BACHELOR'S DEGREE PROGRAMME

B.Tech.

Computer Science and Engineering with specialization in Artificial Intelligence and Machine Learning

Academic Curricula

2024-2028

SCHOOLOFCOMPUTERENGINEERING

KALINGAINSTITUTEOF INDUSTRIAL TECHNOLOGY
BHUBANESWAR – 751024

ODISHA,INDIA

Programme Specific Outcome (PSO)

- Design and develop intelligent automated systems applying mathematical, analytical, programming and operational skills to solve real world problems.

- Apply machine learning techniques, software tools to conduct experiments, interpret data and to solve complex problems.

- Implement engineering solutions for the benefit of society by the use of Artificial Intelligence and Machine Learning.

Guideline and Notes to obtain the Specialization

A student has to follow the B.Tech Computer Science curricula. To get the specialization the student has to take the following as the professional electives in the respective semester from the basket.

PE: Professional Elective				
PE	**CourseCode**	**Course Title**	**Pre-requisites**	**Credits**
PE I	CS30015	Image Processing and Applications		3
PE II	CS30033	Speech and Video Processing	-	3
PE III		Any one Subject from PE III Basket of CSE Syllabus.		3
PE IV	CS40001	Deep Learning Techniques		3
PE V	CS40018	Machine Learning Operations / Generative AI and Large Language Models		3

Course Title	**ImageProcessing andApplications**
CourseCode (Credit)	**CS30015 (L-T-P-Cr: 3-0-0-3)**
Pre-requisites	**MA21002**

Course Objectives

- Tolearnthefundamentalsofimageprocessingandvarious transformationappliedinanimage
- Tolearnimageenhancementtechniques
- Tounderstandimagerestoration
- Toimpartknowledgeondifferentcompressiontechniques
- Todiscussonimagesegmentationandfeaturerepresentations

Course Contents:

UNIT I

Introduction:

Introduction to Digital Image Processing, Characteristics of Digital Image, Basic relationship between pixels,Imagesamplingandquantization,Colormodels,BasicGeometricTransformations,FourierTransform,Cosine, SineandHartleyTransform, Hadamard-Haar-SlantTransform,DiscreteFourierTransform.

UNIT II

ImageEnhancementTechniques:

Spatial Domain Methods, Basic Grey Level Transformation, Histogram Processing, Image subtraction, Im Agile Software Development ageaveraging, Spatial filtering, Smoothing, Sharpening filters, Laplacian filters, Frequency domain filters, Smoothing,Sharpeningfilters,Homomorphicfiltering.

UNIT III

Image Restoration:

Model of Image Degradation/restoration process, Noise models, Spatial and Frequency Filters, Inverse filtering&Wiener Filtering, Leastmean squarefiltering,Constrained leastmeansquarefiltering.

UNIT IV

Image Compression Fundamentals:

Image Compression Models, Lossless compression: Variable length coding, LZW coding, Bit plane coding, Predictive coding, DPCM, LossyCompression:LossyPredictiveCoding,Transformcoding,Waveletcoding.

UNIT V

Image Segmentation & Analysis:

Image Segmentation techniques, Edgedetection,Thresholding,Region,BoundaryExtraction&Representation, Region, Moment representation, chain codes, Polygonal approximation, Texture, Pattern recognition.Applications,Fingerprint/irisrecognition,Remotesensing,Automatic characterrecognition,Medicalimageprocessing.

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1: Compare various image enhancement techniques

CO2: Construction of the image from the degraded image

CO3: Analyze and use appropriate image compression techniques

CO4: Suggest proper image feature for classification problems

CO5:Apply the theory and algorithms that are widely used in digital image processing

CO6: Build image processing applications for real world problems

Textbooks:

1. RafaelC.Gonzalez,RichardEWoods,"DigitalImageProcessing",FourthEditio n,PearsonEducation,2018.

ReferenceBooks:

1. A.K.Jain,"FundamentalsofDigitalImageProcessing",PHI,NewDelhi,1995.
2. SEUmbaugh,"DigitalImageProcessingandAnalysis:ApplicationwithMATLA BandCVIPTools",ThirdEdition,Taylor &Francis,CRCPress, 2018.
3. FrankY.Shih,"ImageProcessingand PatternRecognition", Wiley–IEEEPress,2010.

Course Title	**Speech and Video Processing**
Course Code(Credit)	**CS30033 (L-T-P-Cr: 3-0-0-3)**
Pre-requisites	**Engineering Mathematics, DSP**

Course Objectives:

- To introduce speech properties, issues, and speech-processing concepts for prediction
- To learn feature extraction, selection, and speech recognition algorithms
- To understand the video principles and its processing techniques
- To learn motion estimation, optimization techniques, object tracking, boundary detection, compression techniques
- To implement the algorithms using Python and auxiliary tools.

