UNIVERSITY OF KERALA

कर्मणि व्यज्यते प्रज्ञा

DEPARTMENT OF COMPUTER SCIENCE

UNIVERSITY OF KERALA

AICTE APPROVED

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योगः कर्मसु कौशलम्

M.TECH

COMPUTER SCIENCE

with specialization in

DIGITAL IMAGE COMPUTING

Learning Outcomes-based Curriculum Framework (LOCF) for Post-Graduate Programme

RELEVANT & UPDATED CURRICULUM
Industry-oriented and future-ready

AI CENTRIC AND FUTURISTIC CURRICULUM
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ACADEMIC YEAR

2026

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Preamble

Higher education plays a vital role not only in fostering responsible and ethical individuals but also in guiding learners toward their academic and professional aspirations, including employment opportunities and advanced studies at globally recognized institutions. Accordingly, enhancing the quality of higher education remains a primary institutional priority to equip students with the knowledge, competencies, practical skills, and training required to meet contemporary societal and industry demands.

To achieve these objectives, our institution shall undertake continuous and systematic initiatives to strengthen academic resources, enrich the learning environment, and enhance the quality of teaching and learning processes, thereby ensuring the attainment of desired learning outcomes. One of the significant reforms in postgraduate education is introducing the Learning Outcomes-based Curriculum Framework (LOCF), which makes it student-centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve. The University Grants Commission (UGC) implemented the National Education Policy(NEP) in the Colleges and Universities. Accordingly, University of Kerala decided to implement the LOCF at par with NEP in the curriculum and scheme in the Department of Computer Science. Our M.Tech Programme is designed in alignment with the principles of the National Education Policy, emphasizing multidisciplinary learning, research and innovation, industry-oriented skill development, outcome-based education, and the integration of emerging technologies to prepare graduates for global academic and professional excellence.

Graduate Attributes

The Graduate Attributes (GAs) represent the essential qualities, competencies, and capabilities expected to be attained by graduates of the University of Kerala. These attributes encompass disciplinary knowledge, application of knowledge, professional and life skills, ethical values, attitudes, and human values necessary for holistic personal and professional development. The Graduate Attributes aim to strengthen graduates' professional competence, enhance industry readiness, promote lifelong learning, and encourage engagement in higher studies and research with global relevance. They further enable graduates to perform effectively, innovatively, and responsibly in their chosen professions while contributing constructively as socially responsible global citizens. The Graduate Attributes therefore define the broad characteristics and transferable competencies that extend beyond the scope of a specific discipline or programme of study.

The Graduate Attributes of the University of Kerala

- Continue life-long learning as an autonomous learner.
- Continuously strive for excellence in education.
- Apply and nurture critical and creative thinking.
- Promote sustainable development practices.
- Promote co-operation over competition.
- Balance rights with responsibilities.
- Understand and respect diversity and differences. Do not be prejudiced by gender, age, caste, religion, or nationality.
- Use education as a tool for the emancipation and empowerment of humanity.

1. About the Department of Computer Science

Department of Computer Science, University of Kerala, was established in 1985 under the School of Technology and conducted one Undergraduate and four Post Graduate programmes alongside with PhD programme. The department offers Four Year Undergraduate Programme (FYUGP) and offers three M.Sc programme in Computer Science. The department also offers an M.Tech programme under the Faculty of Engineering and Technology with specialization in Digital Image Computing. All the programmes are in Outcome Based Education (OBE) mode and integrated with industry internships. The department promotes advanced research through Ph.D. programmes in different fields of Computer Science and Engineering.

The thrust area of research focused on Pattern Recognition, Nature Inspired Computing, Cyber Security, Computer Vision, Machine Intelligence, Deep Learning, Robotics, High-Performance Computing and Natural Language Processing. The department has established a strong research culture, resulting in the successful completion of many Ph.D. programmes in Computer Science and Engineering. The alumni are well-placed in National/ International Institutes, Central/State Universities, R&D organisations and multi-national companies. Faculty and students received National and International recognition, including awards from various organisations.

2. About M.Tech Computer Science (Digital Image Computing)

The M.Tech. Programme in Computer Science and Engineering with specialization in Digital Image Computing is an advanced postgraduate programme designed to provide students with comprehensive knowledge of the principles, methodologies, and techniques involved in the processing, analysis, and interpretation of digital images. The programme emphasizes the extraction of meaningful information from visual data for applications in diverse domains such as healthcare, surveillance, robotics, entertainment, remote sensing, and intelligent systems.

The curriculum focuses on advanced areas in image processing. Students acquire the ability to design and implement efficient algorithms to address complex real-world challenges in the domain of image computing.

The programme also aims to develop analytical, research, and problem-solving skills through laboratory practice, project work, and research-oriented learning. Graduates of the programme are well equipped to pursue professional careers in industries, R&D organizations, and academic institutions, contributing to advancements in research areas. The M.Tech programme is approved by the All India Council for Technical Education.

Digital Image Computing offers significant opportunities for students interested in the field of digital image analysis and intelligent visual systems. With the growing use of visual data across various sectors, the programme provides students with the knowledge and technical skills required to address challenges in image processing and computer vision applications. The curriculum covers areas such as image and video analytics, pattern recognition, machine learning and deep architectures, computer vision, and natural language processing, enabling students to develop systems for the analysis and interpretation of visual and text information. The programme thereby prepares students for professional growth and research opportunities in the rapidly evolving field of digital image computing.

The M.Tech. Computer Science (Digital Image Computing) programme is committed to:

- Developing a strong foundation by providing students with a comprehensive understanding of the fundamental concepts and principles of image and video processing, computer vision techniques, and mathematical models used in image computing.
- Enabling students to acquire practical skills in image processing through hands-on experience in the implementation and optimization of image computing techniques using appropriate programming languages and software tools.
- Fostering research and innovation in the field of image processing by exposing students to current trends and emerging technologies, thereby encouraging the exploration of new approaches and the development of novel solutions to complex image processing challenges.
- Enhancing the critical thinking and problem-solving abilities of students through practical assignments, projects, and research activities, enabling them to analyse complex problems, identify suitable algorithms, techniques, and apply them effectively to real-world applications.
- Ensuring that students remain updated with recent advancements in the field of image processing and are well prepared to meet industry and academic requirements in a rapidly evolving technological environment.

3. General Information

3.1 Eligibility for Admission

A Bachelor's Degree in Engineering/Technology (B.Tech/B.E) with at least 55% marks in one of the following branches: Computer Science and Engineering/Information Technology/Electronics Engineering/Electrical Engineering/Electrical & Computer Engineering/Electronics and Computer Engineering/Computer Science and Engineering and Business Systems/Cyber Physical Systems/Computer Science & Design/Robotics and Artificial Intelligence/Internet of Things from the University of Kerala or equivalent recognized degree of a recognized University

OR

First Class Master's Degree, M.Sc. in Computer Science/Artificial Intelligence/Data Science/Machine Learning/Master's in Computer Application (MCA) from the University of Kerala/M.Voc. Software Development with at least 55% marks or an equivalent grade in a point scale wherever grading system is followed from the University of Kerala or equivalent recognized degree of a recognized University. Minimum marks in the qualifying examination for the SC / ST candidates are 50% or an equivalent grade in a point scale wherever grading system is followed.

Admissions for Non-Sponsored category of students will be made on the basis of valid GATE score/ Entrance Examination conducted by the University. Sponsored seats shall also be regulated in accordance with AICTE guidelines. (i) Bachelor's Degree in Engineering / Technology (in branches mentioned above) with at least 55% marks from AICTE approved institutions. Preference will be given to candidates who have qualified GATE. (ii) A minimum two-years of full-time work experience in a MNC company / industry / educational and research institution/ any Government Department or Government Autonomous Organization in the relevant field. (iii) Less than 45 years of age as on first day of the year of admission.

Preference will be given to candidates who have qualified GATE.

The CSS academic council shall be competent to recommend revisions to decide the equivalence of any other system that may come up in admissions. The percentile of marks shall be converted to a percentage and normalized according to the CGPA of the University of Kerala for admission procedures.

3.2 Programme Duration

M.Tech Computer Science (Digital Image Computing) programme shall be a period of two academic years comprising four semesters; each academic year shall be organised into two semesters with a group of courses as given in the curriculum and scheme. The postgraduate programmes shall be under a Credit and Semester System (CSS). The programme shall be offered with different courses, each with an assigned credit.

3.3 Expected Outcome

Programme Objectives

1. Proficiency in programming languages is instilled in students for developing image processing applications for intelligent systems.
2. Develop efficient and robust algorithms to design algorithms for image enhancement, segmentation, pattern recognition and computer vision.
3. Develop skillset in designing and implementing computer vision algorithms, including object detection, tracking, recognition, and scene understanding.
4. Design, Develop and Deploy machine learning and deep learning -based applications using images and speech.
5. Develop engineering skills in designing experiments and evaluating the performance of image processing algorithms.
6. As engineers in image processing, students enhance their problem-solving and analytical thinking skills.
7. Analyze complex image processing challenges, identify the underlying issues, and devise innovative solutions by leveraging their technical knowledge and engineering mindset.

Learning Outcome

1. Develop the engineering skillset for R&D and industry-ready professionals to join the Software industry and work in premiere world class academic institutions.
2. Inspire and Encourage students to do research in Computer Science, image processing, computer vision and allied fields.
3. Demonstrate advanced skills in designing, developing and implementing AI based image processing algorithms.
4. Develop cutting-edge developments in computing technology and contemporary research for society.
5. Design and implement application skillset in AI based image processing algorithms.
6. Develop advanced knowledge in computer vision, machine learning, deep learning and advanced image processing techniques.

3.4 Evaluation

Candidates in each semester shall be evaluated by Continuous Assessment (CA) and End Semester Examinations (ESE). The maximum marks allotted for continuous assessment and University examination for each subject are as prescribed by the scheme of study.

Continuous Assessment: An internal evaluation will be carried out during each semester's progress. The main purpose is to provide students with learning effectiveness and individual profoundness in their curriculum. The evaluation and award of CA marks differ for each course. Guidelines on conducting the continuous assessment of each course and comprehensive evaluation shall be approved by the

Department Council and communicated effectively to the students.

End Semester Examinations: There will be University examinations at the end of the first academic year and the end of every semester onwards in courses as prescribed under the respective scheme of examinations. Courses are assessed through various evaluation process. All written end semester examinations are conducted for a maximum of 3 hours duration.

Letter Grades: Students' performance in individual courses shall be evaluated and assigned grades to indicate the achievement of objectives. The grading scale shall be the same as the national pattern recommended by the UGC/AICTE.

Each grade shall be indicated by a letter as in the table below:

Letter Grade	Grade Point (GP)	Percentage of Total Marks
O (Outstanding)	10	90 and above
A+ (Excellent)	9	85 and above but less than 90
A (Very Good)	8.5	80 and above but less than 85
B+ (Good)	8	70 and above but less than 80
B (Above Average)	7	60 and above but less than 70
C (Average)	6	55 and above but less than 60
D (Pass)	5	50 and above but less than 55
F (Fail)	0	Less than 50 %
Ab(Absent)	0	Failed due to eligibility criteria
CI (Course Incomplete)	0	Course Incomplete

Each grade shall have a corresponding grade point which serves as a means of aggregating letter grades and is not marks or scores.

3.5 Induction Programme

There will be an induction program for first-semester students. It is a unique Foundation Programme designed specifically for the fresher, which includes a wide range of activities right, from workshops, lectures and seminars to sports tournaments, social works and much more. The programme is designed to mould students into well-rounded individuals, aware and sensitized to local and global conditions and foster their creativity, teach values and ethics, and help students to discover their passion.

The programme is structured around the following five themes in:

- *Values and Ethics:* Focus on fostering a strong sense of ethical judgment and moral fortitude.
- *Creativity:* Provide channels to exhibit and develop individual creativity by expressing themselves through art, craft, music, singing, media, dramatics, and

other creative activities.

- *Leadership, Communication and Teamwork*: Develop a teamwork and group communication culture.
- *Social Awareness:* Nurture a deeper understanding of the local and global world and our place in it as concerned citizens of the world.
- *Coding skills:* Students can develop programming skills to improve technical knowledge and standards.

4. Programme Structure

Every course of M.Tech Computer Science (Digital Image Computing) Programmes shall be placed in the following categories.

Sl. No	Category	Code	Credits
1	Core Course (Theory)	CC	26
2	Core Course (Laboratory)	CC	6
3	Core Course (Dissertation)	CC	20
4	Discipline Specific Electives	DE	12
5	Generic Course (offer to Students in other Department)	GC	2
6	Extra Departmental Electives	GC	4
Total Mandatory Credits			76
7	Skill Enhancement Electives	SE	10

Semester-wise credit distribution shall be as below:

Semester	1	2	3	4	Total
Credits	22	20	20	16	78

Programme Code: CIC

Core Course (CC): Course offered by the Department to the students in their Postgraduate programme, related to the area of specialisation. The maximum marks allotted for continuous assessment and University examination for each subject are as prescribed by the scheme of study.

Laboratory Course (CC): The laboratory aims to develop and apply effective theory based on realistic practice; it is the primary way to train students properly in the rapidly advancing courses offered by the department. Each semester offers a laboratory course with at least 6 hours per week. Laboratory report submission is mandatory for each student and is to be submitted to the faculty in charge of the laboratory. The examination will be conducted either by the panel of internal examiners or panel consists of an external examiner. The problem will be given at the time of examination and the marks will be awarded by the examiner/panel.

Skill Enhancement Course (SE): A course that provides value-based or skill-based knowledge should contain theory and laboratory/ hands-on/ training/ fieldwork. The main purpose of these courses is to provide students with life skills in the hands-on mode to increase their skill development and employability. The assessment of the course will be per the regulations of the University for the Teaching Departments.

Generic Course (GC): An elective course chosen from a multidisciplinary perspective to attain domain exposure beyond disciplines. The Generic Course may also be interdisciplinary (to be offered collaboratively by more than one Department/discipline). The maximum marks allotted for continuous assessment and University examination for each subject are as prescribed by the scheme of study.

Discipline-Specific Electives (DE): Courses offered under the main discipline/subject of study, primarily offered to the students of the same discipline each semester. The departments can modify such electives or add new electives from time to time based on the changing academic paradigms related to the course. The maximum marks allotted for continuous assessment and University examinations for each subject are as prescribed by the scheme of study.

MOOC: Massive Open Online Courses (MOOCs) bring knowledge to students in selected disciplines through online platforms. Each student must compulsorily take a MOOC to complete Semester III successfully. Students may enroll in MOOC courses at any time from the first to the third semester. The Department council will announce the source of MOOCs from time to time.

Dissertation: Dissertation is intended to challenge students' intellectual and innovative abilities and allows students to synthesize and apply the knowledge and analytical skills. All students must select a problem statement with a level of industry or research potential, as part of this course. The dissertation shall focus on topics relevant to Image Computing and its interdisciplinary applications. It should enable students to apply theoretical knowledge and practical skills to investigate, analyze, and solve complex problems in the field. The dissertation work can be carried out in any of the following - R&D institutions, MNCs - IT companies and departments. Upon completion of the course, students shall submit a dissertation report documenting the objectives, methodology, analysis, findings, and conclusions of the work carried out. The dissertation may also include relevant observations, outcomes, and recommendations arising from the study. The evaluation of the dissertation shall be conducted through both internal and external assessment processes.

Industry Internship: During the fourth semester (it can be done during the vacation or semester break period), the students must complete the internship programme from the industry or R&D organisations. The students can identify industries and undergo industry training or workshop. A minimum of one month of internship is compulsory to complete Semester IV successfully. Each student should submit an internship certificate along with a detailed study report.

4.1. Programme Outcome (PO)

PO1	A Critical Thinker with a Research mind
PO2	A Communicator and Resilient Leader
PO3	A Receptive, Adaptive Person with an Inclusive mind
PO4	A Life-long Learner
PO5	A Creative and Global Professional
PO6	An Ethical and Socially Responsible Person

4.2 Programme-Specific Outcome (PSO)

PSO1	Develop the ability to apply linear algebra, vector spaces, probability, and matrix factorization techniques for representing and solving image processing problems.
PSO2	Analyse and transform image data using mathematical and computational techniques such as orthogonality, decomposition, and dimensionality reduction.
PSO3	Design, implement, and evaluate machine learning models for classification, regression, and pattern recognition tasks in image data.
PSO4	Process and analyse unstructured data (images, videos, multimodal data) using appropriate data modelling and analytics techniques.
PSO5	Develop algorithms for image enhancement, filtering, segmentation, restoration, and feature extraction based on theoretical foundations.
PSO6	Build computer vision pipelines for object detection, recognition, tracking, and scene interpretation using classical and modern techniques.
PSO7	Design and deploy deep learning models (CNNs, transformers) for high-level visual understanding tasks such as image classification and video analysis.
PSO8	Evaluate model performance using appropriate metrics and optimize algorithms for accuracy, efficiency, and scalability.
PSO9	Formulate research problems, conduct experiments, analyse results, and communicate findings effectively through scientific writing and publications.
PSO10	Apply core concepts to real-world problems in domains such as medical imaging, surveillance, multimedia systems, and industrial vision.
PSO11	Integrate machine learning, deep learning, and vision techniques to develop intelligent image-based systems.
PSO12	Demonstrate the ability to independently design, implement, and validate solutions through dissertation work and practical projects.

