

EXPERIMENTING WITH EMERGING ARTIFICIAL INTELLIGENCE AND AUGMENTED REALITY TECHNOLOGIES UTILIZING PLANETARY SCIENCE DATA FOR STEM EDUCATION AND PUBLIC OUTREACH.

Ping Wang¹, Pengyu Hong², Kristin Bass³, Nicholas Dygert¹, Jeffrey Moersch¹, Vasileios Maroulas¹, Shichun Huang¹, Stan Tomov¹, Quinn Argall⁴, Shalaunda Reeves¹, Melody Hawkins⁵, Janine Al-Aseer¹, Helen Zhang⁶, Flora Yu Zhu⁷, Alice Zhitong Zou⁸, Dejie Xu⁹ & Fei An¹⁰. ¹Univ. of Tennessee, Knoxville (pwang27@utk.edu), ²Brandeis University, ³Rockman et al Cooperative, ⁴American Museum of Science and Energy, ⁵Knox County School District, ⁶Boston College, ⁷Great Neck South High School, ⁸Valley Christian High School, ⁹Univ. of Texas, Austin, ¹⁰Univ. College Cork

Introduction: The rapid permeation of artificial intelligence (AI) into nearly all walks of life and every profession calls for innovative approaches of promoting public AI literacy and education in all settings [1]. Thus, in the past few years, we have been experimenting with emerging AI as a tool with planetary science data for STEM education and public outreach in southern Nevada and then now in East Tennessee through a variety of programs and activities. We have also utilized Augmented Reality (AR) in our design and implementation. The goal of this abstract is to present our efforts using emerging AI and AR tools to expand the appreciation of both planetary science and also new technologies in AI and AR among high school youth and the public at large through a cross-disciplinary approach with the spirit of experimentation.

Development: High-quality images of Mars, including the HiRISE (High Resolution Imaging Science Experiment) images and other images from the rovers on the NASA PDS [2] have provided an opportunity for the public to explore Mars in detail as never before. However, the observation of these images alone does not enable full appreciation of the scientific relevance of these images. In 2020, we developed and implemented an AR program at the Marjorie Barrick Museum of Art on the campus of University of Nevada, Las Vegas, with which we engaged youths and their family members in modelling Mars surface features, including craters and alluvial fans, by using the museum's AR sandbox. The AR sandbox is a 3D, interactive, dynamic tool to help understand mapping and topography. With a specialized software we were able to map contour lines onto the sand that adjusted as the sand was moved in real time.

We developed and implemented a sequence of lessons, titled *HiRISE+AI*, targeting high school youth by utilizing an application-focused approach. We used Amaud Bodin's Python for High School [3] and a heavily revised version of Coursera's Convolutional Neural Networks as our essential learning materials.

We created the *Experiment with AI on Space Topics* Podcast series by utilizing AI-enabled assets, including music and voice [4].

We introduced our public audiences to the HiRISE image data from the NASA PDS with a custom HiRISE

dataset [5]. With the custom HiRISE dataset, we led our public audiences in training Generative Adversarial Networks (GANs) and also Diffusion models. Visual inspection of generated synthetic images during the actual training gives new learners a concrete experience about how an AI model generates synthetic images. Participants developed a deeper understanding of AI ethics through visual inspection of generated realistic images during the training processes with custom HiRISE dataset: if the data fed into the model are flawed from the start and then the AI model could be biased and discriminatory.

AI-based text-to-image systems generate synthetic images by algorithmically detecting features in large volumes of data. We engaged our participants in creating artworks themed on planetary explorations by leveraging the open-sourced text-to-image systems. Just like open-source software all these new AI-based text-to-image systems could not have been created without open sharing of software and data, and thus, we required that our participants (1) use text-to-image systems as part of their artistic toolbox, (2) view AI-generated images by prompts as open-source images, and (3) create artworks themed on planetary explorations with NASA's open data.

Many leading authors in AI/ML, including several researchers in University of Texas, Austin, helped us reaching out to our public audiences by giving Zoom talks and explaining their algorithms and models in plain English. Based on that, we introduced image super resolution, particularly ESRGAN, to our participants. By using ESRGAN, our participants were able to make many old photos during the Apollo missions print-quality high-resolution photos.

We presented our participants' artworks both online and also at the Art Gallery of the Clark County Library from March until May in 2022 [6] by collaborating with the Smithsonian Learning Lab which provided us a high-quality, free travelling exhibits on Apollo missions and other space missions. Afterwards, we were invited to submit our AI artworks for the Surviving Change collection which was on exhibit in 2023 at the Charleston Heights Arts Center, Las Vegas [7].

