Learning Outcomes-based Curriculum Framework (LOCF) for

Post-Graduate Programme

M. Tech. Computer Science

Specialization in Digital Image Computing

Department of Computer Science

www.keralauniversity.ac.in

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Preamble

The role of higher education, apart from living as the best human, is to direct the learners to their desired objectives, either to the dream job or a world-class higher education avenue. Therefore, the improvement in the quality of higher education deserves to be given top-most priority to enable the young generation of students to acquire skills, training and knowledge. The education institute has to plan sustained initiatives to improve and upgrade the academic resources and learning environments by enhancing the quality of teaching to achieve learning outcomes.

One of the significant reforms in undergraduate 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 LOCF in the country's Colleges and Universities. Accordingly, the University of Kerala has decided to implement the LOCF in all its departments under the auspices of the Internal Quality Assurance Cell (IQAC). A series of teacher training workshops were organised by IQAC and the office of the Credit and Semester System (CSS), and the departments have revised the syllabus accordingly through workshops and in consultation with academic experts in the field.

Graduate Attributes

The Graduate Attributes (GAs) reflect particular qualities and abilities of an individual learner, including knowledge, application of knowledge, professional and life skills, attitudes and human values that are required to be acquired by the graduates of the University of Kerala. The graduate attributes include capabilities to strengthen one's professional abilities for widening current knowledge and industry-ready skills, undertaking future studies for global and local application, performing creatively and professionally in a chosen career and ultimately playing a constructive role as a socially responsible global citizen. The Graduate Attributes define the characteristics of learners and describe a set of competencies that are beyond the study of a particular area and programme.

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 Applied Science and Technology and conducted four Post Graduate programmes alongside with Ph D programme in different disciplines of Computer Science. The department offers an M Tech programme under the faculty of Engineering and Technology and three M Sc programmes under the Faculty of Applied Science and Technology. All the programmes are OBE mode and integrated with industry internships. The department gives at most importance to Research and Development besides regular teaching through knowledge dissemination globally. The department has a good track record of producing highly skilled professionals in Computer Science.

The thrust area of research focused on Image Processing, Pattern Recognition, Nature Inspired Computing, Cyber Security, Computer Vision, Machine Intelligence, High-Performance Computing, Data Mining, and Natural Language Processing. A good number of Ph Ds are awarded from this department in Computer Science, and Engineering. The department has achieved an h-index of 15 (Web of Science) with a consistent publication record. The fellows of the department received the highest impact factor, 13.751 (three times), and published their works in reputed journals. Achievement of an average impactor of 5.012 during the last five years. The alums are well-placed in National Institutes, Central/State Universities, R&D organisations and multi-national companies. Faculty and students received National and International recognition, including awards from Government organisations and best paper awards. The passed-out students are well placed in multi-national companies and other R&D Institutions.

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

The curriculum of M.Tech Computer Science with a specialization in Image Processing is an advanced postgraduate program designed to equip students with a comprehensive understanding of the principles and techniques involved in processing, analyzing and interpreting digital images. This specialization focuses on extracting valuable information from visual data, enabling applications in various domains such as healthcare, entertainment, surveillance, and robotics. Throughout the programme, students concentrate on areas such as image classification, segmentation, pattern recognition, computer vision, and machine learning algorithms specifically tailored for image analysis. They gain expertise in handling large-scale image datasets, designing efficient algorithms for image manipulation, and developing innovative solutions to address real-world challenges in image processing. With this degree, graduates are well-prepared to pursue rewarding careers in industries, research institutions, or academia, where their knowledge and skills in image processing can contribute to advancements in fields like medical imaging, remote sensing, digital forensics, and more. M.Tech in Computer Science with a specialization in Image Processing equips students with a range of engineering skills essential for success in the field. The M.Tech programme is AICTE approved affiliated to Department of Computer Science, University of Kerala.

