# Tiny Robot Learning: Expanding Access to Edge ML as a Step Toward Accessible Robotics

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ROBOTICS SCIENCE AND SYSTEMS

## The Big Picture:

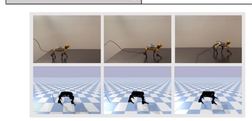
The high barriers to entry associated with robotics, in particular its high cost, has rendered it inaccessibility for many. In this poster we present our early efforts to begin to address these challenges through edge machine learning (ML). We show how **ultra-low-cost computational hardware** can be paired with **open-source software and courseware** to enable hands-on education globally and the beginnings of a globally diverse research community.

## Low-Cost Robotics Challenges:

- Low cost robot hardware often **lack high-performance sensors.**
- The embedded processors on these robots **lack the computational power** needed to support state-of-the-art robotics stacks.

Recent advances in edge ML have enable **neural networks on microcontrollers** charting a path towards the a possible solution through **tiny robot learning.**

| | Unitree A1 | Petoi Bittle | Ratio |
|---|---|---|---|
| Cost | $10,000 USD | $299 USD | 33x |
| Weight | 12 kg | .29 kg | 41x |
| Dimensions | .5 x .3 x .4 m | .2 x .11 x .11 m | 2.5x |
| Degrees of Freedom (DoF) | 12 (Leg: 3) | 8 (Leg: 2) | 1.5x |
| Battery Capacity | 25.2V 4200mAh | 7.4V 1000mAh | 3x |
| Motor Resolution | .022° | 1° | 45x |
| IMU | Yes | Yes | NA |
| Motor Feedback | Yes | No | NA |
| Foot Pressure Sensor | Yes | No | NA |
| LiDAR | Yes | No | NA |
| Computing | ARM Cortex-A72 2.5GHz | Nyboard V1 ATMega328P 20MHz | 125x |
| Optional Additional Computing | NVIDIA TX2 1.3GHz | Raspberry Pi Zero 2W 1GHz | 1.3x |



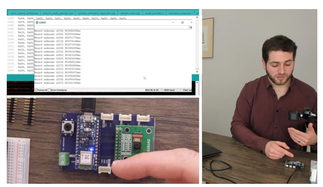
Closing the Sim-to-Real Gap for Ultra-Low-Cost, Resource-Constrained, Quadruped Robot Platforms

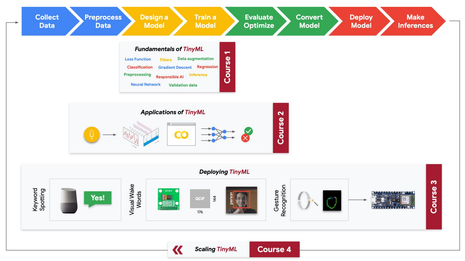

Tiny Robot Learning (tinyRL) for Source Seeking on a Nano Quadcopter


Sniffy Bug: A Fully Autonomous Swarm of Gas-Seeking Nano Quadcopters in Cluttered Environments

## Teaching Embedded ML at Scale on edX:

We developed a hands-on course covering **ML on embedded device on the edX MOOC platform** which has been taken by almost **90,000 students from over 190 countries** since fall 2020.



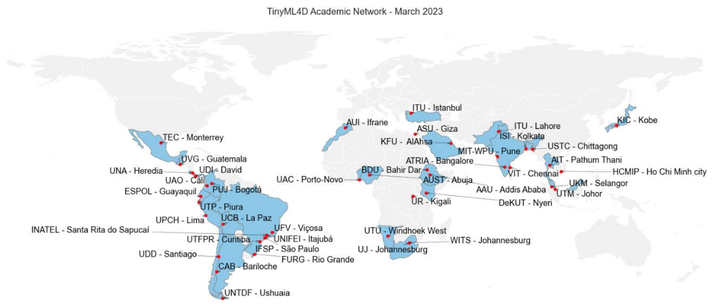


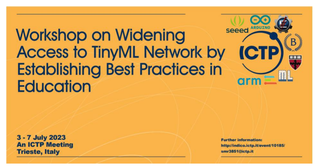

We paired the course with a **low-cost ($50 USD) hardware kit**

## From edX to the World:

We **developed a global network of educators** from across the developing world to scale access to this low cost technology through:

- **1 week workshops** held remotely & in-person globally
- Online **open-source courseware**
- **Hardware donations** via collaborations with industry (e.g., Arduino, Seeed Studio, and Edge Impulse)

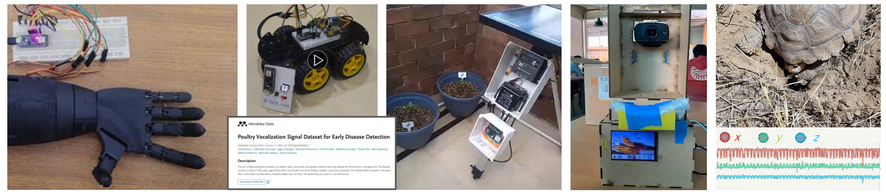



## From Teaching to Research:

We developed a **Show & Tell online seminar series** to enable sharing of **early and in-progress results** and to encourage early career researchers. We have also begun to cultivate and develop a series of **research papers and international collaborations** by developing an **online Discord forum**. Topics have included:

- Irrigation prediction for improved crop yields
- Anemia detection for low-cost human health interventions
- Animal activity detection for conservation efforts
- Robotic prothesis development and control
- Autonomous system navigation
- Development of novel open-source dataset for additional locally relevant applications




## Scaling Tiny Robots – A Call to Action:

- How can we better enable **global access to low-cost robot hardware**? Can we develop a donation or sharing model?
- Can application focused workshops help draw a wider audience and further **improve our community's diversity**?
- How can we better **share our datasets, models, and materials** to reduce the barriers to entry and enable more collaborations?

## Acknowledgments:

This was a **collaborative effort across academia and industry.** You can learn more about our efforts at tinyMLedu.org.