4.3 Mapping of PO to PSO

	PO1	PO2	PO3	PO4	PO5	PO6
PSO1	✓			✓		
PSO2	✓			✓		
PSO3	✓			✓	✓	
PSO4	✓		✓	✓		✓
PSO5	✓			✓		
PSO6	✓			✓	✓	
PSO7	✓			✓	✓	
PSO8	✓			✓		
PSO9	✓	✓		✓		
PSO10		✓	✓	✓	✓	✓
PSO11		✓	✓	✓	✓	✓
PSO12	✓	✓		✓		

4.4 Scheme

Semester	Course Code	Name of the Course	Credits
I	**Core Courses (CC)**		
	CIC-CC-611	Mathematics for Image Processing	4
	CIC-CC-612	Machine Learning Models: Theory and Practices	4
	CIC-CC-613	Unstructured Data Analytics	4
	CIC-CC-614	Principles and Techniques of Image Computing	4
	CIC-CC-615	Image Computing Laboratory	2
	Skill Enhancement Elective (SE)		
	CIC-SE-616	Design Thinking	2
	XXX-GC-X1X	Extra Departmental Elective - I	2
	Generic Course (GC)		
	CIC-GC-617	Computational Imaging	2
		Credit Total: CC -18, DE-2, GC- 2	22
II	**Core Courses (CC)**		
	CIC-CC-621	Computer Vision	4
	CIC-CC-622	Deep Learning and Transformers	4
	CIC-CC-623	Deep Learning Laboratory	2
	CIC-CC-624	Computer Vision Laboratory	2
	Discipline Specific Electives (DE)		
	CIC-DE-625(i)	Robotics and Intelligent System Design	4
	CIC-DE-625(ii)	Medical Image Analysis and Processing	4
	CIC-DE-625(iii)	Image and Video Analytics	4
	CIC-DE-625(iv)	Cyber Security and Cyber Law	4
	CIC-DE-625(v)	Natural Language Understanding	4
	CIC-DE-625(vi)	Quantum Computing and Quantum Machine Learning	4
	Skill Enhancement Elective (SE)		
	CIC-SE-626	Scientific Writing	2
	XXX-GC-62X	Extra Departmental Elective – II	2
		Credit Total: CC -12, DE-6, GC- 2	20
III	**Core Courses (CC)**		
	CIC-CC-631	Research Methodology and Publication Ethics	4
	CIC-CC-632	Dissertation Phase I	8
	Discipline Specific Electives (DE)		
	CIC-DE-633(i)	Swarm Intelligence	4
	CIC-DE-633(ii)	Applications of Image Processing	4
	CIC-DE-633(iii)	Video Processing	4
	CIC-DE-633(iv)	Visual Cognitive Science	4
	CIC-DE-633(v)	Image and Data Compression	4
	CIC-DE-633(vi)	Large Language Models: Theory and Practice	4

	Skill Enhancement Elective (SE)		
	CIC-SE-635	Cyber Ethics	2
	CIC-SE-636	MOOC	2
		Credit Total: CC -12, DE-8	20
IV	**Core Courses (CC)**		
	CIC-CC-641	Dissertation	10
	CIC-CC-642	Viva-Voce	2
	Skill Enhancement Elective (SE)		
	CIC-SE-643	Industry Internship	2
	CIC-SE-644	Professional Growth and Achievements	2
		Credit Total: CC -12, DE- 4	16
		Total Credits for the Programme	78
Generic Courses from other Departments			
I	XXX-GC-X1X	Extra Departmental Elective – I	2
II	XXX-GC-X2X	Extra Departmental Elective – II	2

Semester: 1	Course Code: CIC-CC-611	Credits: 4

MATHEMATICS FOR IMAGE PROCESSING

Preamble: This course offers the mathematical foundations essential for image processing, emphasizing concepts from linear algebra, vector spaces, matrix factorization, complex numbers, and probability theory. This knowledge serves as the basis for advanced techniques in image processing, computer vision, and machine learning.

Prerequisite: Probability, vectors and basic linear algebraic operations.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Apply linear algebra concepts such as matrices, determinants, eigenvalues, and eigenvectors to solve problems related to image representation.	PO2	PSO1	U, Ap	F, C
CO2	Analyze vector spaces, subspaces, basis, and inner product spaces used in image analysis.	PO1	PSO1, PSO5	U, An	C
CO3	Utilize orthogonality concepts and matrix factorizations such as LU, QR, and Singular Value Decomposition	PO4	PSO1, PSO2	An, Ap	C, P
CO4	Apply complex numbers and complex vector spaces including Hermitian and unitary matrices.	PO5	PSO1	U, Ap	C
CO5	Use probability distributions and statistical measures to model uncertainty in image data.	PO2	PSO1, PSO2	An, Ap	C, P
CO6	Apply multivariate statistical methods including covariance matrices, and Markov processes for image signal analysis.	PO3	PSO2, PSO4	An, Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Linear Algebra: Systems of linear equations, Row reduction and echelon forms, Determinant of a matrix, Inverse, Linear dependence and independence, Cramer's Rule. Eigen Space: Properties of Eigen values and Eigen vectors, Eigen values, Eigen vectors, Diagonalization, Orthogonal diagonalization.

MODULE II

Vector spaces and subsapces: Subspaces, null space, column space, basis, dimension, fundamental subspaces. Inner product spaces, Norms of vectors, cosine similarity, Algebra of subspaces, Linear Combination of Vectors, change of basis.

MODULE III

Orthogonality and Matrix Factorization- Orthogonal sets and Basis, projections, Orthogonal diagonalization, Gram- Schmidt orthogonalization, Matrix Factorization- LU decomposition, QR Decomposition.

MODULE IV

Complex Numbers: Algebra of complex numbers, polar form, Euler's formula, complex conjugate, modulus and argument. Complex Vector Spaces: Vectors in C^n, complex inner product, norm and orthogonality, conjugate transpose of a matrix. Hermitian and Unitary Matrices and their properties.

MODULE V

Probability Distribution: Discrete and continuous random variables and their probability distributions - Probability distribution (density) functions - Distribution functions - Mean and Variance - Simple problems. - Binomial, Poisson, uniform and exponential distributions - Mean and Variance of the above distributions - Normal distribution - Properties of normal distribution - Computing probabilities using Binomial, Poisson, uniform, exponential and normal distributions.

MODULE VI

Applications: Role of linear algebra in vector representations, dimensionality reduction. Applications of probability in classification and uncertainty modelling. Case studies: data representation, similarity measures, and basic statistical modelling in real-world datasets.

LEARNING RESOURCES

References

- Gilbert Strang, "Linear Algebra and It's Applications", 4th edition, Cengage Learning, 2006.
- Papoulis and S.U. Pillai , "Probability, Random Variable And Stochastic Processes", , 4/e, TMH.
- Veerarajan , "Probability and Random Processes", 2/e, TMH.
- Ganesh A , "Linear Algebra And Its Applications" ,CBS Publications, 2014.
- Ernest Davis, "Linear Algebra And Probability For Computer Science Applications" , CRC Press, 2012.
- Michael A. Nielsen and Isaac L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2010.

Semester: 1	Course Code: CIC-CC-612	Credits: 4

MACHINE LEARNING MODELS: THEORY AND PRACTICES

Preamble: Machine Learning is a key area of Artificial Intelligence that focuses on developing algorithms that enable computers to learn from data and make predictions or decisions. This course introduces the fundamental concepts, techniques, and algorithms used in machine learning. It covers data preprocessing, regression, classification, neural networks, and model evaluation methods. The course also highlights practical applications of machine learning in real-world domains.

Prerequisite: Programming skill, basic knowledge of mathematics (statistics and linear algebra), programming fundamentals, and data structures is recommended for understanding machine learning concepts.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the fundamentals of machine learning, including types, workflow, dataset preparation, and bias–variance trade-off.	PO5	PSO6	U	F, C
CO2	Describe data preprocessing, dimensionality reduction (PCA, LDA), and exploratory analysis.	PO5	PSO6	U,	C, P
CO3	Understand artificial neural networks, including neuron models, architectures, activation functions, and backpropagation.	PO5	PSO6	An, Ap	C, P
CO4	Analyze regression techniques including linear regression, multiple regression and logistic regression for classification.	PO1	PSO6	An, Ap	C, P
CO5	Explain classification techniques including Decision Trees, Random Forest, k-Nearest Neighbors, ensemble methods, and evaluation of classification models.	PO5	PSO9	An, Ap	C, P
CO6	Apply machine learning algorithms to solve real world problems.	PO1	PSO8, PSO12	An, Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction to Machine Learning: Evolution of machine learning, need for machine learning, types of machine learning – supervised learning, unsupervised learning and reinforcement learning, machine learning workflow, dataset preparation, training and testing datasets, overfitting and underfitting, bias–variance trade-off.

MODULE II

Feature Engineering and Dimensionality Reduction: Data collection and data preprocessing, data cleaning and handling missing values, data normalization and standardization, feature selection and feature extraction, dimensionality reduction, Principal Component Analysis, Linear Discriminant Analysis, data visualization and exploratory data analysis.

MODULE III

Artificial Neural Network: Structure of biological neuron, Artificial neural networks, applications of neural network, Models of ANNs; Feedforward & feedback networks, Activation functions, Neuron Models, learning rules, linear classifiers – Perceptron, Implementing logic functions, Linear inseparability, Multilayer perceptron, Back propagation algorithm.

Module IV

Introduction to regression analysis: Concept of dependent and independent variables, Linear Regression, multiple linear regression, model assumptions, gradient descent optimization, regularization techniques, Logistic Regression for classification problems.

MODULE V

Classification and Clustering Techniques: Decision Tree algorithms, tree construction and pruning, ensemble methods, Random Forest, instance-based learning, k-Nearest Neighbors algorithm, Clustering techniques - Hierarchical clustering with agglomerative and divisive methods, k-Means clustering.

MODULE VI

SVM Concepts, Kernels, and Performance Metrics of ML : Introduction to Support Vector Machine, Hyperplane and margin concepts, kernel functions, nonlinear classification, Model evaluation metrics – accuracy, precision, recall and F1-score, confusion matrix, Cross-Validation techniques, hyperparameter tuning, model selection, Introduction to real-world machine learning applications in healthcare, finance and recommendation systems.

LEARNING RESOURCES

References

- C. M. Bishop, *Pattern Recognition and Machine Learning*. New York, NY, USA: Springer, 2006.
- K. P. Murphy, *Machine Learning: A Probabilistic Perspective*. Cambridge, MA, USA: MIT Press, 2012.
- T. Hastie, R. Tibshirani, and J. Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, 2nd ed. New York, NY, USA: Springer, 2009.
- A. Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, 2nd ed. Sebastopol, CA, USA: O'Reilly Media, 2019.
- S. Theodoridis, *Machine Learning: A Probabilistic and Optimization View*. London, U.K.: Academic Press, 2015.
- A. C. Müller and S. Guido, *Introduction to Machine Learning with Python: A Guide for Data Scientists*. Sebastopol, CA, USA: O'Reilly Media, 2016.

Online Resources

- https://developers.google.com/machine-learning/crash-course
- https://machinelearningmastery.com/feature-engineering-for-machine-learning/
- http://neuralnetworksanddeeplearning.com/
- https://cs229.stanford.edu/notes2020spring/

Semester: 1	Course Code: CIC-CC-613	Credits: 4

UNSTRUCTURED DATA ANALYTICS

Preamble: Most of the real-world data are unstructured especially in the form of audio, video and images. Analysis of the unstructured data uncovers the hidden and the latent meaningful information. Unstructured data does not contain a predefined scheme. Unstructured data analytics tools use machine learning to gather and analyze data that has no pre-defined framework – like human language. This course focuses on exploratory and predictive analysis of unstructured data to handle big data for solving real world problems

Prerequisite: Numerical Analysis

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Analyse the significance of Big Data and its analytics in the real world	PO1	PSO9	An	F, C
CO2	Apply unstructured data analytics to solve real world problems	PO5	PSO4	Ap	C
CO3	Explain the techniques used for text analysis and dimensionality reduction	PO1	PSO2	U	C, P
CO4	Implement word space modelsand language computation models	PO1	PSO3	U	C, P
CO5	Illustrate the process of performing indexing and searching of information	PO1	PSO5	U, An	C, P
CO6	Apply the various methods used for document classification and summarization	PO5	PSO3	Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Big Data and Unstructured Data: Big Data concepts; Structured, Semi-Structured, and Unstructured Data; characteristics and challenges of unstructured data analytics; preprocessing techniques; exploratory data analysis; qualitative and quantitative analysis methods; role of Artificial Intelligence and Machine Learning in unstructured data analytics.

MODULE II

Text Analytics and Representation: Types of unstructured data: text, image, audio, and video; significance and applications of text analytics; text mining process; preprocessing techniques; computational syntax; part-of-speech tagging; named entity recognition; vector space model; document representation; TF-IDF weighting schemes; similarity and distance measures.

MODULE III

Dimensionality Reduction and Information Retrieval : Document collections and feature extraction; dimensionality reduction techniques; Singular Value Decomposition (SVD) and Latent Semantic Analysis (LSA); rank reduction techniques; indexing and retrieval models; PageRank algorithm; Information retrieval systems.

MODULE IV

Semantic Analysis and Word Embeddings :Lexical semantics; WordNet and FrameNet; word sense disambiguation; distributional semantics; word-space models; logical approaches to sentence semantics; word embeddings using Word2Vec and GloVe; contextual representations.

MODULE V

Topic Modelling and Knowledge Discovery **:** Web crawling and indexing; query processing; topic modelling using Latent Dirichlet Allocation (LDA); sentiment analysis techniques; opinion mining; knowledge graphs; graph-based analytics; applications in recommendation and social network analysis.

MODULE VI

Applications of Unstructured Data Analytics: Document classification and summarization; Approaches to text analytics; fake news detection; multimodal analytics; unstructured data analytics for image and audio data; ethical issues and challenges in unstructured data analytics

LEARNING RESOURCES

- Aggarwal, C. C. (2015). Unstructured data analytics: How to improve customer acquisition, customer retention, and fraud detection and prevention. John Wiley & Sons.
- Chen, H., Chiang, R. H., & Storey, V. C. (2012). Business intelligence and analytics: From big data to big impact. MIS Quarterly, 36(4), 1165-1188.
- Feldman, R., & Sanger, J. (2006). The text mining handbook: Advanced approaches in analyzing unstructured data. Cambridge University Press.
- Gandomi, A., & Haider, M. (2015). Beyond the hype: Big data concepts, methods, and analytics. International Journal of Information Management, 35(2), 137-144.
- Hastie, T., Tibshirani, R., & Friedman, J. (2009). The elements of statistical learning: Data mining, inference, and prediction. Springer Science & Business Media.
- Kaisler, S., Armour, F., Espinosa, J. A., & Money, W. (2013). Big data: Issues and challenges moving forward. Journal of Computer Information Systems, 54(2), 12-22.

Semester: 1	Course Code: CIC-CC-614	Credits: 4

PRINCIPLES AND TECHNIQUES OF IMAGE COMPUTING

Preamble: The course emphasizes the fundamental and advanced methods of digital image processing for analysing and enhancing visual information. It covers key operations such as image acquisition, spatial and frequency domain techniques, restoration and segmentation, enabling students to understand how raw image data can be processed into meaningful representations. The course aims to develop a strong understanding of how computational techniques can be used to enhance image quality and extract meaningful insights and also to address real-world challenges in image analysis.

Prerequisite: Data structures and Linear algebra.

