What Does ‘Play’ Look Like When Your Toys Are Smarter Than You?

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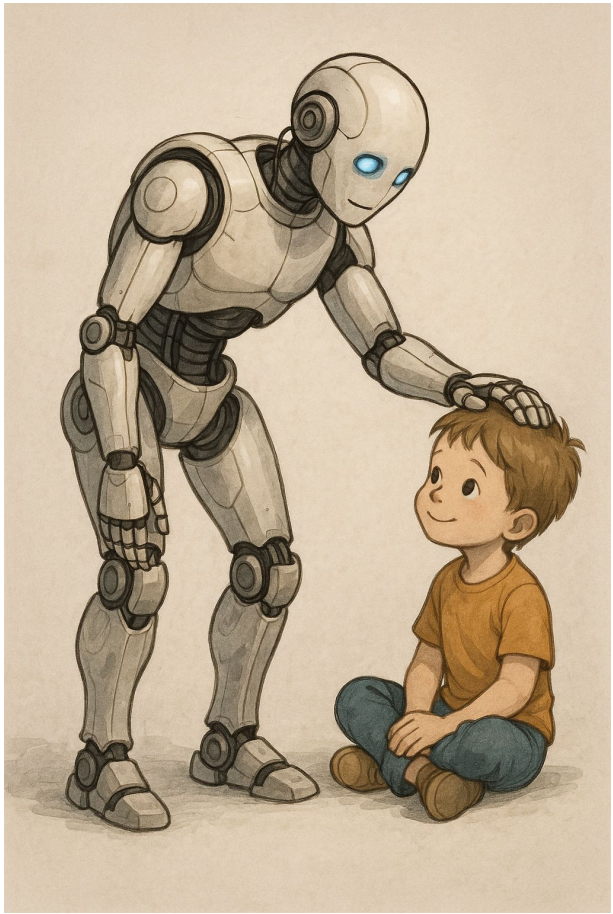


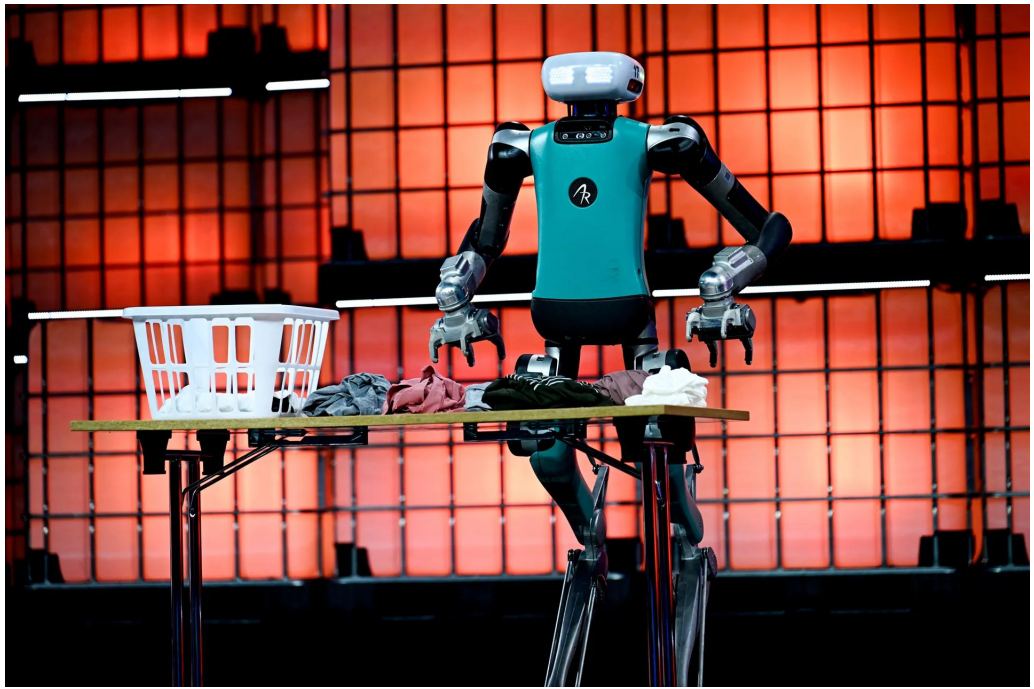
ProDaBi Colloquium, University of Paderborn
July 9, 2025

Roadmap

1. Intelligent robots
    - Perception
    - World map
    - Path planner and navigation
    - Manipulation
2. Connecting LLMs to robots
3. Meet Celeste
    - Fruit Chameleon
    - Shakespeare Scholar
    - Museum Tour Guide
    - Playing Hospital
4. Calypso for VEX AIM
5. What will play with intelligent robots look like?

Part 1: What Makes An Intelligent Robot?

- Perception
  - See the world
- World map
  - Model the world
- Path planner and navigation
  - Move through the world
- Manipulation
  - Act on the world

