

Education in TinyML

Q&A Session with Marco Zennaro

Vijay Janapa Reddi
Harvard University

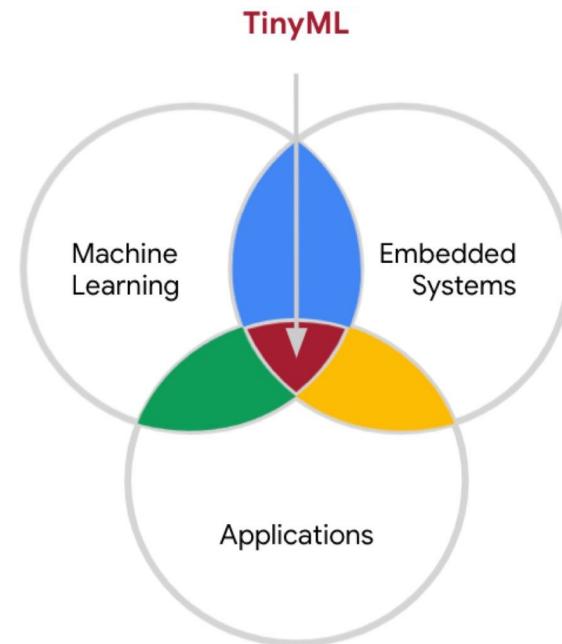


Introduction to TinyML in Education

What exactly is TinyML, and how does it relate to education?

Why is TinyML gaining momentum in the field of education?

What age groups can benefit from TinyML education and outreach?

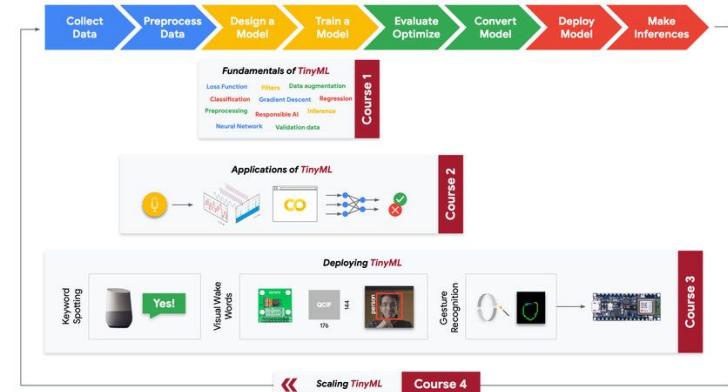


Integration and Applications of TinyML in Edu.

How does TinyML enhance traditional educational methods?

What are some practical applications of TinyML in educational settings?

Can you provide examples of how TinyML is being integrated into curriculum development?



Challenges and Considerations

What are the challenges educators might face when implementing TinyML in the classroom?

Are there any ethical or equity considerations surrounding the use of TinyML in education?

MICROCONTROLLERS (MCU)						
Board Name	Price	Dimensions	Software	Clock Speed	Processor	Memory
Adafruit ATTiny1616 Breakout with Seesaw	\$5	1.2"×0.5"	Arduino IDE, C/C++	20MHz	8-bit ATTiny1616 (single-core AVR)	16kB Flash, 2kB RAM, 256 byte EEPROM
Adafruit ESP32-S2 Feather with BME280 Sensor	\$25	2.1"×0.9"	CircuitPython, Arduino			
Adafruit ESP32-S2 TFT Feather	\$25	2.1"×0.9"	CircuitPython, Arduino			
Adafruit ESP32-S3 Feather	\$18	2.1"×0.9"	CircuitPython, Arduino			
Adafruit Feather M0 with RFM95 LoRa Radio 900MHz (RadioFruit)	\$35	2.0"×0.9" ×0.3"	CircuitPython, Arduino			
Adafruit Feather RP2040 with DVI	\$15	2.1"×0.9"	CircuitPython, MicroPython, Arduino IDE, C/C++			
Adafruit Feather RP2040 Scorpio ★NEW & NOTABLE★	\$15	2.0"×0.9" ×0.3"	CircuitPython, MicroPython, Arduino IDE			

RASPBERRY PI 5
With 2-3x the performance of the previous generation, faster CPU, GPU, WiFi, USB, and microSD, the Raspberry Pi 5 represents a giant leap forward for the credit-card-size computer.

ARDUINO UNO R4 WIFI
Originally announced by Maker Faire, the Arduino Uno is probably the single most recognizable dev board in the makerverse. And now it's back, more powerful than ever, with WiFi, Ethernet, and USB-C.

SEEED XIAO ESP32S SENSE
Dual-core 240MHz MCUs! Deep sleep mode with 16MB of PSRAM and 1MB of ROM. Built-in WiFi/Ethernet, and a battery! Onboard camera and microphone. You get it. Must be seen.

