图像压缩
Image Compression

Contents

- Preview&Fundamentals
- Image Compression Models
- Image Compression Standards
- Error-Free Compression
- Lossy Compression

Preview

- Why image compression
  - The storage and communication requirements of image data are immense
  - Methods of compression the data prior to storage and/or transmission are of significant practical and commercial interest

Preview

- What is image compression
  - Addresses the problem of **reducing the amount of data required to represent a digital image**
  - The underlying basis of the reduction process is the **removal of redundant data**
  - From a mathematical viewpoint, image compression amounts to transforming a 2-D pixel array into a statistically uncorrelated data set

Preview

- Applications
  - Currently, image compression is recognized as an "enabling technology"
  - For example, televideo-conferencing, remote sensing, facsimile transmission (FAX) …
  - An ever-expanding number of applications depend on the efficient manipulation, storage, and transmission of images

Fundamentals

- The term *data compression* refers to
  - The process of reducing the amount of data required to represent a given quantity of information
- *Data* and *information*
  - Data are the means by which information is conveyed
  - Various amounts of data may be used to represent the same amount of information

Fundamentals

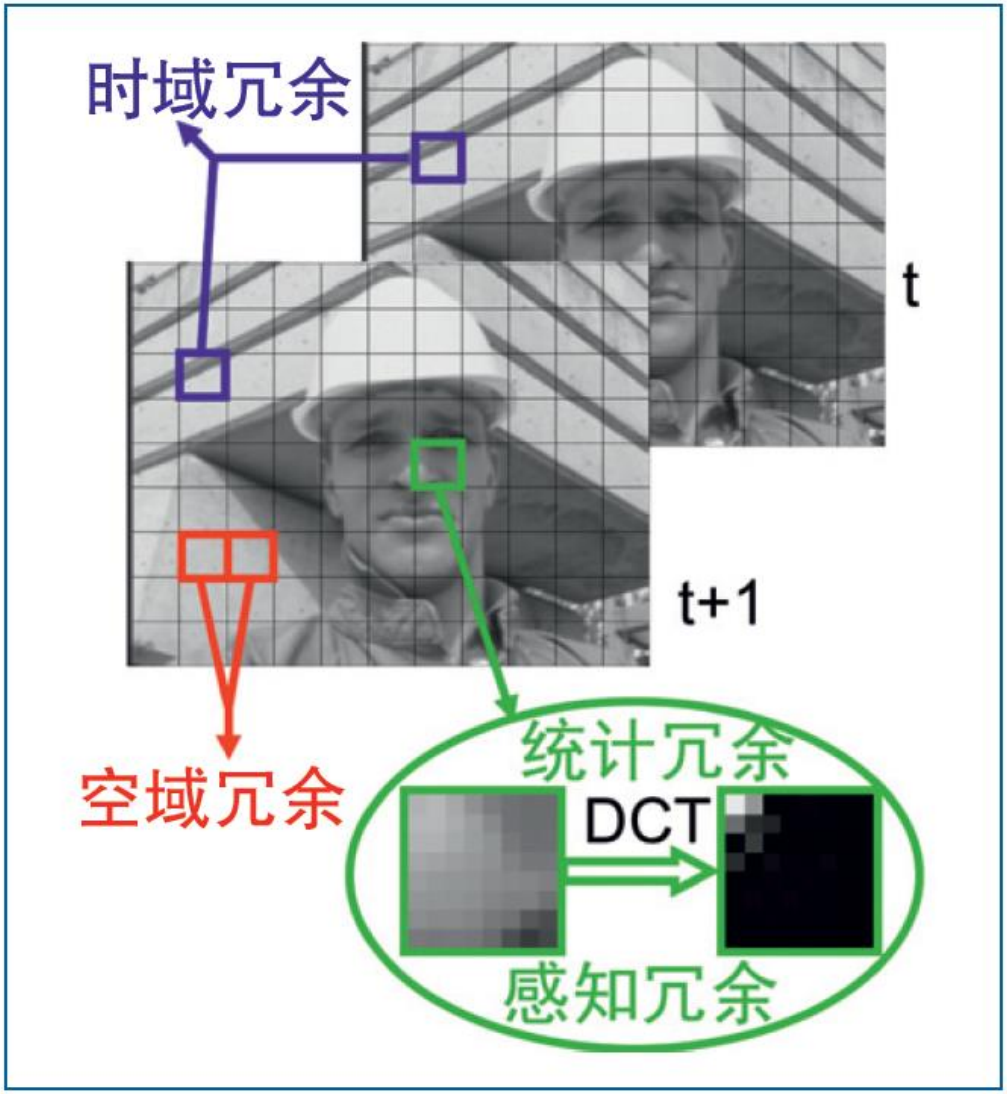
- *Data redundancy*
  - e.g., if two individuals use a different number of words (data) to tell the same story (information), at least one includes nonessential data
  - That is, it contains data (or words) that either provide no relevant information or simply restate that which is already known. It is thus said to contain data redundancy
  - **Data redundancy is a central issue in digital image compression**

