EE544: Computer Vision (Incorporating Deep Learning)

Summary Syllabus[1] (Level 9[2])

Section	Indicative Content
Introduction	Introduction to Python / scikit-image / opencv / PIL. Module development environment. Shape, Colour and Texture basics. CV virtuous circle. Vision systems, Features in CV, Role of data, Role of AI, Traditional versus Deep Learning approaches to Computer Vision. Sample applications.
Interest Point Detection & Feature Extraction	Interest Points Review, Harris/Plessey Corner Detector, Scale Invariant Harris Corner Detector, SIFT – Scale Invariant Feature Transform, SIFT Matching, SIFT Variants, SIFT Applications - Histogram of Oriented Gradients (HOG), RHOG + SIFT, HOG + SVM, Deformable Part Models, Face Detection (Viola Jones), Boosting, Classifier Cascade, Bag of Visual Words - Example applications and case studies.
Classification & Machine Learning	Introduction to scikit-learn, Statistics Review, Principal Component Analysis (First Principals to Practical Applications), PCA Applied to Images: Eigenvalues and Eigenvectors, Training and Testing, Automated Selection of Eigenvalues - Metrics, Feature Normalisation, Hughes Phenomenon, Feature Selection, Supervised & Unsupervised Classification, Hierarchical Clustering / Non-Hierarchical Clustering, Evaluation of Classifier Performance, Parametric vs Non-Parametric Classifiers, Decision Trees, Gaussian Mixture Models, Expectation Maximization - Shallow vs Deep Learning, Support Vector Machines (SVM), SVM Classification, Kernels, SVM Multi-Class Classification, SVM Implementation - Example applications and case studies.
Deep Learning for Computer Vision	Introduction to Keras/Tensorflow, Feature vs Data Driven Approaches, Artificial Neural Networks (ANN), Logistic (Linear) Classifier, softmax, Stochastic Gradient Descent, Multi-Layer Perceptron, Gradient Decent, Backpropagation Learning Algorithm, Overfitting/Regularization, From ANN to Deep Learning, Sparse Coding, Supervised Deep Learning (DL), Convolution Neural Networks (CNN – Convnets), Network Architectures, Transfer Learning, DL APIs, DL Network Architectures (Alexnet to current SOA), Fully Convolutional Networks, Classification + Localization, R-CNN, RNN, Unsupervised Learning, Autoencoders, Style Transfer Network, Generative Adversarial Networks DL Visualization - Example applications and case studies.
3D Imaging (Spatial & Temporal)	Passive Stereoscopic Methods, Camera Calibration/Rectification, Epipolar Geometry, Shape from Stereo, Fundamental Matrix, Rectification Procedure, Stereo Feature Constraints & Matching, Depth Estimation Techniques (Window-based techniques, Dynamic programming, Deep Learning), Colour Stereo Vision, Multiple View Stereo Vision, Active Stereoscopic Methods - Motion Tracking, Motion Field & Optical Flow, Optical Flow: 2D, Optical Flow: Local Approach, Histogram of Optical Flow (HOF), Feature Matching (Motion Correspondence), Kanade Lucas Tomasi Tracking.

See **EE425/EE453: Image Processing & Analysis** for an introductory Level 8 module in this area.

The module will develop solutions within a **Python** based development environment. Specifically we will use the open source and widely adopted **scikit-image, opencv** and **scikit-learn** libraries in designing advanced computer vision and machine learning solutions. Building on this we will develop our deep learning solutions within the very popular **Keras** (a high-level Python based neural networks API / **Tensorflow** (an open-source software library for Machine Intelligence) environment.

[1] Indicative content – details may vary from year to year.

[2] NFQ Level 9 – Master's Degree