EECE-4710 "IoT and TinyML"

Course and Syllabus

Cris Ababei

MARQUETTE UNIVERSITY

BE THE DIFFERENCE.

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What Will We Learn?

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What Will We learn?

- **Part 1: Foundations of Machine Learning (ML)**
- **Part 2: Sensors**
- **Part 3: Applications and Deployment to Microcontrollers**
- **Part 4: Energy Harvesting Techniques**
- **Part 5: Security in IoT**

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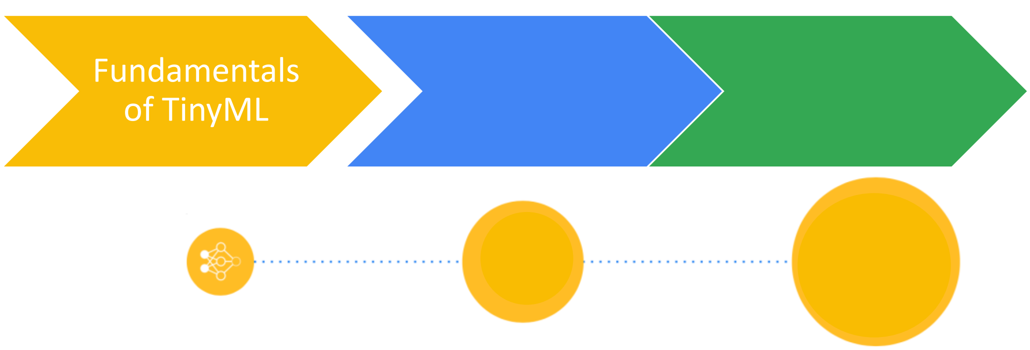
What Will We learn?

Part 1



Part 1: Understanding what is the language of Machine Learning

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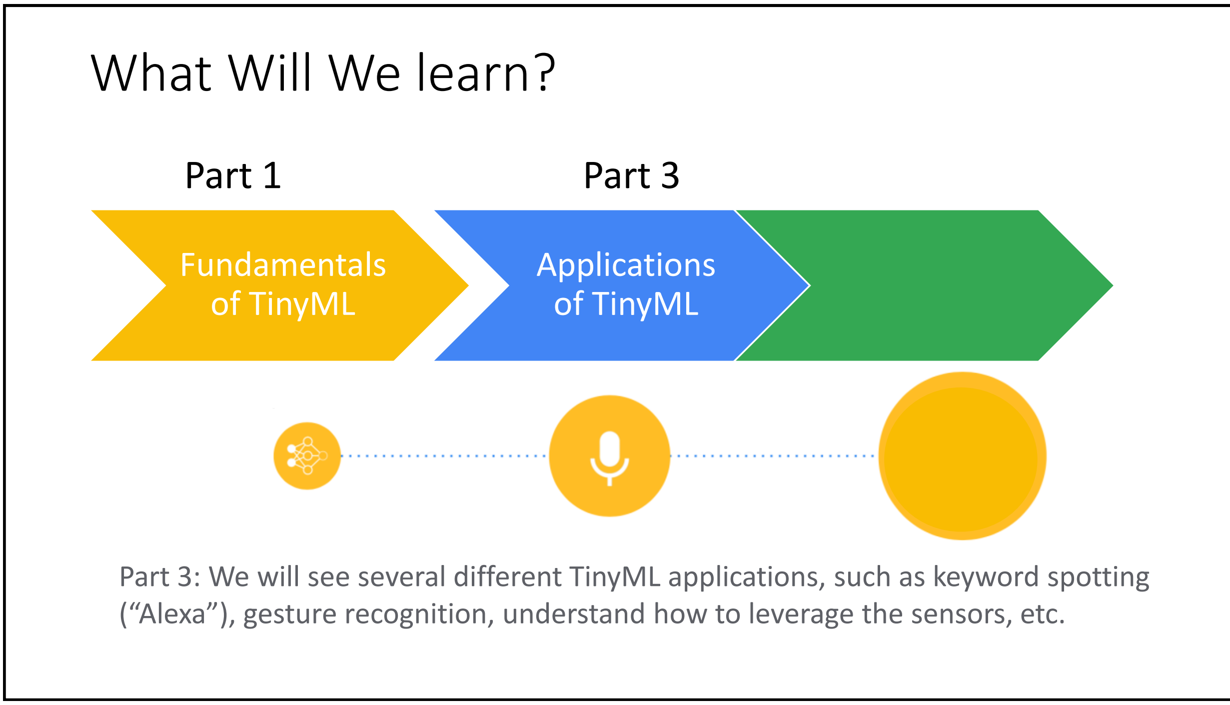
What Will We learn?
Part 1
Part 3
Fundamentals of TinyML
Applications of TinyML
Part 3: We will see several different TinyML applications, such as keyword spotting ("Alexa"), gesture recognition, understand how to leverage the sensors, etc.