COURSE OUTCOMES & TAGGING

	Course Outcomes	PO	PSO	CL	KC
CO1	Explain the elements of image processing and analyze the fundamentals of the electromagnetic spectrum and its relationship to image generation.	PO1	PSO2	An, Ap	P, C
CO2	Analyze and relate 1D signal processing concepts to 2D image processing	PO1	PSO2	An	P,C
CO3	Apply convolution as a fundamental operation in signal and image processing and solve mathematical problems	PO3	PSO2	Ap	P, C
CO4	Analyze frequency-domain and Spatial domain representations of images	PO2	PSO2	An, Ap	C,P
CO5	Illustrate Histogram Equalization and Solve problems related to computation of histogram equalization on an image	PO4	PSO2	An, Ap	P, C
CO6	Apply Smoothening and Sharpening filters and edge detection in images	PO5	PSO2	Ap	P,C
CO7	Analyze and Apply Morphological operations in images	PO5	PSO2, PSO7	An, Ap	C,P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Signal Processing: Introduction to Digital Signal Processing: 1D, 2D signals, Representation of Signals, Signal Processing Pipeline, Operations on Signals, Linear Shift Invariant Systems, Digital Filters - Difference Equation and Impulse Response, Types of IR systems, Signal Frequency (Spectrum) Analysis, Digital Signal Processing in Real-World Applications. Light and Electromagnetic Spectrum- Relation to Image Generation

MODULE II

Image Processing- Image Interpolation Techniques- Simple Image Formation Model- Steps in Digital Image Processing, Intensity transformation and Spatial filtering, Piecewise Linear transformation functions, Histogram Processing, Histogram Equalization, Local Enhancement, Enhancement using Arithmetic and Logic operations, Image Subtraction.

MODULE III

Convolution in Signal and Image Processing: 1-D Linear and Circular Convolution, Methods of 2-D Convolution- Graphical Method- Matrix Method- Z-transform method. Mathematical Problems, Correlation. Image Transforms: Fourier Transform, Inverse Fourier Transform, Hadamard Transform-Wavelets Transforms- Multi-resolution analysis, Applications to Discrete Image Transforms.

MODULE IV

Spatial Filtering: Smoothening spatial filters – Median Filter- Averaging Filter, Sharpening spatial filters- Unsharp masking and High Boost Filter, Gradient operators, Edge detection- Canny Edge Detection- Kirch Compass Edge Detection, Filtering in Frequency domain, Homomorphic Filtering.

MODULE V

Image Restoration: Image Degradation Process, Noise probability density functions, Restoration Filters: Mean Filters, Order-statistics filter, Adaptive Filters, Periodic Noise Reduction, Wiener filtering, *Color Image Processing*- Color Models– RGB, HSI, YCbCr, L*a*b*

MODULE VI

Image Segmentation: Fundamentals, Thresholding– Otsu's method- Region based segmentation- Region Merging and Region splitting. Super pixel Segmentation.

Binary Image Processing- Morphological Operations- Erosion- Dilation -Opening- Closing Structuring elements- Morphological Gradients- Chain code- Shape Number

LEARNING RESOURCES

References

- Anil K. Jain, "Fundamentals of Digital Image Processing", Pearson, 1st Ed., 1988.
- Azriel Rosenfield, Avinash C. Kak, "Digital Picture Processing", Morgan Kaufmann, 2nd Ed., 1982.
- Bernd Jahne, "Digital Image Processing", Springer, 6th Ed., 2005.
- Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", 4th Ed., Pearson, March 2017.
- Scott E Umbaugh, "Digital Image Processing and Analysis", CRC Press, Third Edition, 2018.
- William K. Pratt, "Digital Image Processing: PIKS Scientific Inside", John Wiley & Sons, 4th Ed., 2007.

Semester: 1	Course Code: CIC-CC-615	Credits: 2

IMAGE COMPUTING LABORATORY

Preamble: Image Processing Laboratory is designed to provide hands-on experience in the practical aspects of digital image processing. The lab focuses on implementing fundamental and advanced techniques for analyzing, enhancing, and interpreting visual data. Students gain exposure to key operations such as image acquisition, filtering, transformation, segmentation, and feature extraction, using computational tools such as Python. By integrating theoretical knowledge with experimental practice, the lab equips students with the skills to develop robust solutions for real-world image analysis problems in domains such as medical imaging, remote sensing, and computer vision applications.

Prerequisite: Knowledge of Image Processing, Linear Algebra

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Demonstrate the ability to acquire, display, and manipulate digital images using computational tools such as Python.	PO4	PSO2	An, Ap	P
CO2	Apply fundamental image processing techniques, including image enhancement, noise reduction, and filtering, to improve visual quality.	PO5	PSO5	An, Ap	P
CO3	Develop machine learning algorithms for image segmentation and image classification. Evaluate the performance measures for the algorithms	PO1, PO6	PSO3	An, Ap,E	P
CO4	Implement unsupervised learning methods, such as clustering and dimensionality reduction, for pattern discovery in images.	PO3	PSO2	An, Ap	P
CO5	Apply advanced machine learning techniques to solve real-world image computing problems.	PO3, PO6	PSO3	An, Ap	P
CO6	Implement and analyze performance metrics for machine learning models, such as accuracy, precision, recall, and F1-score.	PO1, PO2	PSO3	An, Ap, E	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

It is advised to complete the problems to be given under each of the following cycles. There may be a set of experiments in each cycle, and all cycles are mandatory. The faculty in charge will give the list of exercises as and when you have completed the minimum experiments in each cycle. The students can suggest new and innovative exercises in the second cycle, provided it can be implemented with the available lab infrastructure.

Image Processing Cycle

- Noise Removal
- Histogram Equalization
- Image Registration

- Edge Detection
- Arithmetic Operations on Images

Advanced Image Processing Cycle

- RGB Color conversions
- Convolution and Correlation
- Image Thresholding
- Object Detection
- Image Dehazing
- Dark Image Enhancement

Machine Learning Cycle

- Dimensionality Reduction- PCA, LDA
- Feature Extraction -HOG- LBP
- Image Classification- K-NN, SVM, XGBoost
- Image Clustering- K-Means Clustering
- Tree based Classifiers

Problems with different algorithms in this category will be given. The dataset to be used will be mentioned in the problem statement itself. Evaluation matrices that have to be projected as out will also be given.

ASSESSMENT

Laboratory Record: 20 Marks
All Students attending the End Semester Viva should prepare a Fair record and should be produced at the time of evaluation. The record should be certified by the Faculty-in-charge of the laboratory countersigned by the Course coordinator.

End Semester Viva: 20 marks
The students should attend the viva that are based on the respective course discipline. Viva questions are an important part of an academic program and often occur after a semester/year.

End Semester Examination: 60 Marks
The examination will be conducted either by the panel of internal examiners or panel consists of an external examiner. The problem will be given at the time of examination and the marks will be awarded by the examiner/panel.

Semester: 1	Course Code: CIC-SE-616	Credits: 2

DESIGN THINKING

Preamble: Design thinking process draws on methods from engineering and design, and combines them with ideas from the arts, tools from the social sciences, and insights from the business world. Students develop a strong understanding of the Design Process and how it can be applied in product generation. Students also learn various techniques and tools used in design thinking and develop skills to identify, analyze, and address user needs and challenges. Through hands-on projects and case studies, students gain practical experience in applying design thinking methodologies to real-world problems

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Create physical prototypes / a visual representation of an idea	PO5	PSO5 PSO6	Cr	C, M
CO2	Develop teamwork and leadership skills in students	PO2 PO3	PSO9 PSO12	An	C, P
CO3	Develop students' professional and entrepreneurial skills in innovation and product generation	PO4 PO5	PSO10 PSO12	U	C, P
CO4	Analyse the significance of empathy in design thinking process	PO1 PO3	PSO10	An	C, P
CO5	Explain the principles and core concepts of design thinking	PO1 PO4	PSO5 PSO9	U	C, P
CO6	Demonstrate the capability of design thinking oriented product generation with social impact	PO6	PSO10 PSO12	An	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction to Design Thinking: Understanding the design thinking process-Human centered design- Principles and core concepts of design thinking - Importance of empathy in design thinking -Techniques for conducting user research and understanding user needs- Creating user personas and empathy maps, Case studies showcasing successful design thinking applications

MODULE II

Problem Definition and Ideation: Defining the problem statement and framing design challenges- Techniques for generating innovative ideas and brainstorming- Conceptualizing solutions and creating prototypes. Introduction to prototyping tools and techniques -Rapid prototyping and iterative design processes- Gathering feedback and incorporating user input

MODULE III

Collaborative Design and Teamwork: Techniques for effective collaboration in design thinking- Design sprints and team-based problem-solving- Conflict resolution and decision-making in design teams

MODULE IV

Design Thinking for Entrepreneurship: Applying design thinking to startup development- Identifying market opportunities and user needs- Designing minimum viable products (MVPs) and conducting user validation

MODULE V

Design Thinking in Social Impact: Design thinking for social innovation and change- Humanitarian design and addressing societal challenges- Case studies on design thinking for social impact

MODULE VI

Applying design thinking methodologies to a computer science problem- Presenting and evaluating final design thinking solutions

LEARNING RESOURCES

References

- Brown, T., "Design thinking. Harvard Business Review", 86(6), 84-92, 2008.
- Liedtka, J., King, A., & Bennett, K., "Solving problems with design thinking: Ten stories of what works", Columbia University Press, 2013.
- Plattner, H., Meinel, C., & Leifer, L. (Eds.), "Design thinking research: Taking breakthrough innovation home" (Vol. 10). Springer, 2020.
- Mootee, I. , "Design thinking for strategic innovation: What they can't teach you at business or design school", Wiley, 2013.
- Brown, T., & Martin, R., "Design for action. Harvard Business Review", 93(9), 50-59, 2015.

Online Resources

https://onlinecourses.nptel.ac.in/noc21_mg04/preview

Semester: 1	Course Code: CIC-GC-617	Credits: 2

COMPUTATIONAL IMAGING

Preamble: Images are pictorial representations of a visual scene. This course focuses on the basic theoretical foundations of image processing, exploring the fundamental concepts andtechniques that underpin image processing. Students can develop a deeper comprehensionof how images are processed, analyzed, and manipulated.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain the steps in digital image processing	PO1 PO5	PSO4 PSO5	U	P
CO2	Apply Edge detection in images	PO1 PO5	PSO4 PSO5	U, Ap	C, P
CO3	Perform Histogram Equalization	PO1 PO4	PSO1 PSO5	Ap, An	C, P
CO4	Describe Otsu thresholding method	PO1 PO4	PSO1 PSO5	U	C,P
CO5	Apply Fourier transform in images	PO1 PO4	PSO1 PSO2	An	P
CO6	Illustrate the process of converting an analog image todigital image	PO1 PO5	PSO1 PSO4	An	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Images - Steps in Image Processing- Types of digital images- Sampling and Quantization- Histograms – Image properties – Histogram Equalization.

MODULE II

Filtering- Low and High Pass filters- Gaussian Filters- Edge Sharpening- Non linear filters- Image Interpolation.

MODULE III

Enhancement by Spatial Filtering- Fourier transforms of Images- Filtering in frequency domain- Homomorphic filtering.

MODULE IV

Image Restoration- Degradation model- Types of Noises- Median Filtering- Mean filters- Wiener Filter.

MODULE V

Image Segmentation- Thresholding- Otsu's Thresholding- Region based segmentation- Edge detection filters- Sobel, Prewit. Applications – Image Enhancement – Histogram Equalization- Image Denoising- MedianFiltering- Edge Detection – Processing images in Frequency domain.

MODULE VI

Applications – Image Enhancement – Histogram Equalization- Image Denoising- Median Filtering- Edge Detection – Processing images in Frequency domain.

LEARNING RESOURCES

References

- Anil K. Jain, "Fundamentals of Digital image Processing", Prentice Hall, US Ed., 1989.
- Alasdair McAndrew, "Introduction to Digital Image Processing with Matlab", CengageLearning, 2004.
- Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", 3rd Ed., PHI, 2007.
- William K. Pratt, "Digital Image Processing: PIKS Scientific Inside", Wiley Interscience, 4thEd., 2007.

Semester: 2	Course Code: CIC-CC-621	Credits: 4

COMPUTER VISION

Preamble: This course introduces the fundamental and advanced concepts of Computer Vision, focusing on image formation, feature extraction, segmentation, motion analysis, and 3D reconstruction. It combines classical geometric methods with modern machine learning and deep learning techniques. Emphasis is placed on both theory and practical implementation, enabling students to develop and apply computer vision algorithms for real-world applications in areas such as robotics, autonomous systems, and medical imaging.

Prerequisite: Basic knowledge of linear algebra, probability and statistics, digital image processing, and programming in Python.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the fundamentals of image formation, camera geometry, and geometric transformations.	PO1	PSO6	U	F, C
CO2	Apply image feature detection and robust feature matching techniques to practical vision problems.	PO5	PSO6	U, Ap	C, P
CO3	Understand and evaluate classical and deep learning-based object detection techniques.	PO1	PSO7	U, Ap	C, P
CO4	Understand motion in videos and implement object tracking algorithms for real-time applications.	PO5	PSO8	U, Ap	C, P
CO5	Understand and apply multiple view geometry and 3D vision concepts for reconstruction and robotics applications.	PO5	PSO6	U, Ap	C, P
CO6	Apply computer vision techniques in real-world applications including segmentation, recognition, retrieval, and autonomous systems.	PO4	PSO10	An, Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Image Formation and Camera Geometry: Pinhole camera model, intrinsic and extrinsic parameters, camera coordinate systems, lens distortion and correction, camera calibration techniques, radiometry and photometry, image intensity and lighting effects, geometric transformations including translation, rotation, scaling, affine and projective transformations, homography estimation.

MODULE II

Image Features and Robust Feature Matching: **F**eature descriptors including SIFT, SURF, and ORB, invariant feature extraction, feature matching techniques using brute force and FLANN, evaluation of feature matching, applications in object recognition and image stitching.

MODULE III

Object Detection Techniques: Classical object detection methods – sliding window, HOG, Viola-Jones algorithm, introduction to modern deep learning-based methods – convolutional neural networks (CNNs), region-based CNNs (R-CNN, Fast R-CNN, Faster R-CNN), YOLO.

MODULE IV

Motion Estimation and Object Tracking: Optical flow estimation – Horn-Schunck and Lucas-Kanade methods, background subtraction, Kalman filter for object tracking, applications in video surveillance, autonomous navigation, and activity recognition.

MODULE V

Multiple View Geometry and 3D Vision: Epipolar geometry, fundamental and essential matrices, camera calibration and re-projection error, stereo vision and depth estimation, triangulation methods, structure from motion, 3D reconstruction techniques, bundle adjustment, applications in robotics, augmented reality, and autonomous systems.

MODULE VI

Applications: Structure from motion, gesture and facial expression recognition, Real-time applications in autonomous vehicles, robotics, medical imaging, and augmented reality.

LEARNING RESOURCES

References

- R. Szeliski, *Computer Vision: Algorithms and Applications*. Springer, 2022.
- D. A. Forsyth and J. Ponce, *Computer Vision: A Modern Approach*. 2nd ed. Pearson, 2012.
- R. Hartley and A. Zisserman, *Multiple View Geometry in Computer Vision*. 2nd ed. Cambridge University Press, 2004.
- Goodfellow, Y. Bengio, and A. Courville, *Deep Learning*. MIT Press, 2016.
- S. Umeyama, *Geometric Computer Vision: From 3D Reconstruction to Recognition*, Springer, 2017
- Torralba, P. Isola, and W. T. Freeman, *Foundations of Computer Vision*. Cambridge, MA, USA: MIT Press, 2024.
- S. J. D. Prince, Computer Vision: Models, Learning, and Inference. Cambridge, UK: Cambridge University Press, 2012.

Online Resources

- http://cs231n.stanford.edu/
- https://cs231n.github.io/
- https://docs.opencv.org/4.x/d9/df8/tutorial_root.html
- https://docs.opencv.org/4.x/d9/d0c/group__calib3d.html
- https://docs.opencv.org/4.x/dc/dc3/tutorial_py_matcher.html
- https://www.pyimagesearch.com/start-here/

Semester: 2	Course Code: CIC-CC-622	Credits: 4

DEEP LEARNING AND TRANSFORMERS

Preamble: Deep learning plays an important role in the modern world. This course aims to impart the ability to students, to build and train new deep architectures, detect the key parameters etc. After the completion of this course, the students are able to develop their own deep architectures to address real world problems.

Prerequisite: Basic knowledge Linear Algebra, Machine Learning

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Demonstrate a strong foundation in deep learning principles and neural network architectures	PO1, PO4	PSO1	U, Ap	C, P
CO2	Illustrate the concepts of convolutional neural networks and familiarize various pretrained models	PO1, PO5	PSO5	U	C
CO3	Implement and evaluate different deep learning models to perform real world applications	PO2, PO4	PSO8	U, Ap	C, P
CO4	Explain the processing of sequence data in different real-world applications	PO1, PO3	PSO4	U	C, P
CO5	Analyze the role of different generative adversarial networks in real world problems	PO4, PO5	PSO10	U, Ap	C, P
CO6	Illustrate attention mechanisms and transformers in deep learning	PO1, PO4	PSO7	U, An,	C, P
CO7	Implement the deep architectures using different deep learning libraries	PO1, PO5	PSO3	U,	C, P
CO8	Implement and analyze the performance of different deep learning architectures for solving various real-world problems	PO4, PO5	PSO12	An	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction to Machine Learning and Deep Learning, Limitations of traditional machine learning approaches, Artificial Neural Networks - Applications of deep learning. Convolutional Neural Network - Convolutional layers, Pooling Layer- Activation Functions (ReLU, Leaky ReLU - PReLU - SeLU)- Padding and Stride - Fully Connected Layer- Flattening – Softmax Activation.

