@encs.concordia.ca)

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Abstract – Autonomous Systems (AS) are perceived as the most advanced intelligent systems evolved from those of reflexive, imperative, and adaptive intelligence. A plenary panel on "Future Development of Autonomous Systems" is organized at the inaugural IEEE ICAS'21. This paper reports the panel discussions about the-state-of-the-art and paradigms of AS, the basic research on theoretical foundations and mathematical means of AS, and challenges to the future development of AS. As an emerging and increasingly demanded field, AS provide an unprecedented approach to contemporary intelligent industries including deep machine learning, highly intelligent robotics, cognitive computers, general AI technologies, and industrial applications enabled by transdisciplinary advances in intelligence science, system science, brain science, cognitive science, robotics, computational intelligence, and intelligent mathematics.

Keywords – *Autonomous systems, intelligence systems, general AI systems, cognitive systems, theoretical foundations, machine learning, challenges, constraints, applications*

1. Introduction

It is recognized that Autonomous Systems (AS) are advanced intelligent systems and general AI technologies triggered by the transdisciplinary development in intelligence science, system science, brain science, cognitive science, robotics, computational intelligence, and intelligent mathematics [1-5]. As an emerging field, AS address the challenges to general AI and the next generation of intelligent systems where both state spaces of their stimuli and behavioral generations are dynamically indeterministic at design time or pending for run-time. These fundamental constraints to current computing and AI theories and platforms indicate the needs not only for novel technical developments, but also for deep basic research on theoretical foundations, advanced theories, intelligent computing platforms/languages, and underpinning intelligent mathematics for rigorous modeling the unprecedented demands for cognitive computing and general AI [6-8].

The primary purpose of this plenary panel on *The Future Development of Autonomous Systems*, at IEEE 1st International conference on Autonomous Systems (ICAS'21) [1], is to provide participants for an interactive means, particularly in the environment of virtual conference, to learn from distinguished experts' perspectives towards the essences and trends in AS development. It also allows participants to obtain professional visions, insights, and feedbacks to strategic questions or fundamental challenges to AS.

This paper presents a summary of the plenary panel. The distinguished panelists represent a group of the world's preeminent scholars and experts in basic research and industrial innovations on AS. The talks, discussions, and interactions with audience show the panelists' visions and perspectives on the trend to future development of AS in the fast emerging and transdisciplinary field across intelligent science, computational intelligence, general AI, computer science, system science, intelligent mathematics, as well as engineering demands from a wide spectrum of modern industries.

2. Autonomous Systems: Basic Research and the Future Development

AS are perceived as a run-time deterministic intelligent system that depends not only on current stimuli or demands, but also on internal goals, status, and knowledge formed by historical learning and current rational inferences. The ultimate goal of AS is to implement a brain-inspired system that may think and act as a human counterpart in hybrid intelligent systems and general AI implementations. AS enable nondeterministic behaviors at run-time closer to that of humans at the level of cognitive intelligence [2, 8]. Well known and potential paradigms of AS may encompass brain-inspired AI systems such as those of deep machine learning systems, machine consciousness and awareness implementations, cognitive robots, surgical robots, self-driving vehicles, autonomous drones, real-time machine inference engines, brain-machine interfaces, and knowledge-based intelligent systems.

A *Hierarchical Intelligence Model* (HIM) is introduced to reveal the levels of intelligence and their increasing complexities and difficulties for implementation in intelligence science and computational intelligence as shown in Figure 1 [2]. According to HIM, the levels of human and AS intelligence are aggregated from reflexive, imperative, adaptive, to autonomous and cognitive intelligence. HIM indicates that both human and machine intelligence are formed layer-by-layer from the bottom up. Without the underpinning layers, the upper layers may not be implemented. The HIM model is logically and neurologically consistent to the discovery of the *Layered Reference Model of the Brain* (LRMB) [9, 10] where the brain encompasses the following layers of natural intelligence: 1) Sensory, 2) Action, 3) Memory, 4) Perception, 5) Cognition, 6) Inference, and 7) Autonomous intelligence [32-36]. The LRMB model provides a brain/cognitive science foundation for modeling brain-inspired systems (BIS). Based on this perspective, any AS is equivalent to a BIS, or vice versa, which is essentially characterized by run-time derived intelligent behaviors beyond those of pretrained or predetermined ones at designed time.

