M. TECH - COMPUTER VISION AND IMAGE PROCESSING

Department of Computer Science and Engineering

In recent times, there has been a dramatic increase of image and video data in every conceivable field due to the proliferation of digital capture devices and also due to the internet increasingly becoming a multimedia phenomenon. Consequently, the field of Computer Vision and Image Processing has emerged as a promising field of study and research due to its wide spread applications in managing the huge influx of image and video data.

Computer Vision started with building machines that can visualize data like human and give inputs for robots; and now has wider objectives to serve applications such as search engines, computational photography, medical imaging, vision for computer graphics and many more. Areas like document and medical image analysis are also developing rapidly. The field of robotics has abundant potential to serve in medical surgery, defense, home security and the community at large. With the advancements in supportive technologies such as digital cameras and video equipments, Computer Vision and Image Processing will become increasingly more capable and affordable as well.

The issues and scope for research in this area of specialization are so vast that it is vital to offer a specialized programme in this area. With this as the goal, the University is offering a two year M.Tech programme in Computer Vision and Image Processing. The objective is to create professionals and researchers with the necessary expertise to handle the various real-world problems where image processing techniques might provide robust solutions.

The programme includes core courses in Digital Image Processing, Signal Processing, Video Processing, and Computer Vision with the necessary background covered in mathematical courses. The programme has an intensive course work for three semesters with suitable elective courses followed by a dissertation where the students would conduct research in this field of study. The department has a well established research facility, “Amrita – Cognizant Innovation lab” which would help the students to build applications on real-time image and video data.

Students have abundant opportunities to pursue internships in major companies and R&D labs like ISRO, NPOL etc. Bright career opportunities are available to students in top companies and research labs.

CURRICULUM

First Semester

Course Code	Type	Course	L T P	Cr
16MA605	FC	Linear Algebra and Partial Differential Equations	4 0 0	4
16CV601	FC	Multidimensional Data Structures and Algorithms	3 0 1	4
16CV603	FC	Multidimensional Digital Signal Processing	3 0 0	3
16CV605	SC	Digital Image Processing	3 0 1	4
16CV607	SC	Digital Video Processing	3 0 1	4
16CV609	SC	Development Tools for Image and Video Processing	0 0 1	1
16HU601	HU	Cultural Education*		P/F
Credits				**20**

* Non Credit Course

Second Semester

Course Code	Type	Course	L T P	Cr
16MA606	FC	Random Processes and Optimization	4 0 0	4
16CV602	SC	Image Analysis	3 0 1	4
16CV604	SC	Pattern Recognition and Machine Learning	3 0 1	4
16CV606	SC	Computer Vision	3 0 1	4
16CS625	SC	Research Methodologies and Seminar	1 0 1	2
16EN600	HU	Technical Writing*		P/F
Credits				**18**

* Non Credit Course

Third Semester

Course Code	Type	Course	L T P	Cr
	E	Elective I	3 0 0	3
	E	Elective II	3 0 0	3
16CV798	P	Dissertation		10
Credits				**16**

Fourth Semester

Course Code	Type	Course	L T P	Cr
16CV799	P	Dissertation		12
Credits				**12**

Total Credits 66

List of Courses

Foundation Core

Course Code	Course	L T P	Cr
16MA605	Linear Algebra and Partial Differential Equations	4 0 0	4
16CV601	Multidimensional Data Structures and Algorithms	3 0 1	4
16CV603	Multidimensional Digital Signal Processing	3 0 0	3
16MA606	Random Processes and Optimization	4 0 0	4

Subject Core

Course Code	Course	L T P	Cr
16CV605	Digital Image Processing	3 0 1	4
16CV607	Digital Video Processing	3 0 1	4
16CV609	Development Tools for Image and Video Processing	0 0 1	1
16CV602	Image Analysis	3 0 1	4
16CV604	Pattern Recognition and Machine Learning	3 0 1	4
16CV606	Computer Vision	3 0 1	4
16CS625	Research Methodologies and Seminar	1 0 1	2

Electives

Course Code	Course	L T P	Cr
16CV701	Modeling and Visualization	3 0 0	3
16CV702	Video Analytics	3 0 0	3
16CV703	Advanced Computer Vision	3 0 0	3
16CV704	Machine Vision	3 0 0	3
16CV705	Medical Image Analysis	3 0 0	3
16CV706	Content Based Image and Video Retrieval	3 0 0	3
16CV707	Document Image Analysis	3 0 0	3
16CV708	Computational Intelligence for Image Processing	3 0 0	3
16CV709	Image Fusion	3 0 0	3

16CV710	Multimedia Security	3 0 0	3
16CV711	Visual Pattern Analysis and Modeling	3 0 0	3
16CV712	GPU Architecture and Programming	3 0 0	3

Project Work

Course Code	Course	L T P	Cr
16CV798	Dissertation		10
16CV799	Dissertation		12

16MA605 LINEAR ALGEBRA AND PARTIAL DIFFERENTIAL EQUATIONS 4-0-0-4

Vector Spaces: Vector spaces - Sub spaces - Linear independence - Basis - Dimension - Inner products - Orthogonality - Orthogonal basis - Gram Schmidt Process - Change of basis - Orthogonal complements - Projection on subspace - Least Square Principle.

