

NASA FRONTIER DEVELOPMENT LAB (FDL): AN ARTIFICIAL INTELLIGENCE RESEARCH ACCELERATOR FOR LUNAR SCIENCE AND EXPLORATION A. F. Zuniga, NASA Ames Research Center, 555 McCord Ave., Moffett Field, CA 94035, allison.f.zuniga@nasa.gov

Introduction: The NASA Frontier Development Lab (FDL) is a new public-private partnerships approach to solving challenging space science and exploration problems with the latest Artificial Intelligence (AI) and Machine Learning (ML) tools and technologies. FDL brings together partners from NASA, SETI, academia, and industry, to work together in an accelerator environment to solve data intensive problems for a range of space science and space exploration technical areas, such as heliophysics, climate change and lunar exploration. FDL leverages AI and ML technologies from its well-established commercial partners, such as, NVIDIA, Intel, Google Cloud, HP and IBM

In this accelerator environment, FDL brings PhD and post-doctoral researchers from space science and teams them up with AI and data science experts for an intensive eight-week research sprint, to solve a range of technical challenges. Each team is composed of at least two space researchers and two data science or AI researchers selected from the top universities from around the world. During the research and development sprints, the teams are supported by mentors and subject matter experts (SMEs) from NASA, SETI and our commercial partners. As has been demonstrated in the last 3 years of operation, the results far exceed what any individual could develop in the same time period, or even in years of individual research.

Over the past three years, FDL's research teams have worked on challenges under five key mission areas: Planetary Defense, Solar Physics, Earth Science, Search for Extra-Terrestrial Life, and Lunar Science and Exploration. This paper will focus on the FDL work that has been performed and currently planned for the specific mission area of Lunar Science and Exploration.

One of the FDL challenges under Lunar Science and Exploration is Lunar Resource Mapping. Based on analysis of lunar samples brought back from the Apollo missions, we know there are a wide variety of lunar resources in the lunar regolith such as, oxygen, silicon, aluminum, iron, and titanium. In addition to Apollo, there have been several remote-sensing lunar missions, such as LCROSS and LRO that have provided direct and indirect evidence of water-ice deposits at the lunar poles. Future lunar architectures can take advantage of these resources if we know exactly where they can be found in sufficient quantity as well its distribution and characterization. This FDL challenge plans to develop

new ML algorithms to create higher fidelity lunar resource maps. These maps will be very useful in designing future missions to extract and take advantage of these resources.

Other FDL lunar challenges being considered at this time are autonomous navigation and control systems with deep reinforcement learning for improved landing performance. Next generation lunar landers will need more advanced guidance, navigation and control capabilities to satisfy increased landing requirements. Most current powered descent phase guidance and control systems use 2 separate and independently optimized systems for guidance and control. This challenge plans to use an integrated guidance and control system that learns a global policy using reinforcement learning to map the navigation system's estimate of the lander's state directly from the commands specifying thrust levels for each engine. The integrated system will be tested on a 6 degree-of-freedom simulation and will be compared to other feedback control methods to evaluate performance.

This presentation will describe the FDL project as well as its goals, objectives and innovative approach for leveraging partnerships, reducing risk and creating an accelerator environment for advancements in lunar resource mapping, technology development and exploration.