MODULE II

Parameter Computation in CNN- CNN Hyperparameters- Fine Tuning- Regularization - Dropout and Batch normalization, Loss Functions- Optimization in deep learning, Gradient Descent, Momentum Optimizer, RMS Prop, Adam optimizer. Transfer Learning - AlexNet, VGG19 – ResNet 50

MODULE III

Sequence Modelling - Bi-directional Recurrent Neural Networks, Recursive Networks, Gated Recurrent Units (GRU)- Unsupervised deep learning: Auto Encoders - Generative Adversarial Network- Architecture - Applications of GANs

MODULE IV

Transformers- Significance of transformers in Text processing -Encoder and decoder architecture -Attention Mechanism -Positional encoding and context representation - Conformer for speech recognition, Vision Transformers (ViT) architecture - Image patch embedding

MODULE V

Transformer-Based Models: Encoder-only models: DeBERTa - Decoder-only models: DeepSeek -Encoder-decoder models - Text-to-Text Transfer Transformer (T5), Domain-Specific Transformers - Longformer

MODULE VI

Usage of deep libraries like Tensorflow, Keras, Pytorch- Image classification using CNNs and Transformers - Image Segmentation using UNet Architecture - Implementation of Vision Transformers, Image Captioning, DeBERTa , Longformer, Conformer

LEARNING RESOURCES

References

- Aston Zhang, Zachary C. Lipton, Mu Li, And Alexander J. Smola, "Dive into Deep Learning", 2021.
- Ian Goodfellow, YoshuaBengio, Aaron Courville, "Deep Learning", MIT Press 2015.
- Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola," Dive into Deep Learning", August 2019.
- Charu C. Aggarwal , "Neural Networks and Deep Learning: A Textbook", Springer, 1st edition, 2018.
- Sudharsan Ravichandran, "Hands-On Deep Learning Algorithms with Python", Packt Publishing Ltd. , 1st edition, 2019.
- Francois Chollet, "Deep Learning with Python", Manning Publications Co., 2nd edition, 2018.

Semester: 2	Course Code: CIC-CC-623	Credits: 2

DEEP LEARNING LABORATORY

Preamble: The lab is designed to provide hands-on experience and focuses on practical aspects of deep learning, including data preprocessing, model design, training, and performance evaluation using deep learning models. Students explore key architectures such as convolutional and recurrent neural networks, along with emerging techniques for real-world applications in image processing, natural language processing, and intelligent systems. By bridging theoretical concepts with experimentation, the laboratory equips students with the skills needed to develop and deploy deep learning solutions.

Prerequisite: Knowledge of Machine Learning, Deep Learning and Programming Skills

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Demonstrate proficiency in using programming frameworks such as Python-based libraries for implementing deep learning models.	PO1	PSO6	U	F, C
CO2	Develop and train Convolutional Neural Networks (CNNs) for image processing and computer vision applications.	PO2	PSO3	U, Ap	C, P
CO3	Utilize pretrained transformer models such as BERT and GPT for solving real-world problems.	PO4	PSO2	Ap, E	C, P
CO4	Analyze and apply optimization techniques, including gradient descent variants, to fine tune the model performance.	PO5	PSO9	Ap, E	C, P
CO5	Design and implement transformer-based architectures for tasks such as text generation, classification, and sequence modeling.	PO2	PSO3	Ap, E	C, P
CO6	Integrate deep learning and transformer models to build end-to-end intelligent systems for image and text processing.	PO1	PSO2	An, Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

It is advised to complete the problems to be given under each of the following cycles. There may be a set of experiments in each cycle, and all cycles are mandatory. The faculty in charge will give the list of exercises as and when you have completed the minimum experiments in each cycle. The students can suggest new and innovative exercises in the second cycle, provided it can be implemented with the available lab infrastructure.

Basic Deep learning Cycle

- Multilayer Perceptron (MLP) using Neural Networks
- Backpropagation Algorithm Implementation
- Image Classification using CNN

- Transfer Learning using Pretrained Models

Advanced Deep learning Cycle

- Sequence Modeling using RNN/LSTM
- Object Detection using YOLO, DETR
- Image Segmentation using U-Net
- Feature Extraction using Deep Learning
- Word Embeddings using Word2Vec, Glove, FastText
- Sentiment Analysis using Deep Learning

Transformer Cycle

- Transformer Applications using Hugging Face Transformers
- Implementation of Self-Attention Mechanism
- Text Generation using GPT
- Text Classification using BERT
- Vision Transformers for Image Classification
- Image Captioning

Problems with different algorithms in this category will be given. The dataset to be used will be mentioned in the problem statement itself. The algorithms need to be evaluated in a qualitative and quantitative metrics.

ASSESSMENT

Laboratory Record: 20 Marks
All Students attending the End Semester Viva should prepare a Fair record and should be produced at the time of evaluation. The record should be certified by the Faculty-in-charge of the laboratory countersigned by the Course coordinator.

End Semester Viva: 20 marks
The students should attend the viva that are commonly based on the respective course discipline. Viva questions are an important part of an academic program and often occur after a semester/year.

End Semester Examination: 60 Marks
The examination will be conducted either by the panel of internal examiners or panel consists of an external examiner. The problem will be given at the time of examination and the marks will be awarded by the examiner/panel.

Semester: 2	Course Code: CIC-CC- 624	Credits: 2

COMPUTER VISION LABORATORY

Preamble: Computer Vision Laboratory focuses on converting core theoretical ideas—feature extraction, object detection, image segmentation, motion analysis, and deep learning-based vision models—into real-world applications by offering practical experience in implementing vision-related algorithms and techniques. The course helps bridge the gap between theory and practice by enabling students to design intelligent vision systems, strengthen analytical thinking, and develops skills applicable to areas such as autonomous systems, medical imaging, surveillance, and augmented reality.

Prerequisite: Fundamental knowledge of programming in Python / C++

- Familiarity with linear algebra concepts (matrices, vectors, transformations)
- Introductory knowledge of Digital Image Processing
- Basic understanding of probability and statistics
- Exposure to libraries such as OpenCV / NumPy / Matplotlib (desirable)

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the fundamentals of image formation, camera geometry, and geometric transformations.	PO1	PSO1	U	F, C
CO2	Apply image feature detection and robust feature matching techniques to practical vision problems.	PO5	PSO2	U, Ap	C, P
CO3	Apply and evaluate classical and deep learning-based object detection techniques.	PO5	PSO7	Ap, E	C, P
CO4	Understand motion in videos and implement object tracking algorithms for real-time applications.	PO5	PSO10	Ap, E	C, P
CO5	Apply multiple view geometry and 3D vision concepts for reconstruction and robotics applications.	PO5	PSO11	Ap, E	C, P
CO6	Apply computer vision techniques in real-world applications including segmentation, recognition, retrieval, and autonomous systems.	PO1	PSO10	An, Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

List of Experiments to be implemented

- Lens distortion correction (radial and tangential)
- Corner detection using Harris and Shi-Tomasi methods
- Feature extraction using SIFT, SURF, and ORB
- Feature matching using brute force and FLANN-based methods
- Implementation of HOG-based object detection
- Face detection using Viola-Jones algorithm
- Object detection using pre-trained CNN models

- Experiments with R-CNN, Fast R-CNN, Faster R-CNN
- Object detection using YOLO models
- Optical flow estimation using Horn-Schunck and Lucas-Kanade methods
- Object tracking using Kalman filter
- Motion visualization and trajectory tracking
- Stereo vision and depth map estimation
- Camera calibration and re-projection error analysis
- Introduction to vision transformers for image classification
- Image classification using pre-trained CNN models
- Gesture and Facial expression recognition

ASSESSMENT

Laboratory Record: 20 Marks

All Students attending the End Semester Viva should prepare a Fair record and should be produced at the time of evaluation. The record should be certified by the Faculty-in-charge of the laboratory countersigned by the Course coordinator.

End Semester Viva: 20 marks

The students attend the viva that are commonly based on the respective course discipline. Viva questions are an important part of an academic program and often occur after a semester/year.

End Semester Examination: **60 Marks**

The examination will be conducted either by the panel of internal examiners or panel consists of an external examiner. The problem will be given at the time of examination and the marks will be awarded by the examiner panel.

Semester: 2	Course Code: CIC-DE-625(i)	Credits: 4

ROBOTICS AND INTELLIGENT SYSTEM DESIGN

Preamble: Robotics and Intelligent System Design is an interdisciplinary course that explores the principles, methodologies, and technologies involved in the design and development of intelligent robotic systems. This course provides students with a comprehensive understanding of the fundamental concepts in robotics, including perception, planning, control, and learning. Students will learn to integrate hardware and software components to design and build intelligent robots capable of performing complex tasks in dynamic environments

Prerequisite: Algorithms and Computer Vision

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Demonstrate the skillset to program and control a robotics system	PO1 PO5	PSO5 PSO12	A	P
CO2	Explain the management and analysis of robotics systems	PO1 PO3	PSO8 PSO10	U	C
CO3	Illustrate the working of a robot understanding the concepts of electronics, programming and robotics	PO1 PO4	PSO5 PSO11	A	P
CO4	Acquire basic Knowledge on Robots	PO4	PSO10 PSO11	U	C
CO5	Ability to process end effectors and robotic controls.	PO1 PO5	PSO1 PSO5	A	P
CO6	Analyze Robot Transformations and Sensors	PO1	PSO1 PSO4	An	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction - Robotics and AI - Embedded Systems -Agent-Task-Environment model -Embodied Systems - Synthetic approaches to science

MODULE II

Mobile Robots: Position, and Orientation -Translational and Dynamics - lying and Swimming Robots - Articulated Robots - Transformations, Path Planning, and Trajectories

MODULE III

Sensors and signal processing- Common sensors and their properties- 1D signal processing Vision Planning approaches to robot control- STRIPS and SHAKEY - Robot manipulator kinematics- Limitations of planning approaches

MODULE IV

Control Theory - Feedback, feedforward and open loop control- Linear first order lag processes- Limitations of control theory -Probability Based Approaches -Markov Decision Processes (MDPs) Navigation

MODULE V

Behaviour-Based Control -The subsumption architecture- Hybrid architectures – Formalising behaviors based control (SMDPs)- Adaptive approaches to robot control - Reinforcement learning for control

MODULE VI

Model Based learning approaches to control -Learning maps - Evolutionary approaches - Parameter Estimation and Adaptive Control - Task Planning and Multi-Agent Systems

LEARNING RESOURCES

References

- Albus, J. I., and Meystel, A. M., Engineering of Mind, J. Wiley & Sons, 2001.
- C. Asfahl, Robots and Manufacturing Automation, J. Wiley & Sons, 1992.
- D. Auslander, J. Ridgely, and J. Ringgenberg, Control Software for Mechanical Systems,Prentice-Hall, 2002.
- G. Bekey, Autonomous Robots, MIT Press, 2005.
- H. Asada and J.-J. Slotine, Robot Analysis and Control, J. Wiley & Sons, 1986.
- H. Choset, Principles of Robot Motion, MIT Press, 2005.
- M. Brady, J. Hollerbach, T. Johnson, T. Lozano-Perez, and M. Mason, Robot Motion:Planning and Control, MIT Press, 1984.
- P. Antsaklis and K. Passino, An Introduction to Intelligent and Autonomous Control,Kluwer, 1993.
- R. Arkin, Behavior-Based Robotics, Bradford, 1998.
- http://www.stengel.mycpanel.princeton.edu/MAE345Lectures.html

Semester: 2	Course Code: CIC-DE- 625(ii)	Credits: 4

MEDICAL IMAGE ANALYSIS AND PROCESSING

Preamble: Medical Image Analysis and Processing focus on computational techniques for enhancing, analyzing, and interpreting medical images to support clinical decision-making. The course builds on foundational concepts from image computing, machine learning, and mathematical modeling to address challenges in biomedical imaging. It introduces students to imaging modalities, pre-processing, segmentation, registration, and classification techniques.

Prerequisite: Mathematics for Image Processing, Machine Learning Models, Principles and Techniques of Image Computing

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Demonstrate fundamental knowledge of medical imaging modalities and the principles of biomedical image analysis.	PO1	PSO4	U	C,P
CO2	Analyze challenges in medical image processing, including noise, artifacts, and enhancement techniques.	PO1	PSO5	An,Ap	C,P
CO3	Apply image processing and segmentation techniques to extract meaningful information from medical images.	PO5	PSO5	An,Ap	C,P
CO4	Implement image registration techniques for aligning multimodal medical images.	PO5	PSO1	Ap	P,M
CO5	Evaluate texture features and statistical models for characterization of biomedical images.	PO1	PSO2	An	C,P
CO6	Apply machine learning and deep learning methods, including convolutional neural networks, for medical image classification and analysis.	PO4	PSO7	An,Ap	C,P
CO7	Analyze and interpret results from medical image analysis systems for diagnostic decision-making and real-world applications.	PO6	PSO10	An, Ev	C,P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction to Medical Image Modalities: Objectives of biomedical image analysis, Computer Aided Diagnosis, Medical imaging modalities- Working Principles of X-ray imaging, Computed Tomography (CT), Nuclear medicine imaging, Ultrasonography, Magnetic Resonance Imaging (MRI).

MODULE II

Image Processing and Segmentation: Removal of artifacts- Space domain filters, Frequency domain filters, Adaptive filters. Image enhancement- Histogram transformation, Contrast enhancement. Image Segmentation - Statistical shape models (SSM) and their limitations, Active Contour Models (snakes).

MODULE III

Image Registration: Motivation and applications of image registration. Types of registration, Rigid models- Transformation Model, Similarity Measures, Multimodal image registration and Joint Histogram methods. Non-Rigid models- Deformation models, Fast Non Rigid Registration.

MODULE IV

Analysis of Texture: Texture in Biomedical Images, Models for generation of texture, Statistical analysis of texture, Law's Measures of Texture Energy, Gray Level Co-occurrence Matrix, Local Binary Patterns, Fractal analysis.

MODULE V

Pattern Classification and Diagnostic Decision: Supervised Pattern Classification- Discriminant and decision functions, Distance functions, The Nearest-Neighbor rule, Unsupervised Pattern Classification- Cluster-seeking methods, Convolution Neural Networks for Analysis, Generative models for synthetic data, Diagnostic Measures.

MODULE VI

Applications: Contrast enhancement and Segmentation of Mammograms, Texture analysis of Tumors, MRI brain image classification, Image enhancement in Retinal images, Histopathological blood cell image analysis, Nodule detection in lung images, Cancer detection in skin images, Ethical issues in medical AI (bias, interpretability).

LEARNING RESOURCES

References

- Sinha G. R, Patel, B. C., "Medical Image Processing: Concepts and Applications", Prentice Hall, 2014.
- Gonzalez R C, Woods R E, "Digital Image Processing", Third Edition, Prentice Hall, 2007
- Rangayyan R M, "Biomedical Image Analysis", Fifth Edition, CRC Press, 2005
- KayvanNajarian, Robert Splinter, "Biomedical Signal and Image Processing", Second Edition, CRC Press, 2014.
- Deserno T M, "Biomedical Image Processing", Springer, 2011.

Semester: 3	Course Code: CIC-DE-625(iii)	Credits: 4

IMAGE AND VIDEO ANALYTICS

Preamble: Image and Video Analytics course provides an in-depth exploration of image and video analytics, focusing on the fundamental principles, algorithms, and techniques used for understanding and extracting meaningful information from visual data. Students will learn how to analyze and interpret images and videos, enabling them to solve various computer vision tasks such as object recognition, scene understanding, motion analysis, and video summarization.

Prerequisite: Image processing, Computer Vision

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Acquire knowledge about various image analytical methods.	PO1 PO4	PSO2 PSO5	U	F,C
CO2	Understand the concepts used in shape representation and description	PO1 PO5	PSO1 PSO2	U	C
CO3	Analyse the importance of various object recognition methods	PO1 PO5	PSO3 PSO6	An	C
CO4	Understand the basic video processing techniques	PO4 PO5	PSO4 PSO6	U	C
CO5	Understand the algorithms available for performing analysis on video data and address the challenges.	PO1 PO3	PSO4 PSO5	U	F, C

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction to Image Analytics- Digitized image and its properties- Multispectral segmentation, thresholding in hierarchical data structures, Edge based segmentation- Border detection in graph segmentation, Border detection as dynamic programming, Region based segmentation- Watershed segmentation.