Fundamentals

- In digital image compression, three basic data redundancies can be identified and exploited
  - *Spatial and temporal redundancy*
  - *Coding redundancy*
  - *Psychovisual redundancy*

- Data compression is achieved when one or more of these redundancies are reduced or eliminated

Spatial and Temporal Redundancy



Fidelity Criteria

- Removal of psychovisually redundant data results in a loss of real or quantitative visual information

- Two general classes of criteria are used as the basis for such an assessment
  - **Objective fidelity criteria**
  - **Subjective fidelity criteria**

Fidelity Criteria

- **Objective fidelity criteria**: the information loss can be expressed as a function of the original image and the decompressed image
  - root-mean-square (rms) error

$$e_{rms} = \left[\frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \left[\hat{f}(x,y) - f(x,y) \right]^2 \right]^{\frac{1}{2}}$$

  - mean-square signal-to-noise ratio

$$SNR_{ms} = \sum_{x-0}^{M-1} \sum_{y=0}^{N-1} \hat{f}(x,y)^2 \Big/ \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \left[\hat{f}(x,y) - f(x,y) \right]^2$$

  - rms value of the signal-to-noise ratio

$$SNR_{rms} = \sqrt{\sum_{x-0}^{M-1} \sum_{y=0}^{N-1} \hat{f}(x,y)^2 \Big/ \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \left[\hat{f}(x,y) - f(x,y) \right]^2}$$

Fidelity Criteria

- **Subjective fidelity criteria:** measuring image quality by the subjective evaluations of a human observer, since most decompressed images ultimately are viewed by humans

Value	Rating	Description
1	Excellent	An image of extremely high quality, as good as you could desire.
2	Fine	An image of high quality, providing enjoyable viewing. Interference is not objectionable.
3	Passable	An image of acceptable quality. Interference is not objectionable.
4	Marginal	An image of poor quality; you wish you could improve it. Interference is somewhat objectionable.
5	Inferior	A very poor image, but you could watch it. Objectionable interference is definitely present.
6	Unusable	An image so bad that you could not watch it.

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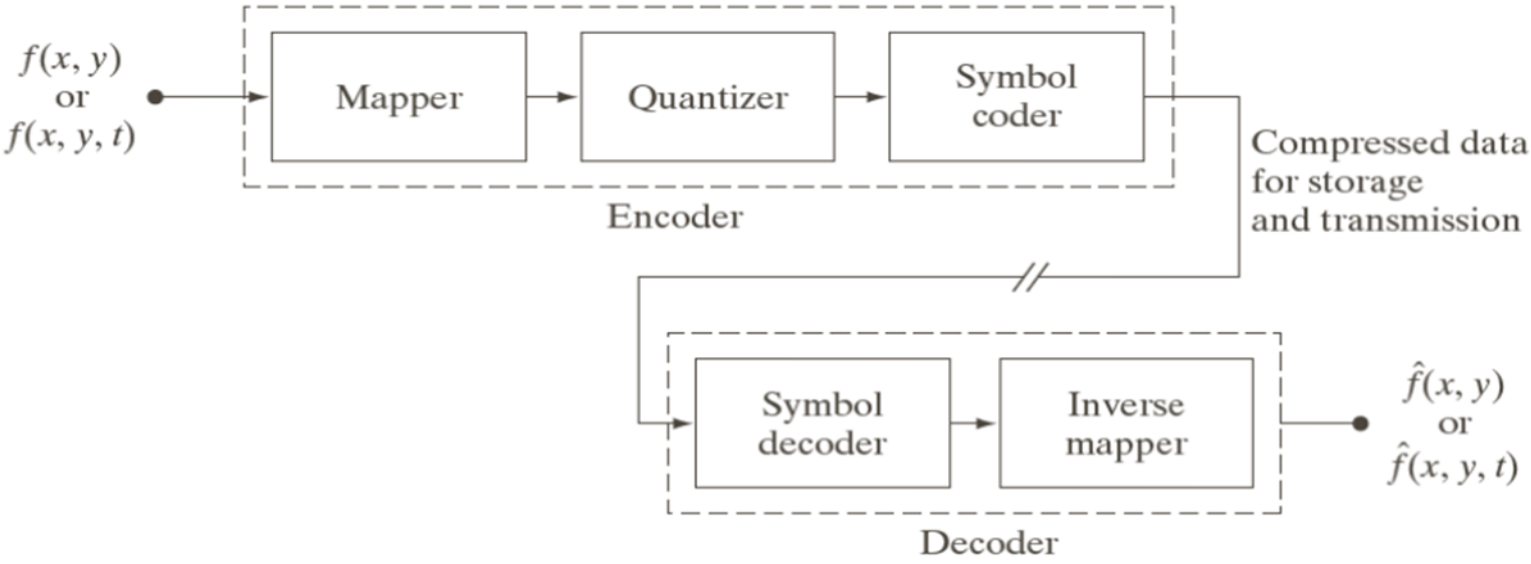
Image Compression Models