The scope of Digital Image Computing offers a wide range of exciting opportunities for students aspiring to dive into the world of digital imagery. With the increasing reliance on visual data in various industries, this specialized program equips students with the skills and knowledge needed to tackle complex image analysis challenges. By focusing on topics like image enhancement, feature extraction, and computer vision, students gain a deep understanding of the algorithms and techniques used to process, manipulate, and extract valuable information from digital images. The program also emphasizes machine learning and pattern recognition, empowering students to develop intelligent systems capable of automatically analyzing and interpreting visual data. As an M.Tech graduate in this field, students open doors to diverse career paths in industries such as healthcare, entertainment, robotics, and more. They can work as image processing engineers, computer vision specialists, data scientists, or researchers, contributing to advancements in fields like medical imaging, virtual reality, autonomous vehicles, and artificial intelligence. With the ever-increasing demand for image processing expertise, students can look forward to a promising and rewarding professional journey filled with innovation and impactful contributions to the digital world.

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

- Develop a strong foundation to provide students with a solid understanding of the fundamental concepts and principles of image processing, digital image representation, computer vision techniques, image analysis algorithms, and mathematical models used in image processing.
- Acquire practical skills in image processing techniques by providing hands-on experience in implementing and optimizing image computing techniques using programming languages and software tools.
- Impart the skillset that foster research and innovation in the field of image processing. Students are exposed to current trends and emerging technologies, enabling them to explore new approaches and develop novel solutions to address complex image processing challenges.
- Enhance their critical thinking and problem-solving abilities of the students through practical assignments, projects, and research work. They learn to analyze complex image processing problems, identify suitable algorithms and techniques, and apply them effectively to solve real-world challenges.
- Keep the knowledge domain updated and prepared to be industry-academia ready students. The field of image processing is rapidly evolving, with new techniques and technologies emerging regularly. The program aims to keep students updated with the latest advancements in the field, ensuring they are equipped with the knowledge and skills needed to adapt to changing trends and industry demands.

This programme prepares students for successful careers in industries, research institutions, or academia, where they can contribute to advancements in image processing and its applications.

3. General Information

3.1 Eligibility for Admission

A Bachelor's degree in Engineering / Technology with at least 55% marks in one of the following branches: Computer Science and Engineering / Information Technology / Electronics Engineering / Electrical Engineering from the University of Kerala or equivalent recognized degree of a recognized University or Master's degree in Computer Science / Computer Application 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. Candidates for sponsored seats will also be governed by the 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.

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 normalised 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 of examination. 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. Every taught course shall be assessed through a written end-semester exam of a maximum of 3 hours' duration. As stated in the syllabus, the end-semester exams shall be summative and aimed at attesting to achieving course outcomes.

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 a three-week induction program for first-semester students. It is a unique three-week immersion 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. Foundation Programme also serves as a platform for the freshers to interact with their batch mates and seniors and start working as a team with them. The program is structured around the following five themes:
The programme is designed keeping in mind the following objectives:

- *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 MTech 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	28
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	20	20	18	18	76

Programme Code: CIC

Core Course (CC): Course offered by a Department to the students in their Postgraduate programme, closely 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 of weekly practicals. The laboratory has two levels of programming exercises- basic and advanced. The basic level gives an awareness of the course through programming exercises. At the advanced level, a mini project/case study/advanced programming exercises are given to understand the application level of the course. Evaluation of Mini Project/Case Study/Advanced programming exercises and semester viva is performed by a panel of teachers in the department approved by the Department Council. Laboratory report submission is mandatory for each student and is to be submitted to the faculty in charge of the laboratory.

Skill Enhancement Course (SE): A course that provides value-based or skill-based knowledge should contain theory and lab/ 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 maximum marks allotted for continuous assessment and University examination for each subject are as prescribed by the scheme of study.

Generic Course (GC): An elective course chosen from an unrelated discipline/subject to seek exposure beyond discipline/s. 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 fresh electives from time to time based on the changing academic paradigms related to the course. The maximum marks allotted for continuous assessment and University examination for each subject are as prescribed by the scheme of study.