Linear Transformations: Positive definite matrices - Matrix norm and condition number - QR-Decomposition - Linear transformation - Relation between matrices and linear transformations - Kernel and range of a linear transformation - Change of basis - Nilpotent transformations - Similarity of linear transformations - Diagonalisation and its applications - Jordan form and rational canonical form. Introduction to Normed Linear space, Banach spaces and Hilbert space.

Partial Differential Equations: Basic definitions, Model Equations: Elliptic, Parabolic and Hyperbolic PDEs, Solving PDEs Numerically- Elliptic, Parabolic and Hyperbolic Equations. Finite Element Method.

TEXT BOOKS / REFERENCES:

1. Howard Anton and Chris Rorres, "*Elementary Linear Algebra*", Tenth Edition, John Wiley and Sons, 2010.
2. Gilbert Strang, "*Linear Algebra and Its Applications*", Fourth Edition, Cengage, 2006.
3. Justin Solomon, *"Mathematical Methods for Computer Vision, Robotics, and Graphics"*, Stanford University, 2013.
4. Lawrence C. Evans, *"Partial Differential Equations"*, American Mathematical Society, 2010.
5. Gilles Aubert, Pierre Kornprobst, *"Mathematical Problems in Image Processing: Partial Differential Equations"*, Springer, 2006.

16CV601 MULTIDIMENSIONAL DATA STRUCTURES AND ALGORITHMS 3-0-1-4

Asymptotic Notation - Standard notations and common functions - Recurrences – Substitution and Master Method - Amortized Analysis – Aggregate Method

Introduction to Stacks and Queues, Linked list, B-Tree, B+ Tree. Multidimensional Data: Introduction – Need for Multidimensional Data Structures. Multidimensional Point Data Structures: Point Quadtrees – Trie-based Quadtrees – KD Trees (Point and Tries). Object based and Image based Representations: Interior bases representations: Cells and tiling, Ordering Space – Blocks - Non Orthogonal Blocks - Region Quadtrees - Region Octrees. Boundary Based Representations: Boundary Model - Voronoi Diagrams - Properties - Delaunay Graphs - Delaunay Triangulations.

TEXT BOOKS/ REFERENCES:

1. Hanan Samet, "*Foundations of Multidimensional and Metric Data Structures*", Morgan Kaufmann, San Fransisco, 2006.
2. Michael T Goodrich and Roberto Tamassia, "*Algorithm Design: Foundations, Analysis and Internet Examples",* John Wiley and Sons, 2001.
3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "*Introduction to Algorithms*", Second Edition, The MIT Press, 2001.

16CV603 MULTIDIMENSIONAL DIGITAL SIGNAL PROCESSING 3-0-0-3

One Dimensional and Two Dimensional Signals and Systems- Separable Signals- Periodic Signals - General Periodicity - 1D & 2-D Discrete Space Systems- 1 D & 2D Convolution. Continuous Space Fourier Transform - Sampling in One and Two Dimensions - Ideal Rectangular Sampling – Sampling Theorem - General Case – Change of Sampling Rate - Sampling Lattice – Reconstruction – Down Sampling and Up sampling by integers.

Discrete Space Transforms – 1D & 2D Discrete Fourier Series - 1D & 2-D Discrete Fourier transform- Properties – Discrete Time Fourier Transform- Short Time Fourier Transform – Fast Fourier Transform - Wavelet Transform - Gabor Transform.

Two Dimensional Systems and Z-Transforms - 2D Spatial Systems – Z-Transforms - Regions of Convergence - Linear Mapping of Variables - Inverse Z-Transform.

Filter Design Fundamentals - Ideal and Finite order Filters - Two Dimensional Filter Design - FIR and IIR filter design - Window Functions - Rectangular and Rotated windows.

TEXT BOOKS/ REFERENCES:

1. Dan E. Dudgeon and Russell M. Mersereau, "*Multidimensional Digital Signal Processing"*, Prentice-hall, 1984.
2. John W. Woods, "*Multidimensional Signal, Image, and Video Processing and Coding",* Second Edition, Academic Press, Elsevier Inc. 2012.
3. Steven W. Smith, "*Digital Signal Processing – A Practical Guide for Engineers and Scientists*", Newnes Elsevier Science, 2013.
4. Alan V Oppenheim and Schafer Ronald W, "*Digital Signal Processing*", Prentice Hall, 2008.
5. Sanjit K Mitra, "*Digital Signal Processing: A Computer-Based Approach*", Third Edition, McGraw-Hill Companies, 2005.

16CV605 DIGITAL IMAGE PROCESSING 3-0-1-4

Image Representation and Properties: Introduction - Image Representation - Image Digitization - Digital Image Properties – Discrete Fourier Transform - Image Pre-Processing in Spatial and Frequency Domain: Pixel Brightness Transformation - Geometric Transformations - Local Preprocessing - Image Smoothing – Edge Detectors - Corner Detectors - Image Restoration.

Image Segmentation: Thresholding – Edge- Based Segmentation – Region Based Segmentation, Mean shift segmentation, Graph cut algorithm– Matching – Evaluation Issues in Segmentation, Watersheds. Color Image Processing: Color Fundamentals – Color Models – Pseudocolor Image Processing – Basics of Full Color Image Processing – Color Transformations – Smoothing and Sharpening – Color Segmentation – Noise in Color Images.