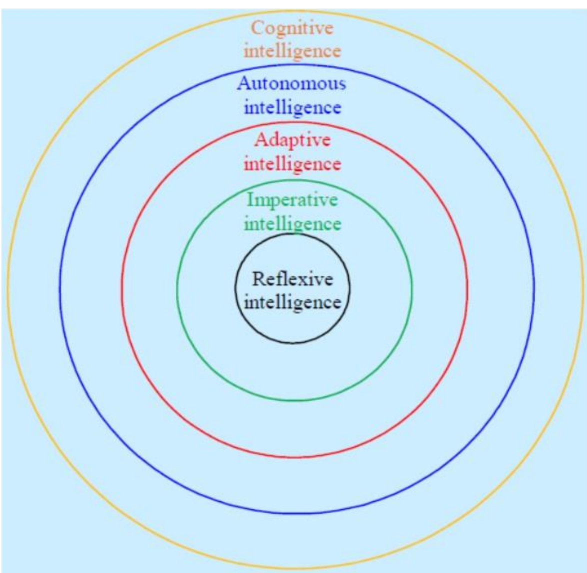


Fig. 1. The hierarchical intelligence model (HIM) of AS

In order to explore the essences and challenges to the design and implementation of AS, as well as for stimulating deep thoughts for the panel discussions, the following set of *Key Fundamental Challenges* (KFC) to AS is proposed to the distinguished panelists and audience based on basic research findings [1, 9, 10] in the emerging field of AS:

The Key Fundamental Challenges (KFCs) to AS

1) What are the *necessary and sufficient conditions* for enabling AS?
2) Why had there rarely existed any *fully functioning AS* developed in the past 60 years?
3) Does that of KFC2 indicate a *theoretical or technical challenge*, or both?
4) How mature are our *computing platforms* for implementing AS?
5) Is *Stored-Program-Controlled* (SPC) computers, or von Neumann machines, adequate enough for designing AS? If not, what kind of computers will be needed for doing so?
6) Are our *programming languages* sufficiently expressive for implementing AS? What would happen to AS if the deterministic conditional if-then-else structures were exhausted at run-time?
7) Are our *mathematical means* ready for formally expressing AS? How would the indeterministic or unpredictable behaviors of AS be formally described in algorithms beyond classic programming languages?
8) Are typical neural-network-based *deep learning systems* an AS? Would they merely a reflexive system after training?
9) Is our *inference power* adequate for expressing real-time and indeterministic behaviors of AS?
10) How may an AS be *trusted and verified* when its state space is infinitive in de facto, such as those of self-driving vehicles and mission-critical robots?

The KFCs to AS recognized in our basic research provide a set of theoretical foundations and basic design criteria for AS development. KFCs may serve as s set of necessary and sufficient conditions for evaluating if any potential theory, methodology, solution, or implementation is suitable for AS or still yet to be. (*This section is contributed by Prof. Yingxu Wang.*)

3. AI Challenges: Knowledge Quantification, Evolution and Education in Autonomous Systems Research

In the eve of the 20th century, the famous German mathematician Hilbert issued his 23 Hilbert's problems in Mathematics. They were all unsolved in 1900 and many of them proved to be very influential for 20th-century Mathematics. Such AI challenges do exist today and, if properly defined and addressed, they can greatly boost AI and autonomous systems research [31]. Subsequently, I define three such problems: knowledge quantification, knowledge evolution/adaptation and knowledge education. Actually, it can be debated, whether they are indeed three independent problems.

Knowledge quantification. The ability of an AI/autonomous system to really operate as such depends on its knowledge of the environment and of itself (self-awareness). Unfortunately, *Knowledge* is such an elusive, yet pervasive and ubiquitous term, as it forms the basis of our society. It is found in philosophy and education texts since antiquity. Yet, the following proverb, attributed to Socrates, applies to it: 'The only thing I know is that I do not know' (εν οίδα ότι ουδέν οίδα). Even its formal definitions do not really converge. Therefore, a proper, epistemologically correct, quantifiable and practical definition of a knowledge is one of the major challenges we face today. This goes hand-in-hand with knowledge quantification.

Knowledge evolution/adaptation. Another equally pressing issue is knowledge acquisition and evolution/adaptation. In recent decade, many advances have happened in using Machine Learning for knowledge acquisition, typically in the form of Deep Neural Networks (DNNs).

Knowledge adaptation has also been addressed in a rather fragmented way, e.g., through transfer/lifelong/continual learning. Despite all this progress, major issues are still unsolved. We cannot quantify AI system (notably DNN) knowledge in a satisfactory way. As a result, we cannot quantify its evolution, when trying to learn e.g., with more/new data or new tasks. And, of course, we cannot optimize knowledge evolution. This is a major issue to be solved that will really boost system adaptation and autonomy.

Knowledge education. It defines the processes of transferring knowledge from AI system(s) and/or human(s) to other AI system(s). In this sense, its scope is much broader then the current knowledge transfer theory. Actually, I claim that the 'teacher-student' model that prevails in human education, as well as other human education theories and paradigms can be adapted to an AI education environment. Such advances can greatly boost both knowledge acquisition and knowledge evolution in AI/autonomous systems. Going the opposite way, novel Knowledge education theories can be adapted and can quantify/improve human education. (*This section is contributed by Prof. Ioannis Pitas.*)

4. Autonomous Systems: What is Missing and a Way Forward?

Despite tremendous progress and impressive results witnessed in the last decade, learning in autonomous systems is still application dependent and subject to constraints [11-12]. It is commonly assumed that real progress towards generalized artificial intelligence will only achieved when human brain inspired information processing systems are available to guide autonomous dynamic systems. Although such systems are not yet developed, desiderata are available to guide developments in the area. In the long term, a practical, human-like, information processing system should:

- Utilize a measurement module that maximizes information gain from the environment.
- Use memory-based attentional mechanisms to process information.
- Deploy a reasoning/decision making engine to identify intelligent choices in an uncertain environment.
- Rely on feedback control to interact with the environment in an efficient and cost-effective manner.