Extra Departmental Generic Course: An elective course chosen from an unrelated discipline/subject to seek exposure beyond discipline/s to be offered collaboratively by more than one Department/discipline.

MOOC: Massive Open Online Courses (MOOCs) bring knowledge to students in selected disciplines through online platforms. Each student must compulsorily take a minimum of 30 hours' duration MOOC to complete Semester III successfully. The Department council will announce the source of MOOCs from time to time.

Dissertation: Dissertation (Project work) is intended to challenge students' intellectual and innovative abilities. It allows students to synthesise and apply the knowledge and analytical skills learned in the different disciplines. All the students must do a project on a problem with industry or research potential as part of this course. The project work can be done in any of the following - R&D institutions, MNCs - IT companies and departments. At the end of the course, all the students should submit a project report with the details of the work done, findings and suggestions for evaluation. There will be internal and external evaluations of the work.

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. The Department council will select industry/ R&D organisations from the student's choice.

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 pragmatically apply mathematical and computing skills to solve image processing problems.
PSO2	Inculcate advanced technical skills in Image Processing and Machine Learning models that enable students to perform better through their critical and analytical skills.
PSO3	Develop an ability to design, develop and implement advanced algorithms on different image processing applications and solve real-world problems using Artificial Intelligence based methods.
PSO4	Acquire the flair of research by enriching students to undertake research-oriented projects and develop the skillset to work in R&D institutions.
PSO5	Possess insight and good understanding of the selected topics in analyzing, compressing and processing of images and videos.
PSO6	Create competence to specialize in Image Processing, Signal Processing and Computation models, including Machine Learning and Deep learning.
PSO7	Develop the research skills for writing technical and scientific publications and enable them to understand publication ethics.
PSO8	Demonstrates the capability of doing a dissertation in advanced image processing by exploiting cutting-edge technologies.
PSO9	Develop specialized skills in computer vision, speech-based applications that use image analysis, speech recognition and natural language processing
PSO10	Possess the competence to process medical images, analyse cyber crimes and security issues to find solutions and acquire a sense of social commitment.
PSO11	Develop skillset for leading a pathway towards pursuing doctoral programme by acquiring the expertise in image processing domain.
PSO12	Promote and develop the skill set to apply data science and machine learning techniques to solve interdisciplinary problems.

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	3
	CIC-CC-612	Image Computing	3
	CIC-CC-613	Digital Signal Processing	3
	CIC-CC-614	Machine Learning	3
	CIC-CC-615	Unstructured Data Analytics	3
	CIC-CC-616	Image Computing Laboratory	3
	Skill Enhancement Elective (SE)		
	CIC-SE-4B1	Design Thinking	2
	CIC-SE-4B2	MOOC	2
	Generic Course (GC)		
	CIC-GC-4B1	Computational Imaging	2
II	**Core Courses (CC)**		
	CIC-CC-621	Computer Vision	3
	CIC-CC-622	Deep Learning	3
	CIC-CC-623	Image and Data Compression	3
	CIC-CC-624	Deep Learning Laboratory	3
	Discipline Specific Electives (DE)		
	CIC-DE-625(i)	Computational Geometry	3
	CIC-DE-625(ii)	Principles of GIS and Remote Sensing	3
	CIC-DE-625(iii)	Automatic Acoustic and Speech Recognition	3
	CIC-DE-625(iv)	Medical Image Analysis and Processing	3
	CIC-DE-626(i)	Cyber Security and Cyber Law	3
	CIC-DE-626(ii)	Bioinformatics	3
	CIC-DE-626(iii)	Robotics and Intelligent System Design	3
	CIC-DE-626(iv)	Natural Language Understanding	3
	Skill Enhancement Elective (SE)		
	CIC-SE-4B3	Scientific Writing	2
III	**Core Courses (CC)**		
	CIC-CC-631	Research Methodology and Publication Ethics	2
	CIC-CC-632	Dissertation Phase I	10
	Discipline Specific Electives (DE)		
	CIC-DE-633(i)	Swarm Intelligence	3
	CIC-DE-633(ii)	Applications of Image Processing	3
	CIC-DE-633(iii)	Brain Computer Interface	3
	CIC-DE-633(iv)	Image and Video Analytics	3
	CIC-DE-634(i)	Theory of Fractals and Applications	3
	CIC-DE-634(ii)	Visual Cognitive Science	3
	CIC-DE-634(iii)	Video Processing	3