Course Contents:

UNIT I

Speech Processing Concepts:

The speech production mechanism, Discrete-time speech signals, Pole-Zero modeling of speech, relevant properties of the fast Fourier transform for speech recognition, convolution, linear and nonlinear filter banks, and spectral estimation of speech using DFT. Linear Prediction analysis of speech.

UNIT II

Speech Recognition:

Real and Complex Cepstrum, application of cepstral analysis to speech signal, feature extraction for speech, static and dynamic feature for speech recognition, robustness issues, discrimination in the feature space, feature selection, MFCC, LPCC, Distance measures, vector quantization models. Gaussian Mixture model, HMM.

UNIT III

Basics of Video Processing:

Video formation, perception and representation: Principle of color video, video cameras, video display, pinhole model, CAHV model, Camera motion, Shape model, motion model, Scene model, two-dimensional motion models. Three-Dimensional Rigid Motion, Approximation of projective mapping.

UNITIV

Motion Estimation Techniques:

Optical flow, motion representation, motion estimation criteria, optimization

methods, pixel-based motion estimation, Block matching algorithm, gradient-based, Intensity matching, feature matching, frequency domain motion estimation, Depth from motion. Motion analysis applications: Video Summarization, video surveillance.

UNITV

Object Tracking and Segmentation:

2D and 3D video tracking, blob tracking, kernel-based counter tracking, feature matching, filtering Mosaicing, video segmentation, mean shift based, active shape model, video shot boundary detection. Inter-frame compression, Motion compensation.

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1: Assess the mechanisms of human speech production systems and methods for speech feature extraction

CO2: Understand the algorithms of speech analysis and speech recognition

CO3: Incorporate the fundamental techniques in digital video processing, including image characteristics and sensors

CO4: Implement motion estimation and object tracking algorithms on video sequence

CO5: Develop approximated real-life speech and video using Python

CO6: Apply suitable Learning Models in different Problems to obtain desirable results

Text books:

1. Fundamentals of Speech recognition – L. Rabiner and B. Juang, Prentice Hall signal processing series.
2. Digital Video processing, A Murat Tekalp, Prentice Hall.
3. Discrete-time speech signal processing: principles and practice, Thomas F. Quatieri, Coth.
4. Video Processing and Communications, Yao Wang, J. Osternann and Qin Zhang, Pearson Education.

Reference Books:

1. Speech and Audio Signal Processing, B.Gold and N. Morgan, Wiley.
2. Digital image sequence processing, Compression, and analysis, Todd R. Reed, CRC Press.
3. Handbook of Image and Video Processing, Al Bovik, Academic press, Second Edition.

Course Title	**Deep Learning Techniques**
Course Code(Credit)	**CS40001 (L-T-P-Cr: 3-0-0-3)**
Pre-requisites	**CS31002**

Course Objectives:

- To introduce building blocks of deep neural network architecture
- To learn deep learning algorithms and their problem settings
- To understand representation and transfer of knowledge using deep learning.
- To learn to use deep learning tools and frameworks for solving real-life problems.
- To use Python for Deep Learning.

Course Contents:

UNIT I

Deep Networks:

Deep Feed forward Networks, Learning XOR, Gradient-Based learning, Hidden Units, Back-propagation, and other Differential Algorithms, Regularization for Deep Learning, and Optimization for Training Deep Models.

UNIT II

Convolutional Networks:

Convolution operation, Motivation, Pooling, Convolution and Pooling as strong prior, Efficient convolution algorithms, Unsupervised features, Sequence Modeling: Recurrent and Recursive Nets, LSTM Networks, Applications, Computer Vision, Speech Recognition, Natural Language Processing.

UNIT III

Linear factor Models:

Probabilistic PCA and Factor Analysis, Independent Component Analysis (ICA), Auto encoders, Regularized Auto encoders, Representational Power, Layer size and Depth, Stochastic Auto encoders, and Applications.

UNIT IV

Representation Learning:

Greedy Layer-wise Unsupervised Pre-Training, Transfer Learning and Domain Adaptation, Deep Generative Models.

UNIT V

Deep Learning with Python:

Introduction to Kerasand Tensor flow,Deep Learning for computer vision, convnets, Deep Learning for Text and Sequences, Generative Deep Learning, Text Generation with LSTM, Deep Dream, Neural Style Transfer, Generating images with variational auto encoders, Generative Adversarial Networks(GAN).

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1: Assess the concept of deep learning.

