



Generative AI for Citizen Science



Mars for All

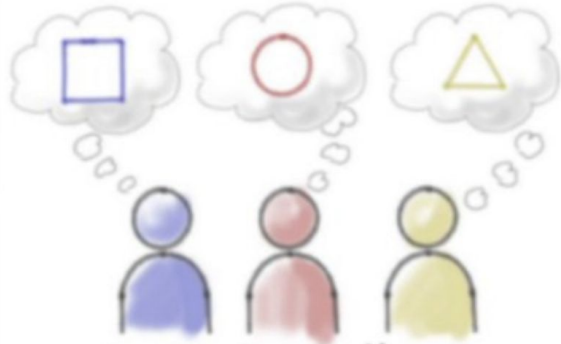
**October
2023**

**Erik Bethke
Million on Mars**

erik@milliononmars.com

LinkedIn: [erikbethke](#)





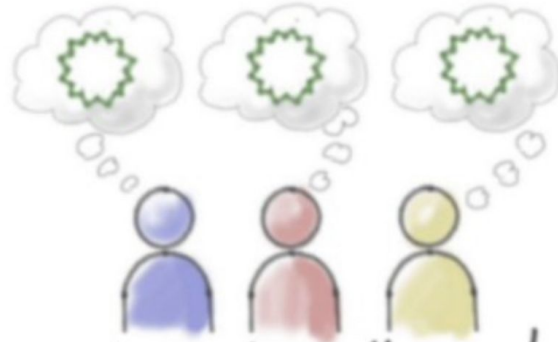
I'm glad we all agree.



oh...



ah ha!



I'm glad we all agree!

What do you think is the meaning of this image?



The image portrays the concept of group dynamics and perspectives. Specifically:

1. In the first panel, each individual has a different shape in mind, but they seem to think they're on the same page, as indicated by the text "I'm glad we all agree."
2. In the second panel, when the actual shape (a square) is revealed, it's evident that none of them were thinking of the same thing, leading to a moment of realization with the caption "oh..."
3. In the third panel, the figures are shown with different shapes again, but this time there's an "ah ha!" moment, indicating a sudden realization or insight.
4. The last panel shows that, after some discussion or thought, all have come to a consensus or shared understanding, as they all envision the same shape and the caption reaffirms "I'm glad we all agree."

Overall, it seems to highlight the importance of communication, understanding, and alignment in group settings. It suggests that even if individuals think they are aligned, without clear communication, misunderstandings can occur. But with effort and discussion, a shared understanding can be achieved.

Idea Generation:

AI can help brainstorm research questions or experimental setups, acting as a virtual "thought partner."



Unleashing the Power of Generative AI for Citizen Scientists

Self-Funding Advantage:

Skip the grant hustle and focus on the work.

Resource Constraint:

A blessing in disguise. Pick projects that fit your budget.

Productivity Gains:

Reports show 15% to 40% increases, even up to 4x for software engineers.

Think: you now have another \$50-300k a year in effective funding from leveraging AI





Please find for me scientific papers that are focused on large scale aeroponics. Please give special attention to the papers that are highly cited, and give extra special attention to papers that cover aeroponics in space settlements - Mars, Moon, LEO, GEO



Finished browsing

Here are some scientific papers and reviews on large-scale aeroponics and aeroponics in space settlements:

Large-Scale Aeroponics on Earth:

1. **"Aeroponics: A Review on Modern Agriculture Technology"** discusses the advancements in aeroponic technology over the years. [Aeroponics: A Review on Modern Agriculture Technology...](#)  sive method of crop production in today's agricultural industry¹.
2. **"Modern plant cultivation technologies in agriculture under controlled environment: a review on aeroponics"** by Imran Ali Lakhier et al., discusses aeroponic cultivation under controlled environments².

Aeroponics in Space Settlements:

1. **"Large-Scale Crop Production for the Moon and Mars: Current Gaps and Future Perspectives"** by Lucie Poulet et al., discusses the challenges and efforts concerning large-scale space crop production, notably on the Moon and Mars. It emphasizes the need for advanced automation, robotics, modeling, and [Frontiers | Large-Scale Crop Production for the Moon and...](#)  convection in microgravity, scheduling and logistics, and crew time issues³.