In the short term, work in this area should commence on narrow focused learning and autonomy tasks. A list of possible activities in the next two-to-five years may include but not limited to research towards the development of:

- Cognitive dynamic system for engineered autonomous systems such as robots and vehicles. Learning should focus on unsupervised learning when learning is characterized by sequential dependencies in the observations arising from the information sources (context dependency), the observation medium (perception), internal system state (structure), or the action taken (feedback loop), sequential multi-class classification, and adaptive state estimation.
- Unified processing framework which includes optimal (sub-optimal), linear (non-linear) inference for cognitive dynamic systems. Preliminary results indicate that a generalized Bayesian learning framework, with quantified risk profile, is an excellent starting point.
- Solutions that promote well-being and quality of life solutions. For example, open research problems (challenges) from the field of EEG-based brain-computer interaction (BCI) can be used to test and demonstrate the utility for such brain inspired learning framework. (*This section is contributed by Prof. Konstantinos N. Plataniotis.*)

5. Incremental Learning for Self-awareness of Autonomous Systems

Multisensor signal data fusion and perception, including processing of signals are important cognitive functionalities that can be included in artificial systems to increase their level of autonomy. However, the techniques they rely on have been developed incrementally along time with the underlying assumption that they should have been used mainly to provide a support to decision tasks driving the actions of those systems. Cognitive functionalities like self-awareness have been so far considered as not primary part of embodied knowledge of an autonomous or semiautonomous system. One of the reasons for this choice was the lack of understanding the principles that could allow an agent, even a human one, to organize successive sensorial experiences into a coherent framework of emergent knowledge, by means of integrating signal processing, machine learning and data fusion aspects. However, the developments of this last decade in many fields carried to the possibility to provide integrated solutions capable to sketch how emergent self-awareness can be obtained by capturing experiences of autonomous agents like for example vehicles and intelligent radios. In this keynote, a Bayesian approach including abnormality detection and incremental learning of generative predictive models as bricks of emergent self-awareness in intelligent agents. Discussion of the advantages of including emergent self-awareness intelligent agents will be also provided with respect to different aspects, e.g. explainability of agent's actions and capability of imitation learning. (*This section is contributed by Prof. Carlo Regazzoni.*)

6. Collaborative Autonomy is the Solution for Driverless Cars

The race to full autonomy is on, but driverless cars need to communicate and collaborate to provide for overall safety and reliability, and smart infrastructure is needed for mass adoption. This requires resilient coordination, self-healing networks, learning, and rapid collaborative decision making with humans and machines. The problem difficulty grows with environmental variation and complexity, tempo, and interaction between autonomous and human operation, while design is complicated by heterogeneity, scale, and communications rate. Interim solutions are possible in pristine or controlled environments, but widely deployed driverless cars must rely on collaboration. (*This section is contributed by Dr. Brian M. Sadler.*)

7. Learning with Limited Supervision in Autonomous Systems

The recent successes in sensing and navigation algorithms in autonomous systems have been mostly around using a huge corpus of intricately labeled data for training machine learning models. But, in real-world cases, acquiring such large datasets will require a lot of manual annotation, which may be very time-consuming, impossible within limited resources, or even prone to errors. However, a lot of real data can be acquired at low to no annotation cost. Such data can be unlabeled or contain tag/meta-data information, termed as weak annotation. Thus, we need to develop methods that can learn recognition models from such data involving limited manual supervision. In this discussion [13-18], we look into two dimensions of learning with limited supervision - first, reducing the number of manually labeled data required to learn recognition models, and second, reducing the level of supervision from strong to weak which can be mined from the web, easily queried from an oracle, or imposed as rule-based labels derived from domain knowledge.

In the first dimension of learning with limited supervision, we will discuss how context information, often present in natural data, can be used to reduce the number of annotations required. In the second dimension - reducing the level of supervision – we will discuss how to use weak labels instead of dense strong labels, for learning dense prediction tasks. We will discuss frameworks to learn using weak labels for action detection in videos and domain adaptation of semantic segmentation models on images. All of these tasks discussed are static in nature. Continuing in the direction of learning from weak labels, we explore sequential decision-making problems, where the next input depends on the current output, e.g., in a navigation task. We look into the problem of learning robotics tasks with a small set of expert human demonstrations via decomposing the complex task into subgoals. (*This section is contributed by Prof. Amit Roy-Chowdhury.*)

8. Interaction-Centered Design for Human-Autonomy Teaming: A Strategic Perspective

The world is facing unprecedented catastrophic risks, arising from the deadly pandemics and epidemics and intersection of exponential technologies. AI and robotics as two representative technologies of the 4th Industrial Revolution continue to advance rapidly to become increasingly exploitable across domains in multiple ways. The trend raises important questions about the benefits, complications, liabilities, and risks associated with increasing autonomy in safety and mission-critical intelligent adaptive systems (IASs) [19]. IASs are human-machine symbiosis technologies that exhibit collective intelligence enabled by optimized human-machine interactions based on their joint capabilities, strengths, and limitations to achieve shared goals [19, 20].