MODULE II

Shape representation and description- Region identification, Contour based shape representation and description, Region-based shape representation and description. Object recognition- Knowledge representation, Statistical pattern recognition, Syntactic pattern recognition.

MODULE III

Video Analytics - Computer Vision: Challenges- Spatial Domain Processing – Frequency Domain Processing-Background Modelling -Shadow Detection. Eigen Faces - Object Detection -Local Features-Mean Shift: Clustering. Computer Vision, Spatial/ Frequency Domain Processing

MODULE IV

Local Features (Harris/SIFT/KB/STIP)- Object Detection and Recognition (Eigen Faces, Sparse Representation), Face Detection and Recognition, Tracking - Object Tracking using Active Contours- Tracking & Video Analysis: Tracking and Motion Understanding – Kalman filters, Bayesian filters, Change detection and Model based tracking

MODULE V

Motion estimation and Compensation- Block Matching Method. Hierarchical Block Matching, Overlapped Block Motion and compensation-Recursive Motion Estimation, Mesh Based Method, Optical Flow Method - Motion Segmentation -Thresholding for Change Detection, Estimation of Model parameters.

MODULE VI

Optical Flow Segmentation-Modified Hough Transform Method- Segmentation for Layered Video Representation-Bayesian Segmentation -Simultaneous Estimation and Segmentation-Motion Field Model, Segmentation (Unsupervised: Watershed, Level set, Active Contour, GraphCut), Segmentation (Supervised: Agglomerative clustering, Segmentation as pixel classification - UNets, FCN), MS Theory, MS Tracking

LEARNING RESOURCES

- A. Murat Tekalp, Digital Video Processing (2 ed.), Prentice Hall, 2015.
- Forsyth, D. A., & Ponce, J. (2012). Computer Vision: A Modern Approach. Pearson.
- Szeliski, R. (2010). Computer Vision: Algorithms and Applications. Springer.
- Sonka, M., Hlavac, V., & Boyle, R. (2014). Image Processing, Analysis, and Machine Vision. Cengage Learning.
- Aggarwal, J. K., & Cai, Q. (2012). Mining Text Data. Springer.
- Moeslund, T. B., Hilton, A., & Krüger, V. (2006). A Survey of Advances in Vision-based Human Motion Capture and Analysis. Computer Vision and Image Understanding, 104(2-3), 90-126.
- Shapiro, L. G., & Stockman, G. C. (2001). Computer Vision. Prentice-Hall.
- Jain, A. K., & Jain, R. (2011). Data clustering: 50 years beyond K-means. Pattern Recognition Letters, 31(8), 651-666.
- Gonzalez, R. C., Woods, R. E., & Eddins, S. L. (2008). Digital Image Processing Using MATLAB. Gatesmark Publishing.
- Jain, A. K., Flynn, P., & Ross, A. (2011). Handbook of Biometrics. Springer.
- Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.

Semester: 2	Course Code: CIC-DE-625(iv)	Credits: 4

CYBER SECURITY AND CYBER LAW

Preamble: Cybersecurity encompasses a broad range of practices, technologies, and measures designed to protect computer systems against attacks. Cyber law covers a wide range of issues, including data protection, privacy, online fraud, intellectual property theft, digital signatures and cybercrime. This course focuses on protecting critical infrastructure, safeguarding sensitive information, combating cybercrime, and promoting responsible use of digital technologies

Prerequisite: Cryptography and Network Security

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the fundamentals of cyberspace, cyber security and threat landscape.	PO1 PO4	PSO9 PSO10	U	C, P
CO2	Analyze and evaluate the importance of personal data its privacy and security.	PO1 PO6	PSO9 PSO10	An	C, P
CO3	Identify the role of human in security systems with an emphasis on ethics, social engineering vulnerabilities and training.	PO1 PO6	PSO9 PSO10	U	C, P
CO4	Evaluate the digital payment system security and remedial measures against digital payment frauds using modern cryptographic techniques.	PO1 PO5	PSO1 PSO5	E	P, M
CO5	Develop a deeper understanding and familiarity with various types of cyber-attacks, cybercrimes, vulnerabilities and remedies thereto.	PO1 PO3	PSO3 PSO10	Cr	P, C
CO6	Generalize the impact based on the Risk assessment, plan suitable security controls, audit and compliance in network security.	PO1 PO6	PSO8 PSO9	U	P
CO7	Analyze and evaluate the security aspects of social media platforms and ethical aspects associated with use of social media.	P01 P06	PS09 PS010	An,E	C, P
CO8	Apply measures for self-cyber-protection as well as societal cyber-protection and perceive existing legal framework on cyber security.	P03 P06	PS010 PS012	Ap	C, P

COURSE CONTENT

MODULE I

Cyberspace -Architecture of cyberspace, Internet infrastructure for data transfer and governance, Concept of cyber security, Understanding Cyber security, Cybercrime, Techno-crime, Techno-vandalism, Classification of cyber-crimes, Attacks and Its Types, Cyber Stalking, Botnets, Attack vector, Cyber Crime and Cloud Computing. Role of Steganography and Cryptography, Steganalysis

MODULE II

Risk Assessment Basis, Risk Analysis, Risk Evaluation , Information Security - Threats - Frauds, Thefts, Malicious Hackers, Malicious Code, Denial-of-Services Attacks, Access Control - Access Control fundamentals, User Identity and Access Management (IAM)

MODULE III

Cryptography-Cryptographic Algorithms-Attack Types-cipher text-only attack, known-plaintext attack, Chosen-Plaintext Attack, Chosen-Ciphertext Attack, International Data Encryption Standard (IDEA): Key Generation, Encryption and Decryption Process, IP Security-IP Security Overview, IP Security Architecture, Authentication Header, Encapsulating Security Payload, Combining Security Associations and Key Management.

MODULE IV

Computer Forensics- Types of Computer Forensics techniques Incident and incident response methodology - Forensic duplication and investigation. Incident response - Preparation for IR: Creating response tool kit and IR team. Forensics Technology and Systems, Understanding Computer Investigation, Data Acquisition.

MODULE V

Analysis And Validation-Validating Forensics Data – Data Hiding Techniques – Performing Remote Acquisition – Network Forensics – Email Investigations, Cell Phone And Mobile Devices Forensics, Introduction to Ethical Hacking – Footprinting. Scanning Networks - Enumeration - System Hacking - Malware Threats – Sniffing

MODULE VI

Tools and Techniques used for Mobile Forensics- Hacking Web Applications – SQL Injection - Hacking Wireless Networks - Hacking Mobile Platforms. Cyber Laws-Cyber Laws in India, IT Act 2000 and IT Act 2008 ,CopyrightAct, PatentLaw, Intellectual Property Law

LEARNING RESOURCES

References

- R. C Mishra, Cyber Crime Impact in the New Millennium, Auther Press. Edition 2010.
- Bill Nelson, Amelia Phillips, Frank Enfinger, Christopher Steuart Computer Forensics and Investigations, Cengage Learning, India Edition, 2016.
- Network Security Essentials: Applications and Standards, William Stallings.
- John R.Vacca, Computer Forensics, Cengage Learning, 2005.
- Nina Godbole, Sunit Belapure Cyber security, Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Wiley publications.

Online Resources

- https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_lw01
- https://nptel.ac.in/courses/106106248

Semester: 2	Course Code: CIC-DE-625 (v)	Credits: 4

NATURAL LANGUAGE UNDERSTANDING

Preamble: The course introduces fundamental techniques such as text preprocessing, morphological analysis, and finite-state methods. The course also covers advanced neural architectures such as Recurrent Neural Networks, LSTM, GRU, and attention mechanisms, leading to transformer-based models such as BERT and GPT and real-world applications such as language identification, topic modelling, and multimodal systems. The focus throughout is on understanding the computational aspects of language processing and developing the ability to design and implement effective NLP solutions

Prerequisite: Natural Language Processing

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Familiarize the concepts and techniques of Natural language Processing and its applications	PO1	PSO3	U	F, C
CO2	Exposure to the concepts of Probabilistic language modelling and its applications	PO4	PSO3	U, Ap	F, C
CO3	Analyse the significance of BERT and GPT in natural language processing	PO1	PSO7	An	P
CO4	Illustrate Machine learning models LSTM and RNN	PO5	PSO3,	An, Ap	C,P
CO5	Implement transformer and advanced algorithms in language computing	PO4	PSO7	An, Ap	C,P
CO6	Demonstrate the skill to write programs to analyse the applications of text analysis.	PO2	PSO12	An, Ap	C,P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I:

Foundations of NLP and Text Processing: Hierarchical levels of language processing. Text Normalization Pipeline: Tokenization (word/sentence/subword), Lemmatization vs. Stemming Porter Stemming Algorithm, morphological analysis (finite-state transducers). Finite-state automata for morphology.

MODULE II

Information basics: Bits, Self-information, Entropy. Noisy channel model; Shannon's source-channel coding theorem. Advanced Measures: Cross-entropy, KL-divergence. Information gain.

MODULE III

Hidden Markov models (HMMs) for sequence prediction: N-gram models, Maximum Likelihood Estimation. (MLE), Laplace Smoothing. Generative Models: Naive Bayes for spam filtering, Viterbi algorithm for POS tagging

MODULE IV

Recurrent Neural Networks (RNNs): Vanishing gradients, BPTT. LSTM, GRU: Gating mechanisms, derivations. Attention Models**:** Dot-product, additive, scaled dot-product, self-attention intuition, Multi-head attention

MODULE V

BERT: Masked LM, Next Sentence Prediction; GPT Evolution: Decoder-only, scaling laws, in-context learning. Prompt engineering (zero/few-shot).

MODULE VI

*Word Embeddings Comparison***:** Static (Word2Vec: Skip-gram/CBOW, GloVe), contextual (BERT embeddings), generative (GPT). Intrinsic/extrinsic evaluation (analogy tasks, downstream accuracy). Applications: Author/language identification (stylometry, LID with XLM-R); topic modelling (LDA), multimodal extensions.

LEARNING RESOURCES

References

- D. Jurafsky, J.H. Martin, Speech and Language Processing, 3rd Online Edition (available at https://web.stanford.edu/~jurafsky/slp3/).
- Eisenstein, Introduction to Natural Language Processing, MIT Press, 2019.
- Natural Language Processing with Python. Steven Bird, Ewan Klein and Edward Loper. 2016
- Natural Language Understanding (2nd Edition) 2nd Edition- 2017. James Allen

Online Resources

- https://web.stanford.edu/class/cs224u/
- https://nptel.ac.in/courses/106105158
- https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_lw01
- https://nptel.ac.in/courses/106105158
-

Semester: 2	Course Code: CIC-DE- 625(vi)	Credits: 4

QUANTUM COMPUTING AND QUANTUM MACHINE LEARNING

Preamble: This course introduces the fundamental principles of quantum computing and explores quantum concepts relevant to computation, quantum circuits, quantum algorithms, and quantum machine learning techniques. The course provides practical understanding with quantum programming tools.

Prerequisite: Linear Algebra, Probability and Statistics, Machine Learning, Python Programming.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain fundamental principles of quantum computing	PO1, PO4	PSO1	U	F, C
CO2	Design and simulate basic quantum circuits	PO1, PO3	PSO10	U, An	C, P
CO3	Analyze standard quantum algorithms	PO1, PO5	PSO11	An, Ap	C, P
CO4	Understand foundations of quantum machine learning	PO1, PO4	PSO3	An, Ap	C, P
CO5	Implement simple quantum programs	PO3, PO5	PSO9, PSO10	An, Ap	C, P
CO6	Analyze and apply quantum machine learning techniques	PO1, PO5	PSO3, PSO12	An, Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Foundations of Quantum Computing: Limitations of classical computing, Superposition, Entanglement, Measurement, Qubits and quantum states, Dirac notation (basic), Bloch sphere representation.

MODULE II

Quantum Gates and Circuits: Single Qubit Gates: Quantum Not Gate, Pauli-X, Y and Z Gates, Hadamard Gate. Multiple Qubit Gates: Controlled Gates, Controlled Not Gate, Density Matrix, From Digital Logic Circuit to Quantum circuits and circuit model.

MODULE III

Quantum Algorithms: Deutsch-Jozsa Algorithm, Grover's Search Algorithm, Shor's Algorithm, Quantum advantage and complexity, Limitations of current quantum hardware.

MODULE IV

Introduction to Quantum Programming: Overview of Qiskit, Creating and simulating quantum gates and quantum circuits, executing circuits using Qiskit Aer (state-vector and QASM simulators). Measurement & Visualization: Extracting probability counts and plotting histograms.

MODULE V

Foundations of Quantum Machine Learning: Motivation for QML, Classical vs Quantum ML, Quantum data encoding methods, Parameterized and variational quantum circuits, Hybrid quantum-classical models.

MODULE VI

Quantum Supervised Learning: Quantum Support Vector Machines (QSVM), Quantum Neural Networks (QNN). Quantum Unsupervised Learning: Quantum K-Means Clustering, Quantum Principal Component Analysis.

LEARNING RESOURCES

References

- Schuld, M., & Petruccione, F. (2021). Machine learning with quantum computers (Vol. 676, pp. 163-169). Berlin: Springer.
- Wittek, P. (2014). Quantum machine learning: what quantum computing means to data mining. Academic Press.
- Ganguly, S. (2021). Quantum machine learning: an applied approach. New York: Apress
- Nielsen, M. A., & Chuang, I. L. (2010). Qsuantum computation and quantum information. Cambridge university press.
- Sutor, R. S. (2024). Dancing with Qubits: From qubits to algorithms, embark on the quantum computing journey shaping our future. Packt Publishing Ltd.
- Quantum Computing for Everyone, Chris Bernhardt
- Introducing Quantum Theory: A Graphic Guide, J. P. McEvoy & Oscar Zarate

Online Resources

- IBM Quantum Learning Platform ,https://learning.quantum.ibm.com,(Hands-on tutorials for Qiskit and quantum programming)
- Qiskit Documentation , https://qiskit.org/documentation (Quantum circuit simulation and programming examples)
- Cirq Documentation (Google Quantum Framework) ,https://quantumai.google/cirq (Quantum circuit development and simulation)

Semester: 2	Course Code: CIC-SE-626	Credits: 2

SCIENTIFIC WRITING

Preamble: Scientific writing equips postgraduate researchers with the ability to communicate research findings in a clear, precise, and structured manner. It emphasizes critical thinking, ethical reporting, technical documentation, and the effective presentation of scientific ideas. Students develop the key skills needed to structure and write strong research papers, analyze and summarize existing literature, credit other scientists correctly to avoid plagiarism, and successfully prepare their work for publication in academic journals.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the meaning, purpose and characteristics of scientific writing and distinguish it from general writing practices	PO1	PSO9	U	C
CO2	Apply research skills including literature review methods, structured reading of research papers and preparation of research reports using IMRAD format	PO1	PSO9	Ap	P
CO3	Analyse scientometric indicators, journal impact measures and author-level indices for evaluating research visibility and quality	PO1	PSO9	An	C
CO4	Demonstrate understanding of indexing databases, intellectual property rights, referencing styles and scholarly identification systems	PO6	PSO9	U, Ap	C
CO5	Apply the research publication workflow including plagiarism checking, peer review awareness and manuscript preparation using document preparation	PO2	PSO9	Ap, An	P
CO6	Design and prepare structured thesis chapters and scientific manuscripts using scientific writing tools	PO2	PSO9	Ap, E	P, M

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Scientific Writing: Meaning and purpose of scientific writing, Characteristics of scientific writing – clarity, precision, objectivity and logical flow, Differences between scientific writing and general writing,

MODULE II

Research Skills: Introduction, Research Process, 3+ levels of reading research paper- Steps to conduct Literature Review and analyze the review- Structure of Research Report, Layout of Research paper, Mechanism of writing a research Thesis, IMRAD format

MODULE III

Scientometrics: Article-Level Metrics: Citation Counts, Usage Metrics, Altmetrics. Citation-

Based Indicators: Journal Impact Factor (JIF), Source Normalized Impact per Paper (SNIP). Ranking Systems: Understanding Journal Quartiles (Q1–Q4). Author-Level Metrics: h-index, i10-index, g-index, m-index (m-quotient), Researcher Visibility: The importance of persistent identifiers (ORCID).

MODULE IV

Indexing Databases: Citation databases- Web of Science, Scopus. Intellectual Property Rights- Copyrights, Trademarks and Patents, IPR Laws. Creative commons licenses. Digital Object Identifier (DOI), Journal - ISSN. Referencing styles- IEEE, Vancover, APA style.