We have been introducing planetary explorations and leading-edge AI tools by invited speakers through

online webinar series and conducting hands-on workshops on implementation of Convolutional Neural Networks (CNNs) models, training GANs, diffusion models, and other generative AI models on Google Colab by utilizing Participatory Live Coding [8] since 2020. For our hands-on workshops, we have been using “use-modify-create” framework [9] throughout. Our staff write and narrate Python code out loud on Google Colab notebooks and invite the public audiences to join them by writing and executing the same code. New Beginners are given Colab notebooks and easy-to-follow instructions in order to reduce cognitive load.

Our high school participants have taken the opportunities to organize STEM clubs and gatherings at their own schools. For example, one of our high school participants (now an undergrad at Stanford University) organized the HiRISE+AI Club at the Clark High School in Las Vegas. Another high school student, a sophomore at the Great Neck South High School in NYC, has been participating in our programs and activities for years. She is now a student volunteer for our Planet+AI program and also a webinar moderator for most of our online webinars by invited speakers. She has been using our materials to organize Planet+AI gatherings at her school [10]. The recent AI-generated optical illusions gathering has been reaching out to a larger audience both at her own school and also with our online audiences.

We have been focusing on AI art (text-to-image / music / audio / video / animation / 3D), Large Language Models (LLMs), and other foundation models such as Segment Anything since March 2023. We led our public audiences in using Segment Anything developed by Meta for Apollo lunar rock thin sections in order to identify minerals in Apollo lunar rocks (See Figure 1). Our participants used AI video restoration techniques to restore the memorable old Apollo videos.

Future Efforts: We have been focusing on NASA’s Solar System Trek since years ago. Computer scientists at JPL have been introducing the Mars Trek back in 2022. We anticipate that utilizing the Solar System Trek, emerging AI/AR technologies, particularly text-to-3D systems, will lead us a journey, seeing planetary explorations through a magical lens where digital data, including images, videos, and 3D models, integrate seamlessly with the physical environment. We have also been actively researching Neural Radiance Field (NeRF) and 4D Gaussian Splatting techniques for dynamic rendering of Apollo lunar rocks.

Findings: Our efforts on Experimenting with AI/AR with planetary science data have been popular among our public audiences, particularly high school students. The spirit of experimentation is the key throughout our programs and activities. We anticipate

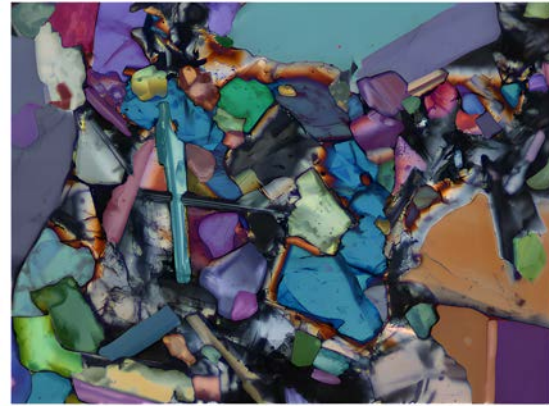


Figure 1 Segmenting Apollo thin section 60335.69 JSC08079-X5

that AI is going to take the transformative role despite their inherent risks and limitations. We anticipate that through our outreach programs and activities, our public audiences will utilize AI as a supportive tool as part of the toolbox which helps sharpen their skills. We expect that experimentation with AI needs careful navigation. We must play an active role in guiding our audiences about both potential benefits and also risks in order to reap rewards from AI benefits and protect against risks. We encourage our participants to critically assess and interrogate AI outputs, rather than passively accept them in order to reap the upsides while actively managing the downsides of using AI.

Acknowledgments: We are grateful for NASA TEAMII funding, NASA University of Tennessee Space Grant funding, and NSF AISL funding for the support of our STEM education and public outreach.

References:

- [1] <https://catalog.data.gov/dataset/national-artificial-intelligence-research-and-development-strategic-plan-2023-update>. [2] <https://pds.nasa.gov/>. [3] Bodin (2020). Python in High School: Algorithms and Mathematics. [4] <https://planet-ai-2023.github.io/tag/podcasts/>. [5] <https://hirise-pds.lpl.arizona.edu/PDS/>. [6] <https://thelibrarydistrict.org/blogs/post/nova77-stem-workshop-hiriseai/>. [7] <https://thelist.vegas/event/surviving-change-exhibition-talk/>. [8] Nederbragt et al. (2020) Ten quick tips for teaching with participatory live coding. PLoS Comput Biol 16(9): e1008090. [9] Lytle et al. (2019). Use, modify, create: Comparing computational thinking lesson progressions for stem classes. In *Proceedings of the 2019 ACM Conference on Innovation and Technology in Computer Science Education* (pp. 395-401). [10] <https://planet-ai-2023.github.io/2023/12/22/experimenting-with-ai-generated-optical-illusions-nyc/>.