Renewable Energy: Generation and Application - ICREGA'24 Materials Research Forum LLC
Materials Research Proceedings 43 (2024) 238-245 https://doi.org/10.21741/9781644903216-31

Impact of artificial intelligence (AI) in Martian architecture (exterior and interior)

Lindita Bande[1,a *], Jose Berengueres[1], Aysha Alsheraifi[1], Anwar Ahmad[1], Saud Alhammadi[1], Almaha Alneyadi[1], Amna Alkaabi[1], Maitha Altamimi[1], Yosan Asmelash[1]

[1] United Arab Emirates University, UAE

[a]lindita.bande@uaeu.ac.ae

Keywords: Martian Architecture, AI Tool, Critical Thinking, RHINO/Grasshopper

Abstract. Martian architecture has gained interest in the recent year. Several grand architectural studios have designed hypothetical buildings as part of a colony of the red planet. This study is a continuation of a previous research on mars Habitat. The use of AI to generate alternatives of design based on an initial idea gives insight of how technology can assist us in such major projects. The methodology followed in this study is as per the below steps: 1- General Description of the initial concept: Organic Architecture, 2- General Description of the initial concept: Minimal Architecture, 3- Use of AI in the selected projects, tool description, 4- Results: Outcomes of AI Applications. The aim of this study is to investigate the impact of the AI on Space Architecture, more specifically Martian Architecture. The initial step in the methodology is to design a colony that connects together but as also well distributed in the plan. The following step is using an AI tool to generate processed (rendered) images of the base image. These AI renders will then be analyzed and the final implication of the findings for the project will be described. The findings of this study can be relevant to relevant authorities in space exploration and space architecture with the help of AI tools.

Introduction

All manuscripts must be in English, also the table and figure text.

A new research outlines the design of Martian Habitat Units (MHUs) for extended human missions on Mars, prioritizing functionality, and aesthetics. Circular clusters of MHUs, each accommodating nine crew members, incorporate solar farms, nuclear fission, and wind turbines for energy. Lighting simulations demonstrate that a radial configuration maximizes natural light usage, meeting 36–44% of the lighting load. This information is crucial for planning energy-efficient systems on Mars. [1]

As per a recent article that discusses the design of a Mars research base for long-term habitation, incorporating art and architecture for a thriving lifestyle. Martian Habitat Units (HMUs) are designed with nuclear power, solar farms, and wind turbines, utilizing innovative features like Anti-Dust Settlement Membranes (ADSMs) for solar farm maintenance. The construction involves local grain 3D-printing, and the design prioritizes fail-safe procedures for crew safety. The technologies are based on current advancements, with potential reconsideration closer to the mission date. [2]

The text underscores escalating challenges in Mars missions due to increasing distance from Earth, jeopardizing ground support and crew capabilities. While fast-transit solutions may alleviate some hazards, they introduce novel risks and complexity. Extended exposure to microgravity raises concerns, requiring research into effective countermeasures. The communication delay and resupply constraints necessitate a shift towards autonomous human-system integration, urging urgent attention to develop and validate suitable architectures. [3]

Materials Research Proceedings 43 (2024) 238-245 https://doi.org/10.21741/9781644903216-31

The Mars Quantum Gravity Mission (MaQuIs) focuses on exploring Mars' gravitational field to study subsurface water occurrences and planetary dynamics. The paper outlines current knowledge, proposes satellite gravimetry using quantum technologies, and discusses scenarios for mission simulation. Authors highlight roles in assembling the consortium, estimating gravitational signals, and detailing inertial measurement systems for the mission. Future steps involve simulation scenarios, evaluating dependencies, and identifying limiting factors for the mission concept and technologies in the Martian environment. [4]

The passage highlights the application of machine learning in processing mass spectrometry data for future space missions. By using various artificial intelligence models, accurate results can be obtained quickly, benefiting in-flight processing. Root transformation and 2D spectrograms enhance accuracy, and pretrained convolutional neural networks (CNNs) perform exceptionally well. Generalization, model assembling, and proper training procedures are essential for small datasets. Increased data availability is crucial for further improvement, and machine learning analysis can be effectively run on the edge for future missions, particularly in analyzing sediments from Mars and other celestial bodies. [5]

