Towards Trustworthy Autonomy : How AI can help address fundamental learning and adaptation challenges

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As autonomy becomes increasingly ubiquitous in complementing and supplementing humans and human-operated defense systems, our dependence on them is correspondingly growing. Soon autonomous systems will provide a spectrum of safety-critical, service-critical, and cost-critical functionalities within the defense context. As such, the major paradigm shift that we currently face is the transition from design-time automated or sand-boxed autonomy; to Artificial Intelligence (AI) enabled self-aware and learning autonomous systems. In that respect, AI enabled autonomy provides a key capability towards operating in complex and unpredictable environments, while: (a) accomplishing goals with through-life resilience against anomalies, failures, and adversaries, and (b) learning and evolving through diverse experiences. In this presentation, we will present the key challenges and recent advances in developing trustworthy learning-enabled (i.e. AI-driven) autonomous systems within defense setting touching essential focus areas such as security, resilience, verification, validation and certification. As such, we will showcase AI technologies towards addressing two fundamental challenges stemming from the real-world defense context. First challenge is AI aided tactics development for autonomous aerial combat using Reinforcement Learning (RL). Specifically, we present the development process of combat optimizers for various Air operational scenarios, and show the discovery of credible novel air combat tactics beyond those in use today. The approach as presented delivers a credible methodology and analysis framework, a supportable, extensible and verifiable synthetics-based evaluation system within which to develop, test and evaluate various ML-based approaches, and a series of representative test scenarios based on air combat tactical information. Second challenge is development of an autonomous AI-driven multi-asset mission planning and routing agent that consider the interactions between multiple parameters to generate optimal results in near real-time at contested environments. Our method relies on a multi-layer approach which allows us to do mission planning at reinforcement learning based war-gaming context while driving fleet composition and target/task assignment through an enhanced variant of CBBA algorithm. The developed system allows us to consider both pre-mission and live mission contexts, and allow us to identify and demonstrate approaches which offer the best outcome in terms of delivering increased operational advantage, generating enhanced survivability and mission effectiveness. Both of the aforementioned challenges, and the respective solutions to these challenges demonstrate what AI could bring to real-world autonomy challenges in defense context. At the end of the presentation, we briefly touch on the new research

aimed at addressing the critical problems of AI explainability, dynamic verifiability and validation, and embedded computational feasibility (from hardware SWAP-C perspective) before deployment and broader adoption of such ASs in safety-critical applications.

Bio: Professor Gokhan Inalhan received his B.Sc. degree in Aeronautical Engineering from Istanbul Technical University in 1997, and the M.Sc. and Ph.D. degrees in Aeronautics and Astronautics from Stanford University, in 1998 and 2004 respectively. In 2003, he has received his Ph.D. Minor from Stanford University on Engineering Economics and Operations Research (currently Management Science and Engineering). Between 2004 and 2006 he had worked as a Postdoctoral Associate at Massachusetts Institute of Technology. During this period, he had led the Communication and Navigation group in the MIT-Draper Laboratory NASA CER project. He has served as Director of Controls and Avionics Laboratory (2006-2016) and Director General of Aerospace Research Centre (2016-2019) at Istanbul Technical University. Gokhan is currently BAE Systems Chair, Professor of Autonomous Systems and Artificial Intelligence at Cranfield University. Gokhan has led and managed numerous grants and industrial projects from FP7, H2020, SESAR, EC Marie-Currie, EPSRC, Innovate UK, ATI, NATEP, BAE Systems, Boeing, Airbus, BR&T Europe and major Euro-Asian aerospace, defense, and aviation companies. In addition to various best paper awards , he and his research are recipient of awards such as IEEE AESS Exceptional Service Award, Boeing Faculty Fellowship, Council of Higher Education Outstanding Achievement and TUBITAK Innovation Success Stories. Gokhan has been serving in Ccience, Technology and Advisory Boards of various government and commercial entities and he is a member of the general assembly of ASDA, CANSO CATS Global Council, and Eurocontrol Agency Research Team. His professional service span technical committees (AIAA Guidance, Navigation and Control TC, AIAA Task Force on Advanced Air Mobility), program and editorial boards in which he has been leading themes including autonomy, artificial intelligence, intelligent systems, and transportation for IEEE CCTA, ICRAT, SESAR SID and AIAA GNC. He is currently the Chair of IEEE Technical Committee on Aerospace Controls and the Editor-in-Chief of IEEE Transactions on Aerospace and Electronic Systems. Gokhan is a life-time member and Associate Fellow of AIAA and a senior member of IEEE.