M. Sc. Computer Science III Semester
Subject Reference no CSC503 Subject Title Computer Vision
No of Credits 4 Theory, 2PracticalAssignment/Sectionals (Internal)20%
Total ContactHrs/Week4 Theory, 4PracticalExternal (SemesterExam)80%

Objective: To provide the mechanics for representation and analysis of Multispectral data.

Prerequisite: Student must have knowledge of Signal Processing, Image Processing, Neural Networksand Artificial Intelligence.
UNIT I:
CAMERAS: Pinhole Cameras, Perspective Projection, Affine Projection, **GEOMETRIC CAMERA MODELS:**Elements of Analytical Euclidean Geometry, Coordinate Systems and Homogeneous Coordinates,Coordinate System Changes and Rigid Transformations, Camera Parameters and the PerspectiveProjection, Intrinsic Parameters, Extrinsic Parameters, A Characterization of Perspective ProjectionMatrices, Affine Cameras and Affine Projection Equations, Affine Cameras, Affine Projection Equations, ACharacterization of Affine Projection Matrices, **GEOMETRIC CAMERA CALIBRATION:** Least-SquaresParameter Estimation, Linear Least-Squares Methods, Nonlinear Least-Squares Methods, A LinearApproach to Camera Calibration, Estimation of the Projection Matrix, Estimation of the Intrinsic andExtrinsic Parameters, Degenerate Point Configurations, Taking Radial Distortion into Account,Estimation of the Projection Matrix, Estimation of the Intrinsic and Extrinsic Parameters, DegeneratePoint Configurations, Analytical Photogrammetry, An Application: Mobile Robot Localization. **RADIOMETRYMEASURINGLIGHT**: Light in, Foreshortening, Solid Angle, Radiance, Light at Surfaces,Simplifying Assumptions, The Bidirectional Reflectance Distribution Function, Example: The Radiometryof Thin Lenses, Important Special Cases, Radiosity, Directional Hemispheric Reflectance, LambertianSurfaces and Albedo, Specular Surfaces, The Lambertian + Specular Model. **SOURCES, SHADOWS, ANDSHADING:** Qualitative Radiometry, Sources and Their Effects, Radiometric, Properties of Light Sources,Point Sources, Line Sources, Area Sources, Local Shading Models, Local Shading Models for Point
Sources, Area Sources and Their Shadows, Ambient Illumination, Application: Photometric Stereo,Normal and Albedo from Many Views, Shape from Normals, Interreftections: Global Shading Models, AnInterreflection Model, Solving for Radiosity, The Qualitative Effects of Interreftections, **COLOR:** ThePhysics of Color, Radiometry for Colored Lights: Spectral Quantities, The Color of Sources, The Color ofSurfaces, Human Color Perception, Color Matching, Color Receptors, Representing Color, Linear ColorSpaces, Non-linear Color Spaces, Spatial and Temporal Effects, A Model for Image Color, Cameras, AModel for Image Color, Application: Finding Specularities, Surface Color from Image Color, Surface ColorPerception in People, Inferring Lightness, Surface Color from Finite-Dimensional Linear Models
UNIT II:
LINEAR FILTERS: Linear Filters and, Convolution, Shift Invariant Linear Systems, Discrete Convolution,Continuous Convolution., Edge Effects in Discrete Convolutions, Spatial Frequency and FourierTransforms, Fourier Transforms, Sampling and Aliasing,Sampling, Aliasing, Smoothing and Resampling,Filters as Templates, Convolution as a Dot Product, Changing Basis, Technique: Normalized Correlationand Finding Patterns, Controlling the