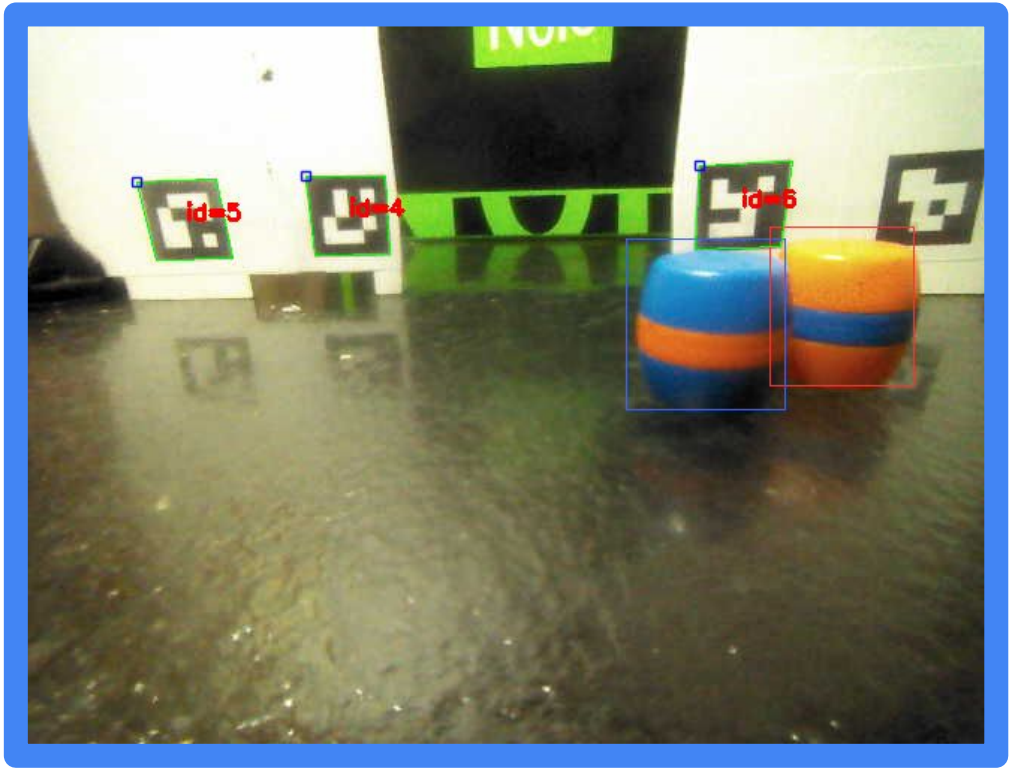


Digit robot from Agility Robotics

Perception

How self-driving cars see the world

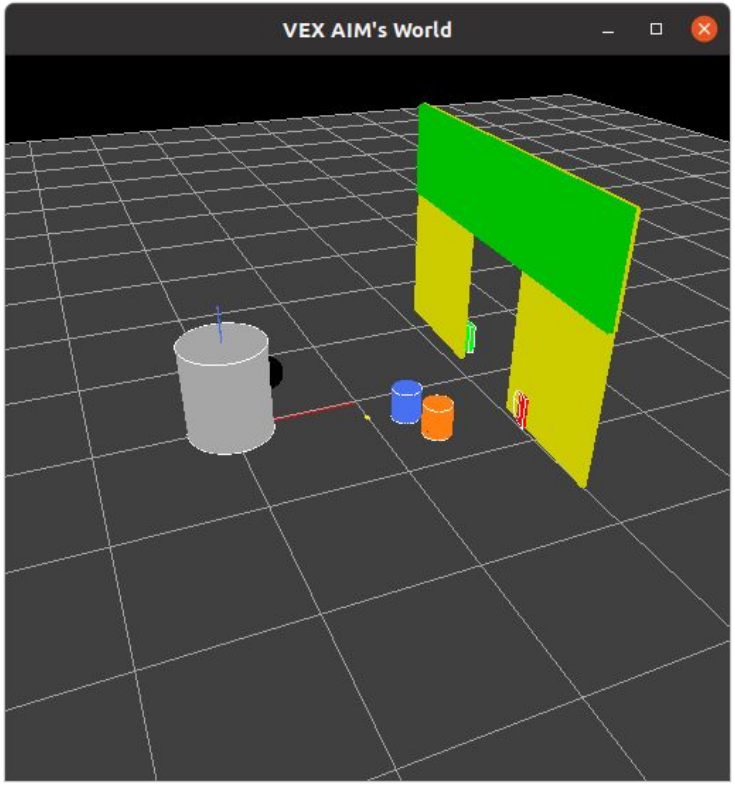
VEX AIM Camera Viewer (from vex-aim-tools)



World Map

This Tesla's world map shows the road and other vehicles.

VEX AIM World Map (from vex-aim-tools)

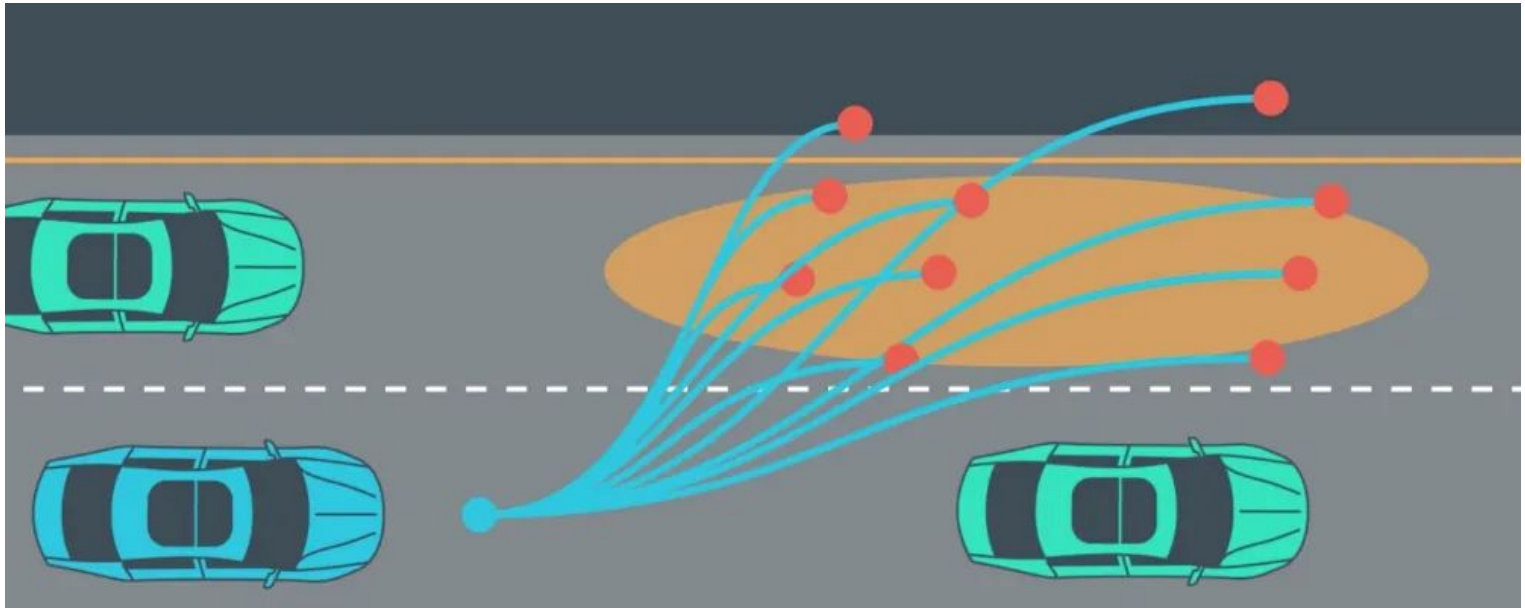


Navigation

Moving through the world using a map and landmarks

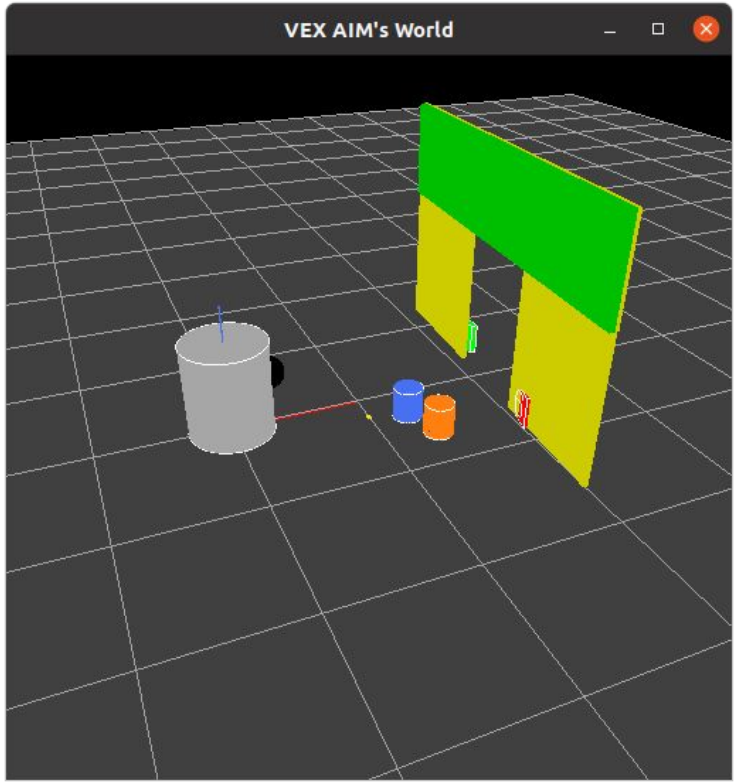
Source: Relay Robotics, generated with Google Gemini