Advanced Data Analysis ①



[2022] Poulet et al. Large-Scale Crop Pr...
PDF

Please summarize this paper for the perspective of a citizen scientist, a professional from another domain who is looking into applying aeroponics for space settlements as a stretch hobby



I'll go ahead and read the paper to provide a summary from the perspective you're interested in. One moment, please.

Finished working

Show work ▼

It appears that the text extraction from the PDF isn't very clean, making it difficult to read and summarize the content. Would you like me to attempt another method to extract the content, or would you prefer to provide some key points for me to focus on in the paper?



fspas-08-00226.xml
File

Let's try this XML version of the paper....



Working... ⚡

Show work ▼





Finished working

Show work ▾

Great, the XML version is much cleaner. Here's a summarized bullet-point perspective for a citizen scientist or a professional looking to apply aeroponics for space settlements:

Title

- Large-Scale Crop Production for the Moon and Mars: Current Gaps and Future Perspectives

Key Points

- **Challenges in Space Farming:** Microgravity affects convection, complicating plant growth. Logistics and crew time are also factors.
- **Nutrients & Water:** The paper discusses the need for recycling nutrients and water for sustainable farming.
- **Crop Choices:** Emphasizes the need for selecting crops that are nutrient-dense and can be grown in confined spaces.
- **Technology Needs:** Automation and AI could play a big role in managing these systems.

Takeaway for You

- Aeroponics might be a solid choice for space farming due to its water efficiency and potentially easier control in microgravity.
- Automation is your friend; given your background, you could contribute by developing systems that make space farming less labor-intensive.

Would you like to know more details about any of these points?



Please go into depth on convection and how it complicates plant growth



Absolutely, let's dive in:

Convection in Microgravity vs Earth

- **Earth:** On Earth, convection helps circulate air and water, facilitating nutrient uptake and gas exchange for plants.
- **Space:** In microgravity, natural convection is weaker or non-existent. This affects how air and water move around the plant.

Complications for Plant Growth

- **Nutrient Uptake:** Weak convection can lead to nutrient imbalances. Nutrients might not circulate effectively, affecting plant health.
- **Gas Exchange:** Reduced air circulation can affect the CO₂/O₂ balance, crucial for photosynthesis and respiration.
- **Water Distribution:** Ineffective water movement could lead to waterlogged or dry conditions at the root zone.
- **Heat Distribution:** Lack of convective heat transfer could lead to uneven temperatures, affecting metabolic rates.

Why It Matters for Aeroponics

- **Misting:** In aeroponics, nutrients are delivered via mist. Weak convection could affect the mist distribution, leading to uneven nutrient delivery.
- **Oxygenation:** Aeroponics systems often rely on air exposure for root oxygenation. Weak air movement could complicate this.



I am at the Mars Society conference, so naturally we are all a bit more focused on Mars with the 38% gravity. It seems that many of these effects are dramatically lessened going from micro gravity to substantial fractional gravity.

What goes to a lesser concern pile, and what remains an item for direct focus?



That's a great context, Erik. Mars' 38% gravity does change the game a bit compared to microgravity environments like the ISS. Here's how the concerns shift:

Lesser Concern Pile

- **Nutrient Uptake:** With some gravity in play, nutrient-rich water would more reliably reach the root zone in aeroponics systems.
- **Gas Exchange:** The CO₂/O₂ balance would be less tricky to maintain, as some natural air circulation would occur.
- **Heat Distribution:** Fractional gravity will help with more natural heat dispersion, reducing "hot spots."

Direct Focus Items

- **Water Distribution:** While improved, you'd still need to focus on ensuring even water distribution, especially in aeroponic misting systems.
- **Crop Selection:** Gravity or not, space on Mars is at a premium. Opting for high-yield, nutrient-dense crops remains critical.
- **Automation:** Crew time is valuable, and you'd still benefit from AI and automation for monitoring and adjustments.