- A compression system consists of two distinct structural blocks: an *encoder* and a *decoder*

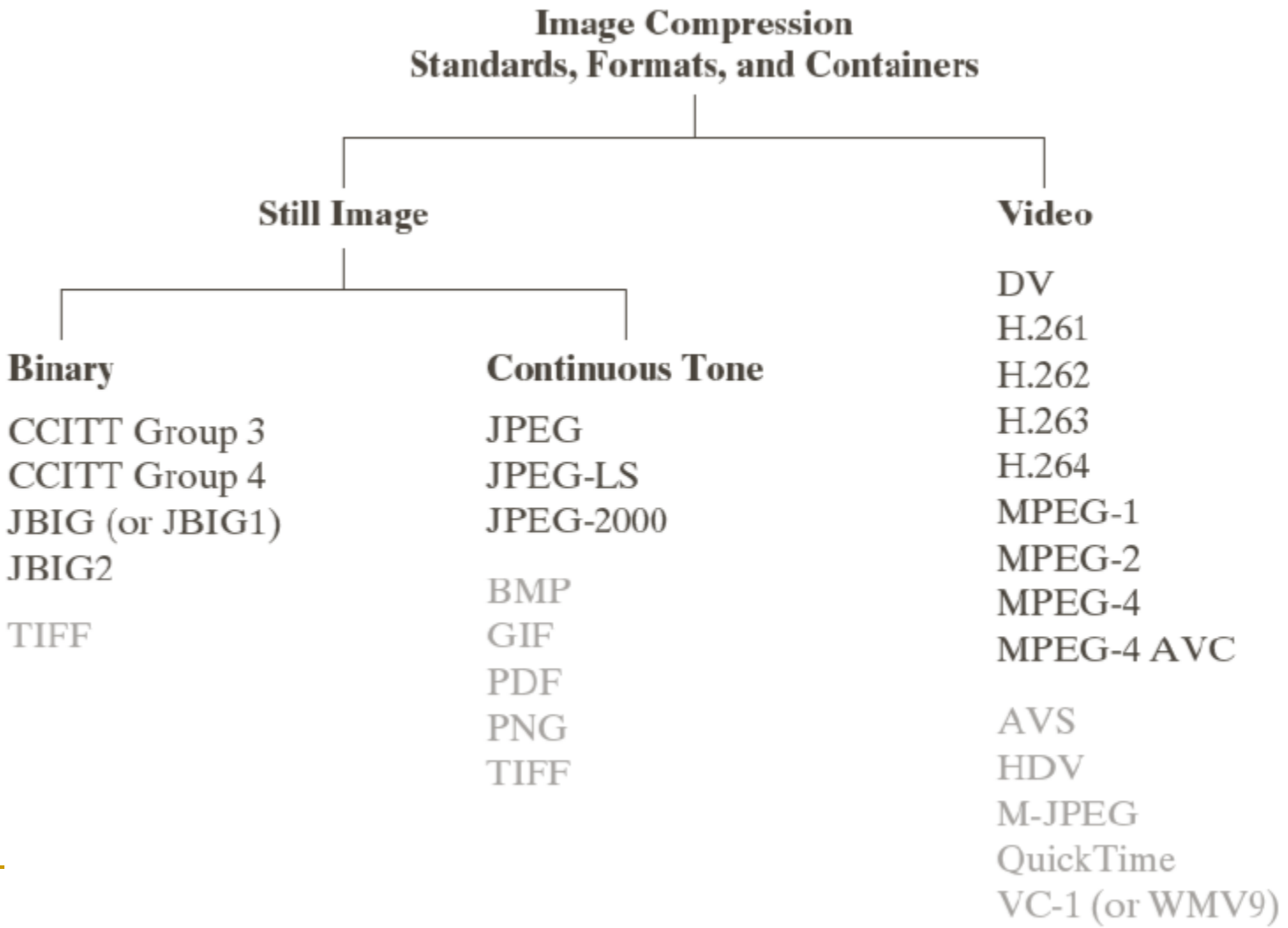


Mapper : transforms the input data into a (usually nonvisual) format to reduce spatial and temporal redundancies

Quantizer : reduces the accuracy of the mapper's output to reduce psychovisual redundancies

Symbol coder : creates a fixed- or variable-length code to represent the quantizer output

Image Compression Standards



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Error-Free Compression

- In numerous applications error-free compression is the only acceptable means of data reduction
  - Archival of medical or business documents (*legal reasons*)
  - Satellite imagery (*both use and cost of collecting*)
  - Digital radiography (*diagnostic accuracy*)

- Error-free compression
  - Composed of mapping and symbol coding operations
