The Humans and Autonomy Laboratory (HAL)

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HAL Humans and Autonomy Lab

About The Humans and Autonomy Lab at Duke University (HAL)

Overview:

The Humans and Autonomy Lab is an interdisciplinary lab that focuses on the multifaceted interactions of human and computer decision-making in complex sociotechnical systems containing embedded autonomy.

Given the increasing amount of autonomous technology in aviation, medicine, and driving, the need for humans as supervisors and collaborators in complex autonomous systems has replaced the need for humans in direct manual control.

HAL employs human-systems engineering principles to autonomous system modeling, design, and evaluation to identify the ways in which humans and computers can leverage the strengths of one another to achieve optimal decisions.

List of Research Projects:

- Determination of UAV & UGV Effectiveness as Autonomy Increases
- Risk-aware, Human-cooperative Planning for Autonomous Systems
- Systems-Theoretic Computational Model for Rail Dispatch/Operations Centers
- Drones in Gabon
- Task Allocation for an Automated Labor In-Cockpit Automation System
- Investigating the Tradespace Between Increased Automation and Optimal Manning for Aircraft Carrier Decks

Determination of UAV & UGV Effectiveness as Autonomy Increases

The United States Army has plans to make significant investments to increase the level of autonomy on board both Unmanned Aerial Vehicles (UAVs) and Unmanned Ground Vehicles (UGVs) to increase mission effectiveness, while simultaneously decreasing operation and training costs. Currently, there is no principled methodology that can be used to understand how increased autonomy could change the training requirements and how such a change could be assessed in advance to inform engineers developing new systems.

In an attempt to remedy this inability, HAL is currently developing a Systems Dynamics model of the interactions between training and unmanned ground/vehicle control system design to accomplish three things: Aid in the assessment of current training and development of future training programs, determine how increasing autonomy may affect various training objects, and make predictions about how future robot systems should be designed in terms of hardware, software, and training programs

Figure 1: Image showing the typical launch of a RQ-7 "Shadow" drone. A UAV frequently used by the Army

Risk-aware, Human-cooperative Planning for Autonomous Systems

The ability to manage risk is an indispensible part of human and machine intelligence when performing tasks under high uncertainty. These tasks could include a range of scenarios including military operations and space exploration. Although machine intelligence plays increasingly significant roles in these scenarios, humans are still the predominant party responsible for the prediction and management of all risk. Our vision is to restructure the landscape of how risk is managed. HAL wants to revise the relationship between humans and robots. This would create a paradigm where both parties share the responsibility of predicting and managing risk. HAL is collaborating with the Jet Propulsion Laboratory, under the direction of the Office of Naval Research to complete this research goal.

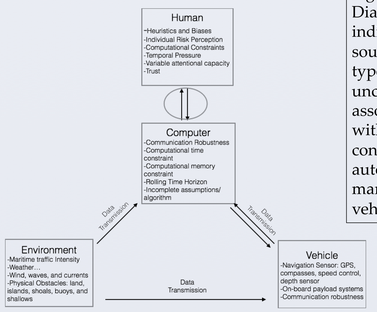


Figure 2: Diagram indicating sources and types of uncertainty associated with the control of an autonomous maritime vehicle

Systems-Theoretic Computational Model for Rail Dispatch/Operations Centers

Positive train control is a set of highly advanced technologies designed to make freight rail transportation safe by automatically stopping a train before certain types of accidents can occur. Positive train control has become increasingly popular in the rail industry over the years and has sparked the need to investigate how this technology will impact future staffing, safety, and overall system performance. HAL, sponsored by the Federal Railroad Administration, is attempting to develop a systems theoretic computational model of an individual locomotive crew and their respective dispatch/operations center. The model will then be validated, and then demonstrate that the model could be used to help answer lingering questions concerning the safety and economic improvements vital to the future of the transportation industry.

Figure 3: Image of a typical locomotive that would utilize positive train control

Drones in Gabon

Gabon, Africa is home to a large proportion of the African forest elephant. The African forest elephant is one of the most heavily poached animals in the world. In addition to being heavily poached, the true estimate of the population size is highly uncertain due to the current methods of population observance. We are partnering with the Nicholas School of the Environment at Duke University and a conservationist group at Wonga Wongue national park in Gabon, to develop a monitoring system capable of non-invasively tracking these elephants in an attempt to better understand population numbers and migration habits. The system is comprised of a quadcopter, ground control station, and thermal video camera.

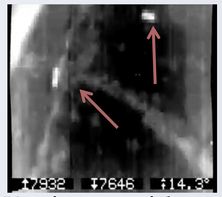


Figure 4: Image of African forest elephants taken from an altitude of 300 ft. utilizing the designed system. Red arrows (2) are pointing to white signatures. Each white signature is an elephant

Key features of the system include an inexpensive price tag, the system will cost less than $2,000. The system is user-friendly, requiring limited training for each operator. The system is maintainable, meaning that the system can be repaired is a crash does occur. Finally, the system is reliable, which means that the system can function in remote regions containing dense canopy cover.

Task Allocation for an Automated Labor In-Cockpit Automation System

We are working with Aurora Flight Sciences on the DARPA ALIAS program. The goal of this project is to provide an autonomous system that can be flexibly installed into any aircraft that is in the Department of Defense inventory. The proposed solution includes an R2D2-style robotic copilot that is able to assist with tasks in the cockpit. In this proposed paradigm, the standard multicrew cockpit instead contain a single human pilot and the ALIAS robotic system.

The goal of our research, within the development of this new paradigm, is to identify task allocation between human and robotic pilots and determine dynamic workload across a variety of missions. Some constraints that impact allocation include capabilities and limitations, workload, task sequencing and timing, and effective roles for safe flight.

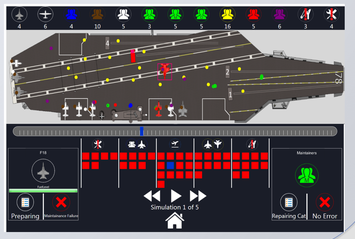
Figure 5: Image of the "R2D2" robot from the Star Wars franchise

Investigating the Tradespace Between Increased Automation and Optimal Manning for Aircraft Carrier Decks

The Office of Naval Research and HAL are interested in determining the impacts of modern automation techniques on the carrier deck environment. Current deck operations are driven by strategies that originated in the 1950s and 1960s. Increasing automation has the potential to reduce the human footprint on the flight deck, and thereby increase safety for carrier personnel. The decision space for this scenario is multi-dimensional, and must include metrics of safety and efficiency, for normal operations as well as emergency operations.

In order to answer questions revolving around this research question, HAL is developing the Personnel Multi-Agent Safety and Control Simulation (P-MASCS). The P-MASCS is an agent based model to assess deck performance under a range of parameters and conditions. In our simulations, each person and aircraft on the flight deck is modeled independently, and can be used to investigate how changes in manning impact the flight deck in both performance and safety.

Figure 6: Screen captured image of an example simulation utilizing P-MASCS



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