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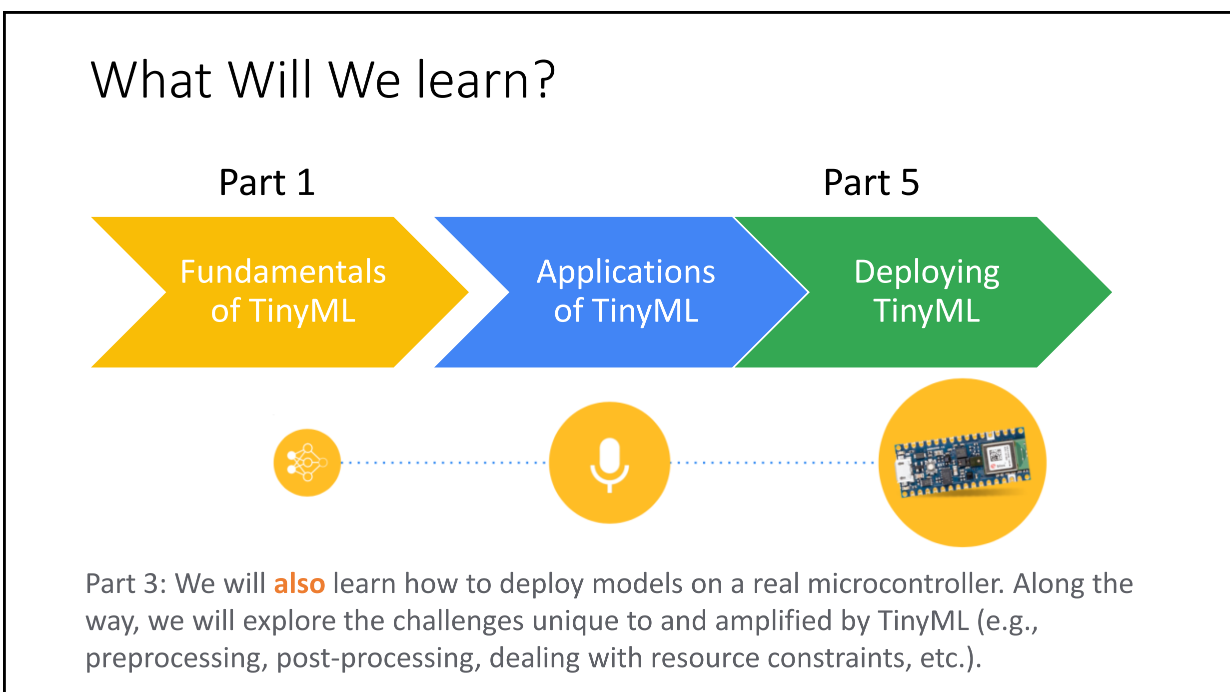
What Will We learn?
Part 1
Part 5
Fundamentals of TinyML
Applications of TinyML
Deploying TinyML
Part 3: We will also learn how to deploy models on a real microcontroller. Along the way, we will explore the challenges unique to and amplified by TinyML (e.g., preprocessing, post-processing, dealing with resource constraints, etc.).

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Background Requirements

- Python
- TensorFlow
- Google Colab
  - Jupyter Notebook
- Anaconda, Spyder
  - Locally on your PC

- Python
- TensorFlow (Lite)
- Google Colab
- Edge Impulse Studio

- Python
- TensorFlow (Lite-Micro)
- Google Colab
- Edge Impulse Studio
- IDE (as Arduino)
- C/C++

This course combines **computer science** with **engineering** to feature real-world application case studies that examine the challenges facing **TinyML deployments**.

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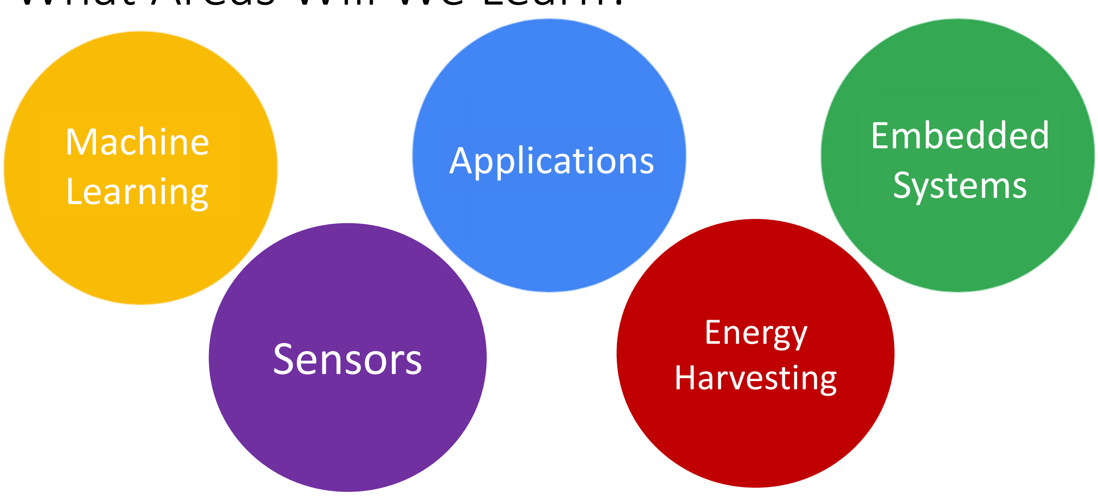
What Areas Will We Learn?