  - Normally provide compression ratios of 2 to 10

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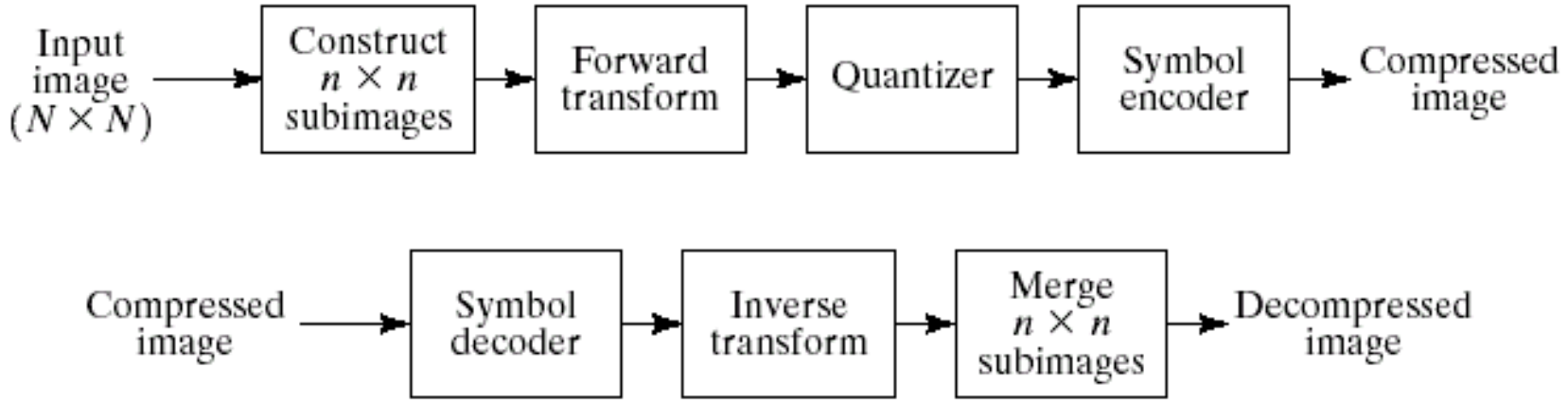
Lossy Compression

- Some of the data is intentionally discarded during the process to achieve higher compression ratios
  - Eliminating certain information that the human eye is less sensitive to or may not notice
- Transform Coding
- JPEG (Joint Photographic Experts Group)

Transform Coding

- In *transform coding*, linear transform (such as Fourier Transform) is used to map the image into a set of transform coefficients, which are then quantized and coded
  - For most natural images, a significant number of coefficients have small magnitudes and can be coarsely quantized (or discarded entirely) with little image distortion

Transform Coding



a
b

FIGURE 8.28 A transform coding system: (a) encoder; (b) decoder.