CO2: Identify the deep learning algorithms that are more appropriate for various types of learning tasks in various domains.

CO3: In corporate transfer of knowledge in machine learning algorithms.

CO4: Implement deep learning algorithms and solve real- world problems.

CO5: Develop Deep Learning techniques using Python.

CO6: Represent Learning Models.

Textbooks:

1. Ian Good fellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, The MIT Press, 2016.

Reference Books:

2. Francois Chollet, “DeepLearningwithPython”, ManningPublications,2017.
3. AurélienGéron, “Hands-On Machine Learning with Scikit Learn and Tensor Flow: Concepts, Tools, and Techniques to Build Intelligent Systems”, FirstEdition,O'ReillyMedia,2017.
4. Josh Patterson, “Deep Learning: A Practitioner's Approach”, First Edition, O'Reilly Media.

Course Title	Generative AI and Large Language Models
CourseCode(Credit)	CS40016 (L-T-P-Cr: 3-0-0-3)
Pre-requisites	Python, Deep Learning

Course Objectives:

- To introduce a generative foundation model
- To learn custom applications using large language models (LLMs)
- To employ advanced techniques to generate models
- To enhance software development through artificial intelligence and deep learning advancements
- To use Python and its tools for model building

Course Contents:

UNIT I

Generative AI Fundamentals: "Drawing" Data from Models, Applications of AI, Probability Rules and Bayes' Theorem, Requirements of Generative Models, Style Transfer and Image Transformation, Challenges of Generative Models. Building Blocks of Deep Neural Networks: Perceptrons, Multi-layer Perceptrons and Back propagation, Convolution and Recursive Networks for Seeing, Convolutional Architectures, CNNs, AlexNet and its Architecture, CNN Innovations, RNNs and LSTMs, Optimization Algorithms – Gradient Descent, ADAM, AdaGrad, Nesterov Momentum, Xavier Initialization.

UNIT II

Teaching Networks to Generate Digits: Retrieving and Loading Database, Modeling data with uncertainty, Boltzmann Machines, Hopefield Networks, Deep Belief Networks, Creating RBM, Creating DBN.

Painting Pictures with Neural Networks Using VAEs: Variational Auto encoders (VAEs), Encodings of Images, Reparameterization Tricks, Inverse Autoregression, Importing Some Benchmark Dataset (CIFAR), Creating Networks using TensorFlow2.

UNIT III

Image Generation with GANs: Generative Adversarial Networks (GANs)- Taxonomy, the discriminator model, the generator model, Training GANs. Vanilla GAN, Deep Convolutional GAN, Conditional GAN, Wasserstein GAN,

Progressive GAN, Challenges.
Style Transfer with GANs:Paired style transfer using pix2pix GAN – The U-Net generator, The Patch-GAN discriminator, Loss, Training pix2pix GAN, Use cases. Unpaired style transfer using Cycle GAN–Adversial loss, Cycle loss, Identity loss, Overall loss. DiscoGAN, DualGAN.
Deep fakes with GANs: Overview, Facial Action Coding System (FACS), 3D Morphable Model, Facial Landmarks detection, Workflow, Replacement using auto-encoders, Re-enactment using pix2pix, Ethical and Technical Challenges.

UNIT IV

Methods for Text Generation: Representing Text – Bag of Words, Distributed representation, Word2vec, GlovVe, FastText. LSTMs and Language Modeling (Character-level), Decoding Strategies – Greedy decoding, Beam Search, Sampling. Stacked LSTMs, Bidirectional LSTMs. Transformers, GPT.

UNIT V

Composing Music with Generative Models: Music generation using LSTMs, GANS; Polyphonic music generation – Jamming model, Composer model, Hybrid model, Temporal model. Composing Video with Generative AI and Applications: Reinforcement learning, Inverse reinforcement learning, Adversarial learning.
Recent research in generative AI, spanning biotechnology, fluid mechanics, video, and text synthesis.

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1: Understand the fundamentals of Deep Neural Networks
CO2: Learn the models to generate digits and photographs using GANs
CO3: Use GANs to generate Images and videos with different types
CO4: Implementing generation models, and integrate different features to it.
CO5: Generate texts, and paragraphs for certain specific situations
CO6: Represent GANS using Python and Deep Learning tools

Textbooks:

1. Joseph Babcock and Raghav Bali, Generative AI with Python and TensorFlow2: Create images, text, and music with VAEs, GANs, LSTMs, Transformer models, Packt Publishing Limited (2021),

Available online:

https://www.scribd.com/document/721021741/Generative-AI-with-Python-and-TensorFlow-2-Create-images-text-and-music-with-VAEs-GANs-LSTMs-Transformer-models-Joseph-Babcock-Raghav-Bali-Z

Reference Books:

1. AltafRehmani, Generative AI for everyone: Understanding the essentials and applications of this breakthrough technology, Bluerose Publishers Pvt. Ltd., 2024.
2. AurélienGéron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Third Edition, O'Reilly Publisher, 2022.