	CIC-DE-634(iv)	Advanced Graphics and Animations	3
	Skill Enhancement Elective (SE)		
	CIC-SE-4B4	Cyber Ethics	2
IV	**Core Courses (CC)**		
	CIC-CC-541	Dissertation and Viva-Voce	18
	Skill Enhancement Elective (SE)		
	CIC-SE-4B5	Industry Internship	2
Generic Courses from other Departments			
I	XXX-GC-41X	Extra Departmental Elective – I	2
II	XXX-GC-43X	Extra Departmental Elective – II	2

5. Syllabus

Semester: 1	Course Code: CIC-CC-611	Credits: 3

MATHEMATICS FOR IMAGE PROCESSING

Preamble: Aim is to develop knowledge in various advanced linear algebra techniques, probability distributions and vector spaces that can be applied to improve the ability to process images.

Prerequisite: Probability, vectors and basic linear algebraic operations.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Solve linear algebra problems	PO1	PSO2	Ap	P, C
CO2	Compute eigen values and eigen vectors which are significant in dynamic problems	PO3	PSO2	Ap	P
CO3	To introduce matrix decompositions methods that reduce a matrix into constituent parts which make it easier to calculate more complex matrix operations	PO2	PSO2	An	C, P
CO4	Analyse the significance of linear algebra in computational problems	PO4	PSO2	An	P
CO5	Identify the relevance of probability distributions in solving real life problems	PO5	PSO2	Ap	P, C
CO6	Use linear algebra to solve the image processing and computer vision applications	PO6	PSO2, PSO7	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, Matrix operations, Inverse, Linear dependence and independence, Determinants and their properties, Cramer's Rule, Positive definite matrices.

MODULE II

Matrix Factorization: LU decomposition, QR Decomposition.
Eigen Space: Properties of Eigen values and Eigen vectors, Eigen values, Eigen vectors, minimal polynomial, Diagonalization, Orthogonal diagonalization, Jordan canonical form, Singular Value Decomposition.

MODULE III

Covariance Matrices and Joint Probabilities, Principal Component Analysis , Multivariate Gaussian and Weighted Least Squares, Random Signals , Stationary Process, Markov Process, Markov Chain- Markovian property and Transition probabilities.

MODULE IV

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 V

Vector spaces: Subspaces, null space, solution space and direct sums and intersection of spaces, spanning and linear dependency, basis, dimension, change of basis, fundamental subspaces, vector subspaces, Algebra of subspaces, Linear Combination of Vectors, Coordinates, Summary of row equivalence.

MODULE VI

Inner products spaces, Norm or length of a vector, angle between vectors, Orthogonality-Orthogonal sets and Basis, projections, Orthogonal bases, Gram-schimi orthogonalization, QR Factorization, Least square problems, Standard Euclidean Inner product.

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.

Semester: 1	Course Code: CIC-CC-612	Credits: 3

DIGITAL IMAGE COMPUTING

Preamble: Digital Image Computing has a significant role in various fields by enabling the manipulation, analysis, and interpretation of digital images. It leverages mathematical and computational techniques to enhance image quality, extract valuable information, and enable automated decision-making based on visual data.