We will learn the **fundamentals of each of these areas**, just enough to focus on the goal of being able to build **TinyML applications**.

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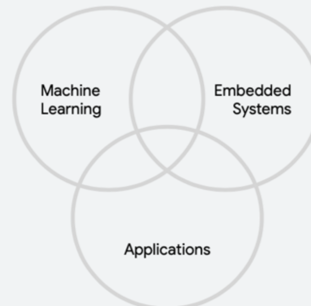
Interactions

In addition, we will bring these diverse topics together to reveal the interesting learnings at the various **intersections**



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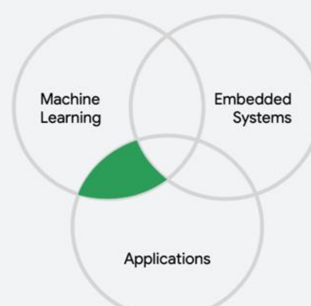
Interactions

How **machine learning** can enable new and interesting **TinyML applications**?



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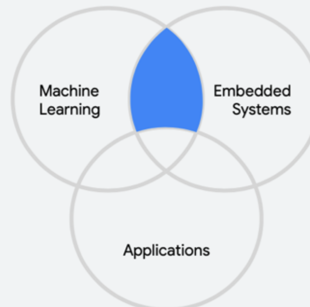
Interactions

What are the **challenges** with enabling **machine learning** on **tiny**, resource-constrained **embedded devices**?



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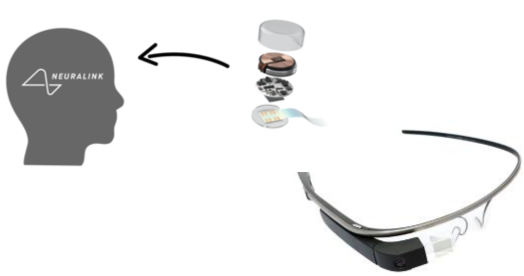
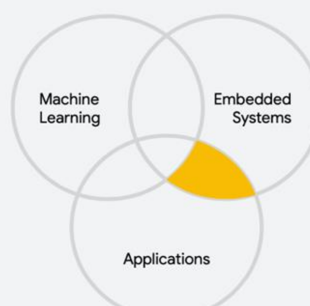
Interactions

What type of new **use cases** can we possibly enable on **embedded systems** that we could not otherwise do before?





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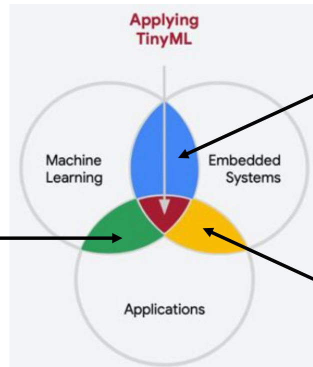
At the End of the Day: Interacting Areas → Intersections



What are the challenges with enabling **machine learning** on **tiny**, resource-constraint **embedded devices**?

How **machine learning** can enable new and interesting new **TinyML applications**?

What type of new **use cases** can we enable on **embedded systems** that we could not do before?

Given your understanding of things at these intersections, you should have the ability to apply TinyML

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How are we going to get there?

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Hands-on Learning

- Software
  - Machine Learning (TensorFlow)
  - Programming environments (Google Colab or Jupyter or Anaconda Spyder)
  - Edge Impulse Studio
- Hardware
  - Arduino Nano 33 BLE Sense
  - Sensors

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TinyML Kit

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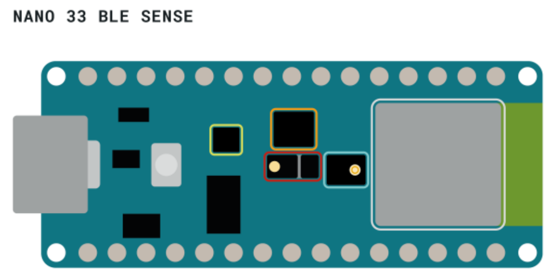
Nano 33 BLE SENSE & OV7675 Camera



