Interest Points Detection

- What is an interest point? Why are they useful? Applications
- Invariance to geometric/photometric transformations (detector + descriptor)
- What features to use? (variation in at least two directions)
- Characteristics of good features (repeatability, saliency, compactness, locality)
- Main steps in corner detection
- Corner detection methods (contour, intensity, parametric)
- Moravec detector (steps, weaknesses)
- Harris detector
  - How does it improve the Moravec detector? (Grad students: should know the proof)
  - Auto-correlation matrix: what information does it encode?
  - Steps of Harris detector, R-measure
  - Strengths (good repeatability, rotation invariance)
  - Weaknesses (not invariant to scale, partial invariant to photometric changes)
- How can we handle scale changes?
  - Scale space
  - Harris – multiscale detector (how does it work?, strengths/weaknesses?)
  - Characteristic scale, automatic scale selection – very important!
  - Harris – Laplace detector (how does it work? main steps, strengths/weaknesses)
  - Harris – DOG detector (how does it work? main steps, strengths/weaknesses)
- How can we handle affine changes? (Graduate Students)
  - Uniform vs Affine Gaussian Scale Space
  - Harris – Affine detector (how does it work? main steps, strengths/weaknesses)
  - Intensity Extrema-Based Region Detector (how does it work? main steps, strengths/weaknesses)
Maximally Stable Extremal Regions (how does it work? main steps, strengths/weaknesses)

Interest Points Description
- Simple feature descriptors (intensity-based, PCA, bank of filters, steerable filters)
- SIFT features (should know the steps very well)
  - Scale space extrema detection (how is it different from Harris-Laplace?)
  - Keypoint localization (no equations, should be able to explain the steps in words)
  - Orientation assignment
  - Keypoint descriptor
- Object recognition using SIFT features
  - Main steps and issues (nearest neighbor search, clusters of features, verification)
- Object categorization using “bag-of-features”
  - Main steps (extract features, learn “visual vocabulary”, represent images by frequencies of “visual words”) and issues
- Other applications of SIFT features

Eigenfaces
- How does Principal Component Analysis (PCA) work?
- What is the criterion that PCA minimizes?
- How is the “best” low-dimensional space being determined using PCA?
- Steps of the PCA approach
- Geometric interpretation of PCA
- Practical issues (e.g., choosing K, computing error, standardization)
- Applying PCA to faces – main steps and practical issues (e.g., \( A^T A \) vs \( A A^T \)), should know how to project a face onto the PCA space (i.e., eigenvectors)
- Face recognition using PCA (i.e., eigenfaces) – main steps, diffs
- Face detection using PCA – main steps, diffs
- Limitations of eigenface approach.

Camera Parameters
- Reference frames (world, camera, image plane, pixel plane)
- Perspective projection (should know how to derive equations), matrix notation
- Properties of perspective projection, vanishing points, vanishing lines
• Orthographic projection (equations), matrix notation, properties
• Weak perspective projection (equations), matrix notation, properties
• Extrinsic camera parameters – what are they? (should know equations)
• Intrinsic camera parameters – what are they? (should know equations)
• Projection matrix – what does it represent?
• Affine model – what does it represent? matrix notation and properties

Camera Calibration
• What is the goal of camera calibration?
• How does (correspondences)
• Direct parameter calibration (no equations but remember how it is done); how is the orthogonal constraint of the rotation matrix enforced?
• Camera calibration using the projection matrix (should know equations for step 1 only, but remember how the whole algorithm works in general)

Stereo
• What is goal of stereo vision?
• Terminology (e.g., baseline, epipolar plane, epipolar lines, epipoles, disparity)
• Triangulation principle
• The two problems of stereo: correspondence + reconstruction
• How is depth recovered from disparity? (Grad students: should know the proof)
• Stereo parameters: extrinsic + intrinsic

Stereo correspondence problem
• What is the correspondence problem? Why is it difficult?
• Main methods: correlation-based, feature-based
• How do correlation-based methods work?
• Main parameters of correlation-based methods. How can we choose them?
• How do feature-based methods work?
• Wide baseline stereo – what features should we use?
• Comparison between correlation-based and feature-based methods

Epipolar Geometry
• What is the epipolar constraint, why is it important?
• How is the epipolar geometry estimated? (essential/fundamental matrices)
What is the essential matrix? What information does it encode? Why is it useful? What is the equation that corresponding points must satisfy using the essential matrix? (Grad students: should know how to prove equations)

What is the fundamental matrix? What information does it encode? Why is it useful? What is the equation that corresponding points must satisfy using the fundamental matrix? (Grad students: should know how to prove equations)

Eight-point algorithm (should know equations). How is the rank(2) constraint enforced?

How the epipoles and epipolar lines are computed assuming knowledge of the fundamental matrix?

What is rectification? Why is it useful? What are the main steps? (Grad student: should know how to define the transformation of step 1)

**Stereo Reconstruction**

Three main methods:
- Known extrinsic and intrinsic parameters
- Known intrinsic parameters
- Unknown extrinsic and intrinsic parameters.

How does the first method work? What is the main issue? (no equations)

What information could be recovered in each case? (no specifics about the last two methods)