Prerequisite: Data structures and Linear algebra.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain the elements of image processing	PO1	PSO2	Ap	P, C
CO2	Solve mathematical problems on Convolution	PO3	PSO2	Ap	P
CO3	Acquire hands-on experience in processing and manipulating digital images	PO2	PSO2	An	C,P
CO4	Perform histogram equalization on an image	PO4	PSO2	An	P
CO5	Perform Smoothening and Sharpening in a gray scale and color images	PO5	PSO2	Ap	P,C
CO6	Compare Otsu thresholding and Binary Thresholding techniques	PO5	PSO2, PSO7	Ap	C,P
CO7	Explain the restoration filters in image processing	PO5	PSO2, PSO7	U, Ap	C,P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
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COURSE CONTENT

MODULE I

Introduction to image and its properties: Image Functions- Dirac distribution and convolution- Images as linear systems- Image Digitization – Sampling – Quantization- Visual Perception of image- Noise in Images.

MODULE II

Convolution: Graphical Method- Matrix Method- Z transform method- Correlation- Inverse Convolution, Finite impulse response system, Infinite impulse response system.
Image Transforms: Fourier Transform, Hadamard Transform- DCT-Wavelets- Applications to Discrete Image Transforms.

MODULE III

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 IV

Spatial Filtering: Smoothening spatial filters, Sharpening spatial filters, Laplacian Filter, Unsharp masking and High Boost Filter, Gradient operators – Edge detection filters, Filtering

in Frequency domain, Frequency domain smoothening filters- Ideal Filter, Butterworth Filter, Gaussian Filter, Frequency Domain Sharpening Filters, Homomorphic Filtering.

MODULE V

Image Restoration: Image Degradation process, Noise probability density functions, Spatial Filtering: Mean Filters, Order-statistics filter, Adaptive Filters, Periodic Noise Reduction - Wiener filtering, Color models – RGB, HSI, YCbCr.

MODULE VI

Image Segmentation: Fundamentals, Thresholding– Otsu's method- Region based segmentation- Feature Extraction- Shape features- Histogram Features- Color features- Spectral features- texture features – Region based Features- SIFT, SURF.

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.
- William K. Pratt, "Digital Image Processing: PIKS Scientific Inside", John Wiley & Sons, 4th Ed., 2007.
- Scott E Umbaugh, "Digital Image Processing and Analysis", CRC Press, Third Edition, 2018.

Semester: 1	Course Code: CIC-CC-613	Credits: 3

DIGITAL SIGNAL PROCESSING

Preamble: Digital signal processing is the process of digitizing real-world signals like audio, video and images. This course focuses on the problem of computation and manipulation using 1- and 2-dimensional signals. The course starts by considering the foundations of basic signal processing theory, signal sampling, quantization, discrete Fourier transform. The signal information is then represented in discrete frequency, time or space so that it can be processed, analyzed and synthesized digitally.

Prerequisite: Linear Algebra, Calculus, Knowledge in Fourier analysis

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Define a digital signal and the frequency range of digital signal.	PO1	PSO3	U	C, P
CO2	Explain the sampling theorem and show graphically how samples are generated from a continuous time signal.	PO5	PSO10	An	C, P
CO3	Explain how digital signals are obtained from continuous time signals.	PO2	PSO3,PSO4	U, An	C,P
CO4	Apply Fourier transform in the analysis of signals.	PO5	PSO5	Ap	P, M
CO5	Implement digital filters.	PO4	PSO11	Ap	P, C
CO6	Explain the practical limitations in DSP implementations.	PO3	PSO3	An	P
CO7	Explain the structure of a DSP processor.	PO2	PSO3	Ap	C, P
CO8	Define a digital signal and the frequency range of digital signal.	PO5	PSO1	Ap, E	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 Fundamentals: Introduction to Digital Signal Processing: Basic Concepts, Digital Signal Processing Examples, Digital Filtering, Signal Frequency (Spectrum) Analysis, Typical Digital Signal Processing in Real-World Applications. Digital Crossover Audio System - Interference Cancellation in Electrocardiography, Speech Coding and Compression, Compact-Disk Recording System, Digital Photo Image Enhancement, Digital Signal Processing Applications.