TEXT BOOKS / REFERENCES:

1. Rafael C. Gonzalez and Richard E. Woods, "*Digital Image Processing*", Third Edition, Pearson Education, 2009.
2. Milan Sonka, Vaclav Hlavac and Roger Boyle, "*Image Processing, Analysis and Machine Vision*", Third Edition, Cengage Learning, 2007.
3. William K. Pratt, "*Digital Image Processing*", Fourth Edition, Wiley Interscience, 2007.
4. Anil K Jain, "*Fundamentals of Digital Image Processing*", Prentice Hall, 1989.

16CV607 DIGITAL VIDEO PROCESSING 3-0-1-4

Video Formation, Perception and Representation: Color Perception and Specification-Video Capture and Display-Analog Video Raster-Analog Color Television Systems-Digital Video.
Time Varying Image Formation Models: Three Dimensional Motion models, Geometric Image Formation, Photometric Image Formation.

Two Dimensional Motion Estimation: Optical Flow-General Methodologies- Pixel Based Motion Estimation-Block Matching Algorithm-Deformable Block Matching Algorithms-Mesh Based Motion Estimation-Global Motion Estimation-Region Based Motion Estimation-Multiresolution Motion Estimation.

Video compression standards- Standardization-Video Telephony with H.261 and H.263,MPEG-1,MPEG-2,MPEG-4/H.264, Compressed Domain Video Processing.
Spatio Temporal Sampling: Sampling for Analog and Digital Video, Sampling Structures for Analog Video, Two-Dimensional Rectangular Sampling, Two-Dimensional Periodic Sampling, Sampling on 3-D Structures, Sampling on a Lattice.

Video Modeling: Camera Model-Illumination Model-Object Model-Scene Model-Two-Dimensional Motion Models.

TEXT BOOKS / REFERENCES:

1. Yao Wang, Jorn Ostermann and Ya-Qin Zhang, *"Video Processing and Communications",* Prentice Hall, 2001.
2. A. Murat Tekalp, "*Digital Video Processing",* Pearson, 1995

16CV609 DEVELOPMENT TOOLS FOR IMAGE AND VIDEO PROCESSING 0-0-1-1

1. OpenSource Tools for Image Processing and Computer Vision
    - OpenCV, OpenGL
2. Beagle Board XM and Beagle Bone Black
    - Application Development using OpenCV/Java for Image Processing concepts
3. NI Vision System Camera with LabView
    - Data Acquisition
    - Basic Image Processing concepts
4. iRobot
    - Matlab programming for Navigation scenario
5. LegoMindstrom
    - Simple Robot Programming
    - Object Detection

16MA606 RANDOM PROCESSES AND OPTIMIZATION 4-0-0-4

Probability Theory: Experiments, Outcomes, Probability, conditional probability and Bayes Theorem. Random Variables and Probability Distributions- Mean and Variance of a Distribution, Binomial, Poisson and Normal Distributions.

Random Processes: General concepts and definitions – Stationarity in random process, autocorrelation and properties – Poisson points, Poisson and Gaussian processes. Spectrum estimation – Ergodicity and mean Ergodic theorem – Power spectral density and properties Markov processes – Markov Chains – Transition Probability matrix, Classification of states Limiting Distributions.

Optimization Techniques: Single variable optimization: Optimality criteria – bracketing methods – region elimination methods – point estimation method – gradient based methods. Multivariable optimization: Optimality criteria – unidirectional search direct search method gradient based methods. Lagrangian and Kuhn-Tucker conditions.

TEXT BOOKS / REFERENCES:

1. Douglas C. Montgomery and George C. Runger, "*Applied Statistics and Probability for Engineers*", Third Edition, John-Wiley & Sons Inc., 2003.
2. A. Papoulis and Unnikrishna Pillai, "*Probability, Random Variables and Stochastic Processes*", Fourth Edition, McGraw Hill, 2002.
3. J Ravichandran, "*Probability and Statistics for Engineers*", First Edition, Wiley, 2012.
4. Scott L. Miller, Donald G. Childers, "*Probability and Random Processes*", Academic Press, 2012.
5. Kalyanmoy Deb, "*Optimization for Engineering Design: Algorithms and Examples*", Prentice Hall, 2002.
6. Singiresu S. Rao, "*Engineering Optimization: Theory and Practice*", Third Edition, New Age Publishers, 2003.
7. Justin Solomon, "*Mathematical Methods for Computer Vision, Robotics, and Graphics*", Stanford University, 2013.

16CV602 IMAGE ANALYSIS 3-0-1-4

Image Morphology: Binary and gray scale Morphological analysis - Dilation and Erosion - Skeletons and Object Marking – Granulometry – Morphological Segmentation. Feature extraction: Global image measurement, feature specific measurement, characterizing shapes, Hough Transform. Representation and Description: Region Identification – Contour Based and Region Based Shape Representation and Description – Shape Classes. Flexible shape extraction: active contours, Flexible shape models: active shape and active appearance. Texture representation and analysis: Statistical Texture Description – Syntactic Texture Description Methods – Hybrid Texture description Methods – Texture Recognition Method Applications. Image Understanding: Control Strategies –RANSAC – Point Distribution Models – Scene Labeling and Constraint Propagation. Image Data Compression: Predictive Compression Methods – Vector Quantization, DCT, Wavelet, JPEG.

TEXT BOOKS / REFERENCES:

1. Milan Sonka, Vaclav Hlavac and Roger Boyle, "*Image Processing, Analysis and Machine Vision*", Third Edition, Cengage Learning, 2007.