Transform Coding

- **The goal of transformation process**
  - 1) decorrelate the pixels of each subimage
  - 2) pack as much information as possible into the smallest number of transform coefficients

- The quantization stage then selectively eliminates or more coarsely quantizes the coefficients that carry the least information
  - These coefficients have the smallest impact on reconstructed subimage quality

Transform Coding

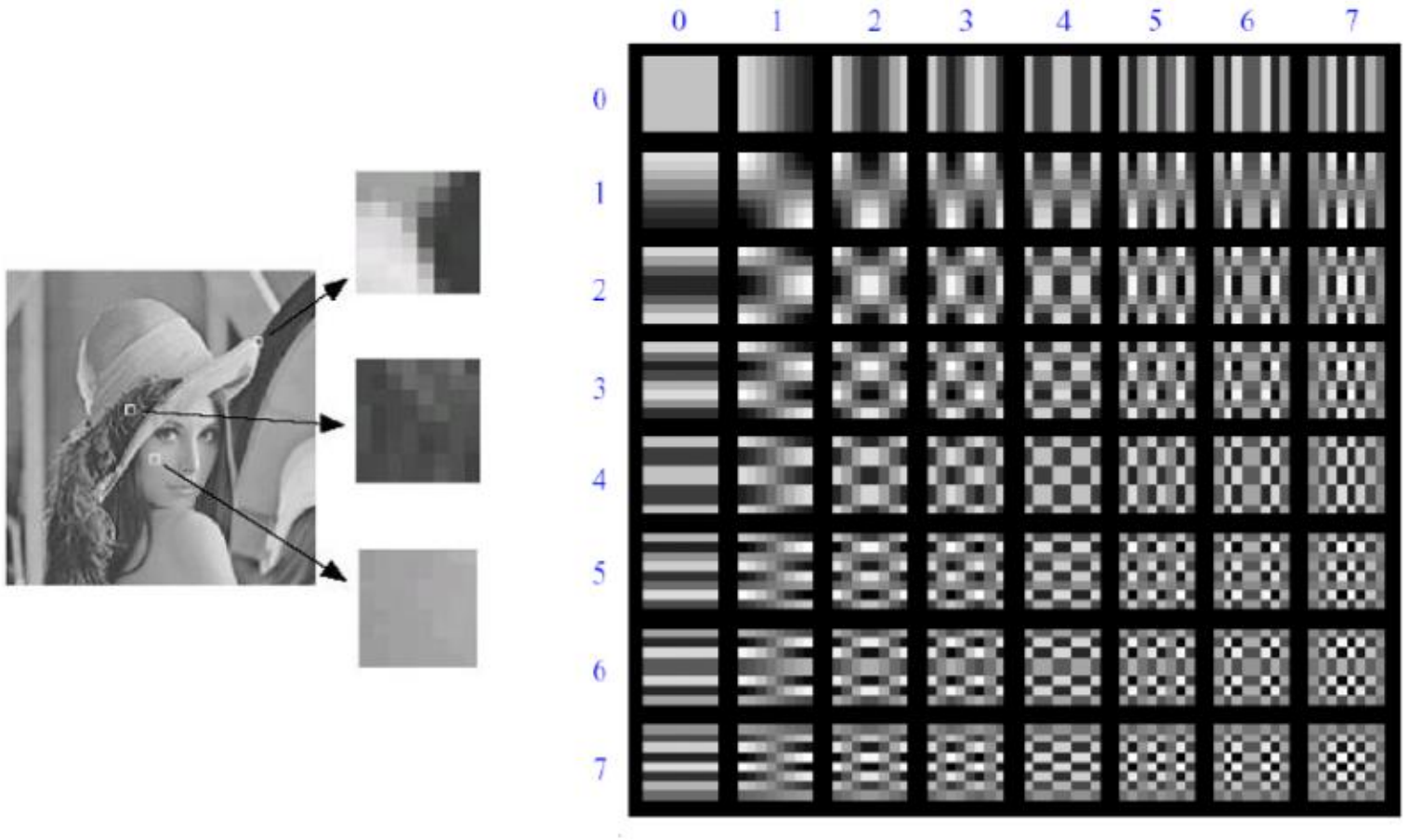
- The choice of a particular transform in a given application depends on