Given your interest in leveraging AI, the reduced focus on convection allows you to channel your expertise into optimizing other elements, like automating nutrient and water cycling or advanced crop monitoring.



Scenario 1: Optimizing Misting Cycles

- Hypothesis: AI-driven misting cycles can optimize water and nutrient distribution in Mars-like gravity, outperforming static schedules.
- AI-aided Test: Use sensors to measure nutrient levels, soil moisture, and plant health. The AI adjusts misting cycles in real-time based on these metrics. Compare against a control group with a static misting schedule.

Scenario 2: Crop Selection AI

- Hypothesis: Machine learning can predict the best crops for Mars-based aeroponics by analyzing multiple variables like growth rate, nutrient density, and resource requirements.
- AI-aided Test: Use existing agricultural data to train a machine learning model. Test its predictions in a simulated Mars environment and measure metrics like yield, nutrient density, and resource usage.

Scenario 3: Automated Stress Response

- Hypothesis: An AI system can detect and mitigate stress conditions in crops faster and more effectively than manual monitoring, under Mars-like gravity.
- AI-aided Test: Implement AI algorithms to analyze real-time sensor data for signs of plant stress (e.g., changes in leaf color, reduced growth rate). The system autonomously adjusts environmental conditions (light, nutrients) and compares outcomes to a manually-managed control group.



fspas-08-00226.xml

File

Lets pretend that we have run an aeroponics study on growing tomatoes, what sort of data is likely to be there - time, light levels, yield, fertilizer in the water etc... make some sample data, and a sample bit of Python to load that data and manipulate it



Great! Let's first create some sample data for the aeroponics study on growing tomatoes.



The data might include:

- Time (hours)
- Light Levels (lumens)
- Yield (grams)
- Fertilizer Concentration in water (ppm)
- pH levels
- Air Temperature (°C)

Here's how the sample data might look in CSV format:

csv

 Copy code

```
Time,Light_Level,Yield,Fertilizer_Concentration,pH_Level,Air_Temperature
0,2000,0,20,6.5,25
1,2000,0,20,6.5,25
2,2000,0,20,6.5,25
...
23,2000,10,20,6.5,25
24,2000,15,20,6.5,25
25,2000,15,20,6.5,25
...
```

I'll generate this sample data first, and then write some Python code to load and manipulate it.

Scripts and Code

Do you know what you want?*

Break your problem down into smaller Qs

The code will come iteratively

I do it every day!

* Many people have trouble on this step

python

 Copy code

```
# Load the CSV into a DataFrame
df_loaded = pd.read_csv(csv_file_path)

# Filter rows where yield is greater than 20 grams
high_yield_df = df_loaded[df_loaded['Yield'] > 20]

# Calculate the average light level for high-yield records
avg_light_level_high_yield = high_yield_df['Light_Level'].mean()

high_yield_df.head(), avg_light_level_high_yield
```

RESULT

4	4	1871	24	24	6.0
7	7	1902	23	22	6.7
9	9	2014	43	18	6.2

Air_Temperature

0	24
2	25
4	26
7	26
9	26 ,
2007.4920634920634)	

Here's what I've done:

- Loaded the CSV into a DataFrame
- Filtered out rows with yields greater than 20 grams
- Calculated the average light level for these high-yield records, which is approximately 2007.49 lumens

Generative AI can help create or suggest effective ways to visualize complex data, enhancing the understanding of research findings.