While AI and robotics can provide solutions to a wide range of capability gaps and challenges, but the digitization of the world is not intended to replace human involvement completely. The use of AI and autonomy in IASs involves complex legal, ethical, moral, social, and cultural issues that may impede their development, evaluation, and application by their human partners as a collaborative human-autonomy symbiotic partnership [21, 22].

However, there currently exists no government policy in this regard, no coordinated approach, no organized community response, and no international research program seeking for answers to the challenge of understanding and mitigating the risks associated with operating autonomous systems [23]. Further, the lack of guidance to support the design of these IASs while keeping potential benefits, as well as limitations and potential harm, in mind. It is imperative that the appropriate and validated processes to ensure that these AI-enabled autonomous system can be used safely and effectively before they are integrated more widely into our systems, activities, operations, and society.

To support the broader applications of these advanced IAS technologies, interaction-centered design (ICD) approach has been validated and applied broadly in mission-critical systems where operators' tasks are often cognitively challenging due to the dynamic and evolving nature of operator state, task, system, and environment status. The ICD framework, its analytical techniques, design methodologies, implementation strategies, and test and evaluation processes have helped the scientific and defence communities understand the optimal means by which human operators can be teamed up with autonomy and AI to conduct missions in complex environments. The ICD approach has been recognized by NATO's Joint Capability Group Unmanned Aircraft Systems (UAS') and became a guiding principle and strategy for three Standardization Recommendations to address human-automation interaction issues. The ICD framework provided guidance on solutions to address a variety of UAS operational issues including intelligent tutoring, trust, and decision-making for weapon engagement [23-25].

This panel talk addresses broader issues when humans transmit their interactions with AI/Autonomy from "on-the-loop" to "in-the-loop" and how ICD-based approach can be applied to deliver effective human-autonomy teaming from a strategic perspective. (*This section is contributed by Dr. Ming Hou.*)

9. Trustworthiness and Cybersecurity of AS in Healthcare

The Novel Coronavirus disease (COVID-19) has abruptly and undoubtedly changed the world as we know it at the end of 2019. Given the current situation of the pandemic and predictions for the post-pandemic era, it is expected for the use of Autonomous Systems (AS) in healthcare to increase significantly in the following years. Beside pandemic effects, such an increase in dependence on AS in Healthcare can be attributed to the growing demand of heath care in rural areas and increasing needs for in-home care. In generally, AS for healthcare is not just about connected medical devices but rather an important component in the vast medical big data systems. Trustworthiness and security of AS for telemedicine and healthcare are of paramount importance as there will be an exponentially larger amount of confidential medical and personal data vulnerable to cyberattacks. Healthcare systems have recently become the most attractive attack target for cybercrimes. It is because of not only the variety, variability, and value of medical information accessible through Electronic Health Records (EHR), but also the fundamental difference between trustworthiness of AS for healthcare and other Critical Infrastructure (CI). For instance, cyber-attacks on Intensive Care Unit (ICU) respirators can immediately put human lives at harm way. It was reported by the Wall Street Journal that cyberattacks on healthcare providers and hospitals have increased to the extent that at some cases, doctors turn away patients and even some healthcare centers have completely stopped their operation due to the impossible situation to handle the post-attack disruption. Capitalizing on the above-mentioned critical aspects of trustworthiness and cybersecurity of AS in healthcare, there is an urgent and unmet quest to examine potential cyber-attacks on healthcare AS; analyze risk liabilities and costs associated with security incidences, develop advanced AS protection and mitigation solutions. (*This section is contributed by Dr. Arash Mohammadi.*)

10. Self-awareness in Heterogeneous Multi-Robots Systems

The research field of this competition is the unsupervised anomaly detection through self-aware [26-28] autonomous systems [29], which is an active topic involving IEEE Signal Processing Society through the Autonomous Systems Initiative, and Intelligent Transportation Systems Society. The competition allows participating teams to create intelligent and autonomous unsupervised algorithms, capable of determining the normal or non-normal behavior of a ground vehicle that interplays with the environment. So, the challenge is focused to discover anomalies automatically [29] in a common dataset that is delivered to all teams who participate in the challenge.

