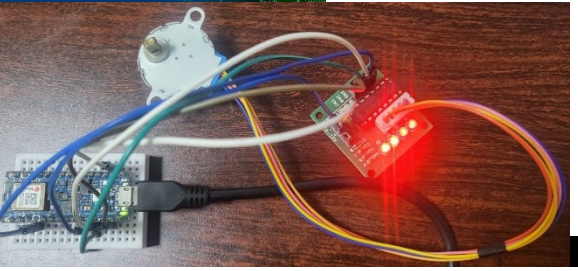
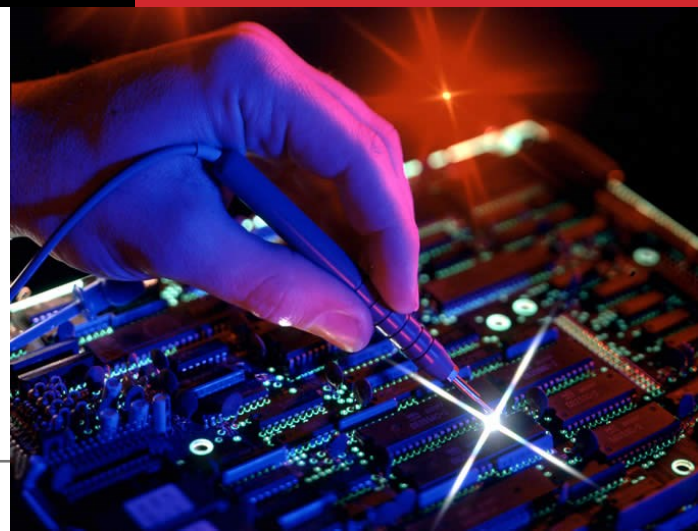
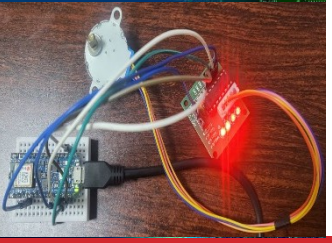


Robotics

OVERVIEW OF TINY ROBOT LEARNING

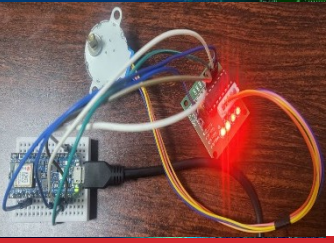
Dennis A. N. Gookyi





CONTENTS

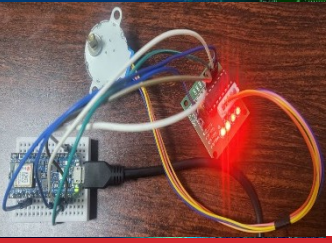
- Overview of Tiny Robot Learning



WHAT IS TINY ROBOT LEARNING (TINYRL)?

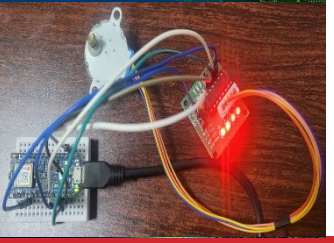
- TinyRL is a field that focuses on deploying machine learning (ML) algorithms on resource-constrained robots

- These robots are typically small, lightweight, and have limited processing power and battery life



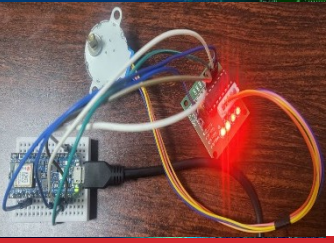
WHY TINY ROBOT LEARNING?

- Tiny robots offer several advantages:
  - Low cost: They are relatively inexpensive to manufacture
  - Size and maneuverability: They can operate in confined spaces inaccessible to larger robots
  - Versatility: They can be used for various applications, from search and rescue to infrastructure inspection



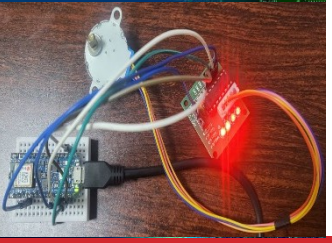
APPLICATIONS OF TINYRL

- Search and rescue: Tiny robots can navigate collapsed buildings or disaster zones to locate survivors
- Precision agriculture: They can monitor crops, detect pests, and deliver targeted pesticides
- Industrial inspection: They can inspect pipes, pipelines, and other hard-to-reach areas for damage



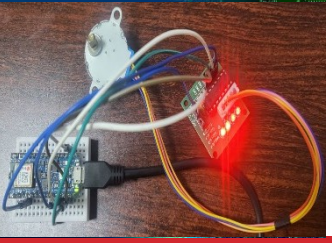
CHALLENGES OF TINYRL

- Limited resources: Tiny robots have limited processing power, memory, and battery life
- Sensor limitations: Their sensors may have lower resolution and range compared to larger robots
- Complex environments: They need to operate in dynamic and unpredictable environments



BASIC ROBOT ARCHITECTURE

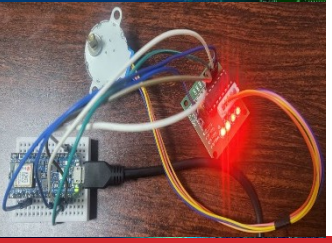
- Sensors: These gather information about the robot's surroundings (e.g., cameras, LiDAR)
- Actuators: These allow the robot to interact with its environment (e.g., motors, wheels)
- Controller: This processes sensor data and controls the actuators to achieve desired behaviors
- Power supply: This provides energy for the robot's operation.



