Computer Vision

EX802-Co2

Lecture	**: (4 hr. per week)**	**Year: I**
Practical	**: (1.5 hr. per week)**	**Part: I**

Course Objectives:

The objective of this course is to impart knowledge of the fundamentals of imaging operations, image formation, filtering, and feature extraction, illustrate the importance of camera calibration, provide the foundation of multiple view geometry and scene reconstruction, introduce motion analysis, visual odometry, and event-based vision, provide techniques for image classification and object detection.

Course Contents:

1. **Visual Perception and Imaging Fundamentals** **[10 hrs.]**
   - 1.1 Computer Vision: Definitions, Goal, Applications, and Challenges
   - 1.2 Human Visual System, Modular Transfer Function
   - 1.3 Color Models, Color Transformations, Color Coordinate Systems
   - 1.4 CCD and CMOS Image Sensors
   - 1.5 Image Sampling and Quantization
   - 1.6 Histogram Processing, Spatial and Frequency Domain Filtering
   - 1.7 Image Degradation and Restoration Process, Image Noise Models
   - 1.8 Image Restoration: Spatial Filtering, Inverse Filtering, Wiener Filtering

2. **Low-Level and Intermediate-Level Vision** **[11 hrs.]**
   - 2.1 Morphological Primitives, HMT, Boundary Extraction, Hole Filling
   - 2.2 Edge Detectors, Corner Detectors, Hough Transform
   - 2.3 Image Thresholding, Otsu's Binarization
   - 2.4 Region-based Segmentation
   - 2.5 Scale Space, Image Pyramids
   - 2.6 Scale Invariant Feature Transform

3. **Camera Models and Camera Calibration** **[9 hrs.]**
   - 3.1 Pinhole Camera Model
   - 3.2 Aperture, Concept of Focus, Depth of Field, Thin Lens Equation
   - 3.3 Extrinsic and Intrinsic Camera Parameters, Calibration Patterns
   - 3.4 Direct Parameter Calibration, Camera Parameters from Projection Matrix
   - 3.5 Geometric Distortion, Radial and Tangential Distortion

4. **Multiple View Geometry and Stereo Correspondence** **[10 hrs.]**
   - 4.1 Multiple View Vision, Epipolar Geometry, Triangulation
   - 4.2 Essential Matrix, Fundamental Matrix, Eight Point Algorithm
   - 4.3 Sparse and Dense Correspondence, Depth Maps
   - 4.4 Feature-based Image Alignment, Robust Least Squares, RANSAC
   - 4.5 Image Stitching, 3D Reconstruction

5. **Motion Analysis** **[10 hrs.]**
   - 5.1 Optical Flow Fields, Optical Flow Estimation
   - 5.2 Motion Blur, Motion Parallax, Structure from Motion
   - 5.3 Kanade-Lucas-Tomasi Object Tracker
   - 5.4 Motion Tracking using Kalman Filters
   - 5.5 Ego-Motion Estimation
   - 5.6 Visual Simultaneous Localization and Mapping
   - 5.7 Event Cameras and Event-based Vision

6. **Image Classification and Object Detection** **[10 hrs.]**
   - 6.1 Visual Bag-of-Words Model for Image Classification
   - 6.2 Haar-like Features, Haar Cascade Classifier
   - 6.3 CNN Architecture, CNN Components, Neural Computations
   - 6.4 Feedforward Calculations and Backpropagation in CNN
   - 6.5 Dropout Layers, Regularization, Batch Normalization
   - 6.6 Image Datasets, Image Classification using LeNet Architecture
   - 6.7 Region Proposals, R-CNN-and SSD based Object Detection

Assignments

1. Solving selected numerical problems and derivation from reference books

2. Reviewing and presenting a paper related to computer vision published within the last five years in a reputed journal

3. Performing a case study related to recent technologies in the field of computer vision

4. Implementing, reporting, and presenting algorithms related to image classification, object detection and recognition

Practical

1. Basic Image Processing, Quantization, Histogram Equalization
2. Image Filtering in Spatial and Frequency Domains
3. Morphological Operations, Edge and Corner Detection, Thresholding
4. Hough Line Transform, Image Pyramids, SIFT Keypoints and Descriptors
5. Image Stitching, KLT Object Tracking
6. Image Classification using CNN
7. Object Detection using Region-based CNN

Evaluation Schemes

a. Internal Examination

Type	Weightage
Minor tests	70%
Assignments	30%

b. Final Examination

There will be five units of questions carrying 12 marks each. The question will cover all chapters of the syllabus. The evaluation scheme will be as indicated in the table:

Units	Chapters	Marks *
1	1, 3	12
2	2	12
3	4	12
4	5	12
5	6	12
Total		**60**
* There may be minor variation in distribution of marks		

References:

1. Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing”, Pearson Education, Fourth Edition, 2017
2. Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer, Second Edition, 2011
3. David Forsyth and Jean Ponce, “Computer Vision: A Modern Approach”, Pearson Education, Second Edition, 2011
4. Carsten Steger, Markus Ulrich, and Christian Wiedemann, "Machine Vision Algorithms and Applications", Wiley-VCH, 2018
5. Abhinav Dadhich, "Practical Computer Vision: Extract insightful information from images using TensorFlow, Keras, and OpenCV", Packt Publishing, 2018
6. Mohamed Elgendy, "Deep Learning for Vision Systems", Manning Publications, First Edition, 2020