MODULE V

Paper Publication Process - Peer Review Process- Publication: Steps for publishing paper in a conference and journal- Plagiarism Checking software. Preparing research papers in LateX- how to Prepare articles /research papers - Prepare References using reference management software including Mendeley.

MODULE VI

Thesis Writing Process: Using Latex style guide and Overleaf- Structure: Title Page, Abstract, Table of Contents, Methodology, Results. Prepare documents with creative common licences. Assisting Research with Gen AI tools.

LEARNING RESOURCES

References

- C. R. Kothari, Research Methodology: Methods and Techniques, New Age International Publishers.
- How to Write and Publish a Scientific Paper Author – Robert A. Day, Barbara Gastel Publisher – Cambridge University Press
- Ganesan R, Research Methodology for Engineers, MJP Publishers, Chennai. 2011
- L. Lamport: A Document Preparation System, User's Guide and Reference Manual, Addison -Wesley, New York, second edition, 1994.
- Guide to LATEX, Fourth edition, Helmut Kopka, Patrick W. Daly
- Paneerselvam. R, Research Methodology, 2nd Edition, PHI, 2014
- Santhosh Kumar Yadav, Research and Publication Ethics, Ane Books 2020
- Saramäki, Jari. How to Write a Scientific Paper: An Academic Self-Help Guide for PhD Students., 2018.

Semester: 3	Course Code: CIC-CC-631	Credits: 4

RESEARCH METHODOLOGY AND PUBLICATION ETHICS

Preamble: This course introduces the fundamental principles of research methodology and ethical practices in scientific research and publication. It provides knowledge on research design, data analysis, publication standards, and intellectual property rights to promote responsible and high-quality research practices.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

	Course Outcomes	PO	PSO	CL	KC
CO1	Understand the fundamental concepts of research methodology including research problems, literature review, and formulation of research objectives.	PO1	PSO9	U, Ap	F, C
CO2	Analyze research designs, research proposals, and evaluate research papers to identify research methods and contributions.	PO1	PSO9, PSO12	U, An	C, P
CO3	Apply appropriate data collection methods, sampling techniques, and statistical tools for research analysis and hypothesis testing.	PO2	PSO1, PSO9	An, Ap	C, P
CO4	Understand the principles and standards of publication ethics, authorship, and responsible research practices.	PO6	PSO9	U, Ap	C
CO5	Identify scientific misconduct and evaluate research visibility metrics such as citation databases, impact factor, and h-index.	PO4	PSO9, PSO8	An, Ap	C, M
CO6	Understand ethical issues in research and apply principles of intellectual property rights, patents, copyright, and plagiarism prevention.	PO6	PSO9, PSO10	An, Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Overview of Research Methodology: Research concepts – meaning – objectives – motivation – types of research – criteria for good research – significance of research – interaction between academic institutions, industrial and research establishments. Research Formulation: Identifying a research problem – literature review – identification of research gap – formulation of research objectives and research questions – confirming a research problem based on the literature review.

MODULE II

Research Design and Planning: Need for research design – features of good research design – types of research designs (exploratory, descriptive, analytical, experimental) – development of research proposal – ethical clearance procedures. Analyse: Analysis of selected research papers to understand formulation of research methods – analytical and experimental methods used – comparison with previous works – identification of novelty and contribution.

MODULE III

Data Collection and Analysis: Sources of data – primary, secondary and tertiary – methods of data collection – sampling methods (probability and non-probability sampling). Data Processing and Statistical Analysis: Editing – coding – classification – tabulation – graphical representation – descriptive statistics – inferential statistics (t-test, ANOVA, chi-square). Hypothesis: Meaning and importance – types of hypothesis – development of working hypothesis – testing of hypothesis.

MODULE IV

Publication Ethics- definition, introduction and importance. Best Practices/Standards Setting, Initiatives & Guidelines: COPE, WAME, Conflict of Interest; Publication Misconduct Violation of Publication Ethics, Authorship and Contributorship; Identification of Publication Misconduct, Complaints & Appeals Predatory Publishers & Journals.

MODULE V

Scientific Conduct and Misconduct: Ethics with respect to science and research – scientific misconducts – falsification – fabrication – plagiarism – selective reporting – misinterpretation of data – predatory publishers and journals. Open Access and Research Visibility: Open access publications and initiatives

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MODULE VI

Research Ethics and Intellectual Property Rights: Ethical issues in research – environmental impacts – informed consent – data privacy and confidentiality. Intellectual Property Rights: Patents – types of patents – legal formalities in filing a patent in India – copyright – copyleft – open access – reproduction of published material – royalty – plagiarism and how to avoid plagiarism – citation and acknowledgement practices.

LEARNING RESOURCES

References

- Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.
- R. Paneersalvam, "Research Methodology",Prentice Hall of India Pvt. Ltd., 2011.
- Mike Martin, Roland Schinzinger, "Ethics in Engineering" ,McGraw Hill Education, Fourth Edition, 2014.
- Vinod Chandra S S, Anand H S - "Research Methodology", Pearson Education, Chennai, 2017.

Semester: 3	Course Code: CIC-CC-632	Credits: 8

DISSERTATION PHASE I

Preamble: Dissertation Phase I is a significant part of the industry/research-based academic program designed to enable students to develop and refine their research ideas and formulate a comprehensive research proposal. This course provides students with the necessary skills, knowledge, and guidance to plan, execute, and report on a substantial project work in their field of study. Students engage in extensive literature review, identify research gaps, and establish a solid theoretical framework to guide their project work

Prerequisite: Image Processing, Computer Vision, Programming.Skills

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Identify a research problem which is significant in the area of computer science	PO 1	PSO2, PSO7	An, Ap	C, P
CO2	Analyze the literature survey in the selected topic as an individual	PO 2	PSO5	An	C, P
CO3	Design the experiment with proper hypothesis	PO 4	PSO12	Ap	C, P
CO4	Evaluate and interpret the experimental results.	PO 5	PSO8, PSO5	An	P
CO5	Analyze effectiveness of the method based on quantitative and qualitative methods.	PO 3	PSO7, PSO9	Ap	C

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

The evaluation is based on the given weightages
Viva (10), Presentation (20), Method (30) and Content (40) as Evaluated by the supervisor).

First Evaluation
Assessment is based on Identification of Problem Domain, Literature (Study of existing systems), Analysis of feasibility, Detailed synopsis. Objectives and Methodology of Project Proposal, Appropriate and justified design methodology, Project plan. Presentation skills, Performance in Viva.

Second Evaluation
Assessment is based on content and methodology, Demonstration of the model, presentationand performance in viva.

Submission of the Dissertation Phase-I report
The dissertation preliminary report should contain the project background, analysis, extensive literature analysis, Design of the Research Proposal/ Proposed Method and implementation plan.

Semester: 3	Course Code: CIC-DE -633(i)	Credits: 4

SWARM INTELLIGENCE

Preamble: Swarm Intelligence is an advanced course that explores the principles, algorithms, and applications of collective intelligence in natural and artificial systems inspired by social insects and animal swarms. This course provides students with a deep understanding of the fundamental concepts underlying swarm intelligence, including self-organization, decentralized control, and emergent behaviour. Students will explore various swarm-based optimization algorithms, such as ant colony optimization and particle swarm optimization, and their applications in solving complex optimization problems

Prerequisite: Linear Algebra, Algorithms and Data Structures

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Describe about bio inspired computing fundamentals.	PO1 PO4	PSO5 PSO9	Ap	F
CO2	Explain about optimization problems and its types.	PO1 PO5	PSO1 PSO5	Ap	C, P
CO3	Familiar with swarm based algorithm and its applications.	PO1 PO3	PSO5 PSO10	U, Ap	C, P
CO4	Compare different Ant Colony Optimization algorithmic models.	PO1 PO5	PSO5 PSO8	Ap	C ,P
CO5	Compare different Artificial Bee Colony Optimization algorithmic models.	PO1 PO5	PSO5 PSO8	App	P, M
CO6	Illustrate Particle swam optimization algorithm with an example.	PO1 PO5	PSO1 PSO5	Ap, An, Ev	P, C
CO7	Compare different natural inspired computing algorithms.	PO1 PO4	PSO5 PSO9	An	P
CO8	Explain about optimization problems and its types.	PO1 PO5	PSO1 PSO5	Ap, Ev	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Models of Life and Intelligence: Fundamentals of bio-inspired models and bio-inspired computing. Evolutionary models and techniques, Swarm models and its self-organisation, swarm and evolutionary algorithms. Optimisation problems – single and multi-objective optimisation, heuristic, meta-heuristic and hyper heuristic functions.

MODULE II

Ant Colony Optimization (ACO): Theoretical Considerations, Combinatorial optimization and meta heuristic, Stigmergy, Convergence Proofs, ACO Algorithm, ACO and Model Based Search, Variations of ACO: Elitist Ant System (EAS), Minmax

Ant System (MMAS) and Rank Based Ant Colony System (RANKAS), ACO Algorithm for Travelling Sales Person problem, ACO algorithm for feature selection.

MODULE III

Particle Swarm Optimization (PSO): Principles of Bird Flocking and Fish Schooling, Evolution of PSO, Operating Principles, PSO Algorithm, Neighbourhood Topologies, Convergence Criteria, Variations of PSO

MODULE IV

Artificial Bee Colony (ABC) Optimization: Behaviour of real bees, ABC Algorithm, Variations of ABC, Case Study: Application of ABC algorithm in solving Travelling Salesman Problem, Knapsack Problem and for feature selection.

MODULE V

Selected swarm NIOs: Glow-worm Swarm optimization, Termite colony optimization, African Buffalo optimization, Herding Behaviour of Krill Swarms, Lagrangian Model of Krill Herding, wild dog optimization, Fire Fly Algorithm

MODULE VI

Applications: Population Based Meta-heuristics, Swarm robots, Swarm localization and display, Swarm Optimisation in Database Warehouse, Ant System for JSSP, Multi-objective Bin Packing Problem Using PSO, GSO for Obstacle Avoidance, Single Machine Scheduling with Due-dates, Multi-robot path planning

LEARNING RESOURCES

References

- Albert Y.Zomaya - "Handbook of Nature-Inspired and Innovative Computing", Springer, 2006
- Floreano, D. and C. Mattiussi -"Bio-Inspired Artificial Intelligence: Theories, Methods,and Technologies", MIT Press, 2008
- Leandro Nunes de Castro - " Fundamentals of Natural Computing, Basic Concepts,Algorithms and Applications", Chapman & Hall/ CRC, Taylor and Francis Group, 2007
- Marco Dorrigo, Thomas Stutzle -" Ant Colony Optimization", Prentice Hall of India, New Delhi, 2005
- Vinod Chandra S S, Anand H S - "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020

Semester: 3	Course Code: CIC-DE -633(ii)	Credits: 4

APPLICATIONS OF IMAGE PROCESSING

Preamble: Objectives of this course is imparting knowledge in various application areas of image processing which includes Medical Image Processing, Remote sensing Principles, Video Surveillance, Vehicle Tracking and Recognition, Biometric applications, vision and Robotics. This course will help to improve the skills of students to analyse developments of current and future research in many areas of image processing

Prerequisite: Image Processing

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the application areas of image processing	PO1, PO5	PSO1 PSO10	U, Ap	F,P
CO2	Discuss methods used to enhance and extract useful information from the medical images and biometric systems	PO1, PO6	PSO5 PSO10	Ap	P
CO3	Apply biological signals in diagnosis, patient monitoring, and physiological investigation	PO1, PO6	PSO5 PSO10	Ap	P
CO4	Understand Computer interpretation of remote sensing image data to process images	PO1, PO5	PSO5 PSO10	U, Cr	
CO5	Familiarize different image representations, geometric image enhancement techniques, image restoration and edge detection, segmentation and registration	PO1, PO4	PSO5 PSO8	U,Ap	F, P
CO6	Understand video surveillance and pedestrian tracking	PO1, PO6	PSO6 PSO8	U,Ap	F, P
CO7	Impart the knowledge to recognize humans and describe activities from information acquired by video cameras	PO1, PO5	PSO6 PSO11	U, Ap	C,P
CO8	Discuss moving objects tracking by estimating positions over time	PO1, PO4	PSO6 PSO8	U, Ap	C,P
CO9	Understand low level vision functions such as sensing and Preprocessing for Robotics	PO1, PO5	PSO5 PSO6	U,Cr	P,M
CO10	Apply high level vision functions to emulate cognition	PO1, PO5	PSO7 PSO11	U, Cr	P,M

COURSE CONTENT

MODULE I

Medical Image Processing: Introduction to medical imaging, brief history, importance, applications, trends, challenges, Formats - DICOM, Radiology Information Systems

(RIS) and Hospital Information Systems (HIS), Medical Image Registration: Introduction, Intensity- based methods, Clinical applications of Image registration

MODULE II

Principles of Remote Sensing– Remote sensing system Classification, Extraction of metric information from remotely sensed images, Integration of Geographic Information Systems and Remote Sensing. Introduction to Advanced Satellite Imaging techniques – PanchromaticImage- Hyperspectral Imagery - Multispectral Imagery- Satellite Image fusion- Qualitative image assessment metrics

MODULE III

Video Surveillance: Pedestrian detection by boosting local shape features: Tree learning algorithms. Occluded pedestrian detection by part combination. Pedestrian tracking by Associating Detection Responses.

MODULE IV

Vehicle Tracking and Recognition: Joint tracking and Recognition framework, Joint appearance- motion generative model, Inference algorithm for joint tracking and recognition, Human Motion Tracking: Image feature representation, Dimension reduction and Movement dynamics learning. Human action recognition: Discriminative Gaussian Process dynamic model Behaviour of real bees, ABC Algorithm, Variations of ABC, Case Study: Application of ABC algorithm in solving Travelling Salesman Problem, Knapsack Problem and for feature selection.

MODULE V

Biometric: Fingerprint Recognition, Fingerprint as a biometric, Fingerprint Sensing, fingerprint features, Feature extraction, feature enhancement, fingerprint classification, Fingerprint matching, Face Detection, feature template, matching, Iris recognition-Iris segmentation- active contours, Fourier-base Trigonometry and Correction - Detecting and Excluding Eyelashes, Tongue print

MODULE VI

Vision and robotics: Low level vision, image acquisition, imaging geometry, basic transformation, perspective transformation, camera model, camera calibration, stereo imaging, Higher Level vision, Segmentation, Edge linking and boundary detection, Use of motion, Description, Segmentation and Description of three-dimensional Structures, recognition, Interpretation

LEARNING RESOURCES

References

- Rangayyan, Rangaraj M. Biomedical image analysis. CRC press, 2004.

- Bankman I.N. "Hand book of Medical Imaging-Processing and Analysis" , Academic Press
- Bovik A.I. "Handbook of Image and Video processing", Academic Press.
- Jiri Jan, "Medical Image Processing, Reconstruction and Restoration- Concepts and Methods", CRC Tayler & Francis, 2006.
- L. Landini, V. Positano, M.L. Santarelli, "Advanced Image Processing in Magnetic Resonance Imaging", CRC Tayler & Francis, 2005
- Guide to Biometrics, By: Ruud M.Bolle, Sharath Pankanti, Nalini K. Ratha, AndrewWSenior, Jonathan H. Connell, Springer 2009,
- Biometrics Personal Identification in Networked Society, Jain, Bolle, Pankanti (ed.s)1999,978-0-387-28539-9
- Lillesand, T.M., Kiefer, R.W. and Chapman, J.W., "Remote Sensing and Image Interpretation by", (5th Ed.), John Wiley & Sons, 2007.
- Remote Sensing and Digital Image Processing, Jarocińska, Anna, van der Meer, Freek D.,Springer, 2016.

Semester: 3	Course Code: CIC-DE -633(iii)	Credits: 4

VIDEO PROCESSING

Preamble: Coverage includes spatio-temporal sampling, motion analysis, parametric motion models, motion-compensated filtering, and video processing operations including noise reduction, restoration, super resolution, deinterlacing and video sampling structure conversion, and compression (frame-based and object-based methods). A number of advanced topics will be covered, including video segmentation and layered video representations, watermarking, video streaming, compressed-domain video processing, and so on.