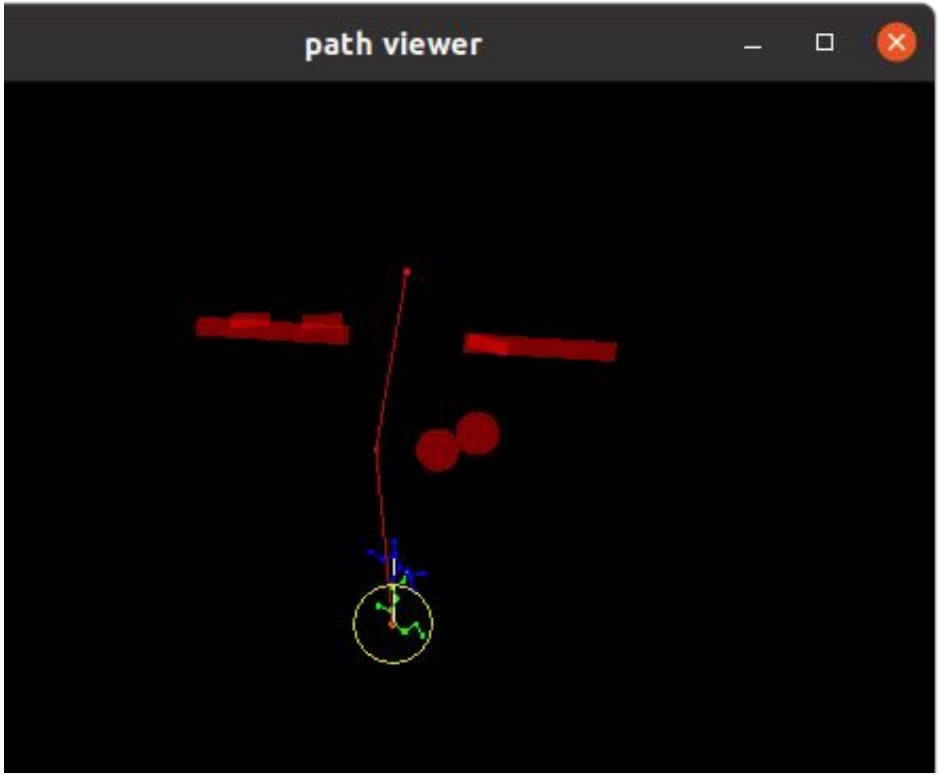
Path Planning



https://medium.com/udacity/self-driving-path-planning-brought-to-you-by-udacity-students-13c07bcd4f32

VEX AIM Path Planning (using vex-aim-tools)