- Color, brightness, proximity and gesture sensor
- Digital microphone
- Motion, vibration and orientation sensor
- Temperature, humidity and pressure sensor
- Arm Cortex-M4 microcontroller and BLE module

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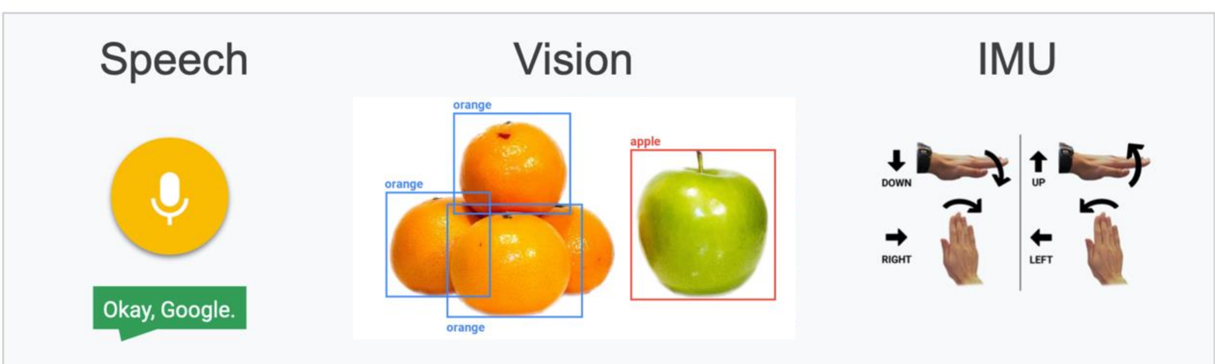
Hands-on Activities



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How is the Course Structured?

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Course Structure

- Weekly 2 lectures of 1h 15 minutes each (16 weeks)
  - Will cover Slides and,
  - Hands-on coding (teachers & students)
- Weekly Additional Readings
- Assignments
  - Hands-on coding
  - Collect results, plot, interpret
  - Write weekly reports
- Final Project (Groups of 3 or 4 students)
  - Report
  - Presentation
- Guest Presenter*

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Course Materials & Grading

- Course materials
  - http://dejazzer.com/eece4710/index.html
  - D2L – For Grades, Discussion Forum
  - GitHub – For code

- Grading is based on the following components:
  - Class participation: 20%
  - Homework assignments: 80%
- Grading scale:
  - A [94-100]%; A- [90-94)%; B+ [87-90)%; B [83-87)%; B- [80-83)%; C+ [77-80)%; C [73-77)%; C- [70-73)%; D+ [67-70)%; D [60-67); F [0-59)%

Credits

- A previous edition of this course was developed in collaboration with Dr. Susan C. Schneider of Marquette University.
- We are very grateful and thank all the following professors, researchers, and practitioners for jump-starting courses on TinyML and for sharing their teaching materials:
- Prof. Marcelo Rovai - TinyML - Machine Learning for Embedding Devices, UNIFEI
  - https://github.com/Mjrovai/UNIFEI-IESTI01-TinyML-2022.1
- Prof. Vijay Janapa Reddi - CS249r: Tiny Machine Learning, Applied Machine Learning on Embedded IoT Devices, Harvard
  - https://sites.google.com/g.harvard.edu/tinyml/home
- Prof. Rahul Mangharam – ESE3600: Tiny Machine Learning, Univ. of Pennsylvania
  - https://tinyml.seas.upenn.edu/#
- Prof. Brian Plancher - Harvard CS249r: Tiny Machine Learning (TinyML), Barnard College, Columbia University
  - https://a2r-lab.org/courses/cs249r_tinyml/

References

- Additional references from where information and other teaching materials were gathered include:

- Applications & Deploy textbook: "TinyML" by Pete Warden, Daniel Situnayake
  - https://www.oreilly.com/library/view/tinyml/9781492052036/
- Deploy textbook "TinyML Cookbook" by Gian Marco Iodice
  - https://github.com/PacktPublishing/TinyML-Cookbook
- Jason Brownlee
  - https://machinelearningmastery.com/
- TinyMLedu
  - https://tinyml.seas.harvard.edu/
- Professional Certificate in Tiny Machine Learning (TinyML) – edX/Harvard
  - https://www.edx.org/professional-certificate/harvardx-tiny-machine-learning
- Introduction to Embedded Machine Learning - Coursera/Edge Impulse
  - https://www.coursera.org/learn/introduction-to-embedded-machine-learning
- Computer Vision with Embedded Machine Learning - Coursera/Edge Impulse
  - https://www.coursera.org/learn/computer-vision-with-embedded-machine-learning

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