The article introduces a GeoAI framework for accurate crater detection by integrating domain knowledge and scale-aware learning. Collaboration between computer scientists and Earth/space scientists enhances object detection models. The methodology aims to reduce the time for cataloging new craters, with future improvements planned for data completeness and efficiency optimization. The research envisions incorporating multi-source data to enhance detection accuracy, and the model and data will be open-sourced to encourage collaborative research in the field. [6]

A new research explores the application of AI methods for cyber risk analytics in extreme environments like outer space. It emphasizes adapting data strategies for collecting relevant cyber-risk data and leveraging IoT systems for diverse data streams. The review identifies potential impact assessment approaches, and the con-clusion introduces a quantitative version of the NIST 'traffic lights' system with multiple risk calculation metrics, enhancing cost and risk evaluation. The study pre-sents a mathematical formula for future cyber risk developments, focusing on coor-dination and reliability in AI/ML-based cyber protection for supply and control sys-tems while anonymizing risk data. [7]

Referring to an article that highlights the rapid growth in conversational studies, particularly in open-domain dialogue systems, with a thriving research community and increased industry efforts. The overview summarizes current progress and antic-ipates a promising future in the AI era, characterized by abundant data and powerful learning techniques. Despite facing challenges in improving conversational AI, the authors express optimism about advancing dialogue systems through dedicated ef-forts and resolving key issues. [8]

New research argues that despite a deep faith in human reason and experience, the main obstacle to a human mission to Mars is a technological barrier, compounded by increasing threats and risks. The author questions the urgent need for a long-term interplanetary program, citing challenges such as overpopulation, limited resources, and climate change. Additionally, the psychological challenges of living in a con-fined space, whether on Earth or in space, are highlighted, raising ethical questions about the quality of life in such conditions. The author suggests that mission planners should prioritize the human factor and consider broader interconnected factors in their planning. [9]

As per a new article reviews the current applications of Artificial Intelligence (AI) in environmental disciplines, emphasizing its role in managing and analyzing large datasets related to demographics, traffic, and energy usage. The integration of big data and AI provides new opportunities for environmental tasks such as model-ing, monitoring, and research. AI tools, particularly machine learning algorithms, contribute to real-time monitoring of air and water

Materials Research Proceedings 43 (2024) 238-245 https://doi.org/10.21741/9781644903216-31

quality, prediction of future trends, accurate detection of key fish species, and optimization of energy efficiency. Collaborations between ecology and data science are highlighted as crucial for effec-tive conservation efforts. [10]

Methodology

This study is a continuation of a previous research on mars Habitat. The use of AI to generate alternatives of design based on an initial idea gives insight of how technology can assist us in such major projects.

The methodology followed in this study is as per the below steps:

- General Description of the initial concept: Organic Architecture,
- General Description of the initial concept: Minimal Architecture,
- Use of AI in the selected projects, tool description.
- Results: Outcomes of AI Applications

General Description of the initial concept: Organic Architecture

The Martian Habitat based on Space Architecture concepts, designed in the likeness of flower petals, symbolizes the resilience of life in the Martian setting. It communicates a powerful message, affirming the existence and vitality of life in this challenging environment (figure 1-5).

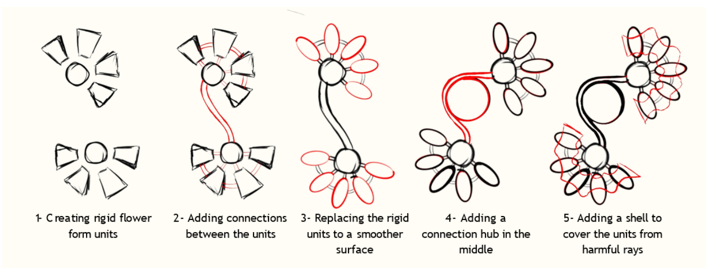


Figure 1. The design concept.

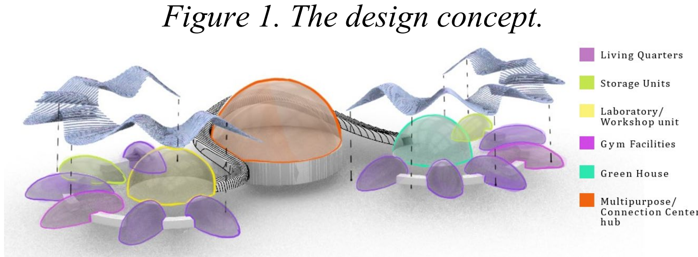


Figure 2. Function distribution in 3D.