The goal of the competition is to detect anomalies in the aerial and ground vehicles behavior based on embedded sensory data in real time and the anomalies detected by the drone camera that observes a vehicle in the surroundings. Phase one of the open competition will be designed to give teams the data sets needed to familiarize themselves with the proposed challenge. Accordingly, the provided data sets will be divided into two groups: experiments with only normal data and experiments with mixed normal and non-normal data. The data sets will be ROS based, with LiDAR, IMU and video camera-synchronized data. The students' main tasks will consist of processing the available data from the experiments containing only normal data and create/train models to differentiate between normal and non-normal data in the experiments that presented mixed information. The proposed challenge falls in the category of unsupervised learning, in which training data contains only normal instances without any anomalies, and the testing data have mixed information. Several tasks are considered, involving a ground and an aerial vehicle and different anomalies can be identified for each task.

The challenge has motivated all participants to create innovative contributions to the field of autonomous systems. Their proposed algorithms use normal known data to infer anomalies on unlabeled new data automatically. One initial step towards decision-making in autonomous systems is the understanding of the data in terms of normal or abnormal information in time series of multisensory data. The detection of anomalies is a topic that comprises several different fields, such as signal processing, intelligent systems, machine learning, and data fusion from smart sensors. It can be applied to diverse platforms and scenarios e.g., fraud detection, social media security, medical image anomaly detection, video and audio surveillance, particularly, the ICAS 2021 challenge considered autonomous ground and aerial vehicles as application cases. (*This section is contributed by Dr. Lucio Marcenaro et al.*)

11. Autonomous Surgical Robotic Systems

The overarching objective of the special track on autonomous medical robotic systems is to present new intelligent and autonomous system technologies for surgery, therapy, rehabilitation, and diagnosis that will reduce the burden on healthcare systems by making medical interventions more efficient, accurate, accessible, and reliable. Autonomy in medicine can significantly enhance medical interventions by utilizing the advantages offered by the real-time data processing and decision-making capabilities of machines. The need for such technologies, which include robotic and wearable systems, stems from the long wait times for medical interventions. This need will be exacerbated by the projected increase in the number of seniors in the coming years.

Autonomy and intelligence have attracted a great deal of interest in several industries. One of the emerging fields of autonomy is in medical robotics, when advanced surgical robotic systems or neurorehabilitation robotic systems are automatized to maximize accuracy and consistency while minimizing the cost and load on the healthcare systems. However, due to the close proximity with humans, the safety and efficacy of these systems are of paramount importance. Also, due to the physiological sources of modalities used in this technology, such as surface electromyography, the signal interpretation would require a specialized intelligence framework. In addition, due to the complexity of the medical tasks and, in general, human behavior, these technologies are challenged to operate in unstructured, uncertain, and stochastic environments. In this special track, we collect novel expert opinions through papers, and we hope to generate a comprehensive set of views discussing the current state, challenges, and future vision in the field. We believe that through the fusion of AI, control, and signal processing, autonomous medical robots can play an imperative role in the future of healthcare systems. The need for such systems is more pronounced due to the pandemic situation and where autonomous systems can play a critical role in securing the health of the patients and clients. The special track aims to also attract student papers and presenters to further enhance and promote the accelerated field of medical autonomy. (*This section is contributed by Dr. S. Farokh Atashzar et al.*)

12. Autonomous Systems: The Case of Ethics

Basically, systems that can change their behavior in response to unexpected event(s) during operation to accommodates for the new environment are called autonomous systems (AS). AS are usually managed, controlled and supervised by an individual or an establishment. AS are ubiquitous such as, just to name a few: (i) Unmanned Aerial Vehicles (UVA); (ii) Unmanned Underwater Vehicle (UUV); (iii) Intelligent Vehicles; and (vi) fake news. AS technologies are truly transformational, with potential benefits in both monetary and risk reduction. For instant, a self-driving car gathers information from its sensors network, analyzes such information to decide and executes actions to achieve a well-defined target at a near minimum cost and the shortest time possible. The rapid spread of such systems has created new ethical imperatives and challenges to the society which led to high demand on research in this field [37-42].

We will examine the development and operation of some autonomous systems and explain the consequences of their autonomous actions in relation to some ethical values including but not limited to safety, bias, and privacy. To facilitate the deliberations in this panel, we assume that the issues of the level of automation and autonomy as well as issues of industrial autonomous systems as related to: (i) logical process execution, (ii) adaptability, (iii) self-governance and the like are resolved. Furthermore, we assume that the artificial intelligence of AS is an integral part of the system rather than unabridged. This simplification and generalization make it easier to tackle the pressing concept of AS ethical and social implications. We will expose the ethical abuses of the use of the UVA and reveal its violations to human rights and to the International Humanitarian Laws (IHL) using the interpretation of normative ethical theories characteristics. Finally, we will suggest some ethical measures for the developers and operators of the UAVs to arrive at thoughtful ethics abiding autonomous. (*This section is contributed by Prof. Saif alZahir*)

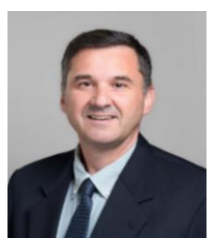
13. Conclusion

This paper has presented a summary of the plenary panel on the Future Development of Autonomous Systems in the inaugural IEEE International Conference on Autonomous Systems (ICAS 2021) held in Montreal, Canada as a virtual conference during Aug. 10-13, 2021. Ten distinguished panelists have been invited to express their visions, insights, and latest breakthroughs towards AS. Highly interesting discussions and interactions with the audience have been conducted. A Hierarchical Intelligence Model (HIM) has been introduced to explain the nature, essences, and constraints of AS in both theoretical foundations and innovative applications. A set of 10 Key Fundamental Challenges (KFCs) to AS has been explored and discussed. The expected future work to address the challenges to AS due to the lack of cognitive, intelligent, computational, and mathematical readiness have been recognized by the panel. It is noteworthy that the individual statements and opinions included in this panel summary may not necessarily be shared by all panellists.

