Simulated Profiling Environment for Embodied Intelligence (SPEEN)

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Abstract

The Simulated Profiling Environment for Embodied Intelligence (SPEEN) is an open-source platform for evaluating embodied Large Language Model agents in a simulated game environment. As LLMs increasingly integrate into robotics and embodied systems, SPEEN addresses the need for standardized evaluation frameworks by providing a well-documented, modifiable environment for benchmarking these agents. The framework offers both structured quantitative benchmarking through diverse scenarios measuring specific capabilities and an open-world sandbox for qualitative assessment of decision-making behaviors over extended periods. These complementary approaches enable researchers to evaluate how effectively embodied LLMs solve unseen tasks, communicate, and interact with responsive environments—key metrics for real-world applications of embodied AI systems.

1 Early Development

1.1 Background

This project originated as a Senior Design Project at UC Davis, where students collaborate with industry professionals to develop solutions addressing practical needs. We were particularly interested in working with Justin Jia (affiliated with Apple), who proposed developing a sandbox environment specifically designed for testing AI programs. Initial discussions and exploratory research guided our focus toward Large Language Models (LLMs) as a primary technology of interest.

1.2 Exploratory Research

1.2.1 Focusing on Large Language Models

Our research identified significant gaps in environmental design for evaluating advanced AI systems. We examined existing benchmarking platforms, particularly NeuralMMO, which provides an open-source environment for measuring **reinforcement learning** algorithm performance. NeuralMMO is a game environment with high discrete input complexity, requiring agents to navigate a 2D grid world with tasks including resource management, exploration, and agent interaction. After studying its development trajectory, we observed that advanced algorithms like Proximal Policy Optimization (PPO), given sufficient compute, could effectively solve most presented tasks regardless of the environment's complexity.

This observation shifted our focus from reinforcement learning toward Large Language Models, which represent more recent advancements in artificial intelligence. We were particularly interested in the growing integration of LLMs into robotics and embodied systems. One crucial insight from Joseph Suarez, NeuralMMO's creator, significantly influenced our approach:

> "It is very easy to create an interesting looking simulator. It is very hard, under the constraints of making useful AI research [to create an environment meant for testing and training AI]... it is not just a game, it is an AI simulation."**[TODO]**cite his thesis defense

Definitions We define agentic AI as systems capable of autonomous decision-making and environmental interaction. Embodied AI, our primary focus, represents a subset specifically concerned with agents that interact with physical or simulated physical worlds.

Environment Design Several proposed embodied AI architectures use Minecraft as their testing environment. While Minecraft offers inherent complexity and extensive documentation, it presents significant limitations for research purposes. First, it requires a commercial license, creating accessibility barriers for researchers. Second, there is no standardized method for providing game state information to agents. Third, the environment was not specifically designed to test embodied AI capabilities.

Although environments that more closely emulate the real world would provide better mapping for real-world robotic applications, we determined that focusing our efforts on standardizing contextualization and prompting systems would be more beneficial. This justified our decision to develop a Minecraft-like environment using the open-source Godot game engine, with a focus on creating flexible prompting and context-provision systems that could later be adapted to more realistic environments.

Open-Source Requirements Our research identified that many successful LLM evaluation solutions are not open-source, limiting their utility for broader research purposes. By building our system with easy integration of new LLMs and prompting architectures, we aim to address this limitation. Our open-source approach ensures transparency, reproducibility, and adaptability—core values for scientific research tools. This constraint guided our decision to use the Godot game engine, which is open-source and allows for easy modification and expansion, and we believe is heading in a positive directions for potential use in environment design and research.

Recap: Project Justification Based on our research findings, we developed SPEEN as an open-source benchmarking environment specifically for evaluating embodied AI performance. In terms of open-source, our designed hope to ensure: easy modification, comprehensive documentation, and adherence to best practices to ensure project longevity. The prompting architecture was engineered to be easily expandable across environment types, allowing for future development of additional architectures or application to different environments. For the purpose of developing a sufficient proof of concept, we also developed a Minecraft-like environment that uses our prompting architecture, providing quantitative and qualitative evaluation use cases. Our design deliberately targets researchers and enthusiasts by addressing the identified limitations in existing systems.

1.3 Technologies

We first needed an environment with which the LLMs can interact with for benchmarking. Game engines are the best option to streamline the creation of simulated environments because they provide the tools for us to conveniently build our environments while abstracting low-level calculations and implementations that would greatly hinder our project development. In spirit of our open-source requirement, we chose Godot to be our game engine due to it also being open-source and many of the project members are familiar with using the game engine, reducing the overhead of learning the fundamentals of using a game engine. Minecraft as our simulated environment would've been ideal since the environment is already made and rich with game features to test the LLMs on, removing the portion of our project timeline to develop the environment. However, Minecraft is not an open-source game which is a required attribute for our project. Furthermore, users of our projects would have to buy a license for the game which restricts accessibility, another core attribute of this project.

We intend for our project to work with any LLMs, cloud-hosted or locally-hosted, so that users can use our project to benchmark currently existing and developing LLMs. Additionally, we need LLMs to test our implementation of our LLM and agent body pipelines. Thus, we chose GPT o-models, Gemini 2.0 Flash-lite, Ollama 4, and Deepseek as our set of models for testing. GPT and Gemini served as test subjects that guided our integration of cloud-hosted LLMs to Godot while Ollama and

Deepseek serves the same purpose but for locall-hosted LLM integration. We also wanted to provide a suite of default options for the users to streamline setup and provide a reference on how they can integrate their own LLMs to our project.