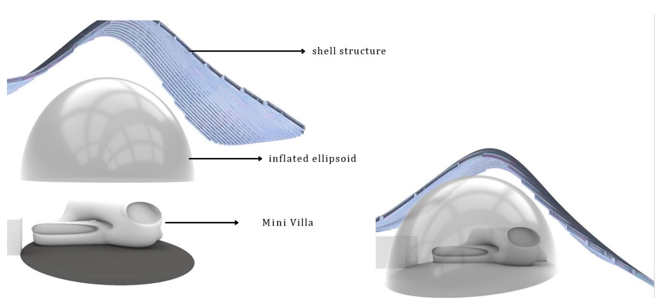


Figure 3. Unit Development, Exterior-Interior.

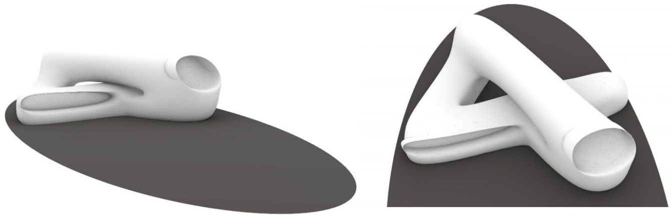


Figure 4. Intererior development, concept.

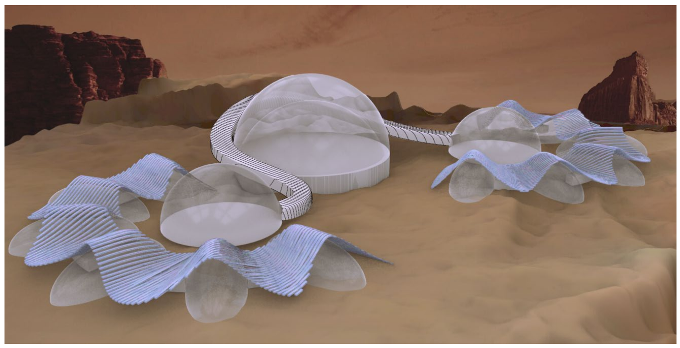


Figure 5. 3D Model from Rhino/Grasshoper, view 1.

General Description of the initial concept: Minimal Architecture

The minimalist Architectural approach uses the dome as the main element of construction. Considering the high radiation in the red planet this shape seems to be the most functional one on an initial stage. Furthermore, much deeper investigation is needed to explore the nature of the materials on the planet, their resistance, endurance, lifecycle. For the current study this particular process is focused on the design of the unit that would create a colony of humans.

Use of AI in the selected projects, tool description.

The use of AI to generate renders based on figure 5 was quite interesting. By adding several keywords and uploading the image the tool generated renders that are shown in the results. In this trial 8 options were selected for the evaluation. There are several options how an image is processed, realistic, creative, more AI Render tools - https://mnml.ai/app/exterior-ai (table 1).

Table 1. Keywords used in the AI Tool.

Options	Keywords
Organic Architecture	
Option 1	Martian architecture, desert landscape, universal light, rocks
Option 2	Islamic architecture, mountain view, desert landscaping and bright light
Option 3	modern architecture, desert view, hard landscape and day light
Option 4	parametric architecture, desert view, soft landscape and evening light
Option 5	minimal architecture, grey field view, soft landscape and morning light
Option 6	classic architecture, desert view, hard landscape and morning light

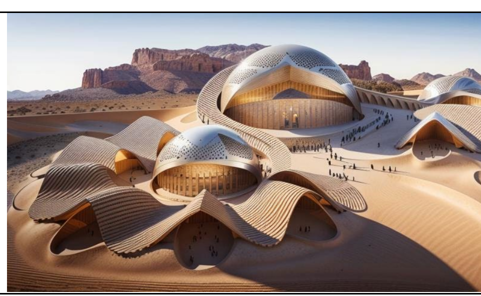
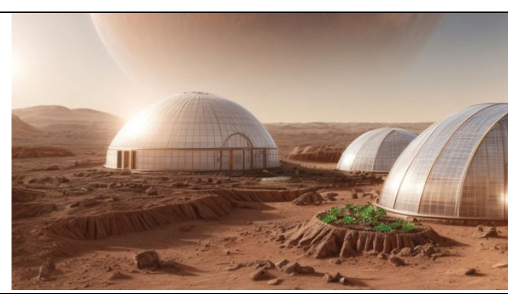
Option 7	concrete facade, modern architecture, rock landscape and evening light
Option 8	concrete facade, modern architecture, desert view, hard landscape and evening light