2. Tinku Acharya, Ajoy K Ray, *"Image Processing- Principles and Applications",* Wiley, 2005.
3. John C. Russ, "*The Image Processing Handbook*", Sixth Edition, CRC Press, 2007.
4. Mark S. Nixon, Alberto S. Aguado, "*Feature Extraction and Image Processing*", Second Edition, Academic Press, 2008.

16CV604 PATTERN RECOGNITION AND MACHINE LEARNING 3-0-1-4

Introduction - Pattern recognition systems - The design cycle - Learning and adaptation - Linear models for classification - Discriminant functions (Two and multiple classes) - Least squares classification functions - Fisher's discriminant analysis for two and multiple classes - Probabilistic generative models - Maximum likelihood solution. Kernel methods: Constructing kernels - Kernel density estimators - Nearest neighbor methods - Gaussian processes and classification - Sparse kernel machines - Support vector machines - Maximum margin classifiers - Multi-class support vector machine. Graphical models: Bayesian networks - Generative models - Linear Gaussian models - Conditional independence. Mixture models and Expectation maximization: K-means clustering - Mixtures of Gaussian - Expectation maximum for Gaussian mixtures. Continuous latent variables: Principal component analysis - Applications of principal component analysis - PCA for higher dimensional data - Factor analysis. Sequential data: Markov models - Hidden Markov models - Maximum likelihood for HMM - Forward-backward algorithm. Combining models - Tree based models - Decision trees - Classification and regression trees (CART).
Deep learning for High-level Vision: Introduction to Deep Learning, main types of Deep Architectures, Application of Deep Learning Architecture to Computer Vision.

TEXT BOOKS / REFERENCES:

1. Christopher M. Bishop,"*Pattern Recognition and Machine Learning*", Springer, 2006.
2. Richard O. Duda, Peter E. Hart and David G. Stork, *"Pattern Classification",* Second Edition, John Wiley and Sons, 2003.
3. Earl Gose, Richard Johnsonbaugh and Steve Jost, *"Pattern Recognition and Image Analysis",* Prentice Hall of India, 2002.

16CV606 COMPUTER VISION 3-0-1-4

Image Formation: Geometric image formation, Photometric image formation - Camera Models and Calibration: Camera Projection Models – Orthographic, Affine, Perspective, Projective models. Projective Geometry, Transformation of 2D and 3D, Internal Parameters, Lens Distortion Models- Local Feature Detectors and Descriptors: Hessian corner detector, Harris Corner Detector, LOG detector, DOG detector, SIFT, PCA-SIFT, GLOH, SURF, HOG, Pyramidal HOG, PHOW-Calibration Methods: Linear, Direct, Indirect and Multiplane methods -

Pose Estimation. Stereo and Multi-view Geometry: Epipolar Geometry, Rectification and Issues related to Stereo, General Stereo with E Matrix Estimation, Stratification for 2 Cameras, Extensions to Multiple Cameras, Self-Calibration with Multiple Cameras, 3D reconstruction of cameras and structures, Three View Geometry.

TEXT BOOKS / REFERENCES:

1. Forsyth and Ponce, "*Computer Vision – A Modern Approach*", Second Edition, Prentice Hall, 2011.
2. Emanuele Trucco and Alessandro Verri, "*Introductory Techniques for 3-D Computer Vision*", Prentice Hall, 1998.
3. Olivier Faugeras, "*Three Dimensional Computer Vision*", MIT Press, 1993.
4. Richard Szeliski, "*Computer Vision: Algorithms and Applications*", Springer, 2011.
5. Milan Sonka, Vaclav Hlavac and Roger Boyle, "*Image Processing, Analysis and Machine Vision*", Third Edition, CL Engineering, 2013.

16CS625 RESEARCH METHODOLOGIES AND SEMINAR 1-0-1-2

Note: The course will be evaluated internally by the Department.

This course is intended to be a self study course. Each student can select an area of self study in consultation with the Faculty, collect and study basic and recent research articles (project reports, review articles, published articles in journals and book chapters.) on the topic. Students will be required to make two in-class presentations. The Seminars will be evaluated for grading purpose. The evaluation will be done by a panel of (at least) two Faculty members.

Topics to be covered:

Selection of project domain; Publication ethics, Tools and evaluation. Selection of tentative project area and process of literature survey – Literature survey components and procedures Basic components of a research paper – procedures and processes, Journal types, Scopus, web of science, Thomson Reuters, Science Citation Index, H-index, Google citations, Presentation of selected project proposal – Oral presentation. Preparation of a report on the selected project proposal in LaTeX format
Attending special invited lectures, practical orientation in searching and collecting literature through library, online tools, presenting a seminar on selected project proposal and submitting project report prepared using LaTeX.

Note: Allotment / Selection of Mentor/Supervisor will be done at Department.

16EN600 TECHNICAL WRITING P/F

Technical terms – Definitions – extended definitions – grammar checks – error detection – punctuation – spelling and number rules – tone and style – pre-writing techniques – Online and offline library resources – citing references – plagiarism – Graphical representation – documentation styles – instruction manuals – information brochures – research papers – proposals – reports (dissertation, project reports etc.)