  1) the amount of reconstruction error that can be tolerated

  2) the computational resources available

- **Compression is achieved during the quantization of the transformed coefficients** (**NOT during the transformation step**)

Lossy Image Compression (JPEG)



Block-based Discrete Cosine Transform (DCT)

Slides: Efros

JPEG 2000

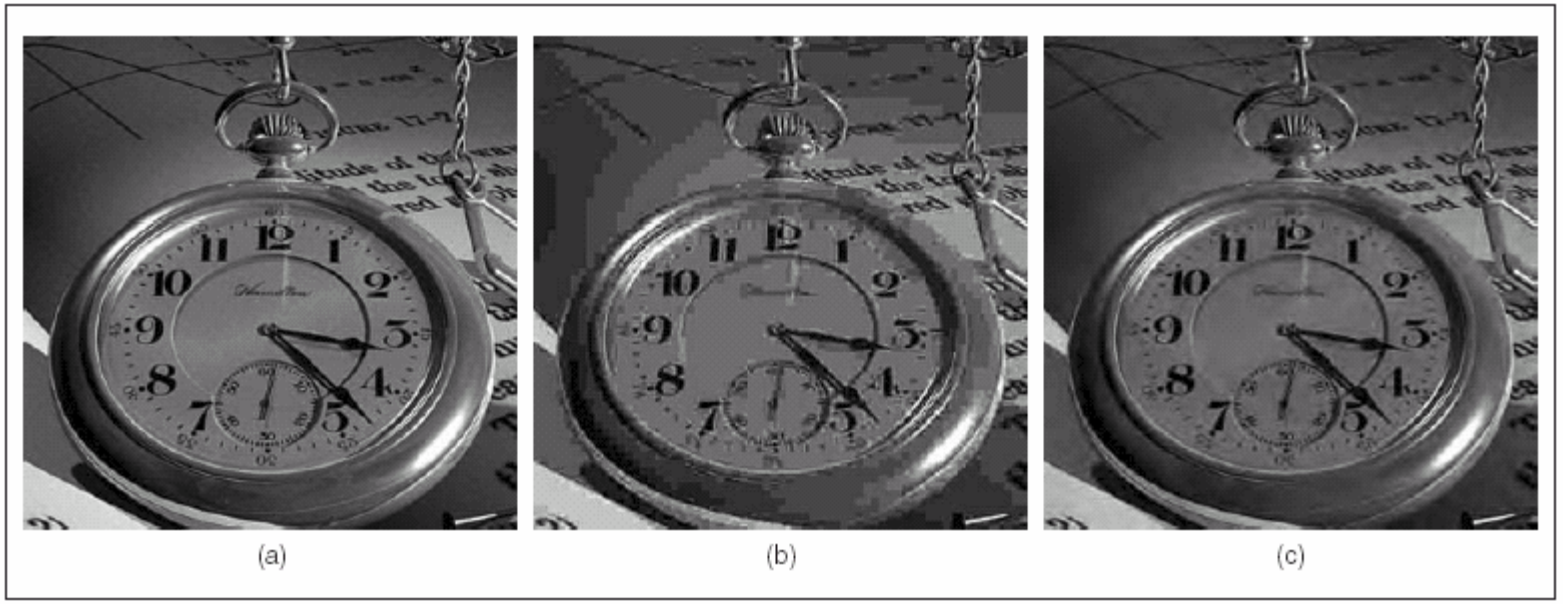
- Improved coding efficiency
- Full quality scalability
  - From lossless to lossy at different bit rate
- Spatial scalability
- Improved error resilience
- Tiling
- Region of interests
- More demanding in memory and computation time

Slides: Zhu Liu

Spatial Scalability

▲ 18. Example of the progressive-by-resolution decoding for the color image "bike."

JPEG2000 vs. JPEG



▲ *20. Image "watch" of size 512 × 512 (courtesy of Kevin Odhner): (a) original, and reconstructed after compression at 0.2 b/p by means of (b) JPEG and (c) JPEG 2000.*

JPEG2000 vs. JPEG

▲ 21. Reconstructed image "ski" after compression at 0.25 b/p by means of (a) JPEG and (b) JPEG 2000.

Summary

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谢谢大家！