Reference Online Source:

https://onlinecourses.swayam2.ac.in/imb24_mg116/course#registration_confirmation

Course Title	**Machine Learning Operations**
Course Code(Credit)	**CS40018(L-T-P-Cr: 3-0-0-3)**
Pre-requisites	

Course Objectives:

- Tointroduce Machine Learning Models, Architectures and Patterns
- Tolearn MLOPs Infrastructures and different tools for implementation
- Toget a deep understanding of MLOPs packaging process and deployment in different environments
- To integrate ML models through CI/CD/CT pipelines and their developments
- Todeploy the ML models in different scenarios for monitoring, testing, evaluation, and improvement.

Course Contents:

UNITI

Introduction to MLOPs:

Principles of MLOPs, Best Practices, MLOPs Strategy, Enterprising MLOPs, Challenges; Architecture and Components – Components (Data source, data versioning, data analysis, code repository, Pipeline orchestration,

Model training and storage, Model deployment and serving, Monitoring, Feature processing); Architecture (Minimum, Production, Enterprise); Deployment patterns; Combining Developments, Staging and Production environment.
Git and GitHub Fundamentals.

UNIT II

MLOPs Infrastructure and Tools.
Storage, Computer, Containers, Orchestration, Machine Learning Platforms; MLOPs-based Machine Learning Systems (Initial, Transition, Operations), Machine Learning Development (Cookiecutter, Repository structure).
ML Life Cycle, Management of ML Life Cycle.

UNIT III

Packaging ML Models:
MLOPs Code Repository, Data Sourcing, Data Analysis, Model Development, Machine Learning Systems, Data Preparation, Model Development, Model Evaluation, Model Versioning, Developing the Package;

Deploying ML Models on different platforms – Heroku, Microsoft Azure, Google Cloud Platform, Amazon Web Services (Basic Concepts).

UNIT IV

MLflow – Platform to Manage the ML Life Cycle:
MLflow tracking, Projects, Models, Model Registry; Continuous Integration, Continuous Deployment, and Continuous Testing (CI/CD/CT) Pipelines using Jenkins, GitHub Actions, Continuous Training, Retraining, and Delivery;
Continual Learning - Requirements, Principles, Stateless and Stateful Training, Challenges; ML Life Cycle, Dockers for ML, Building ML Web Apps using API, Building ML Native Apps

UNIT V

Deployment of ML Models:
CI/CD for ML, Deploying ML Models on different platforms – Heroku, Microsoft Azure, Google Cloud Platform, Amazon Web Services (Implementation); Monitoring and debugging the deployed models. Deployment Strategies (Single, Silent, Canary, Multi-armed bandits), Model Inference and Serving

Post Productionizing ML Models:

Continuous Monitoring – Principles of Model Drift, Model Transparency, Significance of Monitoring; MLOPs Workflow – Logging, Model Evaluation, testing, and evaluation; Frameworks for Model Monitoring, Integrating with Tools. Model Security.

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1: Understand MLOPs process and environments

CO2: Learn the usage of ML tools during the life cycle of ML Models

CO3: Develop ML models and learn their packaging for deployment

CO4: Acquainted with different platforms for ML Model deployment and their life cycle.

CO5: Generate prototypes of ML models through continuous retraining, testing, evaluating, and improvements

CO6: Analyze and ensure the ML Model security for production

Textbooks:

1. Suhas Pote, Machine Learning in Production: Master the art of delivering robust Machine Learning solutions with MLOPs– BPB Publication, First Edition, 2023.
2. Chip Huyen, Designing Machine Learning Systems: An Iterative Process for Production-Ready Applications (Grayscale Indian Edition), O'Reilly.

ReferenceBooks:

1. Andrew McMahon, Machine Learning Engineering with Python - Second Edition: Manage the lifecycle of machine learning models using MLOps with practical examples, Packt Publication.
2. Mark Treveil , Nicolas Omont, Introducing MLOps: How to Scale Machine Learning in the Enterprise (Grayscale Indian Edition), O'Reilly.
3. Yaron Haviv and Noah Gift, Implementing MLOps in the Enterprise: A Production-First Approach (Grayscale Indian Edition), SPD Publication.
4. Raman Jhajj, Mastering MLOPs Architecture : From Code to Deployment – BPB Publication, First Edition, 2024