TEXTBOOKS/REFERENCES:

1. H.L. Hirsch, *Essential Communication Strategies for Scientists, Engineers and Technology Professionals*, Second Edition, New York: IEEE Press, 2002.
2. P.V. Anderson, *Technical Communication: A Reader-Centered Approach,* Sixth Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2008, (Reprint 2010).
3. W.Jr. Strunk and E.B.White, *The Elements of Style*, New York. Alliyan and Bacon, 1999.

16CV701 MODELING AND VISUALISATION 3-0-0-3

Introduction to Graphics, Two-dimensional Geometric Transformations, Three-dimensional Concepts. Modeling: Three-Dimensional Object Representations: Raw 3D data, Surface Representation, Solid Representation, High-Level Representation. Reconstruction of 3D Meshes from Polygon Soup: Cell complex, Solidity Determination, Meshes reconstruction. Advanced Rendering Techniques:Photorealistic Rendering, Global Illumination, Participating Media Rendering, Ray tracing, Monte Carlo algorithm, Photon Mapping. Volume Rendering: Volume graphics Overview, Marching cubes, Direct volume rendering. Surfaces and Meshes. Visualization: Meshes for Visualization, Volume Visualization and Medical Visualization.

TEXT BOOKS / REFERENCES:

1. Tomas Akenine Moller, Eric Haines and Naty Hoffman, *" Real-Time Rendering*", Third Edition, A K Peters Ltd, 2008.
2. Matt Pharr and Greg Humphreys, *"Physically Based Rendering: From Theory to Implementation"*, Second Edition, Morgan Kaufmann, 2010.
3. Lars Linsen, Hans Hagen and Bernd Hamann, *"Visualization in Medicine and Life Sciences"*, Springer-Verlag Berlin Heidelberg, 2008.
4. Donald Hearn and Pauline Baker, "*Computer Graphics*", Second Edition, Prentice Hall of India, 1994.

16CV702 VIDEO ANALYTICS 3-0-0-3

Video Analytics principles. Computer Vision: Challenges - Spatial Domain Processing – Frequency Domain Processing - Background Modeling - Shadow Detection - Eigen Faces - Object Detection - Local Features - Mean Shift: Clustering, Tracking - Object Tracking using Active Contours - Action Recognition - Low Level Image Processing for Action Recognition: Segmentation and Extraction, Local Binary Pattern, Structure from Motion - Action Representation Approaches: Classification of Various Dimension of Representation, View Invariant Methods, Gesture Recognition and Analysis, Action Segmentation.

Case Study: Face Detection and Recognition, Natural Scene Videos, Crowd Analysis, Video Surveillance, Traffic Monitoring, Intelligent Transport System.

TEXT BOOKS / REFERENCES:

1. Richard Szeliski, "*Computer Vision: Algorithms and Applications*", Springer, 2011.
2. Thierry Bouwmans, Fatih Porikli, Benjamin Höferlin and Antoine Vacavant, "*Background Modeling and Foreground Detection for Video Surveillance: Traditional and Recent Approaches, Implementations, Benchmarking and Evaluation",* CRC Press, Taylor and Francis Group, 2014.
3. Rastislav Lukac, Boca Raton, FL,"*Computational Photography: Methods and Applications,* CRC Press, Taylor and Francis Group, 2010.
4. Ahad, Md. Atiqur Rahman, "*Computer Vision and Action Recognition-A Guide for Image Processing and Computer Vision Community for Action Understanding*", Atlantis Press, 2011.

16CV703 ADVANCED COMPUTER VISION 3-0-0-3

Shape from X – Shape from Stereo, Shape from Shading, Shape from Silhouette, Shape from Texture and Shape from Focus. Shape Representation: Statistical Shape Models, Active Shape Models, Combined Appearance Models, Active Appearance Models, View-based Appearance Models, Tracking with View-based Appearance Models. Object Recognition: Shape Correspondence and Shape Matching, PCA, Shape Priors for Recognition, Finding Templates and Recognition, Recognition by Relations between Templates, Robotic vision, Computer Vision on the GPU. Tracking & Video Analysis: Tracking and Motion Understanding - Kalman filters, condensation, particle, Bayesian filters, Hidden Markov models, Change detection and Model-based tracking.

TEXT BOOKS / REFERENCES:

1. Forsyth and Ponce, "*Computer Vision – A Modern Approach*", Second Edition, Prentice Hall, 2011.

2. Emanuele Trucco and Alessandro Verri, "*Introductory Techniques for 3-D Computer Vision*", Prentice Hall, 1998.
3. Olivier Faugeras, "*Three Dimensional Computer Vision*", MIT Press, 1993.
4. Richard Szeliski, "*Computer Vision: Algorithms and Applications*", Springer, 2011.
5. Richard Hartley and Andrew Zisserman, "*Multiple View Geometry in Computer Vision*", Second Edition, Cambridge University Press, 2004.