MODULE II

Signal Sampling and Quantization: Sampling of Continuous Signal, Signal Reconstruction Anti-Aliasing Filtering, Analog-to-Digital Conversion and Digital-to-Analog Conversion, and Quantization. Digital Signals and Systems - Digital Signals, Linear Time-Invariant, Causal Systems, Difference Equations and Impulse Responses, Digital Convolution.

MODULE III

Discrete Fourier Transform – Properties and Application: Discrete Fourier transform - DFT as a linear transformation, Properties - circular convolution. Filtering of long data sequences - FFT-Radix-2 DIT and DIF algorithms. Computational complexity of DFT and FFT -application.

MODULE IV

Digital Filters: Digital FIR Filter: Transfer function - Difference equation, Linear phase FIR filter, Concept of windowing, Direct form and cascade realization of FIR and IIR filters. Direct and parallel Structures. Design of analogue Butterworth filters, Analog frequency transformations, Impulse invariance method. Bilinear transformation, Analog prototype to digital transformations.

MODULE V

Filter Design Techniques: Signal noise – inherent noise, EMI noise, random noise, speckle noise, process induced noises, Basic digital filter structures – FIR and IIR filters design of FIR filters by window method – rectangle – Hanning, Hamming – Kaiser – IIR filters design – bilinear transformation.

MODULE VI

The z-Transform - Definition, Properties of the z-Transform, Inverse z-Transform. DSP Systems- Basic Filtering Type, and Digital Filter Realizations, Difference Equation and Digital Filtering, The Z-Plane Pole-Zero Plot and Stability, Digital Filter Frequency Response, Basic Types of Filtering, Realization of Digital Filters, Application to Speech Spectral Estimation, Application: Speech Enhancement and Filtering.

LEARNING RESOURCES

References

- Lizhe Tan, Jean Jiang, "Digital signal processing: fundamentals and applications", Elsevier Science, 3 ed, 2018.
- John G. Proakis, Dimitris and G.Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications"" 4th Edition 2007, Pearson Education.
- A. Anand Kumar, "Digital Signal Processing ", PHI Learning Pvt. Ltd. 2013.
- Proakis J G and Manolakis D G, "Digital Signal Processing", Pearson Education India.

Semester: 1	Course Code: CIC-CC-614	Credits: 3

MACHINE LEARNING

Preamble: Machine learning (ML) is the science of getting the machines to act in particular situations, without explicitly coding every outcome. ML has been widely applied in the area of pattern recognition, computer vision, self-driving cars, genomic experiments etc. After the successful completion of this course, the students will learn the unsupervised, unsupervised and reinforcement learning algorithms and attain the ability to implement these algorithms. The students are also able to solve the real-world problems using machine learning algorithms.

Prerequisite: Linear algebra, Probability and Calculus.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Demonstrate the capability to articulate the basic concepts of Machine learning	PO3	PSO2	U	C, P
CO2	Compare and contrast different supervised machine learning algorithms	PO2	PSO3	U, Ap	C
CO3	Evaluate unsupervised machine learning algorithms with examples	PO1	PSO6	U	C ,P
CO4	Explain the elements in Reinforcement learning techniques	PO4	PSO2	U	C,P
CO5	Apply machine learning algorithms to solve real world problems	PO6	PSO3	U, Ap	C,P
CO6	Illustrate the dimensionality reduction techniques with practical aspects	PO5	PSO5	U, An	C,P
CO7	Compare the statistical Machine learning Techniques	PO3	PSO2	U	C, P
CO8	Identify the techniques to evaluate the performance of a classifier	PO2	PSO7	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

MODULE I

Introduction to Machine Learning: Steps, Types of machine learning- Supervised learning, Unsupervised Learning, Reinforcement Learning, Classification, Regression - Linear Regression, Logistic Regression, Batch learning and online learning, Instance based learning vs Model Based learning, Challenges of Machine Learning. Cross-Validation and Resampling Methods- K-Fold Cross-Validation, 5×2 Cross-Validation, Bootstrapping, Measuring Classifier Performance: Accuracy, Precision, Recall, F1 Score, Sensitivity, Specificity, ROC, AUC, Confusion matrix.