About the Panelists

Dr. Yingxu Wang is professor of cognitive systems, brain science, software science, and intelligent mathematics. He is the founding President of International Institute of Cognitive Informatics and Cognitive Computing (I2CICC). He is FIEEE, FBCS, FI2CICC, FAAIA, and FWIF. He has held visiting professor positions at Univ. of Oxford (1995, 2018-22), Stanford Univ. (2008, 16), UC Berkeley (2008), MIT (2012), and distinguished visiting professor at Tsinghua Univ. (2019-22). He received a PhD in Computer Science from the Nottingham Trent University, UK, in 1998 and has been a full professor since 1994. He is the founder and steering committee chair of IEEE Int'l Conference Series on Cognitive Informatics and Cognitive Computing (ICCI*CC) since 2002. He is founding Editor-in-Chiefs and Associate Editors of 10+ Int'l Journals and IEEE Transactions. He is Chair of IEEE SMCS TC-BCS on Brain-inspired Cognitive Systems, and Co-Chair of IEEE CS TC-CLS on Computational Life Science. His basic research has been across contemporary science disciplines of intelligence, mathematics, knowledge, robotics, computer, information, brain, cognition, software, data, systems, cybernetics, neurology, and linguistics. He has published 600+ peer reviewed papers and 38 books/proceedings. He has presented 62 invited keynote speeches in international conferences. He has served as honorary, general, and program chairs for 39 international conferences. He has led 10+ international, European, and Canadian research projects as PI. He is recognized by Google Scholar as world top 7 in Autonomous Systems, top 1-Software Science, top 1-Cognitive Robots, top 2-Cognitive Computing, and top 1-Knowledge Science. He is recognized by Research Gate as among the world's top 2.5% scholars with a read-index 398,800+.

Prof. Ioannis Pitas (IEEE fellow, IEEE Distinguished Lecturer, EURASIP fellow) received the Diploma and PhD degree in Electrical Engineering, both from the Aristotle University of Thessaloniki (AUTH), Greece. Since 1994, he has been a Professor at the Department of Informatics of AUTH and Director of the Artificial Intelligence and Information Analysis (AIIA) lab. He served as a Visiting Professor at several Universities. His current interests are in the areas of computer vision, machine learning, autonomous systems, intelligent digital media, image/video processing, human-centred computing, affective computing, 3D imaging and biomedical imaging. He has published over 1000 papers, contributed in 47 books in his areas of interest and edited or (co-)authored another 11 books. He has also been member of the program committee of many scientific conferences and workshops. In the past he served as Associate Editor or co-Editor of 9 international journals and General or Technical Chair of 4 international conferences. He participated in 71 R&D projects, primarily funded by the European Union and is/was principal investigator in 42 such projects. Prof. Pitas leads the big European H2020 R&D project MULTIDRONE: https://multidrone.eu/. He is AUTH principal investigator in H2020 R&D projects Aerial Core and AI4Media. He is chair of the Autonomous Systems Initiative https://ieeeasi.signalprocessingsociety.org/. He is head of the EC funded AI doctoral school of Horizon2020 EU funded R&D project AI4Media (1 of the 4 in Europe). He has 32000+ citations to his work and h-index 85+ (Google Scholar).



Prof. Konstantinos (Kostas) N. Plataniotis received his B. Eng. degree in Computer Engineering from University of Patras, Greece and his M.S. and Ph.D. degrees in Electrical Engineering from Florida Institute of Technology Melbourne, Florida. Dr. Plataniotis is currently a Professor with The Edward S. Rogers Sr. Department of Electrical and Computer Engineering at the University of Toronto in Toronto, Ontario, Canada, where he directs the Multimedia Laboratory. He holds the Bell Canada Endowed Chair in Multimedia since 2014. His research interests are primarily in the areas of multimedia and knowledge media systems image/signal processing, machine learning and adaptive learning systems, visual data analysis, and affective computing. Dr. Plataniotis is a Fellow of IEEE, Fellow of the Engineering Institute of Canada, Fellow of the Canadian Academy of Engineering/L'Academie Canadienne Du Genie, and a registered professional engineer in Ontario.

