Moving to Advanced Research on Human Machine Interface Design

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Introduction

This poster paper will discuss a variety of items related to Human-Machine Teaming and research in support in-creasing control of autonomous machines present in physical problem domains of interest. Many military tasks can be decomposed into their primary elements – intelligence preparation, reconnaissance, movement, maneuver, fires, and support across the combat domains of interest – air, land, sea, etc. There are an increasing number of autonomous and semi-autonomous ground-based systems available, such as the Multi-Utility Tactical Transport (MUTT) Unmanned Ground Vehicle, for movement of materials, or Quadrupedal Unmanned Ground Vehicle (QUGV) for the disposal of explosive ordinance, complemented by aerial platforms considering of a wide variety of Unmanned Aerial Systems (UAS) for the gathering and transmitting of information, held together by a common backbone and network.

The preponderance of new systems and capabilities brings new issues, one of which is critical to research - how to control and manage a large number of systems. Commercial systems of significantly less capability, such as light-up drone shows, involve approximately 2 people per 100 drones; meaning that a single controller for a single drone is simply a non-starter. How can research be applied to scale the complexity of operations upwards without additional demands of personnel?

The Joint All Domain Command and Control Strategy (JADC2) (Hoehn, 2020) states:

> To accelerate decision-making, the Joint Force must discover and access any and all data from all warfighting domains, at all levels of Warfare.

Which makes it clear that (a) the future battlespace will be complex and (b) additional machine intelligence and systems do not necessarily help unless they can significantly augment the human decision-making through the addition of speed. The following image represents the complexity.

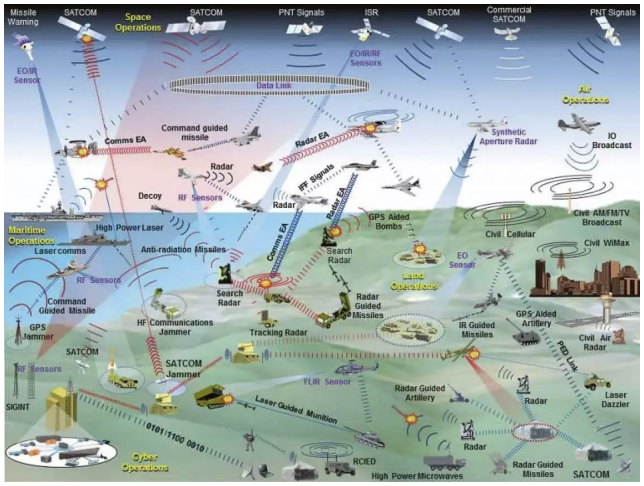

Figure 1: Future battlespace; diagram drawn from JADC2 concept of operations documentation

This poster discusses several portions of early-stage research into a variety of applications, including the following subsections, described in greater detail on the poster. This discussion includes general subsections across a variety of dynamic areas, including:

1. Reasoning about mixed-team processes, including real/synthetic teammates, and how information gathered about the use of synthetic teammates within simulation can be transitioned into utilization for a robotic teammate. Technology is described about how personalization is made to the individual user, how de-identification can be made to preserve the privacy of the user, and how to customize emotion-aware reasoning in order to understand individual users and monitor them within a human-agent team.

2. Embedding affective information into dialogue channels in order to save cognitive bandwidth. The ability to embed this information within a dialogue channel to further augment the user, as well as be aware what types of information it is important to present at which times; some information presented to a clam and undistracted is not important enough to be presented when the opposites are true.
3. Repurposing of foundational dialogue models for specific tasks and purposes. Models built overtop of large language modeling (LLM) technology which can be customized towards individual actions, human negotiation, robotic negotiation, and system negotiation in order to disambiguate instructions which are specific to a given domain based on classification of individual dialogue actions.
4. Utilizing psychological research to design systems in order to infer user intent. This includes systems which can adapt displays, information display, and information placement in order to display only the information relevant to an informed decisions based on the area of gaze direction within a virtual environment and the rate at which new information comes available or is made available. Hypothetical display shown within Figure 3.
5. Theory of mind research for autonomous systems regarding their human operators. This includes enhanced display options made available for making rapid decisions and customizable levels of automation when making them.
6. Simulated environments and agents in order to test the simulations in representative areas. This includes a variety of display options including floor projections, augmented reality sand-table projections, traditional displays, and interactive immersive spaces, as shown in multiple capacities within Figure 2.
7. Common-Sense reasoning augmented by Large Language Model technology for instructing robotic platforms. This additionally includes new-starting research in order to be able to make abbreviated 3D pipelines and drastically reduce rendering times in order to accelerate decision-making.
8. Combinations of abductive and deductive logic networks in order to either (a) dynamically assign behaviors to synthetic units, or (b) use synthetically assigned unit behaviors to drive explanation of events which likely occurred while under only partial observation.

The combination of these efforts serves to address the goals of enhancing human sense-making, optimizing the Soldier/Squad decision dominance, linking simulation and live environments, offloading risk, intelligently using and fading automation strategies, and creating new methods of testing for complex workflows and products. This combination of capabilities works to support a variety of efforts in robotics and automation, as well as the utilization of simulation, automation training, and human training and educational needs.

All of the above items will be discussed at the poster session, which represents a portfolio of ongoing work addressing the problems of human-machine interfacing within a blending of simulation and live military operations. While the near-term application of these technologies is into military problem domains; the poster presentation is cleared for public release.

Figure 2: Combination of display technologies utilized simulateously, including live sand (back), ground projection (center), and head mounted display (worn)

Figure 3: Augmented reality choice display options dynamically customed to user. Conceptual diagram.

References

Hoehn, J. R. (2020). Joint All-Domain Command and Control (JADC2) (p. 3). Congressional Research Service.