MACHINE LEARNING FOR ROBOTS

- ML algorithms enable robots to learn and adapt to their environment

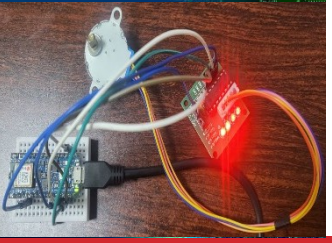
- Common ML techniques for robots include:
  - Reinforcement learning: The robot learns through trial and error by receiving rewards for desired actions
  - Supervised learning: The robot learns from labeled data to perform specific tasks



TINYML VS. TINYRL

- TinyML refers to deploying any ML model on resource-constrained devices

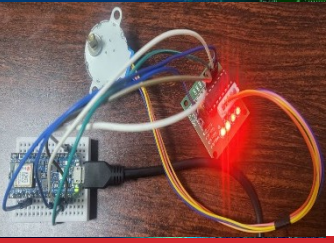
- TinyRL is a subfield of TinyML specifically focused on ML for robots, with additional challenges related to real-time decision-making and interaction with the environment



APPROACHES TO TINYRL

- Traditional RL algorithms can be too complex for TinyRL applications

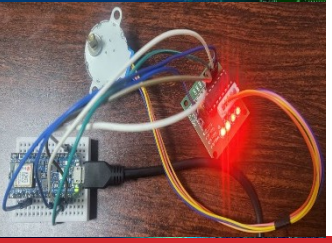
- Common approaches for TinyRL include:
  - Model-based RL: The robot learns a simplified model of its environment to make decisions
  - Lightweight RL algorithms: These algorithms are designed to be efficient and require less memory and processing power



HARDWARE PLATFORMS FOR TINYRL

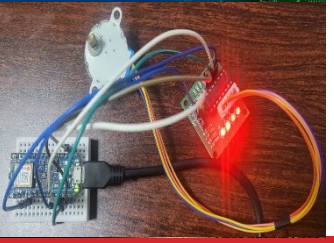
- Microcontrollers (MCUs) are popular platforms for TinyRL due to their low cost and power efficiency

- Examples of MCUs for TinyRL include Arduino Nano and Raspberry Pi Pico



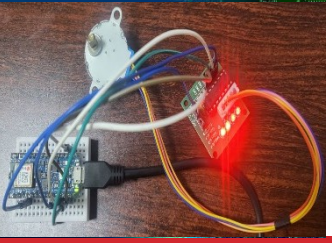
DEVELOPMENT TOOLS FOR TINYRL

- Several tools and libraries can simplify TinyRL development:
  - TensorFlow Lite Micro: A framework for deploying machine learning models on microcontrollers
  - MicroPython: A Python implementation designed for microcontrollers
  - TinyML libraries: Specialized libraries provide pre-built functions for common TinyRL tasks



SIMULATION ENVIRONMENTS FOR TINYRL

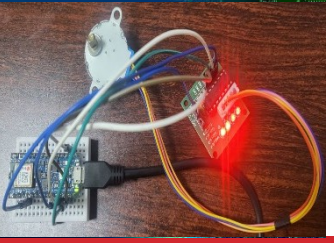
- Simulating robot behavior is crucial for TinyRL development
- Popular simulation environments include:
  - Gym: A toolkit with various simulated environments for robot learning
  - Maze environments: Specialized environments for testing navigation and exploration tasks
  - Robotics simulators: More complex simulators that model robot physics and dynamics



EVALUATION METRICS FOR TINYRL

- Evaluating the performance of TinyRL algorithms is essential

- Common metrics include:
  - Reward: The measure of success for the robot's actions
  - Success rate: The percentage of times the robot completes the desired task
  - Episode length: The average number of steps the robot takes to complete a task
  - Energy consumption: The amount of energy the robot uses during an episode



APPLICATIONS OF TINYRL RESEARCH

- TinyRL research is advancing the capabilities of small robots

- Potential applications include:
  - Swarm robotics: Coordinating the behavior of multiple robots to achieve a collective goal
  - Autonomous exploration: Enabling robots to navigate and explore unknown environments
  - Adaptive control: Allowing robots to adjust their behavior based on changing environmental conditions