Make:
THE ORIGINAL
**GUIDE TO
BOARDS**
2024

DigiKey

We're enamored with the tiny-bitty XIAO for this variant in particular, due to its 160MHz with WiFi and Bluetooth, and the fact that it includes MicroPython, and CircuitPython, this thumbtumb phenom is a steal at just \$5. antenna inclut

ARDUINO NANO ESP32S
The Nano ESP32 represents the highest-on-a-new-partnerhip with Espressif, featuring

Benefits and Impact

How can TinyML help personalize learning experiences for students?



K-12 Workshops

How can students benefit from learning about TinyML, both academically and professionally?

What skills do educators need to effectively teach TinyML concepts to students?



Resources and Support

What resources are available for educators who want to incorporate TinyML into their teaching?

<https://tinyml.seas.harvard.edu>

Welcome to the Tiny Machine Learning Open Education Initiative (TinyMLedu)

Take a Free Course or Teach Your Own Explore our 4D Academic Network

Attend our SciTinyML Workshop View our Research Projects Learn More About Us

Machine Learning Systems with TinyML

ABSTRACT

Machine Learning Systems with TinyML offers readers an entry point to understand comprehensive machine learning systems by grounding concepts in accessible TinyML applications. As resource-constrained edge computing sees rapid expansion, the ability to construct efficient ML pipelines grows crucial. This book aims to demystify the process of developing complete ML systems suitable for deployment - spanning key phases like data collection, model design, optimization, acceleration, security hardening, and integration. The text touches on the full breadth of concepts relevant to general ML engineering across industries and applications through the lens of TinyML. Readers will learn basic principles around designing ML model architectures, hardware-aware training strategies, performant inference optimization, benchmarking methodologies and more. Additionally, crucial systems considerations in areas like reliability, privacy, responsible AI, and solution validation are also explored in depth. In summary, the book strives to equip newcomers and professionals alike with integrated knowledge covering full stack ML system development, using easily accessible TinyML applications as the vehicle to impart universal concepts required to unlock production ML.

Preface

Welcome to Machine Learning Systems with TinyML. This book is your gateway to the fast-paced world of AI systems through the lens of embedded systems. It is an extension of the course, TinyML, from CS249r at Harvard University.

Our aim is to make this open-source book a collaborative effort that brings together insights from students, professionals, and the broader community of applied machine learning practitioners. We want to create a one-stop guide that dives deep into the nuts and bolts of AI systems and their many uses.

"If you want to go fast, go alone. If you want to go far, go together." – African Proverb

This isn't just a static textbook; it's a living, breathing document. We're making it open-source and continually updated to meet the ever-changing needs of this dynamic field. Expect a rich blend of expert knowledge that

<https://mlsysbook.ai>

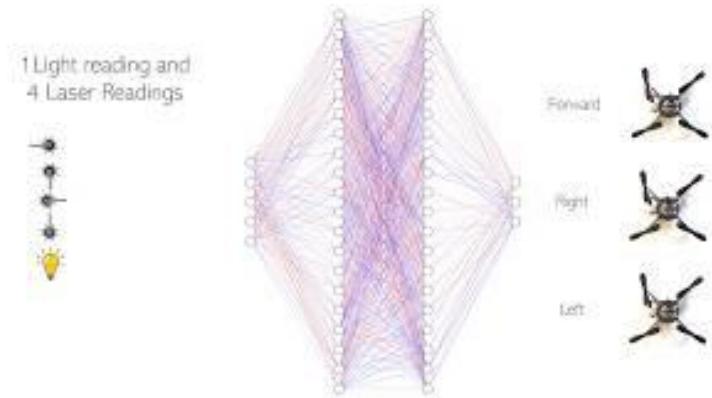
Machine Learning Systems with TinyML

Code Issues 38 Pull requests 2 Discussions Actions Projects Wiki Security

Innovation and Future Trends

In what ways can TinyML contribute to fostering innovation and creativity among students?

What are some potential future developments or trends in the intersection of education and TinyML?



Case Studies and Success Stories

UNIVERSITY COURSES

Can you share any success stories or case studies of TinyML implementation in educational institutions?

CS249R: TINYML
THE FUTURE OF ML IS TINY AND BRIGHT

COURSE OVERVIEW

Tiny Machine Learning is about a fast, privacy-aware, low-cost machine learning technology and infrastructure, including efficient hardware designs, algorithmic optimizations, and reduced capacity of learning models. This course will introduce the basic concepts of TinyML and its applications in real-world scenarios.