16CV704 MACHINE VISION 3-0-0-3

Design and Fabrication of Soft Zoom Lens Applied in Robot Vision - Methods for Reliable Robot Vision with a Dioptric System - An Approach for Optimal Design of Robot Vision Systems -Visual Motion Analysis for 3D Robot Navigation in Dynamic Environments - A Visual Navigation Strategy based on Inverse Perspective Transformation - Vision-based Navigation Using an Associative Memory. Vision Based Robotic Navigation: Application to Orthopedic Surgery - Navigation and Control of Mobile Robot Using Sensor Fusion - Visual Navigation for Mobile Robots - Interactive Object Learning and Recognition with Multiclass Support Vector Machines - Recognizing Human Gait Types - Environment Recognition System for Biped Robot Walking Using Vision Based Sensor Fusion - Non Contact 2D and 3D Shape Recognition by Vision System for Robotic Prehension - Image Stabilization in Active Robot Vision-Real - Time Stereo Vision Applications - Robot vision using 3D TOF systems - Calibration of Non-SVP Hyperbolic Catadioptric Robotic Vision Systems - Computational Modeling, Visualization, and Control of 2-D and 3-D Grasping under Rolling Contacts - Towards Real Time Data Reduction and Feature Abstraction for Robotics Vision - LSCIC Pre Coder for Image and Video Compression - The Robotic Visual Information Processing System Based on Wavelet Transformation and Photoelectric Hybrid-Direct Visual Servoing of Planar Manipulators Using Moments of Planar Targets - Industrial Robot Manipulator Guarding Using Artificial Vision - Remote Robot Vision Control of a Flexible Manufacturing Cell - Robot Vision in Industrial Assembly and Quality Control Processes - Multi-Task Active - Vision in Robotics

TEXT BOOKS / REFERENCES:

1. Ales Ude, "*Robot Vision*", InTech, 2010.
2. Daiki Ito, "*Robot Vision: Strategies, Algorithms and Motion Planning*", Nova Science Publishers Inc, 2009.
3. Christian Wiedemann , Markus Ulrich and Carsten Steger , *"Machine Vision Algorithms and Applications*", Wiley-VCH, 2008.
4. E. R. Davies, "*Computer and Machine Vision, Theory, Algorithms, Practicalities*", Fourth Edition, Elsevier, 2012.

5. Ramesh Jain, Rangachar Kasturi and Brian G. Schunck, "*Machine Vision*", Tata McGraw-Hill, 1995.

16CV705 MEDICAL IMAGE ANALYSIS 3-0-0-3

Medical imaging modalities: Planar X-Ray imaging - X-Ray Computed Tomography – Magnetic Resonance Imaging – Nuclear Imaging – Ultrasonography – Other modalities. Image file formats: DICOM and other medical image file formats. Image Enhancement: Fundamental enhancement techniques- Adaptive Image Filtering – Enhancements by multiscale non linear operators. Image segmentation: Overview and fundamentals of medical image segmentation – Segmentation using Graph cuts – Segmentation using fuzzy clustering – Neural networks – Deformable models. Medical image registration: Rigid body transformation – Non rigid body transformation – Pixel based registration – Surface based registration – Intensity based registration. Medical image fusion: Linear and non linear methods – Wavelet based fusion – Pyramidal fusion schemes – Edge preserving fusion algorithms. Validation of medical image analysis techniques. Case Study: Brain image analysis and atlas construction – Tumour image analysis and treatment planning – Lung Nodule Analysis - Retinal Image Processing and analysis - X-Ray image processing and Analysis. Tools: VTK / ITK, Fiji, Mevislab.

TEXT BOOKS / REFERENCES:

1. Geoff Dougherty, "*Medical Image Processing Techniques and Applications*", Springer, 2011.
2. Thomas M Deserno, "*Biomedical Image Processing*", Springer-Verlag, 2011.
3. A. Ardheshir Goshtasby, "*2-D and 3-D Image Registration for Medical, Remote Sensing, and Industrial Applications*", John Wiley and Sons, 2005.
4. Tania Sthathaki, "*Image Fusion: Algorithms and Applications*", Academic Press, 2008.
5. James T . Dobbins III, Sean M . Hames, Bruce H . Hasegawa, Timothy R . DeGrado, James A . Zagzebski and Richard Frane, "*Measurement, Instrumentation, and Sensors Handbook*", Second Edition: Electromagnetic, Optical, Radiation, Chemical, and Biomedical Measurement, CRC Press 2014.

16CV706 CONTENT BASED IMAGE AND VIDEO RETRIEVAL 3-0-0-3

Architecture and Design: Introduction - Architecture of content-based image and video retrieval - Designing an image retrieval system - Designing a video retrieval system. Feature extraction and similarity measure: Color - Texture - Shape - Spatial relationships - MPEG 7 features. Modeling and analysis of images: Classification and clustering - Annotation and semantic based retrieval

of visual data - Probabilistic models - Relevance feedback. Standards for image data management: Standards relevant to Content based image retrieval - Image compression - Query Specification - Metadata description. Analysis of video: Feature extraction - Semantics understanding - Summarization - Indexing and retrieval of video - Mining large databases. Applications: Architectural and engineering design - Fashion and interior design - Journalism and advertising -Medical Diagnosis - Geographical Information Systems and Remote Sensing - Education and Training - Web Searching.

TEXT BOOKS / REFERENCES:

1. Oge Marques and Borko Furht, "*Content Based Image and Video Retrieval*", Multimedia Systems and Applications, Springer, 2002.
2. Oge Marques, "*Practical Image and Video Processing*", Wiley IEEE Press, 2011.
3. Borko Furht and Oge Marques, "*Hand Book of Video Databases Design and Applications*", CRC Press, 2003.
4. Yogita Mistry and Dr. D.T. Ingole, "*Survey on Content Based Image Retrieval Systems",* International Journal of Innovative Research in Computer and Communication Engineering, 2013.

