Computer Vision

Corse content

Introduction and Digital Image Fundamentals

Image Enhancement and Restoration

Image Enhancement in the ~~Frequency Domain~~

Image Segmentation, Representation and Description

Harris Detector, Sift, Point Matching, Ransac, Local Binary Pattern

Projective Geometry for Computer Vision

Multiple views geometry

Simulations localization and mapping

Optical Flow & Motion Analysis

3D reconstruction with a calibrated camera

Object tracking

Object recognition

Advanced topics

Content in each class

1. Image Processing Enhancement
2. Spatial Filtering
3. Spatial filtering concepts: convolution using zero padding, spatial correlation & convolution, design of spatial filters (Gaussian filters), smoothing, median filtering, sharpening filters
4. Smoothing filters, edge detection, derivative operators
5. Image segmentation: edge linking, boundary detection, basics of thresholding
6. Relationship between 3D world and 2D images
7. Transformations and pose estimation, 3D translation
8. Camera model and calibration: frames, perspective projection, camera matrices, recommended camera parameters

9. Geometric transformations, perspective transforms, camera calibration and orientation, epipolar geometry for image pairs, epipolar lines
10. Epipolar constraint, epipoles, mutual correspondences, essential matrix
11. Camera setup, different types of matrices, normalized 8-point algorithm, robust fundamental matrix estimation
12. Optical flow and motion analysis of objects

Books:

Forsyth & Ponce, Computer Vision: A modern approach, Pearson, 2002, ISBN 0130851981

Gonzalez R.C., woods R.E, Digital Image Processing, Pearson Education (2007)

Deep Learning

Syllabus

Datasets: text, time series, speech, data from IoT devices, image data, video data

Univariate (one feature), multi-variate (multi-dimensional), unimodal (single distribution), multi-modal (multi-distribution)

Structures data (relational databases atleast 1NF/Tabular), unstructured raw data, Semi-structured data (Json, html, tagged database: like NoSQL)

Transform unstructured data to structured data: all ML and DL models can be deployable

Structured data with fixed schema -> vector space

Probably approximately correct (PAC): Establishes the guarantees for upper bound on generalization error (true error), given a number of samples, error tolerance (approximation), confidence parameter, and hypothesis class (learning model). [finite hypothesis, Infinite hypothesis; VC dimension]

Why do we need large number of samples to train a good model

How can we reduce overfitting and underfitting

What will be the right model for a particular task

Security aspect of the model

Learning process: supervised, unsupervised, semi-supervised algorithms

Discriminative and Generative Algorithms: principle behind these topics

Computation graph for any computation, neural network, Universal approximation theorem (why NN works), Multi-layer NN, loss function and optimization algorithms, Hyper-parameter tuning (11 hours)

Books:

Bengio, Yoshua, Ian Goodfellow, and Aaron Courville. Deep Learning. Vol 1. Cambridge, MA, USA: MIT press, 2017

Zhang, Aston, Et al. Dive into deep learning. Cambridge University Press, 2023

Ref: WWW, ICML, CVPR, NeuroIPS, AAAI, COLT, COLING

Video Lectures on Deep Learning: Stanford Public Library

Machine Learning

Syllabus

Regression Introduction

Max likelihood for precision, Bias parameter, geometry of Least Squares, Regularization

Bias Variance trade off in ML, Bias Variance in Regression, Bias Variance in Point Estimation, Baysian regression, Shortcomings of MLE, Gaussian Prior Parameters

Likehood of Data, Posterior Distribution, Equivalence to MLE with regularization, data generation

Data Generation, straight line fit, predictive distribution

Variance of Predictive distribution

Linear Models for classification, Linear Discriminant Functions, Its types, convexciy of Decision region, Least squares for Classification

Ordinary Least Squares/Dimensionality reduction/Multi layer perceptron

Recap, perceptron, Fisher LDA, Generative Classifier, Steps and Methods, Logistic Sigmaoid Function, Softmax

Discrimination v/s generative iris, installation of plotly express, histogram and its categories, setosa, vercicolor, virginica, probabilistic generative models, fixed basic functions and its limitations, logistic regression, gradient of error function, simple sequential algorithm

K-Means Algorithm

Support vector machine

Books:

Pattern learning and Machine learning by Bishop

Image and Video Processing

Syllabus

Fundamentals of Image Processing: introduction image sampling, quantization, resolution, image file formats, elements of image processing system, application of digital image processing

Image Enhancement: Spatial domain methods, histogram processing, fundamentals of spatial filtering, smoothing special filters, sharpening spatial filters. Frequency domain methods; basics of filtering in frequency domain, image smothering, image sharpening, image sharpening, selective filtering

Image Restoration: Introduction to image restoration, image degradation, types of image blur, classification if image restoration techniques, image restoration model, linear and nonlinear, image restoration techniques

Image Segmentation: introduction to image segmentation, point, line and edge detection, region based segmentation, classification of segmentation techniques, region approach to image segmentation, clustering techniques, image segmentation based on thresholding, edge based segmentation

Image Compression: introduction, need for image compression, redundancy in images, classification of redundancy in images, image compression scheme, classification of image compression schemes, image compression standards, JPEG standards

Basic steps of video processing: Analog video, digital video, time varying, image formation models, three dimensional motion models, geometric image formation, photometric image formation, sampling of video signals, filtering operations

2-d motion estimation: optical flow, general methodologies, pixel based motion estimation, block matching algorithms, mesh based motion estimation, global motion estimation, region based motion estimation

Visual scene analysis: Basics of background modeling and foreground detection connected labeling, shot boundary detection

Classes Content

Image system diagram explanation, image digitization, sampling, quantization, digital image

Digital image, image sampling, gray scale, image quantization, image file format

Neighborhood, distance measures, chessboard distance, connectivity and adjacency,

Types of adjacency

Brightness and Contrast, Spatial Domain processing, contrast stretching

Bit Plane slicing, histogram, histogram equalization, cdf

Histogram equalization formula derivation and examples, histogram matching

Spatial domain enhancement, convolution and correlation, linear, non linear, spatial filtering

Neighborhood processing, linear vs non linear spatial filtering

Filters, sharpening, examples of sharpening filters, sharpening filter derivates, sharpening filter gradient computation, example of Laplacian images

Books

Digital Image Processing by Rafeal C Gonalez & Richard E Woods, 3rd Edition

Fundamental of digital Image processing by Anil K Jain

Digital Image processing by William K Pratt

Digital video processing by A.M Tekalp