Chapter 1

• Use one statement to define the three basic signal compression problems.
  Answer: (1) designing a good code for an independent source; (2) transforming a
dependent source to an independent one by using a decorrelation technique (pre-
diction or transforms or filterbanks); (3) transforming the original signal in a lossy
manner (scalar or vector quantization + prediction or transforms or filterbanks) to
achieve a better compression.

• What is a prefix code

• What is the connection between a prefix code and a binary tree (example: the
codewords are \{0, 100, 11\}).

• How one can compute the average length for a prefix code.

• State the Kraft inequality.

• Which is the optimal length of the code for a symbol \(j\) having probability \(p_j\)?

• Which is the lower bound for the average length of prefix codes?

• Which is the length of the Shannon’s code for a symbol \(j\) having probability \(p_j\).
  Give one example.

• Show that by using a prefix code for blocks of symbols, (instead of a prefix code for
  individual symbols) the codelength is closer (or equal) to the entropy.

• How one can encode a binary tree (this is needed e.g. for sending the information
  on which prefix code was used for coding)
Chapter 2

- Huffman algorithm for binary encoding alphabets (by means of an example).
- State whether Huffman code is optimal and/or unique for a given (fixed) probability distribution (the case of binary encoding alphabet).
- You are given a prefix code (the tree) obtained with Huffman algorithm for a source with \( n \) symbols.
  Explain why there are at least \( 2^n - 1 \) different prefix codes which obtain the same average codelength.
  Explain why there may be more than \( 2^n - 1 \) different prefix codes (how Huffman algorithm treats nodes with equal probabilities).
- You are given a prefix code (the tree) obtained with Huffman algorithm for a source with \( n \) symbols.
  Draw the corresponding canonical Huffman code.
- Comment on the memory and speed of Huffman algorithm versus canonical Huffman algorithm.
- What is the Golomb-Rice code of an integer \( i \) (also give an example).

Chapter 3

- The principle of coding in LZ77 family. Give an example (use triplets, e.g. \(<6, 4, b>\), to specify the encoded stream).
- The principle of coding in LZ88 family. Give an example (use pairs, e.g. \(<4, b>\), to specify the encoded stream).
- You are given an example of LZW coding (e.g. part of the figure at page 18). Tell what will be the next codeword and the next dictionary entry.

Chapter 4

- Explain why the cumulative distribution function \( \tilde{F}(x) \) defined by
  
  \[
  \tilde{F}(a_i) = \sum_{k=1}^{i-1} p(a_k) + \frac{1}{2} p(a_i)
  \]
  
  can be used as a prefix code for \( x \).
  
  With how many bits we have to represent the number \( \tilde{F}(x) \) such that the encoding is efficient?
  
  What is the number of bits used to encode \( \tilde{F}(x) \) in Shannon-Fano-Elias Codes? Is the code a prefix code?
• Shannon-Fano-Elias codes are prefix codes. Arithmetic codes are not prefix codes. What is the number of bits used to encode $\tilde{F}(x)$ in each of the above codes?

• You are given the left Table from page 94, and part of the right table. Continue the encoding one step. If you transmit decimal symbols, which symbols can be already transmitted at row 5?

• You are given the left Table from page 96, and part of the right table at page 17 (decoding). Continue the decoding one step.

Chapter 5

• We want to encode the data string $bccb$ from the ternary alphabet $\{a, b, c\}$, using arithmetic coding, and the decoder knows that we have to send a string 4 symbols-long.
  Explain the adaptive zero-model order of assigning probabilities to symbols.

• Prediction by partial matching. Explain using the Example in the text a simple form of PPM.

Chapter 6

• Perform the Burrows-Wheeler transformation (or the inverse transformation) for a given string.

• Explain Move-to-Front transformation.

• Qualitative questions:
  What are the steps in Burrows-Wheeler coding, and what is the role of each step. Is Burrows-Wheeler transformation revertible?

• Define run length codes, give an example.

• You are given part of the table with Elias codewords (and the constructive definition of Elias codes). Continue the table with one more line.

Chapter 7

Many qualitative questions.

• Name several lossless image coding methods, and briefly explain the common principles.

• What is the predictor used in JPEG-LS?
• What is the residual distribution assumed in JPEG-LS?
• Why Golomb-Rice codes are used for residual coding in JPEG-LS?
• You are given the block diagram of JPEG-LS algorithm. What is the role of the block context modeler, and how it operates?

Chapter 8
Many qualitative questions.

• You are given the image of coefficients obtained after the wavelet transformation at 4 levels. Comment on what type of regions are present in the picture, and how you would encode the image.
• Why the matrix $W$ of the linear transformation obtained with discrete wavelet transform must be unitary for progressive coding?
• What is a zero tree?
• You are given a small example. Explain the zero-tree coding.
• Explain the principle of successive approximations.

Chapter 9
Many qualitative questions (how SPIHT improved over EZW, main steps of SPIHT, etc.)

• You are given the example at page 183. Explain SPIHT principle.
• Explain Set partitioning sorting algorithm, by means of an example. (you are given the summary of the algorithm).
• Is the bitstream produced by SPIHT encoded by using an arithmetic coder? Why?

Chapter 10
Many qualitative questions (what kind of functionalities JPEG 2000 has, how ROI is realized, etc.)

Pages from the slides (these page numbers are printed on the slides, do not use the page number counted by the pdf-reader, which is different) that are required for exam:

• The standard JPEG 9-11
• JPEG 2000 Compression Paradigm 12, 26
• Preprocessing 27-29
• Discrete wavelet Transform 50-54, 84
• Quantization 86-92, 103-105
• Entropy (Tier 1) Coding 107, 113-134
• Entropy (Tier 2) Coding 136-145, 154-160
• Rate allocation 162-168
• Region of Interest coding 172-181