16CV707 DOCUMENT IMAGE ANALYSIS 3-0-0-3

Introduction: Data capture - Document image understanding - Concepts and components. Pixel level processing: Thresholding – Basic Document Image Binarization – Edge Preserving Binarization Techniques – Combining Different Binarization Techniques - Case Study: Binarization of Historical Documents.

Noise reduction and Enhancement: Noise in Conventional and Camera Captured Document Images – Border Noise and Frame Noise Removal – Circular Noise and Stroke like Pattern Noise Removal – Clutter Noise Removal – Bleed Through Removal - Case Study: Removing noise from Historical Documents.

Feature level processing: Introduction - Polygonalization - Critical point detection - Line and curve fitting - Shape description and recognition - Case Study: Detection of lines, curves and angles from engineering drawings/maps.

Methodologies: Projection Profile Analysis – Run Length Smearing – Recursive X-Y Cut – White Space Analysis - Connected component computation - Top Down and Bottom Up Strategies.

Skew detection and correction: Projection Profile based Skew Detection- Nearest Neighbour Clustering based Skew Detection – Hough Transform based Skew Detection - Slant Estimation.

Layout analysis - Geometric and logic layout analysis - Page decomposition – Region segmentation - Labelling and classification.

Text analysis and recognition: Text segmentation – Script, Language and Font identification - Character segmentation – Machine printed character recognition - Hand written character recognition – Case Study: Optical Character Recognition (OCR) - Tesseract OCR- Form Processing - Recognition of Braille characters. Commercial state and future trends.

TEXT BOOKS / REFERENCES:

1. L. O. Gorman and R. Kasturi, "*Document Image Analysis*", IEEE Computer Society Press, 1995; IEEE Computer Society Executive Briefings, 1997, ISBN 0-8186-7802-X.
2. David Doermann, Karl Tombre, "*Handbook of Document Image Processing and Recognition", Springer London, 2014, ISBN 0857298585, 9780857298584*.
3. H. Bunke and P. S. P. Wang, "*Handbook of Character Recognition and Document Image Analysis*", World Scientific Press, 1997.
4. H. S. Baird, H. Bunke and K. Yamamoto (Eds.), "*Structured Document Image Analysis*", Springer Verlag, 1992.
5. H. Bunke and Lawrence Spitz (Eds.), "*Document Analysis Systems*", Lecture Notes in Computer Science, Vol. 3872, Springer Verlag, 2006.

16CV708 COMPUTATIONAL INTELLIGENCE FOR IMAGE PROCESSING 3-0-0-3

Computational Intelligence Paradigms overview – Applications of Computational Intelligence for Image Analysis: Image Enhancement – Thresholding – Segmentation – Image Compression and Reconstruction – Registration – Image Retrieval – Hyperspectral Image Clustering – Emotion Recognition

TEXT BOOKS / REFERENCES:

1. Amitava Chatterjee and Patrick Siarry (Eds.), "*Computational Intelligence in Image Processing*", Springer, 2013.
2. Kim-Hui Yap, Ling Guan, Stuart William Perry and Hau San Wong, "*Adaptive Image Processing: A Computational Intelligence Perspective*", Second Edition, Image Processing Series, CRC Press, 2009.
3. Andries P. Engelbrecht, "*Computational Intelligence – An Introduction*", Second Edition, Wiley-Blackwell, 2007.
4. Milan Sonka, Vaclav Hlavac and Roger Boyle, "*Image Processing, Analysis and Machine Vision*", Cengage Learning, 2008.
5. Evangelia Micheli-Tsanakou, "*Supervised and Unsupervised Pattern Recognition – Feature Extraction and Computational Intelligence*", CRC Press, 2000.

16CV709 **IMAGE FUSION** **3-0-0-3**

Introduction to Image Fusion – Spatial and transform domain fusion schemes – fusion rules - Current trends in super-resolution image reconstruction- Introduction – Geometric transformation models – Image degradation models – State-of-the-art SR methods. Multiresolution analysis – Fundamental principles – wavelet based fusion scheme – pyramid – based fusion scheme – 'A truos' wavelet fusion scheme. Image fusion using ICA. Image fusion using optimization of statistical measurements – Introduction – Mathematical preliminaries – Dispersion Minimisation fusion based methods – Kurtosis Maximisation Fusion based methods. Fusion of edge maps using statistical approaches – Introduction – Automatic edge detection – ROC analysis. Region-based multi focus image fusion – spatial domain fusion – fusion using segmented regions. Pixel level image fusion metrics – Signal level performance evolution – Edge based metrics – performance of fusion metrics. Objectively adaptive image fusion - forward adaptive – feed-back adaptive schemes – evaluation parameters – Optimal video fusion. Performance evaluation of image fusion techniques – Signal-to-Noise Ration (SNR) – Peak Signal-to-Noise Ration (PSNR) – Mean Square Error (MSE) – Mutual Information – Fusion Factor – Fusion Symmetry.
Case study : Out-of-focus image fusion – Multi-modal image fusion – Image fusion in remote sensing applications – Image fusion in medical applications.

TEXT BOOKS / REFERENCES:

1. Tania Stathaki, "*Image Fusion- Algorithms and Applications*", First Edition, Academia Press, 2008.
2. Rick S. Blum and Zheng Liu, "*Multi-Sensor Image Fusion and Its Applications*", CRC Press, 2005.