MODULE II

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 III

Supervised Learning: Classification –Separating hyper plane approaches, : Linear Discriminant Classifier , Adaptive decision boundary algorithm, Decision Trees Decision tree algorithms - C4.5 algorithms, ID3 algorithm, CART, Random forest, Support Vector Machines, kernel Functions, linear SVM, Non-linear SVM, Distance measures-,KNN algorithm, Naïve Bayes classifier.

MODULE IV

Unsupervised Learning Algorithms: Clustering: Similarity measures, Clustering criteria, Distance functions, Hierarchical clustering, Single Linkage, Average Linkage and Complete Linkage algorithms, Ward's Method. Partitional Clustering, Forgy's Algorithm, K-means algorithm, Fuzzy C means algorithm.

MODULE V

Reinforcement Learning: Introduction, Elements of Reinforcement Learning, Limitations and scope, stochastic process, Markov Decision Process, Temporal Difference learning, Q-learning, On-policy TD control, Off-policy TD control.

MODULE VI

Dimensionality Reduction: Problems of dimensionality, Need, The Curse of Dimensionality, Main approaches of Dimensionality reduction, Subset selection, Principal Component Analysis, Linear Discriminant Analysis, Applications of machine learning in image processing.

LEARNING RESOURCES

References

- AurélienGéron "Hands-On Machine Learning with Scikt-Learn &TensorFlow", O'Reilly Media, Inc.,2019.
- Bishop, C. M. "Neural Networks for Pattern Recognition". New York: Oxford University Press (1995).
- Duda, R., Hart, P., and Stork, D. (2001). "Pattern Classification". New York: Wiley.
- EthemAlpaydın, "Introduction to Machine Learning Second Edition", The MIT Press Cambridge, Massachusetts, London, England.
- LaureneFauseett, "Fundamentals of Neural Networks", Prentice Hall India, New Delhi,1994.
- Mitchell, T. "Machine Learning". New York: Mc Graw-Hill, 1997.
- Vinod Chandra S S, Anand H S , "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020.
- Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", Cambridge University Press, 2020.

Semester: 1	Course Code: CIC-CC-615	Credits: 3

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	PSO3, PSO5	An	F, C
CO2	Apply unstructured data analytics to solve real world problems	PO3	PSO3, PSO12	Ap	C
CO3	Explain the techniques used for text analysis and dimensionality reduction	PO4	PSO3, PSO12	U	C, P
CO4	Implement word space models and language computation models	PO5	PSO3, PSO12	U	C, P
CO5	Illustrate the process of performing indexing and searching of information	PO4	PSO3, PSO12	U, An	C, P
CO6	Apply the various methods used for document classification and summarization	PO3	PSO3, PSO12	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, Unstructured data analysis challenges, Unstructured data analysis techniques-Exploratory Data Analysis, Qualitative data analysis, Artificial Intelligence and Machine Learning, Application areas of unstructured analytics

MODULE II

Unstructured data: Text, images, audio. Text analysis-importance and applications, *Computational Syntax*: part of speech tagging and named entity recognition, Language computational models: Vector Space Model-representation, weighting Schema –tf-idf, similarity measures.

MODULE III

Document collection and Feature set, dimensionality reduction techniques- Principle Component Analysis, Singular value decomposition-matrices and their relevance in text analysis, rank reduction.