Prerequisite: Image Processing, Computer Vision

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Learn the video representation, and fundamental processing steps.	PO1, PO4	PSO1, PSO10	U	F,C
CO2	To provide deep understanding of two-dimensional, three-dimensional transforms and video processingconcepts	PO1, PO5	PSO2, PSO5	U	F,C
CO3	Understand the Representation of video, principles and methods of motion estimation	PO1, PO5	PSO2, PSO6	U	F,C
CO4	To provide deep understanding of two-dimensional, three-dimensional transforms and video processing concepts	PO1, PO5	PSO2, PSO5	U	F,C
CO5	Know the different enhancement techniques in both spatial and frequency domains.	PO1, PO4	PSO5, PSO8	U	F,C
CO6	To understand the video enhancement and restoration techniques.	PO1, PO6	PSO5, PSO6	U	F,C
CO7	Understand the fundamentals of Image Compression.	PO1, PO4	PSO5, PSO8	U	F,C
CO8	To strengthen the research skills of students in image and video processing	PO1, PO9	PSO8, PSO9	Ap, An	C,P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Basic steps of Video Processing: Analog Video, Digital Video. Principles of color video processing, composite versus component video, Time-Varying Image Formation models Three-Dimensional Motion Models, Geometric Image Formation, Photometric ImageFormation, Sampling of Video signals, Filtering operations.

MODULE II

2-D Motion Detection and Estimation: Regularization theory, Optical computation, Stereo Vision, Optical flow, General Methodologies, Pixel Based Motion Estimation, Block-MatchingAlgorithm, Mesh based Motion Estimation, Global Motion Estimation,

MODULE III

Region based Motion Estimation, Multi resolution motion estimation, Waveform based coding, Block based transform coding, Predictive coding, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation, Structure from motion, Motion Tracking in Video.

MODULE IV

Video Enhancement and Restoration- Video Quality Assessment- Restoration- Super-resolution *Video Sampling and Interpolation* : Basic Linear Filtering with Applications to Image Enhancement-Computational Models of Early Human Vision- Motion Detection andEstimation- Optical Flow Methods- Motion Compensated Filtering.

MODULE V

Video Segmentation- Motion Segmentation-Tracking- Motion Tracking in Video - 2D and 3D Motion Tracking in Digital Video- Methods using Point Correspondences-Optical Flow and Direct Methods-Optimization- Pel-Recursive Methods- Bayesian Methods.

MODULE VI

Application of motion estimation in Video coding: Content dependent video coding and Joint shape and texture coding, MPEGs and H.26x standards- Video Stabilization and Mosaicing- A Unified Framework for Video Indexing, Summarization, Browsing and Retrieval- Video Surveillance

LEARNING RESOURCES

- Wang, Y., Ostermann, J., & Zhang, Y. Q. (2002). *Video processing and communications* (Vol. 1, pp. 241-248). Upper Saddle River: Prentice hall.
- M. Tekalp, "Digital Video Processing", Prentice Hall International.
- Bovik, A. C. (2010). *Handbook of image and video processing*. Academic press.
- Bovik, Alan C. *The essential guide to video processing*. Academic Press, 2009.

  Szeliski, Richard. *Computer vision: algorithms and applications*. Springer Nature, 2022.

Semester: 3	Course Code: CIC-DE -633(iv)	Credits: 4

VISUAL COGNITIVE SCIENCE

Preamble: Visual cognition refers to decision-based scene analyses that combine prior knowledge with retinal input to generate representations. Visual Cognition course is devoted to research at the interface of visual perception and cognition, and studies may address any aspect of visual cognition such as object, face, and scene perception; visual attention; visual memory and visual imagery; visual word recognition and reading; eye movement control. Image processing techniques play a significant role in understanding and studying visual Cognition

Prerequisite: Image processing, Computer vision

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Analyze the importance of mental imagery in visual cognition	P01 P04	PS01 PS09	An	C,P
CO2	Illustrate the process of eye tracking and gaze detection	P01 P02	PS02 PS06	U, Ap	C,P
CO3	Evaluate the impact of color models on visual perception	P01 P05	PS02 PS05	E, An	C,P
CO4	Explain the methods of object recognition	P01 P05	PS05 PS06	U	F,C
CO5	Analyze the relation between visual attention, emotions and color perception	P01 P03	PS02 PS09	An	C,P
CO6	Apply Neuroimaging techniques including fMRI, EEG in visual cognition	P01 P09	PS09 PS011	Ap	C,P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction to Visual Cognitive Science- What is the importance of visual cognition? Visual Perception- Sensation vs. perception -Visual sensory systems and their organization- Gestaltprinciples of perceptual organization -Depth perception and visual illusions

MODULE II

Attention and Visual Search - Selective attention mechanisms - Attentional spotlight and visual search paradigms - Feature-based and object-based attention - Artists as Experts in Visual Cognition: An Update, Can you tell the difference: Is it man-made or AI-made art? – Crowding "Visual crowding: a fundamental limit on conscious perception and object recognition"

MODULE III

Object Recognition - Bottom-up and top-down processes in object recognition - Theories of object recognition (e.g., template matching, feature-based models) - Face perception and face recognition - From Visual Cognition to Social Cognition – Biological motion- Face, Object andScene Perception

MODULE IV

Theories of visual cognition- Importance of mental imagery in visual cognition- Visual Imagery and Mental Representations - Nature and functions of mental imagery - Cognitive and neural mechanisms of visual imagery -Relationship between perception and imagery

MODULE V

Applied Visual Cognitive Science - Computer vision and image recognition- Visual Perception to Attention - Eye Tracking and Gaze detection- Neuroimaging techniques (e.g., fMRI, EEG) in visual cognition research, Cognitive Aspects of Color Perception- Color preferences and their cognitive basis - Color Models- Color and Visual Attention- Color- emotion associations and their cognitive basis

MODULE VI

Applications: Image Segmentation - scene perception- semantic segmentation, Visual Attention Analysis- Analyse eye tracking to find the ROI in a scene, Visual Search and Target Detection - target saliency, feature integration, and attentional guidance

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LEARNING RESOURCES

References

- Cavanagh, P. (2011). Visual cognition.V ision research, 51(13), 1538-1551.
- Goldstein, E. B., &Brockmole, J. R. (2017). Sensation and perception (10th ed.). CengageLearning.
- Palmer, S. E. (1999). Vision science: Photons to phenomenology. MIT Press.
- Itti, L., & Koch, C. (2001). Computational modelling of visual attention. Nature ReviewsNeuroscience, 2(3), 194-203.
- Riesenhuber, M., &Poggio, T. (1999). Hierarchical models of object recognition in cortex.Nature Neuroscience, 2(11), 1019-1025

Semester: 3	Course Code: CIC-DE-633(v)	Credits: 4

IMAGE AND DATA COMPRESSION

Preamble: This course covers lossless and lossy compression methods, including statistical coding, dictionary-based techniques, and quantization. It also examines modern approaches like vector quantization, wavelet-based compression, and JPEG standards, providing students with both theoretical knowledge and practical skills for designing efficient compression systems for multimedia communication and data storage.

Prerequisite: Basic knowledge of Probability and statistics, Linear algebra, Digital image fundamentals and programming skills.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain the fundamental concepts of data compression, including redundancy, entropy, and coding principles.	PO1	PSO1, PSO5	U, Ap	F, C
CO2	Analyze and implement statistical coding techniques such as Huffman coding, adaptive Huffman coding, arithmetic coding, and run-length coding.	PO1	PSO5, PSO8	U, An	C, P
CO3	Apply dictionary-based compression methods including LZ77, LZ78, and Lempel–Ziv–Welch (LZW) algorithms.	PO2	PSO5, PSO10	An, Ap	C, P
CO4	Understand context-based compression techniques such as Prediction by Partial Matching (PPM) and Burrows–Wheeler Transform (BWT).	PO6	PSO5, PSO8	U, Ap	C
CO5	Analyze scalar and vector quantization methods including Lloyd–Max quantizer and vector quantization algorithms such as LBG and tree-structured VQ.	PO4	PSO2, PSO5	An, Ap	C, M
CO6	Examine lossless and lossy image compression techniques including JPEG, wavelet compression, differential predictive coding, and fractal compression	PO6	PSO4, PSO10, PSO11	An, Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Fundamentals of Data Compression: Introduction to compression – Need for compression – Applications in multimedia systems – Compression techniques – Lossless and lossy compression – Compression model – Modeling and coding principles. Mathematical preliminaries for lossless compression – Basics of information theory – Entropy – Redundancy – Uniquely decodable codes – Prefix codes – Kraft–McMillan inequality.

MODULE II

Statistical Coding Techniques: Huffman coding – Construction of Huffman trees – Adaptive Huffman coding – Arithmetic coding – Coding of sequences – Generation of binary codes – Run-length coding and its applications.

MODULE II

Dictionary-Based Compression Techniques: Static dictionary methods – Digram coding – Adaptive dictionary techniques – LZ family algorithms: LZ77 – LZ78 – Lempel–Ziv–Welch (LZW) algorithm – Performance considerations and practical implementations.

MODULE IV

Context-Based Compression Methods: Context modeling and prediction – Prediction by Partial Matching (PPM) – Burrows–Wheeler Transform (BWT) – Context based compression frameworks – Applications in text and image data compression.

MODULE V

Quantization Techniques for Compression: Quantization problem and rate–distortion considerations – Scalar quantization – Uniform quantizer – Lloyd–Max quantizer – Vector quantization – Codebook design – Linde–Buzo–Gray (LBG) algorithm – Tree structured vector quantization – Structured vector quantization.

MODULE VI

Image Compression Techniques: Image compression models – Lossless image compression methods – Huffman coding – Run-length coding – LZW coding – Arithmetic coding. Lossy image compression – Block truncation coding – Differential predictive coding – Wavelet-based compression – Model-based compression – Fractal compression – JPEG compression standard.

LEARNING RESOURCES

References

- Alistair Moffat, Andrew Turpin, "Compression and Coding Algorithms", Kluwer Academic Publishers, 1st Ed., 2002.
- David Salomon, "Data Compression – The Complete Reference", Springer, 4th Ed., 2006.
- John Miano, "Compressed Image File Formats", Addison Wesley Professional, 1st Ed., 1999.
- Khalid Sayood, "Introduction to Data Compression", Morgan Kaufmann Publishers, 4th Ed., 2012.
- Mark Nelson, Jean-Loup Gailly, "The Data Compression Book", John Wiley & Sons, 2nd Ed., 1995.
- Peter Wayner, "Compression Algorithms for Real Programmers", Morgan Kaufmann, 1st Ed., 1999.
- Scott E Umbaugh, "Digital Image Processing and Analysis", CRC Press, Third Edition, 2018.
- Vasudev Bhaskaran, Konstantinos Konstantinides, "Image and Video Compression Standards", Kluwer Academic Publishers, 2nd Ed., 2003.

Semester: 3	Course Code: CIC-DE-633(vi)	Credits: 4

LARGE LANGUAGE MODELS: THEORY AND PRACTICE

Preamble: Large Language Models (LLMs) have revolutionized the field of Natural Language Processing by probing machines to understand, generate, and reason with human language at unprecedented scales. The course provides a comprehensive introduction to the theoretical foundations and practical implementations of LLMs, covering topics from classical language modeling to modern transformer-based architectures. Students will explore representation learning, generative modeling, prompt engineering, agent-based AI systems, and real-world applications such as question answering, summarization, and code generation.

Prerequisite: Machine Learning Models: Theory and Practices, Unstructured Data Analytics, Natural Language Understanding, Deep Learning and Transformers

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain the fundamental concepts of language modeling, including statistical and neural approaches	PO1	PSO1	U	C
CO2	Analyze transformer architectures and training methodologies used in large language models.	PO1	PSO7	An	C
CO3	Apply pre-training, fine-tuning, and alignment techniques for building LLM-based solutions.	PO5	PSO11	Ap	P
CO4	Design effective prompt engineering strategies for solving complex language tasks.	PO5	PSO4	An, Ap	C, P
CO5	Develop LLM-based applications using tools, APIs, and frameworks such as Hugging Face and LangChain.	PO4	PSO10	Ap	P
CO6	Analyze and implement agent-based LLM systems with task decomposition and evaluation strategies.	PO1	PSO12	An, Ap	C, P
CO7	Evaluate the performance and limitations of LLM-based systems across various real-world use cases.	PO6	PSO8	E	C, M

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Foundations of Language Modelling: Concept of language modelling, Natural Language as Sequential and Contextual Data, Statistical Language Models (N-gram concept, sparsity problem), Word Representation Evolution: One-hot encoding, Distributed Representations (Word2Vec, GloVe)- Contextual Embeddings, Limitations of Traditional NLP Pipelines.

MODULE II

Concept of Self-Attention and Context Window: Transformer Paradigm, Pre-training and Transfer Learning in Language, Decoder-only Transformers, Training LLMs, Fine-tuning LLMs , Aligning LLMs with the World (RLHF, instruction tuning), Prompting LLMs.

MODULE III

An Introduction to Generative Models **:** Text Classification, Text Clustering and Topic Modeling. Text Embedding Models and Representation Learning- Pre-Training Strategies, ELMo, BERT,

Encoder-only Model, Encoder-decoder and Decoder-only Models. Introduction to HuggingFace ecosystem.

MODULE IV

Prompt Engineering: General prompt design, In-context learning, Prompt engineering strategies, Chain of Thought, Problem Decomposition, Self-refinement, Ensembling, Retrieval Augmented Generation (RAG) and Tool use.

MODULE V

Agent-based LLM: Degrees of autonomy in AI systems, benefits of agentic AI, applications of agentic AI. Task decomposition. Evaluating agentic AI, Agentic design patterns, Reflection Design Pattern, Agent development framework with LangChain.

MODULE VI

Use Cases: Applications of LLMs, Question Answering (QA) system using pretrained models, sentiment classification using BERT, Encoder-decoder models for summarization pipeline of long documents, Retrieval-based QA systems, Code Generation from natural language prompts, Application development through API integration.

LEARNING RESOURCES

References

- Xiao, T., Zhu, J., Foundations of Large Language Models, arXiv preprint arXiv:2501.09223
- Chakraborty, T., Introduction to Large Language Models: Generative AI for Text, 1st Edition, Wiley India Pvt. Ltd., New Delhi, 2025
- Jurafsky, D., Martin, J. H., Speech and Language Processing, Pearson, 3rd Edition
- Vaswani, A. et al., Attention Is All You Need, NeurIPS, 2017.

Online Resources

- https://readwise-assets.s3.amazonaws.com/media/wisereads/articles/foundations-of-large-language-/2501.09223v1.pdf
- Hugging Face Transformers- https://huggingface.co/docs/transformers
- https://www.philschmid.de/huggingface-transformers-examples

Semester: 3	Course Code: CIC-SE-635	Credits: 2

CYBER ETHICS

Preamble: This course aims to equip students with a comprehensive understanding of ethical principles, legal frameworks, and responsible practices in the digital domain. As computing technologies increasingly influence every aspect of society, it becomes essential for professionals to address issues related to privacy, data security, intellectual property, and responsible use of information systems. Students learn the concepts of data privacy, cybersecurity, and common cyber threats, as well as they develop an awareness of intellectual property, digital content management, and legal frameworks.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain fundamentals of cyber ethics, ethical theories, and social impacts of digital technologies.	PO1, PO6	PSO1, PSO12	U	F, C
CO2	Analyze intellectual property, copyright, software ethics, and ethical management of digital content.	PO1, PO6	PSO10, PSO11	U, Aa	C, P
CO3	Understand principles of digital privacy, data protection, and ethical governance in computing systems.	PO1, PO6	PSO10, PSO12	U	C, P
CO4	Identify cyber crimes, security threats, and ethical responsibilities in cybersecurity and prevention	PO1, PO6	PSO5, PSO10	U	F, P
CO5	Evaluate social, organizational, and professional ethical issues in cyberspace and IT practices.	PO1, PO2	PSO10, PSO12	E	C, P
CO6	Understand cyber law, policies, and emerging ethical challenges in technologies like AI, blockchain, and cloud computing.	PO1, PO6	PSO10, PSO11	U	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Foundations of Cyber Ethics: Introduction to cyber ethics, evolution of cyber ethics in the digital society, need and importance of cyber ethics in advanced computing environments, ethical theories and principles in computing, moral responsibility in cyberspace, ethical decision-making in information systems, social and cultural impacts of digital technologies.

MODULE II

Intellectual Property Rights and Digital Content Ethics: Concept of intellectual property rights in cyberspace, copyright, patents and trademarks in digital environments, ethical and legal issues in software development, open source and proprietary software ethics, plagiarism and academic integrity, licensing models, ethical management of digital content and research data.

MODULE III

Privacy, Data Protection and Information Governance: Concept of digital privacy and confidentiality, ethical issues in data collection and data mining, data ownership and consent, privacy preserving techniques, data protection policies and governance frameworks, ethical implications of big data analytics and artificial intelligence, user trust and transparency in digital systems.

MODULE IV

Cyber Crimes, Security and Ethical Responsibilities: Overview of cyber crimes, hacking, identity theft, phishing, ransomware and cyber terrorism, ethical issues in cybersecurity practices, vulnerability assessment and responsible disclosure, ethical hacking principles, cybercrime investigation and prevention strategies, legal implications of cyber attacks.