Tables

Summary Table: Key Performance Indicators

- Rows: KPIs like water usage, energy consumption, average nutrient levels
- Columns: AI-optimized, Static Schedule, % Improvement

Event Log Table: AI Decisions

- Columns: Timestamp, Adjusted Variable (e.g., misting duration), Old Value, New Value

Anomaly Table: Detected Anomalies and Responses

- Columns: Timestamp, Anomaly Detected, AI Action, Outcome

Charts

Time-Series Line Chart: Nutrient Levels Over Time

- X-axis: Time (in days or hours)
- Y-axis: Nutrient concentration (in ppm)
- Series: AI-optimized vs. Static Schedule

Heatmap: Soil Moisture Distribution

- X-axis: Spatial location (e.g., grid squares in the growing area)
- Y-axis: Time (in days)
- Color: Soil moisture levels

Box Plot: Plant Health Metrics

- X-axis: Metrics like leaf count, height, chlorophyll levels
- Y-axis: Value ranges
- Boxes: AI-optimized vs. Static Schedule

Radar Chart: Overall System Performance

- Axes: Water usage, nutrient efficiency, plant health, energy consumption
- Series: AI-optimized vs. Static Schedule

•

Slide Title: The Rocket Equation & Generative AI

$$\Delta v = v_e \ln \left(\frac{m_i}{m_f} \right)$$

- Δv : Change in velocity of the rocket
- v_e : Exhaust velocity of the rocket engine
- m_i : Initial mass of the rocket
- m_f : Final mass of the rocket after burning fuel

latex

 Copy code

```
\begin{frame}{The Rocket Equation \& Generative AI}

\[
\Delta v = v_e \ln \left( \frac{m_i}{m_f} \right)
\]

\textbf{Where:}

\begin{itemize}
  \item \(\Delta v\) : Change in velocity of the rocket
  \item \(\ v_e\) : Exhaust velocity of the rocket engine
  \item \(\ m_i\) : Initial mass of the rocket
  \item \(\ m_f\) : Final mass of the rocket after burning fuel
\end{itemize}

\textbf{Generative AI Can Help:}

\begin{itemize}
  \item Optimize fuel usage
  \item Simulate various scenarios
  \item Assist in mission planning
\end{itemize}

\end{frame}
```

Leveraging AI for Optimized Misting Cycles in Mars-Based Aeroponics

Abstract

- Brief overview of the problem, the method (AI-optimized misting cycles), and the key findings. Highlight labor savings and citizen science empowerment.

Introduction

- Context of Mars colonization and the role of aeroponics.
- Importance of optimizing misting cycles.
- The potential for AI and its importance for citizen scientists.

Literature Review

- Previous work on aeroponics and Mars agriculture.
- The role of AI in agriculture and space

Objectives and Hypotheses

- Statement of the research question: "Can AI-driven misting cycles optimize water and nutrient distribution in Mars-like gravity?"
- Hypotheses, including expected outcomes and their significance.

Methodology

- Description of the aeroponic setup.
- AI algorithms used.
- Sensor types and placements.
- Control vs. experimental group.
-

Data Collection

- Description of data types: nutrient levels, soil moisture, plant health.
- Data collection methods and frequency.

Charts and Tables

- Time-Series Line Chart: Nutrient Levels Over Time
- Heatmap: Soil Moisture Distribution
- Box Plot: Plant Health Metrics
- Summary Table: Key Performance Indicators
- Event Log Table: AI Decisions
- Anomaly Table: Detected Anomalies and Responses

Analysis

- Interpretation of the charts and tables.
- Findings related to the hypotheses.

Discussion

- Implications of the results.
- Limitations and suggestions for future work.
- Specific note on labor savings and potential for citizen scientists to leverage this research.

Conclusion

- Summary of key findings and their broader implications.

Acknowledgments

- Thanks to contributors and advisors.

References



I know this is all just hand-wavy, but from the title how is our experimental design to address the Mars gravity piece?

!?



Ah, gotcha. Simulating Mars-like gravity on Earth for plants is a challenge. While mechanical setups like centrifuges work for small-scale, short-duration experiments, they're not practical for a plant growth cycle.

Potential Workarounds

1. **Reduced Pressure Environments:** While not a direct proxy for gravity, you could experiment with reduced pressure to simulate some aspects of Mars. This could have an effect on how mist behaves, for example.
2. **Computational Simulation:** Use computational models to predict how the AI-driven misting system would behave under Mars-like gravity. While not as convincing as empirical data, a well-validated model can be persuasive.
3. **Data from Previous Mars Missions:** Use existing data on soil and environmental conditions from Mars rovers or landers to inform the AI model. This is a bit of a stretch but could add some Mars-specific context.