Television by Finding Hands by Normalized Correlation,Technique: Scale and Image Pyramids, The Gaussian Pyramid, Applications of Scaled Representations,**TEXTURE:** Representing Texture, Extracting Image Structure with Filter Banks, Representing Texture Using the Statistics of Filter Outputs, Analysis (and Synthesis) Using Oriented Pyramids,The LaplacianPyramid, Filters in the Spatial Frequency Domain, Oriented Pyramids, Application: SynthesizingTextures for Rendering, Homogeneity,, Synthesis by Sampling Local Models, **THE GEOMETRY OFMULTIPLE VIEWS:** Two Views, Epipolar Geometry, The Calibrated Case, Small Motions, TheUncalibrated Case, Weak Calibration, Three Views, Trifocal Geometry, The Calibrated Case, TheUncalibrated Case, Estimation of the Trifocal Tensor, **STEREOPSIS:** Reconstruction, Image Rectification,Human Stereopsis, Binocular Fusion, Correlation, Multi-Scale Edge Matching, Using More Cameras ThreeCameras, Multiple Cameras,**AFFINE STRUCTURE FROM MOTION:** Elements of Affine Geometry, Affine Spaces and BarycentricCombinations, Affine Subspaces and Affine Coordinates, Affine Transformations and Affine ProjectionModels, Affine Shape, Affine Structure and Motion from Two Images, Geometric Scene Reconstruction,Algebraic Motion Estimation, Affine Structure and Motion from Multiple Images, The Affine Structure ofAffine Image Sequences, A Factorization Approach to Affine Structure from Motion, From Affine toEuclidean Images, Euclidean Constraints and Calibrated Affine Cameras, Computing Euclidean Upgradesfrom Multiple Views, Affine Motion Segmentation, The Reduced Row-Echelon Form of the Data Matrix,The Shape Interaction Matrix, **PROJECTIVE STRUCTURE FROM MOTION:** Elements of ProjectiveGeometry, Projective Spaces, Projective Subspaces and Projective Coordinates, Affine and ProjectiveSpaces, Hyperplanes and Duality, Cross-Ratios and Projective Coordinates, Projective Transformations,Projective Shape, Projective Structure and Motion from Binocular Correspondences, Geometric SceneReconstruction, Algebraic Motion Estimation, Projective Motion Estimation from MultilinearConstraints, Motion Estimation from Fundamental Matrices, Motion Estimation from Trifocal Tensors,
Projective Structure and Motion from Multiple Images, A Factorization Approach to Projective Structurefrom Motion, Bundle Adjustment, From Projective to Euclidean Images

UNIT III:

APPLICATION: IMAGEBASEDRENDERING: Constructing 3D Models from Image Sequences, SceneModeling from Registered Images, Scene Modeling from Unregistered Images, Transfer-BasedApproaches to Image-Based Rendering, Affine View Synthesis, Euclidean View Synthesis, The Light Field,**SEGMENTATION BY CLUSTERING** What Is Segmentation? Model Problems, Segmentation as Clustering,Human Vision: Grouping and Gestalt, Applications: Shot Boundary Detection and BackgroundSubtraction, Background Subtraction, Shot Boundary Detection, Image Segmentation by ClusteringPixels, Segmentation Using Simple Clustering Methods, Clustering and Segmentation by K-means,
Segmentation by Graph-Theoretic Clustering, Terminology for Graphs, The Overall Approach, AffinityMeasures, Eigenvectors and Segmentation, Normalized Cuts, **SEGMENTATION BY FITTING A MODEL:**The Hough Transform, Fitting Lines with the Hough Transform, Practical Problems with the HoughTransform, Fitting Lines, Line Fitting with Least Squares, Which Point Is on Which Line?, Fitting Curves,Implicit Curves, Parametric Curves, Fitting as a Probabilistic Inference Problem, Robustness, Mestimators,RANSAC, Example: Using RANSAC to Fit Fundamental Matrices, An Expression for Fitting

Error, Correspondence as Noise, Applying RANSAC, Finding the Distance, Fitting a Fundamental Matrixto Known Correspondences.