MODULE V

Social, Organizational and Professional Ethics in Cyberspace: Ethical issues in social media platforms, digital communication ethics, cyber bullying and online harassment, misinformation and fake news, digital divide and social responsibility of technology developers, professional ethics in information technology, ethical responsibilities of IT professionals and researchers.

MODULE VI

Cyber Law, Policy and Emerging Ethical Issues : Overview of cyber law and global regulatory frameworks, introduction to Information Technology Act, 2000, digital governance and compliance, legal responsibilities of organizations handling digital data, ethical issues in emerging technologies such as cloud computing, artificial intelligence and blockchain, future challenges in cyber ethics and policy development.

Learning Resources

References

- R. A. Spinello, *Cyber Ethics: Morality and Law in Cyberspace*, 5th ed. Burlington, MA, USA: Jones & Bartlett Learning, 2013.
- M. J. Quinn, *Ethics for the Information Age*, 7th ed. Boston, MA, USA: Pearson, 2017.
- D. G. Johnson, *Computer Ethics*, 4th ed. Boston, MA, USA: Pearson, 2018.
- B. Barkha and U. Rama Mohan, *Cyber Law and Cyber Crimes*, 2nd ed. New Delhi, India: Bharat Law House, 2019.
- G. Reynolds, *Ethics in Information Technology*, 6th ed. Boston, MA, USA: Cengage Learning, 2020.
- C. Ess, *Understanding Cyber Ethics: From Theory to Practice*, Abingdon, UK: Routledge, 2017
- W. J. Freitas, *Ethics in a Computing Culture*, Boston, MA, USA: Cengage Learning, 2019.
- Government of India, *Information Technology Act, 2000*, New Delhi, India: Ministry of Electronics & Information Technology. [Online]. Available: https://www.meity.gov.in/content/information-technology-act-2000

Semester: 3	Course Code: CIC-SE-636	Credits: 2

MASSIVE ONLINE OPEN COURSE (MOOC)

Preamble: MOOCs enable access to quality education for as many students as possible andcontribute to the continuous education of various social groups. MOOCs help the students to develop the skills needed for employability.

Prerequisite: Nil

COURSE CONTENT

Massive Open Online Courses (MOOCs) are free online courses for anyone to enroll. MOOCs provide an affordable and flexible way to learn new skills, advance students' career and deliver quality educational experiences at scale. Millions of people worldwide use MOOCs tolearn for various reasons, including career development, changing careers, college preparations, supplemental learning, lifelong learning, corporate eLearning and training, and more. For instance, SWAYAM provides an integrated platform for online courses, using Information and Communication Technology (ICT) and covering courses for post-graduate subjects, including skill sector courses, to ensure that every student benefits from learning material through ICT.

The Department Council will announce the sources of MOOC at the time of beginning of each Semester. Students can choose their course from MOOC as per their choice and informthe course coordinator before they join. Each student must submit a report on what MOOC has completed during their M.Tech programme to complete their Semester III.

Learning Resources

Online Resources
https://www.ugc.gov.in/pdfnews/8449573_Intruction-Manual.pdf

Semester: 4	Course Code: CIC-CC-641	Credits 10

DISSERTATION

Preamble: The Dissertation and Viva course is an advanced-level course designed to providestudents with an opportunity to undertake independent research in their chosen field of study. This course is typically offered at the postgraduate level and serves as a culminating experience for students to demonstrate their research skills, critical thinking abilities, and in-depth understanding of a specific research topic. The Dissertation and Viva Voce course is designed to guide students through the process of conducting independent research and presenting their findings in the form of a dissertation.

The objectives of this course are to

- Develop advanced research skills
- Foster critical thinking and analytical abilities
- Enhance academic writing and presentation skills

Demonstrate subject matter expertise by applying the concepts learned from curriculum Develop the skillset to build a research/industry project.

Prerequisite: Dissertation Phase I

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Identify a specific area for Dissertation and Prepare Preliminary study on the topic and give a presentationon it.	PO2	PSO 4 PSO7	U,A	C,P
CO2	Investigate the related and recent works in the area ofdissertation	PO5	PSO4	U,A	C,P
CO3	Apply critical thinking and design new strategies forthe work	PO3	PSO2	An	C,P
CO4	Propose a new algorithm in the area of study	PO2	PSO4	Ap,Cr	P, M
CO5	Implement and analyze the performance of the proposed method.	PO6	PSO4	An	P,C
CO6	Demonstrate the competence of drafting a researchpaper	PO2	PSO7	An,Ap	P,C,M

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

The dissertation provides an opportunity for the students to work on real-world problems. The candidates are required to work on a research/industry project for the Dissertation Course. This course is an extension of the research work done for the Dissertation Phase I.

COURSE CONTENT

The goal of M.Tech Computer Science (with specialization in Digital Image Computing) dissertation is to

- Strengthen their Background, technical and domain knowledge and sharpen their skills so that students have better career/placement opportunities.
- The dissertation work preferably should be a research/industrial project with innovativeideas/research preferably with respect to the solution for the current problems.
- The phases of the dissertation include conceptualization of the topic, writing research/industrial project proposal, research, analysis, implementation and dissertation.
- Students must do their projects under the supervision of a faculty that is allotted by the Department Council. The second stage should be the extension of the first Phase Dissertation.
- Evaluation procedure Evaluation of each stage of the project is done in 3 reviews – First,Interim and Final reviews. In each semester, the project is evaluated by the project supervisor and the M.Tech Committee (Internal Evaluation Committee)
- Out of the total marks for the project work, 40% marks shall be allotted for Internal Evaluation and 60% of marks for the End Semester Presentation and Viva. The End Semester Examination of the project work shall be conducted by the same committee appointed for the industry-oriented project. In addition, the project supervisor shall alsobe included in the committee. The topics for industry-oriented project work shall be different from one another. The evaluation of project work shall be made at the end of Semester IV. The Internal Evaluation shall be based on three evaluations of the project topic. All students must attend a course viva of the programme at the end of project work. All students will be evaluated by a panel of experts on their knowledge of different courses in the program, and the final dissertation work. There will be an evaluation of their professional development acquired by the programme.

ASSESSMENT

Assessment of the dissertation course is conducted based on following criteria.

First Review (Internal)

Project Synopsis/ Proposal Evaluation

Assessment is done based on Identification of Problem Domain, Literature (Study of existing systems), Analysis of feasibility, Detailed synopsis. Objectives and Methodology of Project Proposal, Appropriate and justified design methodology, Project plan. Presentation skills, performance in viva.

Second Review (Internal)

rogress evaluation/ Implementation

Assessment is done based on Demonstration of project, presentation skills, performance inviva. Incorporation of suggestions, progress.

Final review (External)

Evaluation of project Completion, Demonstration, Report – Thesis Evaluation
Assessment is done based on Incorporation of suggestions, progress- Level of completion, Outcome linked with proposed objectives. Report - Definition of project scope and goals, Literature survey, Presentation of methods, Analysis and Results, References to relevant and recent scientific publications, Overall organization of the Report/thesis.

There will be a viva-voce as a part of the final review at the end of the Dissertation and viva course. The students are required to submit Hard bound copies of the thesis during the external evaluation for Dissertation.
The publication as part of the M.Tech Dissertation will be given due credit for assessment based on the decision of the Department Council.

Semester: 4	Course Code: CIC-CC-643	Credits: 2

INDUSTRY INTERNSHIP

Preamble: The Internship course provides students with the opportunity to intern in the professional setting of a company, and help develop their abilities as a professional.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Apply classroom and laboratory concepts and principles in an industry work environment.	PO1	PSO12	U, Ap	C,P
CO2	Establish goals by working with supervision to define work objectives for the internship experience	PO1	PSO12	An,Ap	C, P
CO3	Demonstrate time and project management skills by completing the work objectives within the specified time limits	PO4	PSO12	An	P
CO4	Demonstrate the ability to work as a team member to successfully complete the assigned work objectives in an assigned company work group.	PO2	PSO12	An, Ap	P
CO5	Demonstrate the ability to effectively present ideas and solutions in the context of written, oral, and electronic media. And promote work ethics	PO2	PSO9	U, An, Ap	C, P
CO6	Demonstrate and promote a proper work ethic.	PO6	PSO9	U, Ap	P

COURSE CONTENT

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements focused on particular tasks or projects with defined timescales. An internship may be compensated, non-compensated, or sometimes may be paid. The internship has to be meaningful and mutually beneficial to the intern and the organization. The internship program's objectives and activities must be clearly defined and understood. The following are the intended objectives of internship training:

- Will expose students to the industrial environment, which cannot be simulated in the classroom, creating competent professionals for the industry.
- Provide possible opportunities to learn, understand and sharpen the real-time technical/managerial skills required on the job.
- Exposure to the current technological developments relevant to the subject area of training.

- Experience gained from the 'Industrial Internship' in the classroom will be used in classroom discussions.
- Create conditions conducive to the quest for knowledge and its applicability on thejob.

LEARNING RESOURCES

On-line Sources

https://aicte-india.org/sites/default/files/AICTE%20Internship%20Policy.pdf

Semester: 4	Course Code: CIC-CC-644	Credits: 2

PROFESSIONAL GROWTH AND ACHIEVEMENTS

Preamble: The Professional Growth and Achievements is an activity-oriented course designed to promote the holistic development of students beyond the formal academic curriculum. It provides a structured framework for recognizing and rewarding student engagement in co-curricular and extra-curricular domains such as sports, cultural activities, professional development, innovation, and social responsibility.

This course aims to nurture students by encouraging participation in activities that build leadership, teamwork, creativity, ethical awareness, and social commitment. It aligns with the Graduate Attributes of the University by fostering lifelong learning, inclusiveness, and community engagement.

Students are required to accumulate a minimum prescribed activity score through participation and achievements in the given activities before the programme completion. The course emphasizes both participation and excellence, with higher weightage assigned to notable achievements such as awards and research publications.

The course ensures that students actively engage in personal and professional development alongside their academic progression.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Demonstrate active participation in co-curricular and extra-curricular activities contributing to personal and professional development.	PO4	PSO10, PSO11,	Ap	P, M
CO2	Exhibit leadership, teamwork, and interpersonal skills through engagement in sports, cultural, technical, and social initiatives.	PO2	PSO8, PSO11	Ap	C, P
CO3	Develop professional competencies through participation in workshops, training programmes, internships, and innovation activities.	PO5	PSO9, PSO10, PSO11	Ap	P, M
CO4	Apply creativity and critical thinking in cultural, literary, entrepreneurial, and technical activities.	PO1	PSO9, PSO11	An, Ap	C, P
CO5	Demonstrate social responsibility, ethical awareness, and environmental consciousness through community-oriented activities.	PO6	PSO12	Ap	C, P
CO6	Engage in research dissemination activities such as paper presentations and publications, contributing to academic and professional growth.	PO1, PO2	PSO10, PSO11	Ap, Cr	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

CREDIT DISTRIBUTION AND ASSESSMENT

Credits and Assessment

This course carries 2 credits and requires students to earn a minimum of 50 activity points as a mandatory condition for the successful completion. The activity points are awarded based on participation and achievements across approved activity categories such as sports, professional development, innovation, cultural engagement, and social service. All activity points claimed must be supported by valid document evidence and are subject to verification and approval by the departmental committee.

Activity Categories and Credit Distribution

Students may earn points from the following categories:

1. Sports Activities

2. Professional Activities

3. Entrepreneurship / Innovation

4. Cultural & Literary Activities

5. Research & Publication

6. Leadership and Management

7. Social & Environmental Activities

General Rules for Point Allocation

The allocation of activity points shall adhere strictly to the prescribed maximum limits for each category. Duplicate counting of the same activity is not permitted under any circumstances. Only the activities completed within the stipulated programme duration will be considered for evaluation. Students must submit valid supporting documents such as certificates, proof of participation, DOI links, or acceptance letters for publications, which are mandatory for Claiming points. All activities and submitted evidence must be duly verified and approved by the Department Activity Committee before the final allocation of points.

Assessment and Validation Mechanism

Students are required to maintain an Activity Log Book or Portfolio documenting all eligible activities along with supporting evidence. The recorded activities shall undergo periodic verification by the faculty coordinator to ensure authenticity and consistency. The final evaluation of accumulated activity points will be carried out by a Departmental Committee or Panel of Teachers. In cases of ambiguity, discrepancy, or conflict in the allocation of points, the Department Council or the designated panel shall take the final and binding decision.

Students must secure a minimum of 50 activity points to successfully complete the course. Students will be required to earn the deficit points through additional approved activities as prescribed by the department. Submission of false, fabricated, or invalid documents will lead to cancellation of the claimed points and may also result in disciplinary action as per university regulations.

Activity Categories	Sl. No	Activity	Achievement Levels and Assigned Activity Points					** Approval Document	Max. Points	Min. Duration of activity
		*Level	I	II	III	IV	V			
Sports Activities	1	Sports Participation	4	7	12	20	30	a	30	2 Years
		First Prize	5	5	5	10	10	Additional points can be provided for winning. The maximum limit for activity points is 30. But for Level IV and V winning, the maximum point limit is enhanced to 40.		
		Second Prize	4	4	4	8	8			
		Third Prize	2	2	2	6	6			
Cultural and Literary Activities	2	Music Participation	4	6	10	20	30	a	30	2 Years
	3	Performing Arts	4	6	10	20	30	a	30	2 Years
	4	Literary arts	4	6	10	20	30	a	30	2 Years
		First Prize	5	5	5	10	10	Additional points can be provided for winning. The maximum limit for activity points is 30. But for Level IV and V winning, the maximum point limit is enhanced to 40.		
		Second Prize	4	4	4	8	8			
		Third Prize	2	2	2	6	6			
Research and Publications	5	Tech Fest, Tech Quiz	5	10	15	20	25	a	25	2 Years
	6	MOOC with final assessment certificate (NPTEL/SWAYAM)			10					2 Years

	7	Competitions conducted by Professional Societies - (IEEE, IET, CSI, ISTE etc.)	5	7	10	15	20	a	20	2 Years
	8	Attending Full time Conference/ Seminars / Exhibitions/ Workshop/ STTP conducted in offline mode C1- State Level C2- National Level C3- International Level		**C1** 5	**C2** 10	**C3** 15				2 Years
	9	Paper Presentation in Conference/ Seminars conducted in offline mode C1- State Level C2- National Level C3- International Level		**C1** 5	**C2** 10	**C3** 15				2 Years
	10	Poster Presentation in Conference/ Seminars conducted in offline mode C1- State Level C2- National Level C3- International Level	7					a	15	2 Years
	11	Industrial Training/ Internship (atleast for 5 full days)	10					a/b	10	2 Years
		Internship (offline / more than 30 days in MNC approved by DC)	30					a/b	10	2 Years
		Internship Online (more than two weeks)	15					a/b	10	2 Years
	12	Industrial/ Exhibition visits	2					a/b/d	5	2 Years

	13	Foreign Language Skill (TOEFL/ IELTS/ BEC exams etc.)	15			a	25	2 Years
Entrepreneurship and Innovation	15	Start-up Company – Registered legally	20			d	30	2 Years
	16	Patent-Filed	15			d	30	2 Years
	17	Patent - Published	20			d	30	2 Years
	18	Patent- Approved	25			d	30	2 Years
	19	Patent- Licensed	40			d	40	2 Years
	20	Prototype developed and tested	30			d	30	2 Years
	21	Awards for Products developed	30			d	30	2 Years
	22	Innovative technologies developed and used by industries/users	30			d	30	2 Years
	23	Got venture capital funding for innovative ideas/products.	40			d	40	2 Years
	24	Startup Employment (Offering jobs to two persons not less than Rs. 10000/- per month)	40			d	40	2 Years
	25	Societal innovations	25			d	25	2 Years
Leadership & Management			Office Bearers	Executive Members	Committee Members			
	29	Student Professional Societies (IEEE, IET, ISTE, CSI etc.) and Student Associations	15	10	5	d	20	2 Years

Participation in Departmental Activities	30	Participation in Student Association Activities/ Talks/ Hackathons	(Within Department) 5	(Outside Department) 10	(Outside University) 15	a	20	2 Years
	31	Average >= 90% Attendance (Sem I to Sem III) (Only 90% or more attendance will be considered for points.)	10			a	10	2 Years
Social and Environmental Activities	31	Participation Environmental initiatives (cleanliness drives, sustainability projects, (max 2 activities)	**Social initiatives:** 5	10	15			2 Years

*Level I Department Events
*Level II University Events
*Level III State Events
*Level IV National Events
*Level V International Events

**Approval Documents: (a) Certificate (b) Letter from Authorities (c) Appreciation recognition letter (d) Document Evidence (e) Legal Proof

* All activity points shall be gained during programme.