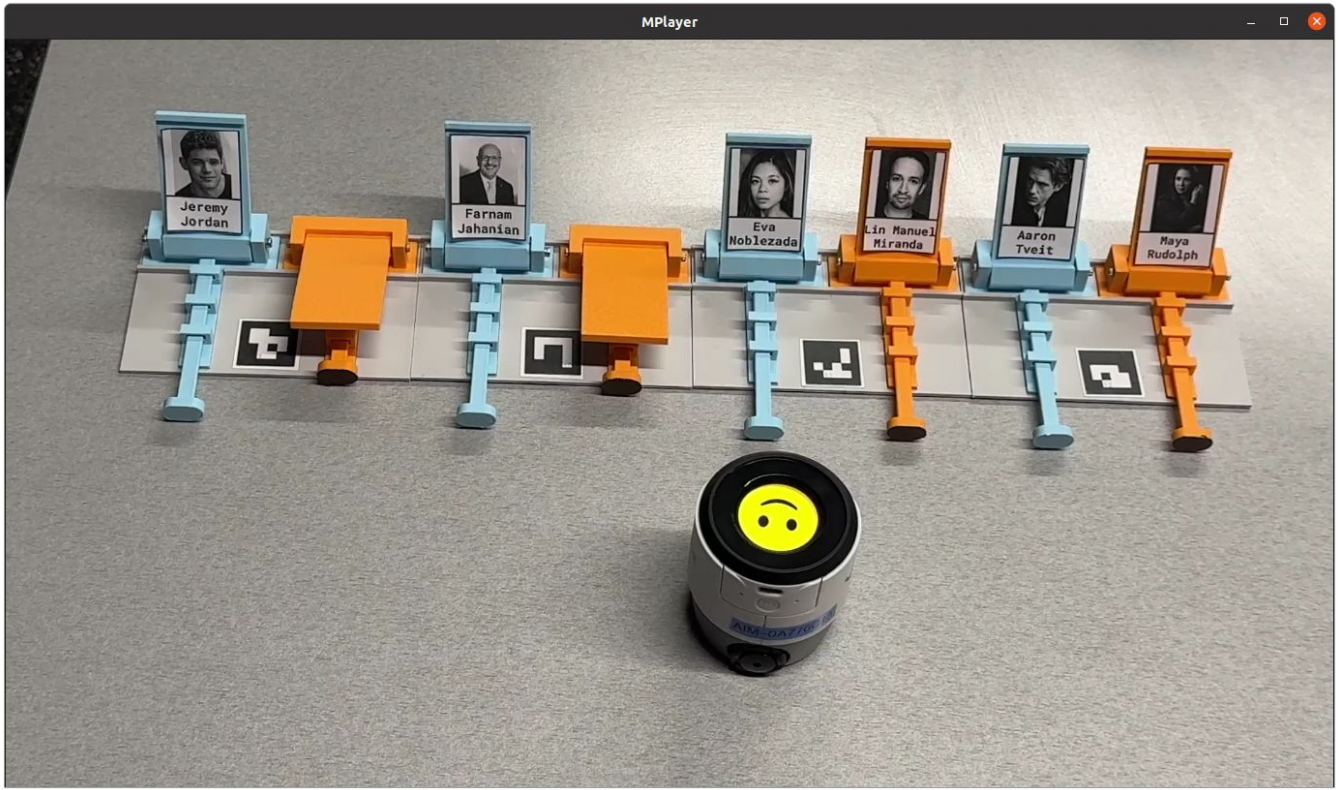
Manipulation

Acting on the world

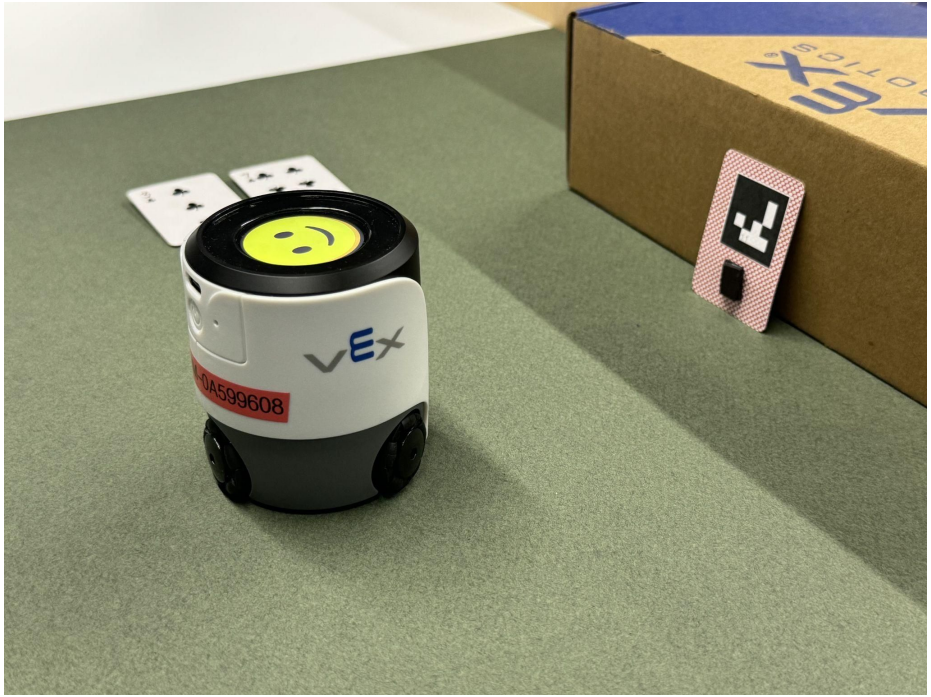
Tesla's Optimus robot

VEX AIM Manipulation

“Guess Who?” game by Ella Sanfilippo



VEX AIM Manipulation



Blackjack by Howard Ma and Yulin Chen

2. Connecting LLMs to Robots

- The robot shares its perceptions and world map with the LLM.

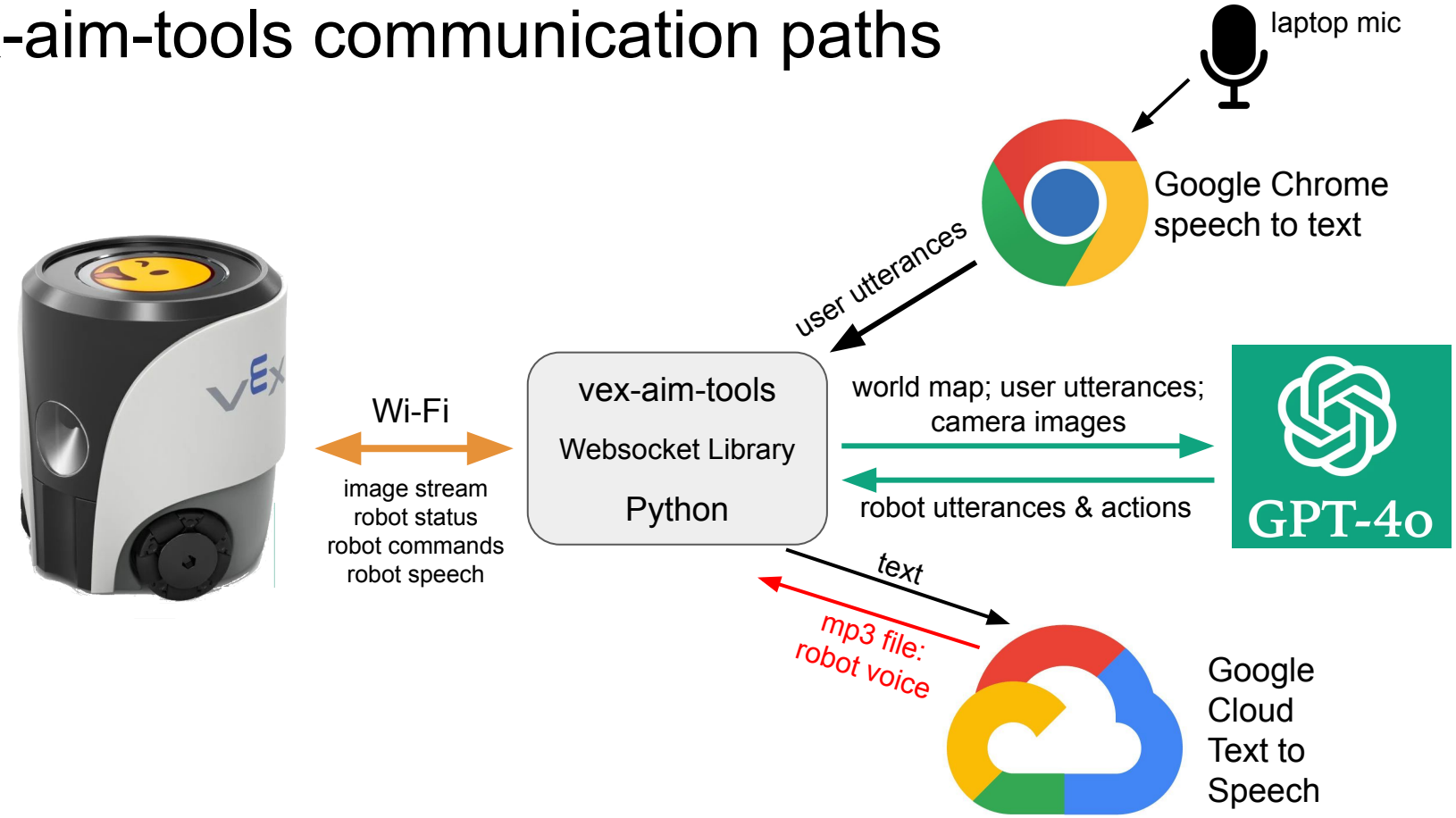
- The LLM provides the robot with:
  - Language understanding
  - Personality
  - Enhanced vision capabilities
  - World knowledge
  - Reasoning abilities

- The LLM can also control the robot's body by generating commands the robot will recognize, e.g. "#forward 100".

vex-aim-tools: programming framework for VEX AIM

- Built on top of the VEX AIM Python Websocket Library
  - Interface with the robot via a Wi-Fi connection
- Parallel state machine formalism for control flow
- Visualization tools for world map, path planner, etc.
- Speech recognition via laptop microphone and Chrome speech to text
- Speech generation via Google Cloud Text-to-Speech API
- Computer vision using OpenCV, DepthAnything, etc., plus GPT-4o
- Provides for GPT-4o API calls
- Executes robot actions requested by GPT-4o or the user’s Python code

vex-aim-tools communication paths



3. Meet Celeste

- Robot: VEX AIM
- LLM: OpenAI’s GPT-4o
- Linked together through vex-aim-tools Python package from Touretzky lab at Carnegie Mellon

Excerpts From the Celeste Preamble (1)

You are an intelligent mobile robot named Celeste.

