

**1. Course Number and Course Title:**

COE 594-13 – Tiny Machine Learning (tinyML)

**2. Credit Hours:**

3 – 0 – 3

**3. Prerequisites and/or Co-Requisites:**

Prerequisite: Approval of the CSE Head of Department

Co-requisites: None

Competencies: Undergraduate knowledge of microcontrollers and machine learning

**4. Name and Contact Information of Instructor:**

Name: Dr. Mohamed Hassan

Email: mhassan@aus.edu

Office: ESB 2171

Office Hours: Posted on office door and iLearn; also by appointment

**5. Course Description (Catalog Description):**

Introduces the emerging field of Tiny Machine Learning (tinyML), where Machine Learning (ML) meets ultra-low-power embedded devices. Explores the fundamentals of ML algorithms and their adaptations for constrained hardware. Covers frameworks for optimizing and deploying ML for microcontrollers. Studies applications in vision, audio, and sensor-driven IoT systems.

**6. Textbook and other Supplemental Material:**

Textbook:

- Pete Warden & Daniel Situnayake, *tinyML: Machine Learning with TensorFlow Lite on Arduino and Ultra-Low-Power Microcontrollers*, O'Reilly Media, 1st ed., 2020.

Other supplemental material:

- Gian Marco Iodice, *tinyML Cookbook: Combine artificial intelligence and ultra-low-power embedded devices to make the world smarter*, Packt Publishing, 1st ed., 2022.

**7. Course Learning Outcomes:**

Upon completion of the course, students will be able to:

1. Design tinyML models tailored for ultra-low-power embedded devices.
2. Adapt state-of-the-art tinyML frameworks to novel hardware and software platforms.
3. Evaluate the performance, robustness, and efficiency of tinyML models.
4. Analyze architectural trade-offs in deploying tinyML solutions on diverse hardware platforms.
5. Critique contemporary tinyML research by identifying methodological strengths, weaknesses, and unresolved challenges.
6. Communicate technical findings effectively through scholarly writing, oral presentations, and project demonstrations.

**8. Teaching and Learning Methodologies:**

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Methods include lectures, academic paper reviews, case studies, class discussions, and group work. Students learning is assessed via homework assignments, paper reviews, team research project and exams.

### 9. Course Topics and Schedule:

Topic/Activity	Weeks
Introduction to tinyML	Week #1
Fundamentals of ML and tinyML	Week #2
tinyML Challenges	Week #3
tinyML Embedded Hardware	Week #4
tinyML Embedded Software	Week #5
tinyML Sensor Ecosystem	Week #6
tinyML Framework: Tensorflow Lite Micro	Week #7
tinyML Optimizations: Pruning and Quantization	Week #8
tinyML Applications: Audio	Week #9
tinyML Applications: Visual	Week #10
tinyML Applications: Anomaly Detection + Midterm Exam	Week #11
tinyML Applications: Autonomous Systems Navigation	Week #12
tinyML Applications: Personalized Healthcare	Week #13
Paper Presentations, Applications and Optimizations	Week #14
Final Project Demos	Week #15
Final Exam	Week #16

### 10. Schedule of Laboratory and other Non-Lecture Sessions:

The paper review is done individually and is due in Week #13. Students must conduct a review on a research paper that they choose from an assigned pool of papers, and they present it to the class in Week#14.

The research project is conducted by teams of two students and is due at the end of the semester. Student teams are required to submit a project proposal related to tinyML, and apply the knowledge and techniques acquired throughout the course to create a working demo. They will submit a final short paper that outlines the techniques applied, explains the steps taken, and provides a thorough analysis of the results. Students will demo their projects in Week #15.

### 11. Out-of-Class Assignments with Due Dates:

Assignment	Due Date (tentative)
Homework 1: DNN	Week #3
Homework 2: CNN	Week #6
Homework 3: Quantization	Week #8
Homework 4: Keyword spotting	Week #10
Paper review	Week #13
Homework 5: End-to-End tinyML Deployment	Week #14
Research project	Week #15

### 12. Student Evaluation:

Assessment	Weight	Due Date (tentative)
Homework	20%	cf. Section 11
Midterm Exam	20%	Week #11

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Paper Review and Presentation	10%	Cf. Section 11
Research Project	25%	Cf. Section 11
Final Exam	25%	Week #16

**13. Assessment Instruments:**

Assessment	Course Learning Outcomes
Homework	O1– O4
Midterm Exam	O3 – O5
Paper Review and Presentation	O5, O6
Research Project	O 1 – O6
Final Exam	O3 – O5

**14. Contribution of Course to Program Outcomes:**

MSMLR Program Outcomes	Emphasis in this course	Course Learning Outcomes
1. Perform research emphasizing creativity, independent learning, and scientific methods in the field of Machine Learning.	●	O1-O5
2. Apply advanced mathematics, computer science knowledge, and software tools in identifying, formulating, and solving real world problems.	○	O1, O3
3. Demonstrate an in-depth understanding of modern Machine Learning approaches, algorithms, and tools.		
4. Select and use techniques, skills, and modern tools necessary for research or professional practice.	◐	O2, O5
5. Communicate effectively through technical presentations and reports.	○	O6
6. Recognize the need for, and engage in, lifelong learning in professional areas.		
7. Attend to professional and ethical responsibilities within global and societal contexts.		

MSCOE Program Outcomes	Emphasis in this course	Course Learning Outcomes
1. Perform research emphasizing creativity, independent learning and scientific methods in a chosen area of computer engineering.	●	O1-O5
2. Apply advanced mathematics and engineering knowledge in identifying, formulating and solving engineering problems.	○	O1, O3
3. Select and use techniques, skills and modern tools necessary for research or professional practice.	◐	O2, O5
4. Communicate effectively	○	O6

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5. Recognize the need for, and engage in, lifelong learning in professional areas		
6. Attend to professional and ethical responsibilities		

Emphasis: ● High; ● Medium; ○ Low; Blank – Nothing Specific Expected

**15. Letter Grade Policy:**

Total (T)	Letter Grade
$90 \leq T$	A
$85 \leq T < 90$	A-
$80 \leq T < 85$	B+
$75 \leq T < 80$	B
$70 \leq T < 75$	B-
$65 \leq T < 70$	C+
$60 \leq T < 65$	C
$T < 60$	F