16CV710 **MULTIMEDIA SECURITY** **3-0-0-3**

Introduction - Applications and Properties: Applications – Properties – Evaluating Watermarking Systems. Basic of Cryptographic Techniques: Symmetric Key Encryption – Hash Keys – RSA – DES – Key Management. Models of Watermarking: Communication based watermarking – Geometric models of watermarking – Modeling Watermarks Detection by correlation. Watermarking with side information: Informed Embedding – Informed coding – Dirty paper codes. Perceptual Models: Evaluation – Perceptual model – Watson's model – Adaptive watermarking. Robust watermarking – Watermark Security. Secret Writing and Steganography – Case Study: Watermarking for Copyright Protection. Biometric Features for User Authentication: Pattern, Speaker and Behavior Recognition - Speaker Recognition - Face Recognition. Media Sensor Network - Voice over IP (VoIP) Security- Key Managements and Emerging Technology.

TEXT BOOKS / REFERENCES:

1. Ingemar Cox, Matthew Miller, Jeffrey Bloom and Mathew Miller, *"Digital Watermarking: Principles and Practice"*, Morgan Kaufmann Series in Multimedia Information and Systems, 2008.
2. Stefan Katzenbeisser and Fabien A. P. Petitcolas, *"Information Hiding Techniques for Steganography and Digital Watermarking"*, Artech House, 1999.
3. Juergen Seitz, *"Digital Watermarking for Digital Media",* Information Science Publishing, 2005
4. B. Schneier, *"Applied Cryptography"*, Second Edition, Wiley, 1996.
5. Menezes, P. van Oorschot and S. Vanstone, *"Handbook of Applied Cryptography"*, CRC Press, 1997.

16CV711 VISUAL PATTERN ANALYSIS AND MODELING 3-0-0-3

Pattern Analysis and Statistical Learning: Statistical classification, Visual pattern representation, statistical learning. Unsupervised Learning for Visual Pattern Analysis: Cluster analysis, Clustering algorithms, Representational Models Component Analysis: Overview, Generative and Discriminative models. Manifold Learning: global, local and hybrid methods
Functional Approximations: Modeling and Approximating visual data, Lifting schemes, Temporal filtering in video coding.

Supervised Learning for Visual Classification: Support vector machine, Boosting algorithm.
Statistical Motion Analysis, Tracking of Visual Objects, Robust Visual Tracking, Multi Target Tracking in Video. Cognition Process: cognitive model, brain research and visual science, visual cognition, cognitive mechanisms.

TEXT BOOKS / REFERENCES:

1. Nanning Zheng and Jianru Xue, "*Statistical Learning and Pattern Analysis for Image and Video Processing (Advances in Pattern Recognition Series)*", Springer-Verlag London Limited, 2009.
2. Christopher M Bishop, "*Pattern Recognition and Machine Learning*" Springer, 2006.
3. Ian T. Babney, "*NETLAB: Algorithms for Pattern Recognition (Advances in Pattern Recognition series)*", Springer, 2002.

16CV712 GPU ARCHITECTURE AND PROGRAMMING 3-0-0-3

Thinking in Parallel: Parallelism Vs. Concurrency, Types and levels of parallelism, Different grains of parallelism, Flynn's classification of multi-processors, Introduction to parallelization

and vectorization: Data dependencies, Bernstein conditions for Detection of Parallelism, Motivation for Heterogeneous Computing, Definition of thread and process, Parallel programming models, Parallel Programming constructs: Synchronization, Deadlocks, Critical sections and Data sharing .

Compute Unified Device Architecture (CUDA): Introduction to heterogeneous architectures-GPU in particular. Introduction to GPU computing, evolution of GPU pipeline and general purpose computation on GPU, GPU architecture case studies: NVIDIA G80, GT200, Fermi, Kepler etc. CUDA Architecture, CUDA programming model, execution model, thread organization: Concept of grid, block and thread, thread index generation, warp. GPU primitives, algorithms and applications: GPU primitives: scan (exclusive or inclusive), scatter, gather, reduce, memory model: Introduction to global, shared, local memories, usage of cache, texture cache, constant memory. CUDA structure, API and library (CUDPP, CUBLAS, FFT etc.) details. CUDA example programs (Vector dot product, Matrix multiplication (with the usage of tiling and shared memory) etc.). Graph algorithms and dense linear algebra using GPU.GPU Programming using OpenACC:Introduction to OpenACC, basic steps of OpenACC programming. OpenACC programming examples (Image Convolution, Matrix multiplication)

Optimizations and Tools: Memory coalescing; thread and warp divergence, avoiding bank conflicts, Reduction operation using prefix sum example. Usage of shared memory optimally, Performance issues in algorithms, Need of profilers and analyzers, Introduction to CUDA Tools: GDB, MemCheck, Command line & Visual Profilers, Parallel NSight: Debugger, Analyzer& Graphics Inspector.

TEXT BOOKS / REFERENCES:

1. David Kirk, Wen-meiHwu , "*CUDA: Programming Massively Parallel Processors: A Hands- on Approach*", Second Edition, Morgan Kaufmann Publishers, 2012.
2. Jason Sanders, Edward Kandrot, "*CUDA by Example: An Introduction to General-Purpose GPU Programming",* First Edition, Addison Wesley, 2010.
3. Michael J. Quinn , "*Parallel Programming in C with MPI and OpenMP*", Tata McGraw-Hill, 2003