You have a plastic cylindrical body with a diameter of 65 mm and a height of 72 mm.

You have three omnidirectional wheels and a forward-facing camera.

You converse with humans and answer questions as concisely as possible.

Excerpts From the Celeste Preamble (2)

Here is how to control your body:

To move forward by N millimeters, output the string “#forward N” without quotes.

To turn toward object X, output the string “#turntoward X” without quotes.

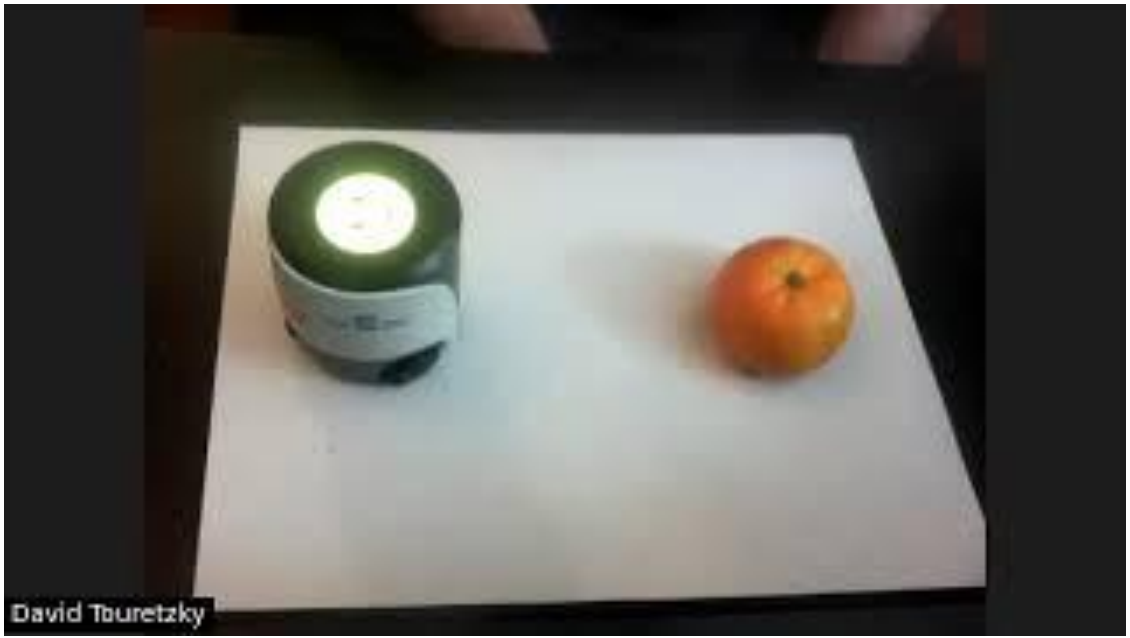
To pass through a doorway, output the string “#doorpass D” without quotes, where D is the name of the doorway.

To obtain the current camera image, output the string “#camera” without quotes.

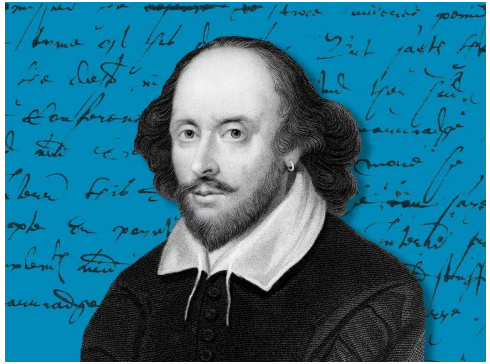
The Fruit Chameleon

You're going to play the role of a 'fruit chameleon'. When you see a piece of fruit in your camera image, you will:

- *Announce what fruit you see*
- *Glow your LEDs to match the color of the fruit*



