

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

COE 594-14 – Modern Video Codec Design

**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-level knowledge of programming

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

Name: Dr. Ihab Amer

Email: iamer@aus.edu

Office: ESB 2177

Phone: 06 515 4836

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

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

Introduces video codec architectures with emphasis on design tradeoffs. Evaluates competing requirements such as throughput, power consumption, cost, programmability, time-to-market, quality, bitrate, latency, and error resiliency. Models algorithms and analyzes design-space tradeoffs in video systems. Provides hands-on experience implementing digital video codec systems. Examines emerging AI methods in video codec architectures, including the use of AI for compression and the contribution of compression technologies to improve the accuracy, efficiency, and robustness of AI systems.

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

Textbook:

- Iain Richardson, *Coding Video: A Practical Guide to HEVC and Beyond*, Wiley, 1st ed., 2024.

Other supplemental material:

- Iain Richardson, *The H.264 Advanced Video Compression Standard*, Wiley, 2nd ed., 2010.
- Iain Richardson, *Video Codec Design: Developing Image and Video Compression Systems*, Wiley, 1st ed., 2002.
- Jan Rabaey, *Low Power Design Essentials*, Springer, 1st ed., 2009.
- Selected recent publications in the intersection of video compression and AI

**7. Course Learning Outcomes:**

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

1. Analyze use cases to identify the computational requirements of the target platform.
2. Develop different algorithms to assess the impact of design decisions on a video codec implementation.
3. Model simplified video-codec components to explore architectural choices.
4. Quantify the tradeoffs between the performance per watt and the quality per bitrate through software experiments.

5. Critique state-of-the-art research in video codec architectures, including AI-driven methods.
6. Conduct independent research in video codec architecture and present findings in written and oral form.

**8. Teaching and Learning Methodologies:**

Methods include lectures, problem and project-based learning methods (assignments, exams, review paper, research project, presentation), and class discussions.

**9. Course Topics and Schedule:**

Topic/Activity	Weeks
Fundamentals of digital video signals	Week #1
Introduction to digital video compression	Week #2
Inter prediction: Motion estimation and motion compensation	Week #3
Intra frame prediction and transform coding	Week #4
Use cases and customer needs of a codec system	Week #5
Techniques to improve quality per bitrate at the expense of performance per watt	Week #6
Techniques to improve performance per watt at the expense of quality per bitrate	Week #7
Latency aspects of a codec System, and tradeoffs with quality + Midterm exam	Week #8
AI-assisted video compression: Pre-analysis and decision prediction	Week #9
AI-assisted video compression: Decision prediction and impact of standards	Week #10
Neural video codecs	Week #11
Compression technologies for improved AI accuracy, efficiency, and robustness	Week #12
Low power design essentials: Static vs dynamic power	Week #13
Low power design essentials: Techniques to reduce power	Week #14
Class presentations	Week #15
Final exam	Week #16

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

The project is conducted by teams of 2-3 students. Students develop a complete abstract codec system and navigate its design space to appreciate the tradeoffs between its design aspects. Students need to submit the source code and comprehensive report, as well as to demo their work to the course instructor. In milestone #1, students will develop the baseline encoder-decoder system; in milestone #2, they will develop features to trade between performance per watt and quality per bitrate; in milestone #3, they will develop a rate control algorithm and assess the impact on latency, in addition to working on a forward-looking research-oriented feature. The milestones of the project go hand in hand with the content delivered in the weekly lectures.

Students will also conduct a survey on a specific topic related to applications of AI on multimedia systems or applications of compression technologies on AI systems, then write a short paper to summarize their findings. They will also present the same to the class.

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

Assignment	Due Date (tentative)
Homework 1: Codec fundamentals	Week #5
Homework 2: Performance/Quality tradeoffs of a codec system	Week #10
Homework 3: Rate control and latency aspects of a codec system	Week #13
Project	Week #13

Review paper	Week #14
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**12. Student Evaluation:**

Assessment	Weight	Due Date (tentative)
Review paper and presentation	15%	Week #14
Homework	15%	Cf. Section 11
Midterm Exam	20%	Week #8
Project	25%	Week #15
Final Exam	25%	Week #16

**13. Assessment Instruments:**

Assessment	Course Learning Outcomes
Review paper and presentation	O5 – O6
Homework	O1 – O4
Midterm Exam	O1 – O4
Project	O1 – O4
Final Exam	O1 – O6

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

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.	◐	O5 – O6
2. Apply advanced mathematics and engineering knowledge in identifying, formulating and solving engineering problems.		
3. Select and use techniques, skills and modern tools necessary for research or professional practice.	●	O1 – O4
4. Communicate effectively.	◊	O5 – O6
5. Recognize the need for, and engage in, lifelong learning.		
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