Multimedia and Video Communications

(SSY150, 7.5p)

Dept. of Signals and Systems, Chalmers Univ. of Technology, Sweden

2009-03-17

Teachers involved in this course

Lecturer and examiner: Irene Gu

Guest lecturer: Dr. Per Fröjdh (Ericsson Research)

Teaching assistants:

Mohsen Nosratinia (labs.1 & 2)
Enliang Zheng (labs. 2,3,4)
Zulfiqar Hasan Khan (lab.3)

Student representatives:

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Course Examination and Grading

1. Up to 80% from the 4 laboratory work and reports (2 persons/group) + Individual assessment (20%, 15%, 15%, 30%). Lab.3 is optional.
2. Up to 20% from the written exam in the end of the course

Pass with 3, 4:
4 Labs. + individual oral questions
Pass with 5:
Add a written exam
(concepts, problem solving on theoretical issues)

Course Literatures

Main course book:

Abdul H.Sadka, Compressed video communications (e-book available at Chalmers, hardcopy is approx. 650kr at Chalmers bookstore)

Other reference books:

(1) W.Simpson, Video over IP (e-book available at Chalmers)
(2) Fan Zhai and Aggelos Katsaggelos, Joint source-channel video transmission;
(3) Ming-Ting Sun and Amy R. Reibman, Compressed video over networks;
(4) King N. Ngan, Chi W.Yap, Ken T.Tan, video coding for wireless communication systems;
(5) M.van der schaar, P.A.Chou, Multimedia over IP and wireless networks.
(6) L.R. Babiner, R.W. Schafer, digital processing of speech signals.

Scheduled Lectures and Consultations

Lectures (12 x 2 hrs):

- **Tuesdays 15:00-17:00 in HC1 (except 28/4 in HC3!)**
- **Thursdays 10:00-11:45 in HC3**

Tutorials (2 x 2 hrs):

- **Week 17: Tuesday + Thursday**

Consultations (weeks 12-14, 17-21):

- **Wednesdays 1:30-4:00 pm**
- **Fridays 1:30-4:00 pm**

Why do we need this course ?

- Growing demands in multimedia communications, especially, on audio and video over Internet and wireless networks, e.g. video conferencing, distance learning, telemedicine,...
- Growing research activities and needs for multimedia R&D, e.g. in Ericsson and other Swedish companies.

Course Contents

Fundamentals on:

1. Compression and coding of multimedia signals

* Modeling and compression for speech/audio signals;
* Transforms, subband filters and compression of 2D images;
* Motion compensation, compression and standards for video coding.

2. transmission media, losses and protection

* Network fundamentals, protocol stack;
* IP-based networks for multimedia communications;
* Erasure network modeling, packet delay, loss and protection.

3. Network-adaptive multimedia communications

* Error resilience, packet loss protection;
* End-to-end performance optimization;
* Cross-layer design.

Date	Topic(s)	literatures
17/3	**Introduction, course outline**	
19,24/3	**Modeling and compression of speech and audio signals (I) + Lab-1 demo**	Chap. 3 (Rabiner's book); Chap. 4(Simpson's book)
26/3	**2D image transformations, subband filtering and compression**	Chap.3 (van der Schaar); + "JPEG /still image compres."
31/3	**Lab-2 demo + Video compression and motion compensation (I)**	Chapters 2 + 4 (Sadka's book)
2/4	**Guest Lecture by Dr. Per Fröjdh: Advances in video compression and coding standards + mobile comm. in Ericssion**	
21,23/4 (tutorials)	**Saving the environment: tele-conferencing and other communication approaches (I) (II)**	
28/4	**Video compression (II) + Lab.3 demo**	Chapters 2 + 4 (Sadka's book)
30/4, 5/5	**IP-based multimedia communications (I): networks; (II) erasure channels & network modeling + Lab.4 demo**	Chap.3 (Sun), Chap.4,5 (Sadka); Part C (van der Schaar).
7,12/5	**End-to-end performance optimization for multimedia communications (I),(II)**	Chapter 2 (Zhai), Chapters 3,4,5 (Sadka)
14/5	**Course reviews and exercises**	

Also, a 2-hour lecture by a guest lecturer from Ericsson Research

An invited lecture is scheduled on April 2, from Dr. Per Fröjdh on "Advances in video compression and coding standards + mobile communications in Ericsson".

Gives us more insight on what Swedish industry is currently doing and where their interests lie.