He has served as the Editor-in-Chief of the IEEE Signal Processing Letters. He was the Technical Co-Chair of the IEEE 2013 International Conference in Acoustics, Speech and Signal Processing, and he served as the inaugural IEEE Signal Processing Society Vice President for Membership (2014 -2016) and General Co-Chair for the 2017 IEEE GLOBALSIP. He served as the 2018 IEEE International Conference on Image Processing (ICIP 2018), and as General Co-Chair of the 2021 International Conference on Acoustics, Speech and Signal Processing (ICASSP21). He will be the General Chair of the 2027 IEEE

International Conference on Acoustics, Speech and Signal Processing (ICASSP2027).

Prof. Carlo S. Regazzoni obtained the M.S. and PhD degrees from University of Genova, in 1987 and 1992, respectively. Since 2005, he is full professor of Cognitive Telecommunications systems at DITEN, University of Genova, Italy. He is coordinating international Interactive and Cognitive Environment PhD courses at UNIGE since 2008. His research interests include cognitive dynamic systems, adaptive and self-aware multimodal signal processing, Bayesian machine learning, Cognitive radio. He is author of peer-reviewed papers on more than 100 international journals and 350 at international conferences. He served in IEEE Signal Processing Society in many roles, including VP conferences in 2015-2017, Italy SPS Chapter Chair, 2010-2012, IEEE AVSS SC chair 2000-2010. He was General Chair, Technical Program chair and other roles in several international IEEE conferences within his research field. He is/has been associate/guest editor of several int. journals including July 2020 special issue of the Proceedings of the IEEE on Self Awareness in Autonomous Systems.

Dr. Brian M. Sadler (IEEE Life Fellow) is a senior scientist at the US Army Research Laboratory. He is Vice-Chair of the IEEE Signal Processing Society Autonomous Systems Initiative, an IEEE Distinguished Lecturer, and has been an Associate Editor for several journals in signal processing, networking, and robotics. His research interests include collaborative autonomy and intelligent systems.

Prof. Amit Roy-Chowdhury received his PhD from the University of Maryland, College Park (UMCP) in 2002 and joined the University of California, Riverside (UCR) in 2004 where he is a Professor and Bourns Family Faculty Fellow of Electrical and Computer Engineering, Director of the Center for Robotics and Intelligent Systems, and Cooperating Faculty in the department of Computer Science and Engineering. He leads the Video Computing Group at UCR, working on foundational principles of computer vision, image processing, and statistical learning, with applications in cyber-physical, autonomous and intelligent systems. He has published over 200 papers in peer-reviewed journals and conferences. He is the first author of the book Camera Networks: The Acquisition and Analysis of Videos Over Wide Areas. He is on the editorial boards of major journals and program committees of the main conferences in his area. His students have been first authors on multiple papers that received Best Paper Awards at major international conferences, including ICASSP and ICMR. He is a Fellow of the IEEE and IAPR, received the Doctoral Dissertation Advising/Mentoring Award 2019 from UCR, and the ECE Distinguished Alumni Award from UMCP.

Dr. Ming Hou received his PhD in Human Factors from the University of Toronto, Canada in 2002. He is currently a Senior Defence Scientist at Defence Research & Development Canada (DRDC) and the Principal Authority of Human-Technology Interactions within the Department of National Defence (DND), Canada where he received the prestigious Science and Technology Excellence Award in 2020. Dr. Hou is responsible for delivering technological solutions, science-based advice, and evidence-based policy recommendations to senior decision makers within DND and the Canadian Armed Forces (CAF) and their partner organizations. He also provides advice about the investment in and application of advanced technologies and methodologies for human-machine systems requirements and for AI and Autonomy science, technology and innovation strategies to the CAF and DND. He is an Integrator of the Canadian government $1.6B IDEaS program with responsibilities for guiding national R&D activities in AI, Automation, Robotics, and Telepresence. As the Canadian National Leader and Scientific Authority during Autonomous Warrior 2018 Joint Service Exercise, Dr. Hou led Canadian research and development activities to support international collaborative projects. Dr. Hou is the Co-Chair of Human Factors Specialist Committee within NATO Joint Capability Group on Unmanned Aircraft Systems (UAS). His book: "Intelligent Adaptive Systems: An Interaction-Centered Design Perspective" provided guidance for the development of NATO STANRECs on "Human Systems Integration Guidance for UAS", "Sense and Avoid Guidance for UAS", and "UAS Human Factors Experimentation Guidebook". As one of the four invited Lecturers, Dr. Hou delivered NATO Lecture Series on "UAVs: Technological Challenges, Concepts of Operations, and Regulatory Issues". Dr. Hou also serves for multiple international associations/programs as chairs or board members.

