Universidade Federal de Santa Catarina
Centro Tecnológico
Departamento de Informática e Estatística
Programa de Pós-Graduação em Ciência da Computação

COURSE PLAN

A critério do professor, não havendo alunos estrangeiros matriculados, a disciplina poderá ser ofertada em língua portuguesa.

1) Identification

Course: Selected Topics in Computer Science: video coding (Tópicos Especiais em Computação: codificação de vídeo)
Workload: 60 hours-class - 4 credits
Semester: 2020.1
Professor: José Luís Almada Güntzel

2) Levels

Master and Doctorate

3) Prerequisites

Knowledge of programming, data structures and digital design proved through undergraduate and/or graduate courses successfully followed.

4) Syllabus

Basic concepts of video compression, the hybrid video encoder model: coding steps, state-of-the-art video coding standards and their most relevant features; selected aspects of video coders and decoders implemented in software and in hardware (accelerators).

5) Objectives

General:

Present an overview of digital video compression flow at the light of the state-of-the-art video coding standards and provide the possibility of understanding one coding step in more details by means of a hardware or software implementation.

Specific:

- Present the basic concepts related to the video compression area;
- Present and analyze the most important coding tools used in the block-based hybrid video encoder model;
- Understand the most relevant specificities and differences between some of the state-of-the-art video coding standards;
- Study specific features of coders and decoders implemented in software and in hardware;
- Allow students to go into the details of a coding step by implementing an algorithm or a technique in software or in hardware.

6) Course Outline

Part 1: The block-based hybrid video encoder model:

- Basic concepts: color space, redundancy of information, rate, distortion, block partitioning, frame hierarchy, encoding evaluation metrics, and encoder flow overview;

- Prediction: intra prediction, inter prediction, motion estimation;
- Transform and Quantization: DCT, DST, KLT and respective inverses;
- Quantization parameter;
- Entropy coding: CABAC, CAVLC

Part 2: State-of-the-art video coding standards and their most relevant features:

- Advanced Video Coding (AVC)
- High-Efficiency Video Coding (HEVC);
- Versatile Video Coding (VVC);
- AOMedia Video Codec (AV1);
- Essencial Video Coding (EVC).

Part 3: Selected aspects of video coding implementation:

- The Common test conditions;
- Complexity-, QP- and Rate-constrained encoding;
- Rate-distortion tradeoff, coding efficiency vs. energy tradeoff;
- Dedicated hardware implementation;

7) Assessment and Grading

The assessment instruments are:

- Two seminars on topics selected from the course outline (grades S1 and S2)
- Project:
  - Specification (grade Spec)
  - Implementation (grade Imp)

The final grade (G) will be computed as:

$$G = 0.3 * S1 + 0.3 * S2 + 0.1 * Spec + 0.3* Imp$$

8) Schedule

To be announced in the beginning of the semester.

9) Bibliography

[1] RICHARDSON, Iain E. H. The H.264 Advanced Video Compression Standard, Second Edition. [S.l.]: John Wiley & Sons Ltd, 2010.

[2] WIEN, Matthias. High Efficiency Video Coding: Coding Tools and Specification. Springer, 2015, (Signals and Communication Technology)

[3] SZE, Vivienne, BUDAGAVI, Madhukar, SULLIVAN, Gary J. High Efficiency Video Coding (HEVC): Algorithms and Architectures. Springer, 2014, (Integrated Circuits and Systems).

[4] CORRÊA, G. et al. Complexity-Aware High Efficiency Video Coding. [S.l.]: Springer International Publishing, 2015. ISBN 9783319257785. DOI: 10.1007/978-3-319-25778-5 .

10) Complementary Bibliography

[5] DOMINGUEZ, Humberto Ochoa; RAO, K. R. Versatile Video Coding. River Publishers. March 2019. ISBN: 9788770220477

[6] MONTGOMERY M. Next generation video: Introducing AV1, Apr. 2018. [Online]. Available:

https: //people.xiph.org/~xiphmont/demo/av1/demo1.shtml.

[7] Essential Video Coding. MPEG, The Moving Picture Experts Group. [Online] Available: https://mpeg.chiariglione.org/standards/mpeg-5/essential-video-coding

[8] WIEN, M. High Efficiency Video Coding - Coding Tools and Specification. **Tutorial**. IEEE International Conference on Multimedia and Expo (ICME 2013). San Jose, California, USA. July 15-19, 2013

[9] RICHARDSON, Iain E. H. Video codec design: developing image and video compression systems. Chichester, England: John Wiley and Sons, 2002. ISBN 0-470-84837-5.

[10] RICHARDSON, Iain E. H. 264 and MPEG-4 video compression: video coding for next-generation multimedia. [S.l.]: John Wiley & Sons Inc, 2003.

[11] BOSSEN, F. Common test conditions and software reference configurations, Joint Collaborative Team on Video Coding (JCT-VC), JCTVC-F900, no., 2011

[12] P. de Rivaz and J. Haughton, Av1 bitstream & decoding process specification, 2018. [Online]. Available: https://aomediacodec.github.io/av1-spec/av1-spec.pdf.

[13] Jonatan Samuelsson , Kiho Choi , Jianle Chen , Dmytro Rusanovskyy The Emerging MPEG-5 EVC Standard: Applications, Technology and Results. [Online]. Available: https://www.ibc.org/download?ac=10463

[14] Selected papers of state-of-the-art in video coding.