# 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