The University Of Sheffield.

Electronic & Electrical Engineering.

EEE6219 COMPUTER VISION

Credits: 15

Course Description including Aims

This unit focuses on introducing current approaches to computer vision with the main emphasis on a layered approach from low-level image processing through to high-level scene understanding methods. The coursework component of this unit aims to provide an understanding of using appropriate tools and methods for solving practical computer vision problems.

The unit aims to...
1. introduce current approaches to computer vision
2. emphasise the hierarchical nature of the subject
3. emphasise the role of quantitative assessment of performance

Outline Syllabus

1. Fundamental Background Material
    - The Gaussian Distribution
    - Means and Variances of Random Variates
    - Covariance Matrices
    - Parameter Estimation
    - Ordinary Least-squares
    - Robust Estimation
    - RANSAC
    - Least Median Squares
    - Singular-value Decomposition
2. Camera Models and Image Formation
    - Lens Defects
    - Sensors
3. Camera Geometry
    - Homogeneous Geometry and Geometrical Transformations in 2-and 3-D
    - Rotations and Quaternions
    - Camera Matrix
    - Camera Calibration
    - Image Sampling
4. Geometric Transformations
5. Histogram Equalisation
6. Linear Filters
    - Averaging in the Gaussian Filter
    - Steerable Filters
    - Gabor Filters

- Filtering in the Fourier Domain
- Median Filtering

7. Image Pyramids
   - Gaussian Pyramid
   - Laplacian Pyramid
   - Applications of Pyramids
8. Edge Detection
   - Canny Edge Detector
   - Colour Edge Detection
9. Edge Linking and Polygonalisation
10. Hough Transforms
11. Image Feature Detectors and Feature Descriptors
    - Corner Detectors: Harris-Stephens Corner Detector
    - Harris-Laplace Detector
    - Hessian-based Detectors
    - Scale-Invariant Feature Transform (SIFT)
    - Object Recognition
    - Sparse Representations and Bag of Visual Words
    - Performance of Feature Detectors
12. Segmentation
    - Snakes
    - Level Sets
    - Split-and-Merge Segmentation
    - Otsu Thresholding
    - Watershed Algorithm
    - Graph-based Segmentation
    - Felzenschwalb and Huttenlocher Approach
    - Normalised Graph Cuts: Spectral Decomposition
    - Energy Minimisation and Markov Random Fields: Flow-based Algorithms
    - Conditional Random Fields
13. Motion Estimation
    - Brightness Constancy Assumption
14. Optic Flow
    - Temporal Aliasing
    - Regularisation and Energy Minimisation
15. Multiview Geometry
    - Epipolar Geometry
    - The Fundamental Matrix
    - 3-D Reconstruction
16. Stereo Reconstruction
    - Auto-calibration
    - Image Rectification
    - Disparity
    - Sparse and Dense Stereo Matching
17. Tracking
    - The ‘Data Association’ Problem
    - Motion Models and State-space Representation
    - Kalman Filtering
    - Extended Kalman Filtering
    - Particle Filtering

Time Allocation

30 lectures together with 2 support sessions for the assignement

Recommended Previous Knowledge

UG level 3 (or equivalent) understanding of basic signal processing, computing and/or applied mathematics.

Assessment

3 questions out of 4 inTwo hour examination (75%). Coursework – programming (25%).

Recommended Books

Computer Vision: Algorithms and Applications, Richard Szeliski
Computer Vision – A Modern Approach, David A. Forsyth, Jean Ponce

UK-SPEC/IET Learning Outcomes

Outcome Code	Supporting Statement
SM1p	Knowledge and understanding of basic image analysis algorithms are taught in this module to provide the students with the foundation of computer vision systems. Current and future trends are described. It is tested in the exam.
SM2p	Mathematical principles, together with probabilistic and statistical analysis are described in the context of understanding of computer vision algorithms, in particular, the handling of uncertainty. It is tested in the exam.
SM4m	Current state-of-the-art in computer vision is described. This is tested in the exam.
SM5m	A range of mathematical and statistical models relevant to computer vision are covered as the basis of state-of-the-art algorithsm; their limitations are discussed. This is tested in the exam.
SM1fl	A comprehensive understanding of the fundamental underlying principles of computer vision and its analysis is described. This is tested in the exam.
SM2fl	The forefront of current challenges in computer vision are described together with the necessary advance that are needed to address them. This is tested in the exam.
EA1p	Engineering principles are explored for application to computer vision algorithms. The inevitable trade-offs in enginering systems are described. It is tested in the exam.
EA2p	Methods for the quantitative analysis of performance are motivated and discussed. These are tested in the exam.