M.A.N.T.I.S -- Muon Analysis for Non-Invasive Tomography and Image Simulation: Simulating Atmospheric Muon Flux for Remote, Non-Invasive Subsurface Imaging

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MANTIS is the first entirely computerized muon-based subsurface imaging system. Its goal is to deliver a fully non-invasive and remote method for underground imaging that eliminates the need for heavy machinery, on-site detectors, and large field teams. By leveraging natural atmospheric muons, machine learning models, and computational simulation, the system enables detailed subsurface mapping without excavation or user input. This approach minimizes environmental impact, reduces cost and time, and makes high-resolution subsurface intelligence broadly accessible. The project established a control site at SURF in South Dakota. Geo-environmental mapping, three-dimensional modeling, and a Geant4 pilot simulation were developed, incorporating muon flux data and environmental variables. Multiple validation procedures based on data visualization were performed of the site. The system was expanded into a full-stack architecture through custom software development and enhanced simulation workflows. Machine learning was applied to over eight million custom-generated datasets. MANTIS simulation outputs integrate 32 independent data reference feeds, including inSAR, GRACE, and Sentinel-2. Final enhancements included a simplified user interface, advanced data modeling, and validation across multiple test sites. Results confirm that muon-based subsurface imaging can be performed entirely through computer simulation. Simulations show that optimal imaging requires surrounding targets with high-resolution, low-noise virtual detectors. Validated tests confirm that modeled muon interactions can reliably reveal hidden underground structures, with applications in disaster response, infrastructure planning, mining, and national security.

Awards Won:

First Award of $6,000

Association for the Advancement of Artificial Intelligence: AAAI Student Memberships for each finalist that is part of the 1st, 2nd, and 3rd Prize Winning projects and 5 Honorable Mention winning projects (up to 3 students per project) (in-kind award / part of the 1st-3rd prize)

International Council on Systems Engineering - INCOSE: Certificate of Honorable Mention, a 1-year free student membership to the INCOSE, and free virtual admission to the 2022 International Symposium of the INCOSE