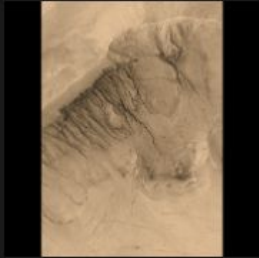
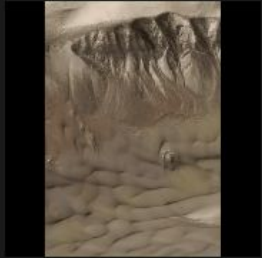
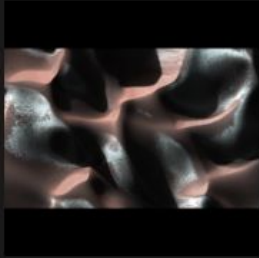
Modified Experimental Groups

- **Group 1:** Control group with static misting schedule, under Earth conditions.
- **Group 2:** AI-optimized misting, under Earth conditions.
- **Group 3:** AI-optimized misting, under reduced pressure conditions.
- **Group 4:** Computational model predictions for AI-optimized misting under Mars-like gravity.

Methodology Section Update

Specify that Groups 1-3 are empirical, while Group 4 relies on computational simulation informed by existing data and known physical laws relating to gravity's effect on fluid dynamics and plant physiology.

Training images



Generative AI Art



Great Terrain!

Search (ex. 'sunset', 'castle', 'blue')

