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 features both structured quantitative benchmarking through diverse scenarios measuring specific capabilities, and an open-world sandbox environment for qualitative assessment of decision-making and goal-oriented behavior over extended periods. These complementary approaches enable researchers to evaluate how effectively embodied LLMs can 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 was started from the Senior Design Project at UC Davis, where students work with clients in-industry to develop a project that meets their needs. We were particularly interested in working with *Justin Jia* affiliated with *Apple*, who was interested in designing some kind of sandbox environment specifically designed to help test AI programs, to whom we were successfully assigned. Exploratory research and early project discussions with our client led us to focus our work on Large Language Models (LLMs), which will be described in the following section.

1.2 Exploratory Research

1.2.1 Focusing on Large Language Models

Our exploratory research identified significant gaps in environmental design for evaluating AI systems. We first examined existing projects in this space of benchmarking and testing, including NeuralMMO, which provides an open-source environment for measuring reinforcement learning algorithm performance.

NeuralMMO offers a game environment with high discrete input complexity, requiring agents to navigate a 2D grid world with diverse tasks including resource management, exploration, and agent interaction. After years of continued development and increasing environmental complexity, we observed that advanced algorithms like Proximal Policy Optimization (PPO), given sufficient compute, could effectively solve most tasks presented. This observation shifted our focus from reinforcement learning toward Large Language Models (LLMs), which represent more recent advancements in artificial intelligence. We were particularly interested in growing research and integration of LLMs into robotics and embodied systems. A 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 For clarity, we define agentic AI as systems capable of autonomous decision-making and environmental interaction. We further focus on embodied AI, a subset that specifically interacts with physical or simulated physical worlds.

Environment Design Several proposed prompting and embodied AI architectures build upon Minecraft as the chosen game environment. This choice creates barriers for researchers and enthusiasts by requiring a license to operate. Minecraft would be an good choice of environment given its inherent complexity and large corpus of information about it available on the internet. In a similar sense, the output of embodied AI architectures is easily intepretable, which positively contributes to the understandability of AI output in terms of benchmarking.

However, a significant fallback of using Minecraft is that there is not standardized solution for providing game state information to the agents, nor is the environment designed to test embodied AI. While environments designed to specific more closely emulate the real world would be a better mapping, we believed that building the necessary overarching systems for the interaction of an LLM and any frontend environment would be a better project focus. This justifies our choice to keep our developed environment similar to Minecraft, further justified by the time constraints of the project. We hope to see our solutions for prompting and providing context about the game environment to an LLM backend, which was built within the open-source Godot game engine, to be applied in the development of similar environmental design that better maps to real-world robotics also using Godot.

Open-Source A similar problem we identified that further inspired our project direction is the fact that some of the supposedly successful solutions are not open-source. By building our systems to allow for easy integrations of newly developed LLMs or prompting architectures into our environment, we hope to solve this identified drawback.

Project Justification Based on our research, we decided to take our project in the direction of developing an open-source benchmarking environment specifically for evaluating embodied AI performance and behavior. We planned to tailor our environment for testing large language models, highlighting easy modification, comprehensive documentation, and adherence to best open-source practices to ensure project longevity and utility. The prompting architecture should be easily expandable to any environment type or setup to allow for future development into additional prompting architectures or transferring the same architecture to new environments. This justified our choice to develop our environment to be similar to Minecraft, while allowing the backend prompting architecture to be easily modifiable and transferrable to separate environments developed within the Godot game engine. Our design deliberately targets researchers and enthusiasts, with solutions built specifically to solve the identified drawbacks.

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.

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.

3 Citations, figures, tables, references

These instructions apply to everyone.

3.1 Citations within the text

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.

The documentation for `natbib` may be found at

`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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```

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```
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3.2 Footnotes

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).

[1] Sample of the first footnote.

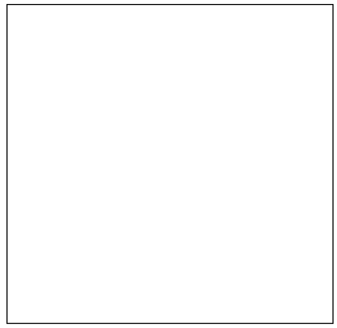

Figure 1: Sample figure caption.

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

Note that footnotes are properly typeset *after* punctuation marks.[2]

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All artwork must be neat, clean, and legible. Lines should be dark enough for purposes of reproduction. The figure number and caption always appear after the figure. Place one line space before the figure caption and one line space after the figure. The figure caption should be lower case (except for first word and proper nouns); figures are numbered consecutively.

You may use color figures. However, it is best for the figure captions and the paper body to be legible if the paper is printed in either black/white or in color.

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All tables must be centered, neat, clean and legible. The table number and title always appear before the table. See Table 1.

Place one line space before the table title, one line space after the table title, and one line space after the table. The table title must be lower case (except for first word and proper nouns); tables are numbered consecutively.

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`

This package was used to typeset Table 1.

3.5 Math

Note that display math in bare TeX commands will not create correct line numbers for submission. Please use LaTeX (or AMSTeX) commands for unnumbered display math. (You really shouldn't be using $$ anyway; see `https://tex.stackexchange.com/questions/503/why-is-preferable-to` and `https://tex.stackexchange.com/questions/40492/what-are-the-differences-between-align-equation-and-displaymath` for more information.)

[2]As in this example.

3.6 Final instructions

Do not change any aspects of the formatting parameters in the style files. In particular, do not modify the width or length of the rectangle the text should fit into, and do not change font sizes (except perhaps in the **References** section; see below). Please note that pages should be numbered.

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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.

If your file contains type 3 fonts or non embedded TrueType fonts, we will ask you to fix it.

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} ...
\includegraphics[width=0.8\linewidth]{myfile.pdf}
```

See Section 4.4 in the graphics bundle documentation (`http://mirrors.ctan.org/macros/latex/required/graphics/grfguide.pdf`)

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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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