**ELC 470-2 (1.0 CU)**

**Video Processing and Compression**

**Course Information**

**Spring 2015**

Professor

Dr. Larry Pearlstein

Classroom Hours

TF 9:30 PM – 10:50 PM/AR128 (Lecture)

W 9:00 PM – 9:50 PM/AR102 (Design hour)

Course Description

An introduction to video processing and video compression:

* The basics of human vision that motivate image representation
* Spatial resolution and conveying depth information
* Temporal considerations and 3D (spatio-temporal) sampling
* Linear and non-linear image filtering
* Quantization
* Information and entropy
* Pixel representations, formats and colorspaces
* Transforms, especially DCT, DST and WHT
* Lossless compression methods
* Motion compensated prediction
* Video coding standards, history, details of MPEG-2 and HEVC
* Transport multiplex, lip-synch, transport across networks
* Future of video coding

Instructor Information

Office Location: AR 130B

Phone: (267) 566-5699

E-Mail: pearlstl@tcnj.edu

Office Hours

Wednesdays: 2:00-3:30

Thursdays: 2:00-3:30

+ by appointment (send me EMAIL)

+ whenever my door is open

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|  | **Tuesday Lecture** | **Design Hour** | **Friday Lecture** |
| **1**  **Week of 1/26** | Chapter 1  Introduction | Watch YouTube Internet cat videos & Netflix.  Browse public CODEC source code.  Rate video quality and identify artifacts. | 2.2.0, 2.2.3, 2.2.4, 2.3.1, 2.4-2.9  (selected topics)  Human Visual System |
| **2**  **Week of 2/2** | Chapter 3  Video sampling  Statistics  Quiz Review | Quiz 1 | Filtering |
| **3**  **Week of 2/9** | Filtering with Matlab | Design Assignment 2  Filtering with Matlab | Chapter 3  Quantization  Prediction  Entropy  (Huffman Coding) |
| **4**  **Week of 2/16** | Chapter 4  Pixels, formats, gamma | Design Assignment 3  Prediction & Entropy in Matlab | Chapter 4  Color spaces, rates/distortions |
| **5**  **Week of 2/23** | Chapter 4  Color spaces, rates/distortions | Design Assignment 4  Color Space Conversion | Chapter 5  WHT and DCT |
| **6**  **Week of 3/2** | Chapter 7  Arithmetic coding | TBD | Chapter 8  Motion estimation |
| **8**  **Week of 3/9** | Chapter 9  Hybrid Video CODEC | Review for Exam | Midterm Exam |
| **8**  **Week of 3/16** | SPRING BREAK ☺ | | |
| **9**  **Week of 3/23** | Chapter 10  Picture Quality | Search out new video content and identify characteristics and artifacts. | Chapter 12  Standards, + details  MPEG-2 Video  Sequence, Picture, Slice Headers |
| **10**  **Week of 3/30** | MPEG-2 Video  Macroblock decoding | Develop simple lossless end-to-end intra frame compression system: Quadtree prediction – VLC – VLD – Recon | MPEG-2 Video  Coefficient decoding |
| **11**  **Week of 4/6** | MPEG-2 Video Encoding  Supplementary | Simple CODEC continued | H.264 vs MPEG-2  Supplementary |
| **12**  **Week of 4/13** | H.265  Supplementary | Compare MPEG-2 and H.265 RD characteristics | MPEG-2 PES and trick play |
| **13**  **Week of 4/20** | MPEG-2 transport packets and multiplex | MPEG-2 and H.265 MOS test data collection | JPEG |
| **14**  **Week of 4/27** | Chapter 11, selected topics | MOS analysis | Chapter 13, selected topics |
| **15**  **Week of 5/4** | Frame rate conversion, ethical issues  Supplementary | Review for Exam | Review for Exam |

Textbook

Communicating Pictures: A Course in Image and Video Coding, David Bull

1st Edition, 2014

ISBN: 978-0-12-405906-1

Prerequisites

CSC 215 – Computer Science I

ELC 321 – Signals and Systems

Grading Policy

Quizzes[[1]](#footnote-1) 15%

Assignments 20%

Midterm 30%

Final Exam 35%

Tips for Success

Read the book sections prior to their discussion in class.

Do all homework promptly.

Do not be shy about asking questions, either during class or outside of the class.

Come to office hours, or make an appointment, if you still have confusion or questions.

College Level Policies

Attendance Policy: <http://www.tcnj.edu/~recreg/policies/attendance.html>

Academic Integrity Policy: <http://www.tcnj.edu/~academic/policy/integrity.html>

Americans with Disabilities Act (ADA) Policy: <http://www.tcnj.edu/~affirm/ada.html>

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| **2**  **Week of 2/2** | Chapter 3  Video sampling  Statistics  Filtering | Filtering with XnView & Matlab | Chapter 3  Quantization  Prediction  Entropy |
| **3**  **Week of 2/9** | Chapter 4  Pixels, formats, gamma | Set up Linux accounts. Create synthetic images. | Chapter 4  Color spaces, rates/distortions |
| **4**  **Week of 2/16** | Chapter 5  WHT and DCT | Develop, run and test ‘C’ program for RGB to YUV conversion. | Chapter 7  Variable length codes |
| **5**  **Week of 2/23** | Chapter 7  Arithmetic coding | Compression scams.  Develop lossless compression scheme to code names of TCNJ Greek Organizations. | Chapter 8  Motion estimation |
| **6**  **Week of 3/2** | Chapter 8  Motion estimation | Review for Exam | Midterm Exam |
| **7**  **Week of 3/9** | **SPRING BREAK ☺** | | |
| **8**  **Week of 3/16** | Chapter 9  Hybrid Video CODEC | Download and run ffmpeg to do encoding, decoding and remultiplexing. | Chapter 9  Hybrid Video CODEC |
| **9**  **Week of 3/23** | Chapter 10  Picture Quality | Search out new video content and identify characteristics and artifacts. | Chapter 12  Standards, + details  MPEG-2 Video  Sequence, Picture, Slice Headers |
| **10**  **Week of 3/30** | MPEG-2 Video  Macroblock decoding | Develop simple lossless end-to-end intra frame compression system: Quadtree prediction – VLC – VLD – Recon | MPEG-2 Video  Coefficient decoding |
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| **14**  **Week of 4/27** | Chapter 11, selected topics | MOS analysis | Chapter 13, selected topics |
| **15**  **Week of 5/4** | Frame rate conversion, ethical issues  Supplementary | Review for Exam | Review for Exam |