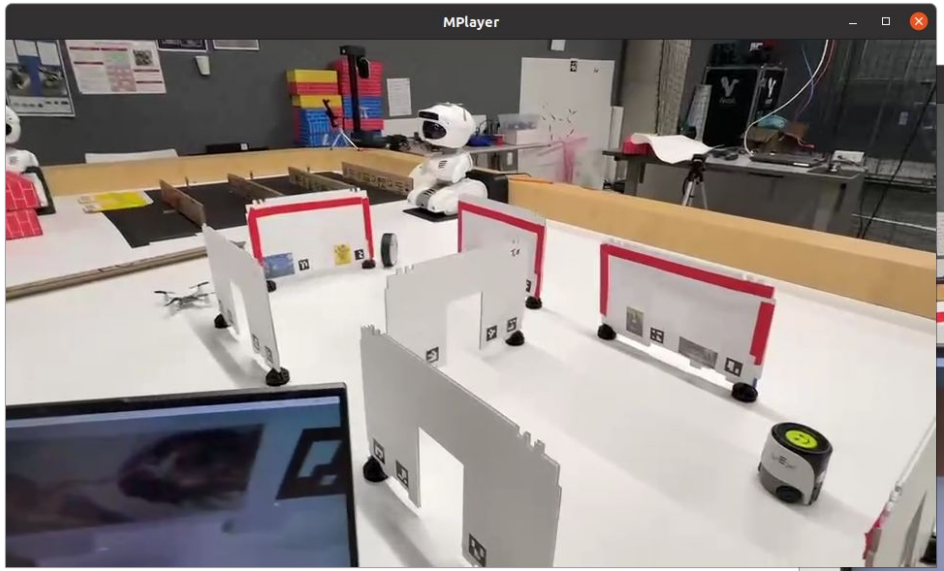
Shakespeare Scholar

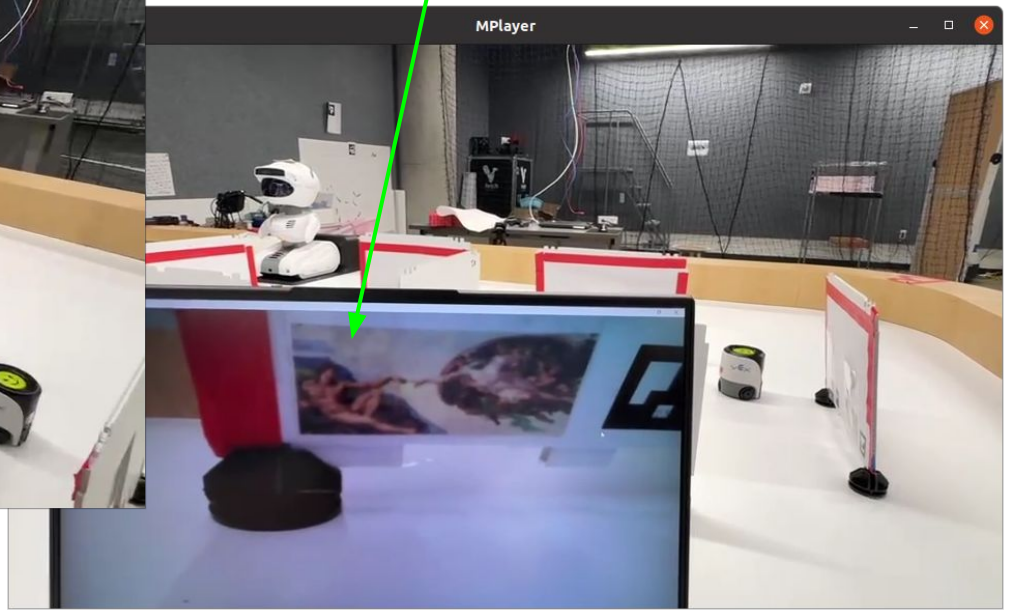


We're going to play a game called Shakespeare scholar. When I give you part of a Shakespeare quote, you will move forward by 50 mm, complete the quote, state the play and scene that the quote is from, and then move backward by 50 mm.

If the quote is not from Shakespeare, you will say 'That's not Bill' and then spin around by 360 degrees.

Museum Tour Guide





The Creation of Adam, by Michelangelo

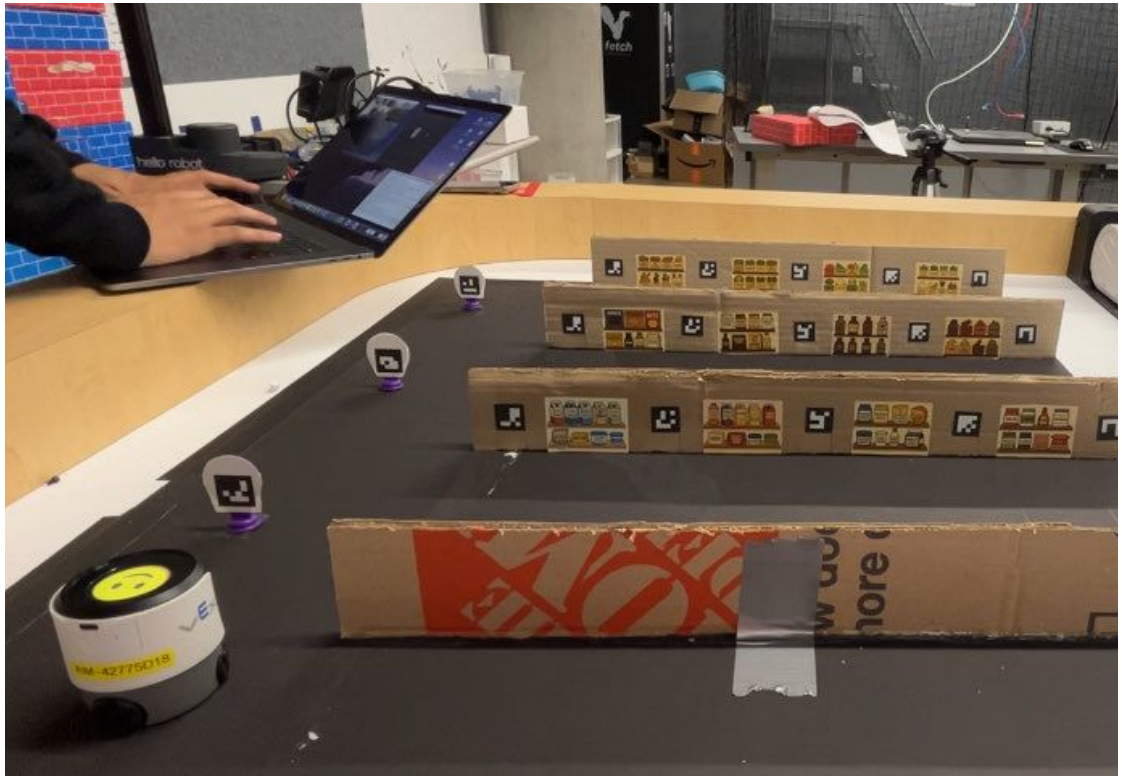
Thomas Chun Fai Lee and
Ziyan Xin

“Grocery Getter” (Food Shopping Assistant)