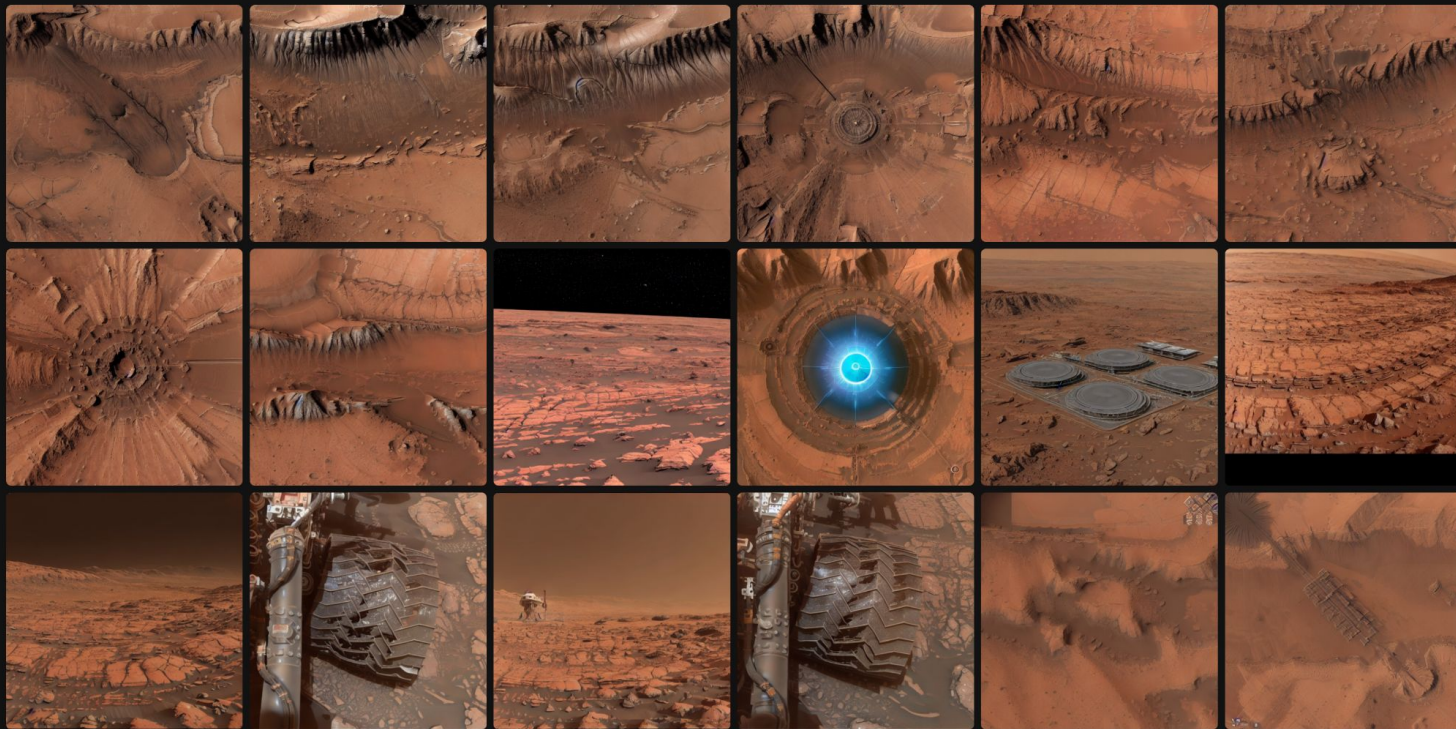


Generator

MarsTerrain2

+ Collections

+ Generate Images



But is AI Ethical? Plagiarism?

Trained on vast data, but what about ethics? Is it plagiarism or progress?

AI's Core Function: It's all about compressing and decompressing knowledge.

Science is Original Generative AI

The Scientific Method discovers and compresses mechanics of the universe into models





Decompressing on Mars

Compressing Civilization:

To settle Mars, we need to compress all of human knowledge—science, technology, art, music

Decompressing on Mars:

Unfurl that compressed knowledge to build a new world

Thank you!

Selected Generative AI Tools

- GPT4
- Midjourney
- Eleven Labs

AI News

<https://theaibreakdown.beehiiv.com/>

Prompting Guides

<https://github.com/openai/openai-cookbook>

<https://www.promptingguide.ai/>

erik@milliononmars.com

LinkedIn: [erikbethke](#)

Company: <https://www.milliononmars.com>



Thank you

erik@milliononmars.com



Time-Dependent Schrödinger Equation in 3D (Spherical Coordinates)

$$i\hbar \frac{\partial \Psi}{\partial t} = \left[-\frac{\hbar^2}{2\mu} \left(\frac{\partial^2}{\partial r^2} + \frac{2}{r} \frac{\partial}{\partial r} + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial}{\partial \theta} \right) + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2}{\partial \phi^2} \right) + V(r, \theta, \phi, t) \right] \Psi$$

Where:

- Ψ is the wave function
- t is time
- μ is the reduced mass
- r, θ, ϕ are the spherical coordinates
- $V(r, \theta, \phi, t)$ is the potential energy

latex

 Copy code

```
\begin{frame}{Advanced Quantum Mechanics \& The Power of Generative AI}

\textbf{Time-Dependent Schrödinger Equation in 3D (Spherical Coordinates)}

\[
i\hbar \frac{\partial \Psi}{\partial t} = \left[ -\frac{\hbar^2}{2\mu} \left( \frac{\partial^2}{\partial r^2} + \frac{2}{r} \frac{\partial}{\partial r} + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left( \sin \theta \frac{\partial}{\partial \theta} \right) + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2}{\partial \phi^2} \right) + V(r, \theta, \phi, t) \right] \Psi
\]

\textbf{Where:}

\begin{itemize}
    \item  $\Psi$  is the wave function
    \item  $t$  is time
    \item  $\mu$  is the reduced mass
    \item  $r, \theta, \phi$  are the spherical coordinates
    \item  $V(r, \theta, \phi, t)$  is the potential energy
\end{itemize}

\textbf{Generative AI Can:}

\begin{itemize}
    \item Solve complex quantum systems
    \item Simulate quantum phenomena in exoplanetary conditions
    \item Assist in cutting-edge research for new propulsion technologies
\end{itemize}

\end{frame}
```