Educational Objectives

(What TCNJ ECE engineers should be able to accomplish during the first few years after graduation)

* To contribute to the economic development of New Jersey and the nation through the ethical practice of engineering;
* To become successful in their chosen career path, whether it is in the practice of engineering, in advanced studies in engineering or science, or in other complementary disciplines;
* To assume leadership roles in industry or public service through engineering ability;
* To maintain career skills through life-long learning.

Electrical and Computer Engineering Student Outcomes

(What TCNJ Electrical and Computer Engineering students are expected to know and be able to do at graduation. What knowledge, abilities, tools and skills the program gives the graduates to enable them to accomplish the Educational Objectives)

The Student Outcomes listed below are expected of all graduates of the Electrical or Computer Engineering Program.

ECE graduates will have:

**a. an ability to apply knowledge of mathematics, science and engineering;**

Math used extensively in homework problems and exams.

**b. an ability to design and conduct experiments, as well as to analyze and interpret data.**

Student will perform experimentation with image and video processing and compression, will interpret data and will submit reports.

c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;

d. an ability to function in multidisciplinary teams;

**e. an ability to identify, formulate and solve engineering problems;**

Students do homework problems.

f. an understanding of professional and ethical responsibility;

g. an ability to communicate effectively;

**h. the broad education necessary to understand the impact of engineering solutions in a global and societal context;**

The technical details of international standards are emphasized, as well as their impact

i. a recognition of the need for and an ability to engage in life-long learning;

**j. a knowledge of contemporary issues;**

Video compression, in its present form, is a relative new field, and the latest developments are covered.

**k. an ability to use the techniques, skills and modern engineering tools necessary for engineering practice;**

‘C’, Matlab, Linux and XnView will be used for assignments.

Course Objectives[[2]](#footnote-2)\*

Objective 1: To understand the basics of human vision and color representation and reproduction in image and video processing. [a, e]

Objective 2: To be understand basic image and video processing functions and be able to implement them in ‘C’ and Matlab. [a, b, e, k]

Objective 3: To understand why video compression is useful, how it works and how to operate compression tools and utilities. [a, b, e, h, j, k]

Objective 4: To understand video delivery mechanisms including broadcast transport streams and streaming network delivery. [a, b, e, h, j, k]

Topics Covered:

1. The basics of human vision that motivate image representation
2. Spatial resolution and conveying depth information
3. Temporal considerations and 3D (spatio-temporal) sampling
4. Linear and non-linear image filtering
5. Quantization
6. Information and entropy
7. Pixel representations, formats and colorspaces
8. Transforms, especially DCT, DST and WHT
9. Lossless compression methods
10. Motion compensated prediction
11. Video coding standards, history, details of MPEG-2 and HEVC
12. Transport multiplex, lip-synch, transport across networks
13. Future of video coding

Evaluation:

A. Midterm Examination

B. Final Examination

C. Assignments

Performance Criteria[[3]](#footnote-3)\*\*:

Objective 1: An understanding of the basics of human vision and color representation and reproduction in image and video processing. (A, B)

Objective 2 An understanding of basic image and video processing functions and the ability to implement them in ‘C’ and Matlab. (A, B, C)

Objective 3: An understanding of how video compression works. (C)

Objective 4: An understanding of video delivery mechanisms. (C)

ELC 470-2: ADDITIONAL INFORMATION

**1. DESCRIPTION OF DESIGN ACTIVITY**

Students will design, debug and run programs for implementing video processing functions.

**2. ENGINEERING STANDARDS**

We will go into details of the ISO/IEC 13818-2 (MPEG-2 Video) compression standard, and the basics of the ATSC Digital Television Standard, and ITU-T H.265 and H.265 standards.

**3. REALISTIC CONSTRAINTS**

Economic: We will consider the economic impact of standards.

Environmental: N/A.

Sustainability: N/A.

Ethical: Video compression can involve rights management and privacy issues.

Social Impact: Video compression has had a significant effect on society.

**4. MODERN AND PROFESSIONAL ENGINEERING TOOLS USAGE**

MATLAB, ‘C’ language IDE, XnView & Linux used throughout the course.

**5. COMPUTER USAGE**

Students use Linux and Windows computers to run video encoding and multiplexing tools, image utilities, develop and run ‘C’ and MATLAB code.

**6. FEEDBACK MECHANISMS**

Examinations: Students take a Midterm Exam and a Final Exam.

Reports: Some assignments will require submissions in the form of a report.

Homework: Homework is assigned and graded. The assignments represent a mixture of problems, factual questions, programming and data processing experimentation.

1. Quizzes will be given in class throughout the term, and will be announced one class in advance. There will be no makeup quizzes – missed quizzes will get a grade of 0, but the bottom grade will be dropped. [↑](#footnote-ref-1)
2. \* Small letters in brackets refer to the Student Outcomes [↑](#footnote-ref-2)
3. \*\* Capital letters in brackets refer to the evaluation methods used to assess student performance [↑](#footnote-ref-3)