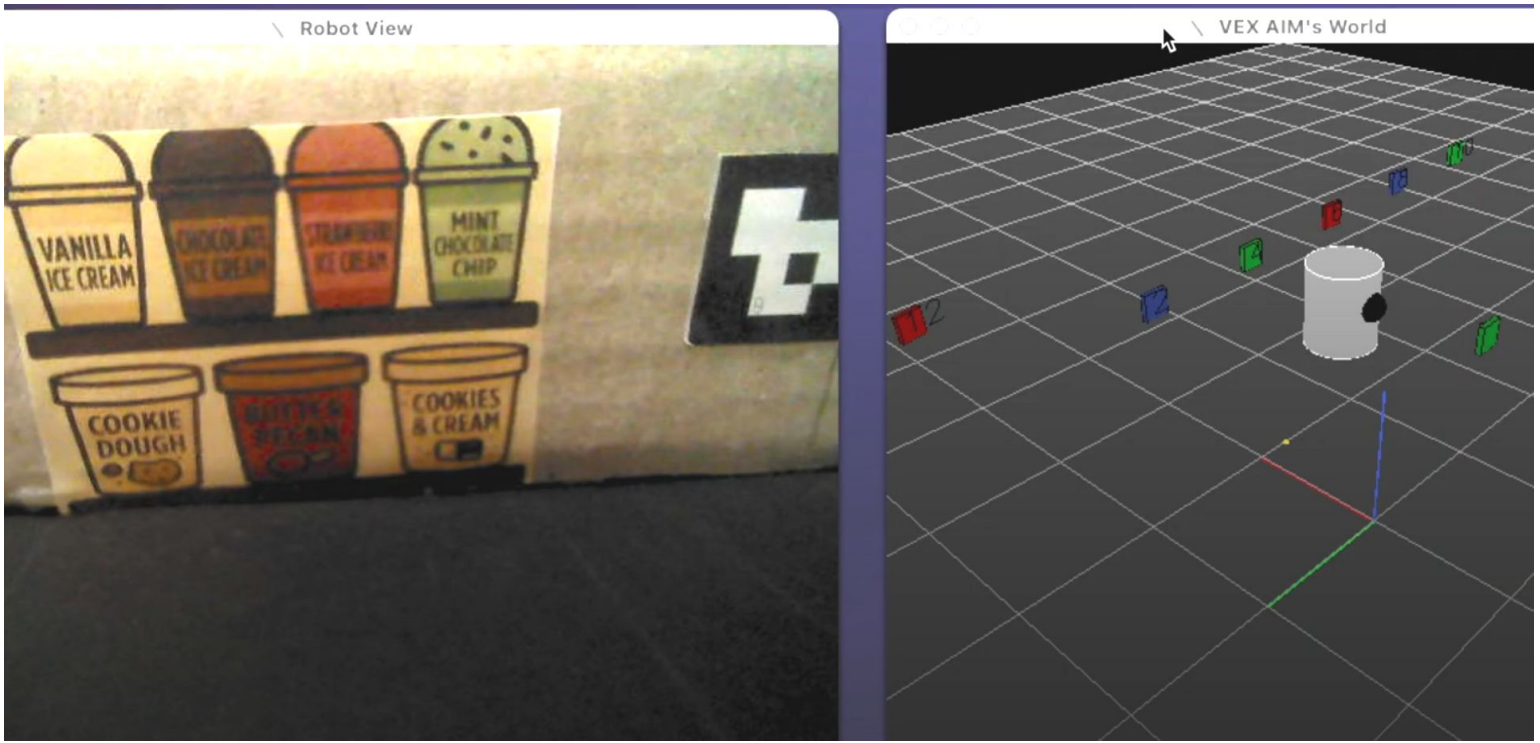
Taha Zirapury and
Lynn Zhang

Can suggest recipes if you say “I want to bake a cake”.

Can respond to vague prompts like “I’m thirsty”.



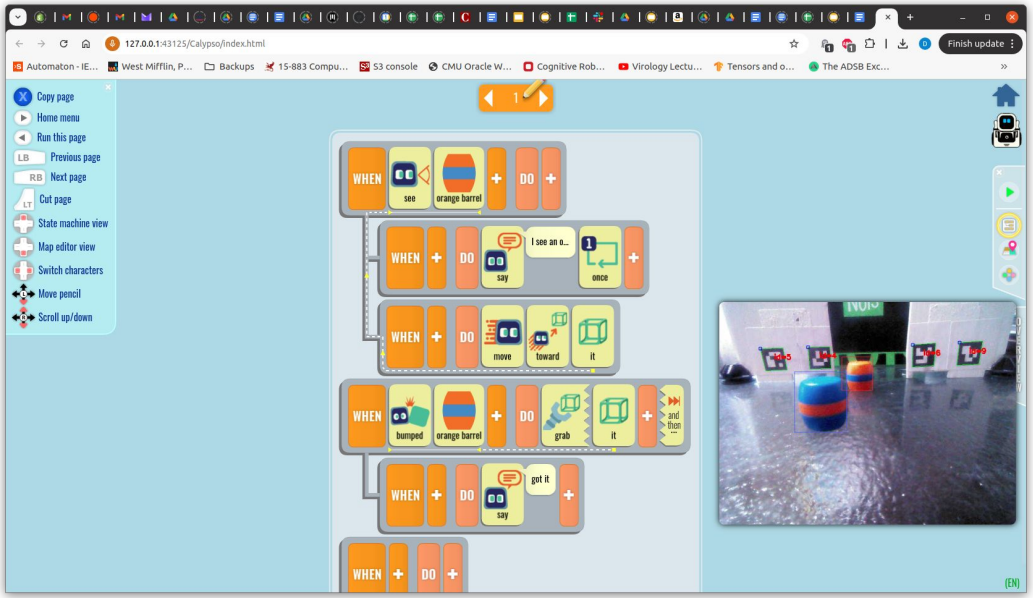
“Grocery Getter” (Food Shopping Assistant)



4. Calypso for VEX AIM

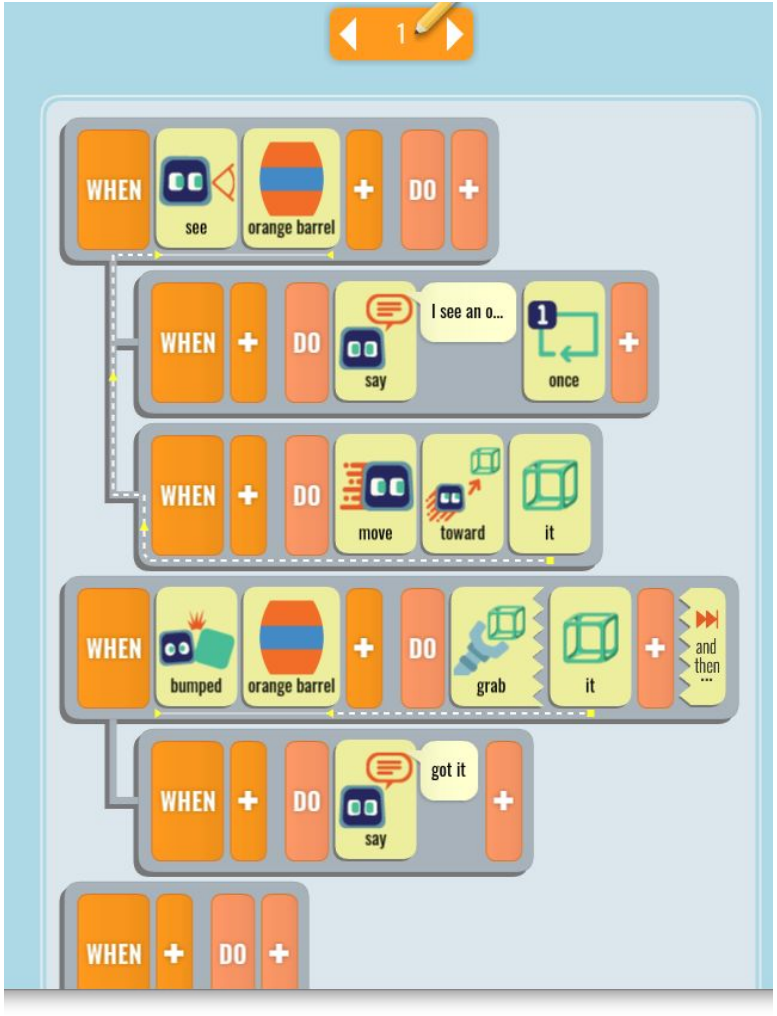
- *“PhD-level robot programming done by eight year olds.”*

- Built-in world map, path planner, speech recognition, state machine formalism, and **GPT-4o interface**.

