EL6123 Video Processing
Midterm Summary
Spring 09

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Basics of Video

- Color representation and perception
- Camera model: perspective projection
- Color video capture and display
Analog Video Systems

- Raster video representation
- Progressive vs. interlaced video, pros and cons
- Multiplexing of different color components, Bandwidth estimate
- Multiplexing of different TV signals
- How color TV receiver works, compatibility with B&W TV systems
- Migration to digital TV
- Different digital video format
Multidimensional Signals and Systems

- Space domain and Frequency domain characterization of signals
  - CSFT, DSFT
  - Physical meaning of spectrum
- Linear and shift invariant systems
  - Can be characterized by impulse response <-> Frequency response
  - Convolution relation between input and output in original signal domain
  - Multiplication Relation in frequency domain
  - Concept of filtering
Frequency Domain Characterization of Video Signals

• What does spatial and temporal frequency mean?
  – Spatial frequency in terms of angular frequency

• Relation between spatial and temporal frequency for moving objects
Human Visual System

- Spatial frequency response
  - Most sensitive in what range?

- Temporal frequency response
  - Most sensitive in what range?
  - What is the highest temporal frequency we can respond?

- Spatial-temporal frequency response
  - Tradeoff between spatial/temporal sensitivities

- Smooth pursuit effect
  - Enable us to respond to higher temporal frequencies
3D motion characterization

- Rigid body motion
  - 6 parameters
- Non-rigid motion
  - Global plus local
- Typical camera motions
Projection of 3D to 2D motion

- Know how to map 3D motion to 2D using the perspective projection
- Special case when planar objects undergo rigid motion
  - 2D motion is projective mapping
  - Approximation of projective mapping
- Properties of affine and bilinear mappings
- Covered, uncovered regions
Optical Flow Equation

• What is this?
• How to use it for motion estimation
• Uncertainty in motion estimation
2D Motion Representations

- Global
- Dense (pixel wise or block wise)
- Region based
Motion Estimation Criteria

- Minimizing prediction error (square or absolute)

- Minimizing error in meeting constraint set by optical flow equation
Search algorithm

- Exhaustive search
- Gradient descent
- Can be applied to either error criterion
Block Based Motion Estimation

- **BMA**
  - Assume each block undergo the same translation, determine the best motion vector for each block

- **DBMA**
  - Assume each block undergo the same deformable mapping, determine the best mapping parameter
    - Node-based representation
    - Affine or bilinear mapping

- How to solve the best parameters by minimizing either error criterion, using either search algorithm
EBMA algorithm

• Know how to implement EBMA in matlab with integer and half-pel accuracy search
• Know tradeoff between complexity and accuracy
• Know how to combine integer and half-pel for fast implementation
  – Integer first
  – Half-pel for refinement
• Know the limitation of EBMA
HBMA

• Know the general concept of multi-resolution processing and benefit
• Know how to implement HBMA in matlab
• Know how to estimate complexity
DBMA

• Understand how it works
  – Difference between polynomial and node-based parameterization
  – How to set up an optimization framework for given motion model and optimization criterion
  – How to search the parameters using gradient descent or exhaustive search
Global Motion Estimation

- What representations are appropriate for different camera motions?
  - Direct method
    - Directly estimate motion parameters
  - Indirect method
    - Estimate dense motion field first
    - Determine global motion parameters from dense motion field using least square fitting
Other more advanced approaches

- Mesh-based
- Region-based
- Not required for the midterm
Fundamentals of Source Coding

• Probabilistic characterization of source
  – Marginal, joint, conditional distributions
• Definition and computation of various entropies
  – Marginal, joint, conditional entropies
  – Relations among them
  – Special cases of independent variables
• Entropy as bound for lossless coding
• Mutual information as bound for lossy coding
Huffman coding

- Basic method (one symbol at a time)
- High order (multiple systems considered as a super symbol)
- Conditional
- Comparison with bound
Arithmetic Coding

• Know the basic algorithm
• Pros and cons compared to Huffman coding
Midterm Exam Logistics

• Scheduled time: 3/4/09 3-5:40, RH605
• Closed-book, 1 sheet of notes allowed (double sided OK)
• Office hour (LC256)
  – Monday 3/2  3-5PM
  – Wed. 3/4  10-12 AM