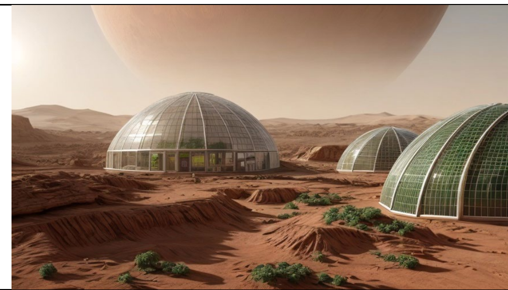
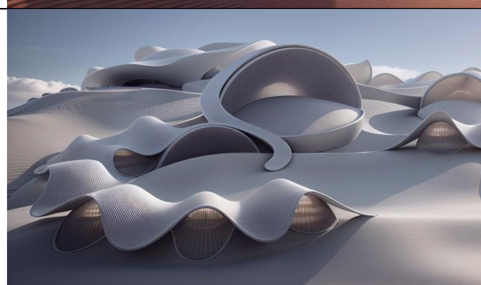
Meanwhile the tool used for the Minimalistic Design is PromeAI (Free AI art generator).The use of AI in architecture helps the designer to visualize and get a creative idea easily and continuously, with just a simple image you can create different buildings using different architectural styles. Everyone can create shapes using any 3d software like Revit or SketchUp and insert it in any AI rendering tools like Prome AI or ReRender AI and write any keyword like modern or classic and decide if the AI tool should change the shape and decide if the AI tool should be creative completely or to keep the shape but just put some ideas to the shape. AI tool will generate images that would save the architect some time in rendering because the architect will have a reference images. Prome AI allow you to generate 200 images every day, but the architect or student that have a membership in the website the images that is generated using the tool will be unlimited. Prome AI generate 3 images so that you choose the best one. There are many tools in the Prome AI for example erase and replace tool which you can select what you want to change in the image. 2d images also can be used in AI tools to generate a creative piece of art. Choosing the mood and the place that you want the building to be in can be easilty created using AI for example of you want the building to be in mars AI can make it happen. For example, if you want the building to float in the sea AI will generate it to your imaginations. Some AI tool have some restrictions to what you can do with them (number of imaged to generate, the architecture style, the creativity, Etc.).

Results

The results of the 8 trials in organic architecture and minimalistic architecture are shown in table 2. Each option has a different outcome impacting the shape of the building, the openings, the relation to the outdoor. However, the shell structure remains in both scenarios.

Table 2. Ai Generated images from AI Tool

Ai Generated images from AI Tool		
Organic Architecture		Minimal Architecture
Option 1		
Option 2		

Option 3		
Option 4		
Option 5		
Option 6		
Option 7		
Option 8		

Discussion and Conclusions

Discussions

This study highlights the benefits of AI tools in architectural education, demonstrating how it can assist students, especially in designing sustainable houses in challenging environments like the Mars. The results are in agreement with similar studies elsewhere (Tholander et al. 2023; Ildirim et al. 2023). Said tools offer a variety of design options, which are instrumental in aiding critical assessment and decision-making. Regarding the implications for Martian architecture itself, the results underscore an awareness for the need for energy-efficient design while considering Mars' unique environmental challenges, such as radiation and dust storms. We note the ability of AI generated designs to incorporate and balance both functionalities, like energy systems and dust protection, and aesthetics. Furthermore, the broader implications of these findings extend beyond academic settings. They offer valuable insights for the space exploration industry, indicating that AI tools can significantly enhance the added value of the design process (figure 6).