ABOUT THE COURSE

This course is designed for students who have a basic understanding of machine learning and want to learn how to apply it to real-world problems. It covers topics such as neural network architectures, optimization techniques, and deployment to embedded devices. By the end of the course, students will be able to build their own TinyML projects and understand the challenges and opportunities of this exciting field.

PREVIOUS YEARS

Fall 2021

Efficient AI Computing. Transforming the Future.

TINYML and Efficient Deep Learning Computing

6.S940 - Fall - 2023 - <https://efficentml.ai>

ABOUT **LOGISTICS** **ALL COURCES**

This course focuses on efficient machine learning and systems. It is a crucial area as deep neural networks demand extraordinary levels of computation, rendering its deployment on memory devices and power-limited mobile platforms challenging. This course will introduce the latest research that can enable powerful learning applications on re-constrained devices. Topics include model compression, pruning, quantization, low-precision arithmetic, data partitioning, model parallelism, joint training, compression, and on-device fine-grained. It also introduces application-specific acceleration techniques for large language models and diffuse models. Students will get hands-on experience with learning model compression techniques and deploying large language models (LLMs) on a laptop.

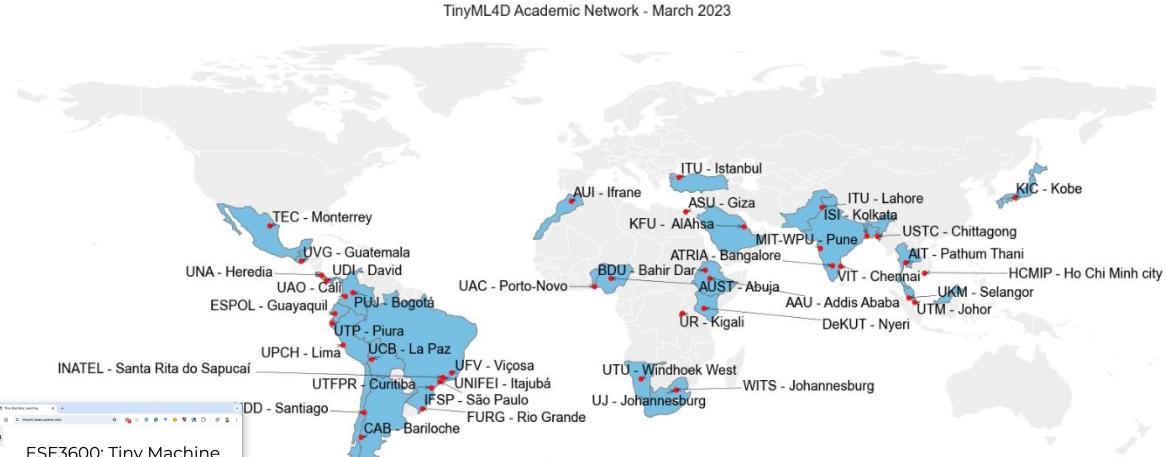
ESE3600: Tiny Machine Learning.

ESE 3600 TinyML Where Embedded Systems & Machine Learning meet

Embedded Systems **TinyML** **Machine Learning**

Course Overview

Embedded Machine Learning is a cutting-edge field that brings the combined power of machine learning to the edge. This course will introduce the intersection of machine learning (ML) and embedded systems (ES). We will cover the challenges of deploying machine learning models to edge devices and point-right at the data source. It is markedly different from general deep learning machine learning approaches. This course will introduce the concepts of TinyML and how they differ from general ML. The course will cover how to process data to fit a dataset, design a model, evaluate and validate it, and finally deploy it to an edge device. The course will also cover how to make inference and run predictions. This will enable future predictions development across medical devices, home automation, and more. The course will also cover how to handle data privacy and security concerns in the development of programs and how to handle them. The course will also cover how to handle the challenges of program development and how to handle them. The course will also cover how to handle the challenges of program development and how to handle them.



Learn More!

Wednesday, 8 May 2024

09:00 - 12:00 Education & Applications

09:00 **Day Opening 5'**

09:05 **Educational Activities at TinyML Foundation 40'**

Speaker: Evgeni GOUSEV (TinyML Foundation)

09:45 **Experiences using TinyML tools in teaching biomedical engineering 40'**

Speaker: Moises MEZA RODRIGUEZ (Universidad Peruana Cayetano Heredia, Peru)

10:25 **TBD - Data Fusion in Tinyml, Model Compression, Model Aggregation, Weightless Neural Networks and applications in biology and federated learning 35'**

Speaker: Claudio MICELI (UFRJ, Brazil)

11:00 **Arduino and Education 55'**

Speaker: David CUARTIELLES RUIZ (Arduino (Co-Founder))

11:55 **Day Closing 5'**

*“The future of machine
learning is tiny and bright!”*