Our implementation required selecting appropriate technologies for both the simulation environment and LLM integration. We chose the Godot game engine for environment development due to its open-source nature, robust capabilities, and team familiarity, which reduced development overhead. While Minecraft would have provided a ready-made rich environment, its proprietary nature conflicted with our open-source requirements and would have imposed licensing costs on users.

For LLM integration, we designed a flexible architecture supporting both cloud-hosted and locally-hosted models. We implemented and tested integration with multiple models including GPT, Gemini 2.0 Flash-lite, Ollama, and Deepseek. This diversity allowed us to develop robust integration patterns while providing users with default options that demonstrate how to connect additional models. Our implementation includes a standardized API interface that abstracts the underlying model specifics, allowing researchers to easily benchmark different LLMs the same environment.

2 Implementation

Paragraphs There is also a `\paragraph` command available, which sets the heading in bold, flush left, and inline with the text, with the heading followed by 1 em of space.

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These instructions apply to everyone.

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The `natbib` package will be loaded for you by default. Citations may be author/year or numeric, as long as you maintain internal consistency. As to the format of the references themselves, any style is acceptable as long as it is used consistently.

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```
http://mirrors.ctan.org/macros/latex/contrib/natbib/natnotes.pdf
```

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```
\citet{hasselmo} investigated\dots
```

produces

> Hasselmo, et al. (1995) investigated…

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```
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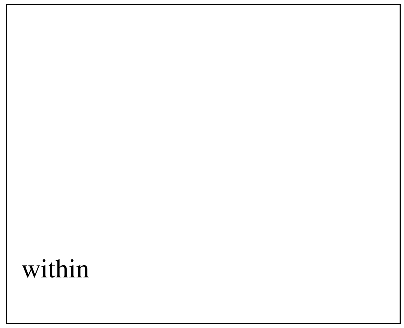

Figure 1: Sample figure caption.

Table 1: Sample table title

Part		
Name	Description	Size (μm)
Dendrite	Input terminal	$\sim$100
Axon	Output terminal	$\sim$10
Soma	Cell body	up to 10^6

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Footnotes should be used sparingly. If you do require a footnote, indicate footnotes with a number[1] in the text. Place the footnotes at the bottom of the page on which they appear. Precede the footnote with a horizontal rule of 2 inches (12 picas).

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Note that publication-quality tables *do not contain vertical rules.* We strongly suggest the use of the `booktabs` package, which allows for typesetting high-quality, professional tables:

`https://www.ctan.org/pkg/booktabs`

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[1] Sample of the first footnote.
[2] As in this example.

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- `xfig` "patterned" shapes are implemented with bitmap fonts. Use "solid" shapes instead.
- The `\bbold` package almost always uses bitmap fonts. You should use the equivalent AMS Fonts:

  ```
  \usepackage{amsfonts}
  ```

  followed by, e.g., `\mathbb{R}`, `\mathbb{N}`, or `\mathbb{C}` for $\mathbb{R}$, $\mathbb{N}$ or $\mathbb{C}$. You can also use the following workaround for reals, natural and complex:

  ```
  \newcommand{\RR}{I\!\!R} %real numbers
  \newcommand{\Nat}{I\!\!N} %natural numbers
  \newcommand{\CC}{I\!\!\!\!C} %complex numbers
  ```

  Note that `amsfonts` is automatically loaded by the `amssymb` package.

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4.1 Margins in LaTeX

Most of the margin problems come from figures positioned by hand using `\special` or other commands. We suggest using the command `\includegraphics` from the `graphicx` package. Always specify the figure width as a multiple of the line width as in the example below:

```
\usepackage[pdftex]{graphicx} ...
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```

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Acknowledgments and Disclosure of Funding

Use unnumbered first level headings for the acknowledgments. All acknowledgments go at the end of the paper before the list of references. Moreover, you are required to declare funding (financial activities supporting the submitted work) and competing interests (related financial activities outside the submitted work). More information about this disclosure can be found at: `https://neurips.cc/Conferences/2025/PaperInformation/FundingDisclosure`.

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[1] Alexander, J.A. & Mozer, M.C. (1995) Template-based algorithms for connectionist rule extraction. In G. Tesauro, D.S. Touretzky and T.K. Leen (eds.), *Advances in Neural Information Processing Systems 7*, pp. 609–616. Cambridge, MA: MIT Press.

[2] Bower, J.M. & Beeman, D. (1995) *The Book of GENESIS: Exploring Realistic Neural Models with the GEneral NEural SImulation System.* New York: TELOS/Springer–Verlag.

[3] Hasselmo, M.E., Schnell, E. & Barkai, E. (1995) Dynamics of learning and recall at excitatory recurrent synapses and cholinergic modulation in rat hippocampal region CA3. *Journal of Neuroscience* **15**(7):5249-5262.

A Technical Appendices and Supplementary Material

Technical appendices with additional results, figures, graphs and proofs may be submitted with the paper submission before the full submission deadline (see above), or as a separate PDF in the ZIP file below before the supplementary material deadline. There is no page limit for the technical appendices.

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    Question: For crowdsourcing experiments and research with human subjects, does the paper include the full text of instructions given to participants and screenshots, if applicable, as well as details about compensation (if any)?

    Answer: **[TODO]**

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