Having funs: hand-on learning through 4 laboratory work

Laboratory exercises (maximum 2 persons / group)

(1) speech model: analysis, synthesis and compression (dead line 2009-3-29)

(2) 2D image compression using transforms and subband filters (dead line 2009-04-05)

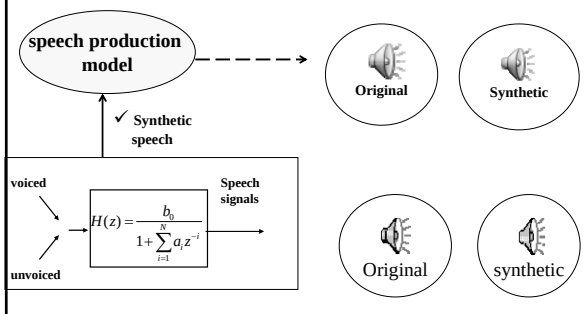
(3) Video compression using block-matching motion compensation (dead line 2009-05-03)

(4) Multimedia communications over IP networks (dead line 2009-05-15)

What can we learn from Lab.1: "Speech model: analysis, synthesis and compression" ?

- Record and save a sound or speech file to a computer, and then load the speech file in Matlab.
- Make a Matlab program on LPC (Linear predictive coding) analysis and then synthesis of single tone sound (stationary) and a speech sentence (nonstationary). Listen to the resulting sound. From this, you can learn how speech compression is achieved: a 20ms of speech signal only requires less than 20 parameters to characterize.
- Model the vocal cord excitations of speech by some impulses or white noise, to the LPC model, and listen to the synthetic speech.
- Estimate the pitch period using the cepstrum method, or the ACF method.

Examples of what you can achieve: Speech/audio synthesis



What can we learn from Lab.2: "2D image compression using transforms and subband filter" **?**

1. Apply 2D Discrete Cosine Transform (DCT) to images:
   * Learn the relation between a 1D transform and its corresponding 2D transform, if the (transform) kernel is separable.
   * Learn how to achieve compression through setting small value DCT coefficients to zeros
2. Block-based 2D DCT for image compression:
   Divide a nonstationary image into small (approx. stationary) blocks, and apply compression to each DCT transformed image block.
3. 2D subband flters for image compression:
   Learn to use the GUI in Matlab wavelet toolbox, 'wavemenu', to perform this task.
4. Compare the performance of these two compression methods.

Examples of what you can obtain:

Image compression using block-based DCT

Apply: DCT, with non-overlapping 8x8 blocks

Original image

Reconstructed image
(retain 4.2% coefficients)

Examples of what you can obtain:

Image compression from wavelets

(biorthogonal spline wavelets)

Original Image

Compressed image

What can we learn from Lab.3 (optional):

"Video compression using block-matching motion compensation" **?**

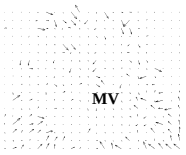
1. Learn how to handle video data in Matlab
   e.g. read/save video files, play movies, extra video frames.
2. Learn how video compression can be achieved by using a simple motion compensation method called "block matching".
3. Learn the basics of inter and intra coding modes in video.
4. Learn to use an objective criterion for evaluating the quality of compressed video.

Examples of what you can obtain:

e.g. Image-2 can be obtained by using block matching motion compensation from image-1

Image-1

Image 2



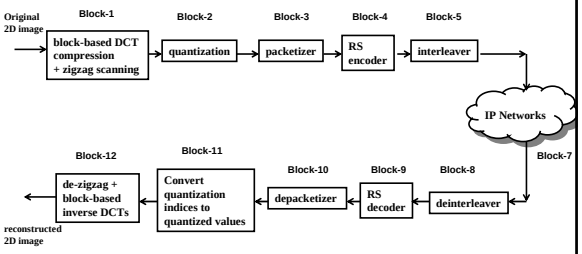
Motion vectors
From optical flows

What can we learn from Lab.4:

"Multimedia communications over IP networks" **?**

1. Building Matlab programs for the blocks of a simple multimedia communication system (see the figure), using functions in the Matlab communication toolbox.
   include: image compression, zigzag scanning, scalar quantization, RS codec, interleaving, and their inverse process.
2. Tests:
   * the impact of packet losses (in the network layer) to the received image, under erasure network model.
   * the impact of bit errors (in the physical layer) to the received image.

Fig. Block diagram of end-to-end image communication system over IP networks: to be built and tested in Lab.4.



Examples of what you could obtain if applied to video (instead of image in this Lab.):
e.g. video communication over erasure channel

20% losses, 70kbps 10% losses, 70kbps

(1 image=99 macroblocks, 1 packet = 25 macroblocks, Macroblock size= 16x16 pixels, random packet losses)

What you need to do immediately after this lecture ?

- Select your own groups:
  You are asked to form your own group for the Labs.: each group contains a maximum 2 persons.
- Register your group from the course website:
  You shall register your group from the course website as soon as possible, so you can start work perhaps in next week.

Course Website

For more details and new updates, please check the course website in ”Student portal” (or, “Studieportalen” in Swedish)

http://www.student.chalmers.se/

Choose the course code: SSY150