Dr. Arash Mohammadi (S'08-M'14-SM'17) is an Associate Professor with Concordia Institute for Information Systems Engineering, Concordia University, Montreal, QC, Canada. Prior to joining Concordia University and for 2 years, he was a Postdoctoral Fellow with the Department of Electrical and Computer Engineering, University of Toronto, Toronto, ON, Canada. Dr. Mohammadi is a registered professional engineer in Ontario. He is Director-Membership Developments of IEEE Signal Processing Society (SPS); General Co-Chair of "2021 IEEE International Conference on Autonomous Systems (ICAS)," and Guest Editor for IEEE Signal Processing Magazine (SPM) Special Issue on "Signal Processing for Neurorehabilitation and Assistive Technologies". He serves as Associate Editor on the editorial board of IEEE Signal Processing Letters. He was Co-Chair of "Symposium on Advanced Bio-Signal Processing and Machine Learning for Assistive and Neuro-Rehabilitation Systems" as part of 2019 IEEE GlobalSIP, and "Symposium on Advanced Bio-Signal Processing and Machine Learning for Medical Cyber-Physical Systems," as a part of IEEE GlobalSIP'18; The Organizing Chair of 2018 IEEE Signal Processing Society Video and Image Processing (VIP) Cup, and the Lead Guest Editor for IEEE Transactions on Signal & Information Processing over Networks Special Issue on "Distributed Signal Processing for Security and Privacy in Networked Cyber-Physical Systems". He is recipient of several distinguishing awards including the Eshrat Arjomandi Award for outstanding Ph.D. dissertation from Electrical Engineering and Computer Science Department, York University, in 2013; Concordia President's Excellence in Teaching Award in 2018, and 2019 Gina Cody School of Engineering and Computer Science's Research and Teaching awards in the new scholar category.

Dr. Lucio Marcenaro received the degree in electronic engineering and the Ph.D. degree in computer science and electronic engineering from Genoa University in 1999 and 2003, respectively. Since 2021, he is an Associate Professor of Telecommunications with the Department of Electrical, Electronic, Telecommunications Engineering and Naval Architecture (DITEN), University of Genoa. He has 20 years of experience in image and video sequence analysis. He has authored about 130 technical papers on signal and video processing for computer vision.

Lucio Marcenaro is associate editor of the IEEE Transactions on Image Processing and IEEE Transactions on Circuits and Systems for Video Technology, technical program co-chair for 13th International Conference on Distributed Smart Cameras (ICDSC) and for the first IEEE International Conference on Autonomous Systems (IEEE ICAS 2021), co-organizer for the 2019 Summer School on Signal Processing (S3P), General Chair of the Symposium on Signal Processing for Understanding Crowd Dynamics. He is Senior Member of IEEE and active within the IEEE Signal Processing Italy Chapter and Director of Student Services Committee (2018-2021).

Dr. S. Farokh Atashzar is an Assistant Professor of Electrical and Computer Engineering, as well as Mechanical and Aerospace Engineering at New York University (NYU). He is also with NYU WIRELESS and NYU Center for Urban Science and Progress (CUSP). Prior to joining NYU, He was a senior scientist in the Department of Bioengineering, Imperial College London, UK, sponsored by the Natural Sciences and Engineering Research Council (NSERC) of Canada. From February 2017 to August 2018, he served as a post-doctoral scientist at Canadian Surgical Technologies and Advanced Robotics (CSTAR) center. His many awards included the highly competitive NSERC Fellowship in 2018. He was ranked among the top 5 applicants in Canada for the 2018 NSERC PDF competition in the Electrical and Computer Engineering sector. Recently he has received an NSF-RAPID-COVID award to conduct research on the topic of smart wearables for detecting health anomalies using machine intelligence for COVID-19 patients. Also, he has recently received an NSF/FDA award based on his collaboration with the medical and regulatory sectors and to generate new computational brain-muscle connectivity models to analyze the recovery process of post-stroke patients. He serves as the associate editor on several journals, including IEEE Robotics and Automation Letters (RAL), Biomedical Engineering Online (a Springer-Nature journal). He has also been actively contributing to organizing several conferences. In this regard, he has been the associate editor and publication chair for IEEE ISMR 2020-2021 and Technical Vice-Chair of IEEE International Conference on Autonomous Systems. He is also the Co-chair of IEEE Technical Committee on Telerobotics.

Professor Saif alZahir received his PhD and MS degrees in Electrical and Computer Engineering from the University of Pittsburgh, Pennsylvania and the University of Wisconsin-M in 1994 and 1984 respectively. He did his postdoc at UBC, Vancouver, BC, Canada. Dr. alZahir is involved in research in the areas of image processing, deep learning, forensic computing, data security, VLSI, Networking, Corporate Governance, and Ethics. In 2003, The Innovation Council of British Columbia, Canada, named him British Columbia Research Fellow. He authored or co-authored more than 100 journal and conference articles, contributed to two books, and 5 book chapters. He is the founder and editor-in-chief of International Journal of Corporate Governance, London, England, (2008 – present), Associate Editor, IEEE ACCESS – CTSoc. Dr. alZahir is the General Chair of the IEEE – International Conference in Image Processing 2021, Anchorage, Alaska, USA; the General Chair, of the IEEE International Symposium on Industrial Electronics, ISIE, 2022; and was the General Chair of additional three international conferences including the IEEE Nanotechnology Materials and Devices Conference (NMDC) September 2015. Finally, he served on many TPCs for international conferences.

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