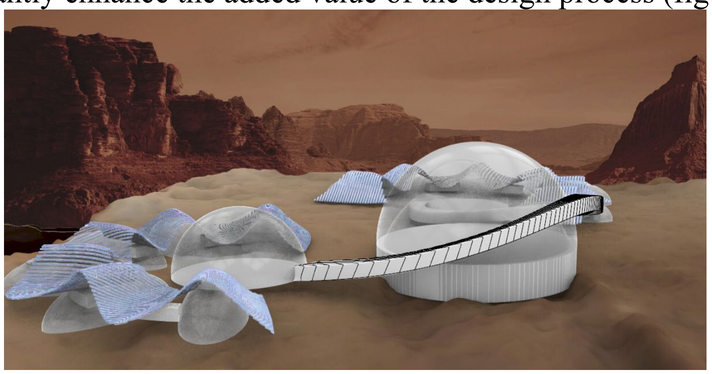


Figure 6. 3D Model from Rhino/Grasshoper, view 2.

Conclusions

The profound impact of Martian exploration efforts in driving progress is undeniably significant. Similar to the Apollo missions five decades ago, as noted by Comstock (2007), the research and development (R&D) outcomes from Mars missions are anticipated to enhance life quality on Earth as well. For instance, the development of computers is attributed to the Apollo space missions. Notably, the Apollo 11 moon landing in 1969 played a crucial role, perhaps unintentionally, in advancing computer technology. The Apollo Guidance Computer (AGC), created for the Apollo program to navigate and guide spacecraft, was among the first to incorporate integrated circuits (ICs). Other notable developments from the Apollo missions included advancements in satellite TV, water purification systems, and new insulating materials for spacecraft, now utilized in building construction (Denver et al., 1981). These findings hold particular relevance for space exploration authorities and architectural firms specializing in extreme environments, demonstrating, as corroborated by other sources, the potential of AI to enhance creative processes. (figure 7).

References

[1] Amini, K., Janabadi, E.D. and Fayaz, R. (2022) 'Lighting and illumination investigation of long-term residence on Mars for the case of a set of designed martian habitat units (mhus)', Acta Astronautica, 192, pp. 210–232. https://doi.org/10.1016/j.actaastro.2021.12.021

[2] Amini, K. et al. (2022) 'Design of a set of habitat units and the corresponding surrounding cluster for long-term scientific missions in the pre-terraforming era on Mars', Icarus, 385, p. 115119. https://doi.org/10.1016/j.icarus.2022.115119

[3] Valinia, A. et al. (2023) 'Risk trade-space analysis for Safe Human Expeditions to Mars', Acta Astronautica, 211, pp. 192–199. https://doi.org/10.1016/j.actaastro.2023.05.039

[4] Wörner, L. et al. (2023) 'Maquis—concept for a mars quantum gravity mission', Planetary and Space Science, 239, p. 105800. https://doi.org/10.1016/j.pss.2023.105800

[5] Nasios, I. (2024) 'Analyze mass spectrometry data with artificial intelligence to assist the understanding of past habitability of Mars and provide insights for future missions', Icarus, 408, p. 115824. https://doi.org/10.1016/j.icarus.2023.115824

[6] Hsu, C.-Y., Li, W. and Wang, S. (2021) 'Knowledge-driven geoai: Integrating spatial knowledge into multi-scale deep learning for Mars Crater Detection', Remote Sensing, 13(11), p. 2116. https://doi.org/10.3390/rs13112116

[7] Radanliev, P. et al. (2020) 'Design of a dynamic and self-adapting system, sup-ported with Artificial Intelligence, machine learning and real-time intelligence for predictive cyber risk analytics in extreme environments – cyber risk in the colonization of Mars', Safety in Extreme Environments, 2(3), pp. 219–230. https://doi.org/10.1007/s42797-021-00025-1

[8] Yan, R. and Wu, W. (2021) 'Empowering conversational AI is a trip to Mars: Progress and future of open domain human-computer dialogues', Proceedings of the AAAI Conference on Artificial Intelligence, 35(17), pp. 15078–15086. https://doi.org/10.1609/aaai.v35i17.17771

[9] Szocik, K. (2019) 'Should and could humans go to Mars? yes, but not now and not in the near future', Futures, 105, pp. 54–66. https://doi.org/10.1016/j.futures.2018.08.004

[10] Konya, A. and Nematzadeh, P. (2024) 'Recent applications of AI to Environmental Disciplines: A Review', Science of The Total Environment, 906, p. 167705. https://doi.org/10.1016/j.scitotenv.2023.167705