UNIT IV:

SEGMENTATION AND FITTING USING PROBABILISTIC METHODS: Missing Data Problems, Fitting,and Segmentation, Missing Data Problems, The EM Algorithm, The EM Algorithm in the General Case,The EM Algorithm in Practice, Example: Image Segmentation, Revisited, Example: Line Fitting with EM,Example: Motion Segmentation and EM, Example: Using EM to Identify Outliers, Example: BackgroundSubtraction Using EM, Example: EM and the Fundamental Matrix, Difficulties with the EM Algorithm,Model Selection: Which Model Is the Best Fit? Basic Ideas, AIC-An Information Criterion, Bayesian
Methods and Schwartz' BIC, Description Length, Other Methods for Estimating Deviance, **APPLICATION:FINDING IN DIGITAL LIBRARIES:** Background: Organizing Collections of Information, How Well Doesthe System Work?, What Do Users Want?, Searching for Pictures, Structuring and Browsing, SummaryRepresentations of the Whole Picture, Histograms and Correlograms, Textures and Textures of Textures,Representations of Parts of the Picture, Segmentation, Template Matching, Shape and Correspondence,Clustering and Organizing Collections, Video **TRACKING WITH LINEAR DYNAMIC MODELS:** Trackingas an Abstract Inference Problem, Independence Assumptions, Tracking as Inference, Overview, LinearDynamic Models, Drifting Points, Constant Velocity, Constant Acceleration, Periodic Motion, HigherOrder Models, Kalman Filtering, The Kalman Filter for a ID State Vector, The Kalman Update Equationsfor a General State Vector, Forward-Backward Smoothing, Data Association, Choosing the Nearest-Global Nearest Neighbours, Gating and Probabilistic Data Association, Applications and Examples,Vehicle Tracking

UNIT V:

MODELBASEDVISION: Initial Assumptions, Obtaining Hypotheses, Obtaining Hypotheses by PoseConsistency, Pose Consistency for Perspective Cameras, Affine and Projective Camera Models, LinearCombinations of Models, Obtaining Hypotheses by Pose Clustering, Obtaining Hypotheses UsingInvariants, Invariants for Plane Figures, Geometric Hashing, Invariants and Indexing, Verification, EdgeProximity, Similarity in Texture, Pattern and Intensity, Application: Registration in Medical ImagingSystems, Imaging Modes, Applications of Registration, Geometric Hashing Techniques in MedicalImaging, Curved Surfaces and Alignment **FINDING TEMPLATES USING CLASSIFIERS:** Classifiers, UsingLoss to Determine Decisions, Overview: Methods for Building Classifiers, Example: A Plug-in Classifierfor Normal Class-conditional Densities, Example: A Nonparametric Classifier Using Nearest Neighbors,Estimating and Improving Performance, Building Classifiers from Class Histograms, Finding Skin PixelsUsing a Classifier, Face Finding Assuming Independent Template Responses, Feature Selection, PrincipalComponent Analysis, Identifying Individuals with Principal Components Analysis, Canonical Variates,Neural Networks, Key Ideas, Minimizing the Error, When to Stop Training, Finding Faces Using NeuralNetworks, Convolutional Neural Nets, Support Vector Machines for Linearly Separable Daiasets, FindingPedestrians Using Support Vector Machines **ASPECT GRAPHS:** Visual Events: More DifferentialGeometry, The Geometry of the Gauss Map, Asymptotic Curves, The Asymptotic Spherical Map, LocalVisual Events, The Bitangent Ray Manifold, Multilocal Visual Events, Computing the Aspect Graph, Step I:Tracing Visual Events, Step 2:

Constructing the Regions, Remaining Steps of the Algorithm, An Example,Aspect Graphs and Object Localization

Books:

1. Computer Vision: A Modern Approach, Forsyth Ponce , Pearson Education
2. Image Processing, Analysis and Machine Vision, Milan Sonka, Thomson Learning

References:

1. Machine Vision, Jain R C Kasturi R, McGrawHill
2. Three Dimensional Computer Vision, Y Shirai, Springer Verlag
3. Computer And Robot Vision Vo I and II, Haralick R M And Shapiro L G, Addison Wesley
4. Computational Vision, Wechsler, Academic Press
5. Robot Vision, Horn B K P, Cambridge MIT press
6. Digital Image Processing & Computer Vision, Robert J Schalkoff, John Willey Publication

Lab Exercise: CSC553 Practical based on CSC503

At least two experiments should be carried out on each unit.