Filtering

- An image as a function
- Digital vs. continuous images
- Image transformation: range vs. domain
- Types of noise
- LSI filters
  - cross-correlation and convolution
  - properties of LSI filters
  - mean, Gaussian, bilinear filters
- Median filtering
- Image scaling
- Image resampling
- Aliasing
- Gaussian pyramids
- Bilinear Filters

Edge detection

- What is an edge and where does it come from
- Edge detection by differentiation
- Image gradients
  - continuous and discrete
  - filters (e.g., Sobel operator)
- Effects of noise on gradients
- Derivative theorem of convolution
- Derivative of Gaussian (DoG) operator
- Laplacian operator
  - Laplacian of Gaussian (LoG)
- Canny edge detector (basic idea)
  - Effects of varying sigma parameter
- Approximating an LoG by subtraction
- Hough Transform (lines, circles, “generalized” (from midterm))

Segmentation

- Graph representation of an image
- Intelligent scissors method
- Image histogram
- K-means clustering
- Morphological operations
  - dilation, erosion, closing, opening
- Normalized cuts method
- Matting—separate foreground from background (basic idea)

Motion

- Optical flow problem definition
- Aperture problem and how it arises
- Assumptions
  - Brightness constancy, small motion, smoothness
- Derivation of optical flow constraint equation
- Lukas-Kanade equation
  - Derivation
  - Conditions for solvability
  - meanings of eigenvalues and eigenvectors
- Iterative refinement
  - Newton’s method
  - Coarse-to-fine flow estimation
- Feature tracking
  - Harris feature detector
  - L-K vs. discrete search method

Projection

- Properties of a pinhole camera
  - effects of aperture size
- Properties of lens-based cameras
  - focal point, optical center, aperture
  - thin lens equation
  - depth of field
  - circle of confusion
- Modeling projection
  - homogeneous coordinates
  - projection matrix and its elements
  - types of projections (orthographic, perspective)
- Camera parameters
  - intrinsics, extrinsics
  - types of distortion and how to model

Mosaics

- Image alignment (using Lucas-Kanade)
- Image reprojection
  - homographies
  - cylindrical projection
- Creating cylindrical panoramas
- Image blending
- Image warping
  - forward warping
  - inverse warping

Projective geometry

- Homogeneous coordinates and their geometric intuition
- Homographies
- Points and lines in projective space
  - projective operations: line intersection, line containing two points
  - ideal points and lines (at infinity)
- Vanishing points and lines and how to compute them
- Single view measurement
  - within a reference plane
  - height
- Cross ratio
- Camera calibration
  - using vanishing points
  - direct linear method

Stereo

Things to take away from this lecture

- Cues for 3D inference, shape from X (basic idea)
- Epipolar geometry
- Stereo image rectification
- Stereo matching
  - window-based epipolar search
  - effect of window size
  - sources of error
- Active stereo (basic idea)
  - structured light
  - laser scanning

Multiview stereo

- Baseline tradeoff
- Multibaseline stereo approach
- Voxel coloring problem
- Volume intersection algorithm
- Voxel coloring algorithm

Light, perception, and reflection

- Light field, plenoptic function
- Light as EMR spectrum
- Perception
  - color constancy, color contrast
  - adaptation
  - the retina: rods, cones (S, M, L), fovea
  - what is color
    - » response function, filters the spectrum
    - » metamers
- Finding camera response function (basic idea, not details)
- Materials and reflection
  - what happens when light hits a surface
  - BRDF
  - diffuse (Lambertian) reflection
  - specular reflection
  - Phong reflection model
  - measuring the BRDF (basic idea)

Recognition

- Classifiers
- Probabilistic classification
  - decision boundaries
  - learning PDF's from training images
  - Bayesian estimation
- Principle component analysis
- Eigenfaces algorithm
  - use for face recognition
  - use for face detection

Texture (not on exam!!)

- Markov chains
- Text synthesis algorithm
- Markov random field (MRF)
- Texture synthesis algorithm (basic idea)