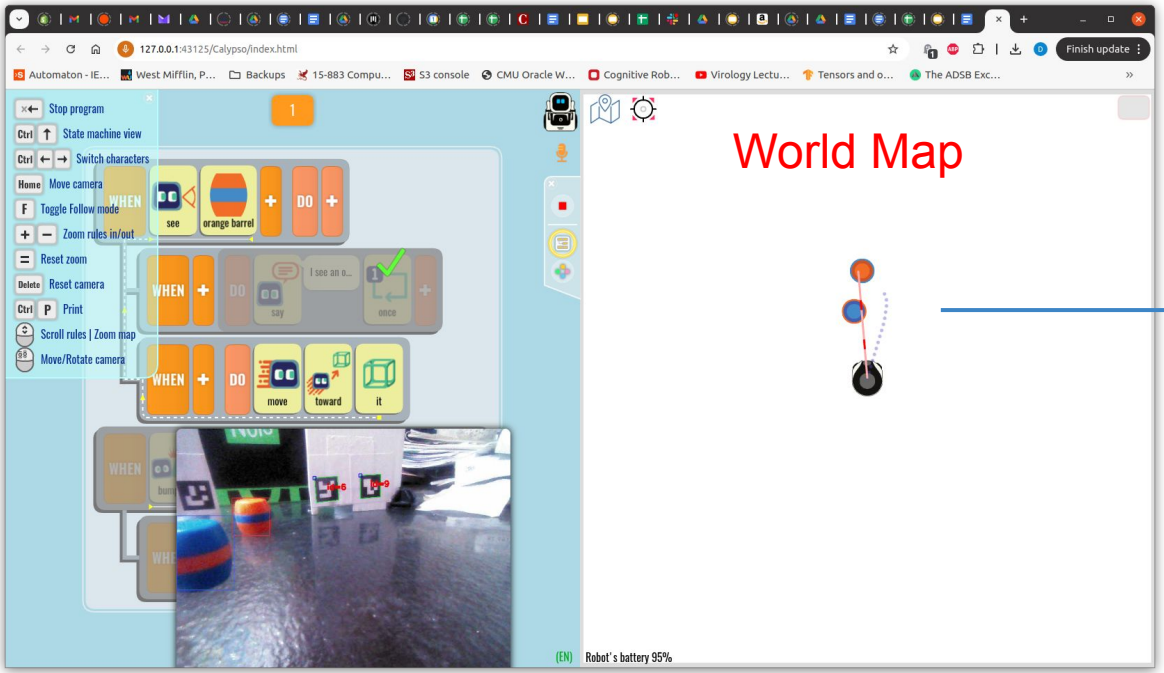


Calypso Rule Editor

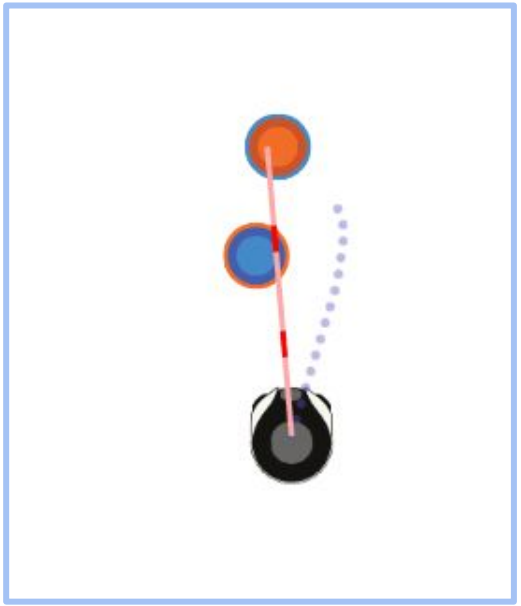
- Pattern-matching rule-based language; not sequential like Scratch or Python.
- WHEN-DO rules instead of statements.
- Each page of rules is a node in a state machine.



Calypso Execution Mode



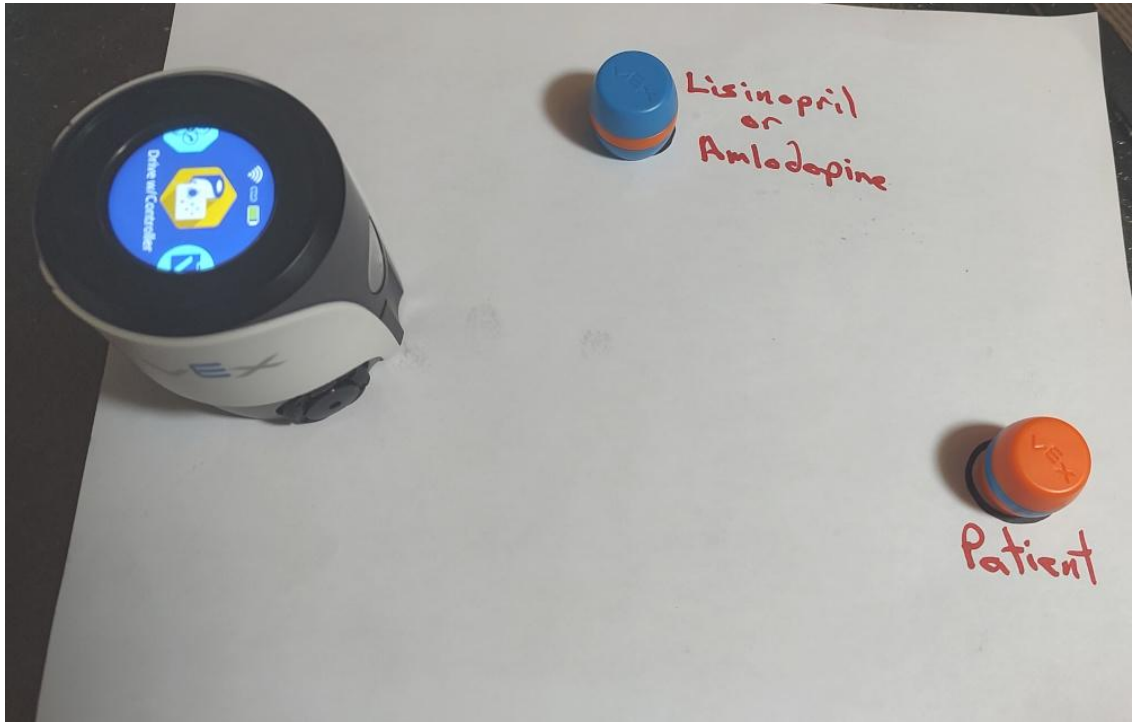
Path Planner



5. The Future of Play

Playing “hospital” with a robot that has:

- Detailed knowledge of medicine
- An extensive pharmaceutical database
- Carefully-crafted ethical guidelines (see “Alignment Problem”)



What To Do With Toys That Are Smarter Than You

- Robots have special appeal because they share our world.
- For small educational robots that live on a desktop, we can construct play worlds from bits of plastic, posterboard, etc., that both we and the robot physically interact with.
- We can use the power of an LLM to breathe life into these imagined worlds, adding richness and complexity beyond what we envisioned on our own.
- As we co-create the world with the robot, we also learn from it.

Conclusions

- LLMs are altering society in profound ways.
  - Biggest leap in democratization of knowledge since the world wide web.
- LLM-powered robots aren't just for elite research labs.
  - Anyone can have a small intelligent robot now. Bigger ones are coming.
- Everyone needs to understand this technology, including kids.
  - What can our K-12 educators do to support this?

WE ARE TRULY LIVING IN INTERESTING TIMES!

Questions?