MODULE IV

Computational Semantics-Lexical semantics: WordNet and FrameNet, Word Sense Disambiguation, Distributional Semantics & Word-Space models, Logical approaches to sentence semantics, GloVe, word2vec

MODULE V

Indexing and searching of information- crawling, indexing, query processing. Latent Dirichlet Allocation (LDA)-working and its importance. Sentiment analysis from text. Knowledge graph in unstructured data analytics.

MODULE VI

Document classification and summarization using VSM and weighting scheme. The Power of UDA in Sports, The Power of UDA to Improve Fraud Detection and Prevention

LEARNING RESOURCES

References

- 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-616	Credits: 3

IMAGE COMPUTING LABORATORY

Preamble: This laboratory course provides a hands-on session for developing and designing basic and advanced image processing algorithms with machine learning and to perform qualitative and quantitative experimental evaluations. The course focuses on demonstrating the image processing lab experiments to solve the real-world problems.

Prerequisite: Digital Image Processing

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Implement basic image processing and machine learning algorithms	PO4	PSO2	A	P
CO2	Perform image restoration using wiener filtering	PO5	PSO5	A	P
CO3	Implement a mini project in image processing using machine learning techniques	PO1, PO6	PSO3	A	P
CO4	Perform convolution and correlation on images	PO3	PSO2	A	P
CO5	Implement filtering algorithms in spatial and frequency domain	PO3, PO6	PSO3	A	P
CO6	Solve real life problems using image processing and machine learning	PO1, PO2	PSO3	A	P
CO7	Apply and evaluate the feature extraction and dimensionality techniques on images	PO1, PO5	PSO11, PSO8	A	P
CO8	Implement feature extraction methods and ML classification algorithms	PO4, PO5	PSO11	A	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.

Preprocessing Cycle

- Familiarizing reading and displaying images.
- Edge Detection Filters
- Restoration Filters
- Gray Level Transformation function

Image Processing Cycle

- Histogram Processing
- Smoothening and Sharpening
- Image processing in Spatial Domain
- Image Processing in Frequency Domain

- Image Segmentation
- Thresholding

Machine Learning Cycle

- Dimensionality Reduction
- Feature Extraction
- implementing Classifiers
- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning
- Neural Networks

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

Basic laboratory programs: 30 marks
The programming exercises marked as basic level, to provide practical awareness for the main objective of the course.

Mini Project/Case Study Evaluation: 50 marks
At the advanced level, advanced programming exercises are given to understand the application level of the course.

End Semester Viva: 20 marks
The students have to attend a viva voce examination, where the knowledge in the different courses undergone in the semester and presentation skill of the students are evaluated systematically.

Laboratory Record
All Students attending the End Semester Viva should produce a practical laboratory record at the time of evaluation. The record should be certified by the Faculty-in-charge of the laboratory countersigned by the course coordinator.

Semester: 1	Course Code: CIC-SE-4B1	Credits: 3

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	PO2	PSO4	Cr	C, M
CO2	Develop teamwork and leadership skills in students	PO3	PSO2	An	C, P
CO3	Develop students' professional and entrepreneurial skills in innovation and product generation	PO4	PSO2	U	C, P
CO4	Analyse the significance of empathy in design thinking process	PO1	PSO6	An	C, P
CO5	Explain the principles and core concepts of design thinking	PO5	PSO8	U	C, P
CO6	Demonstrate the capability of design thinking oriented product generation with social impact	PO6	PSO10	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-SE-4B2	Credits: 2

MASSIVE ONLINE OPEN COURSE (MOOC)

Preamble: MOOCs enable access to quality education for as many students as possible and contribute 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 to learn 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 inform the course coordinator before they join. Each student must submit a report on what MOOC has completed during their M Sc programme to complete their Semester III.

LEARNING RESOURCES

Online Resources

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

Semester: 1	Course Code: CIC-GC-4B1	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 and techniques that underpin image processing. Students can develop a deeper comprehension of 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	PSO 1 PSO5	U	P
CO2	Apply Edge detection in images	PO2, PO6	PSO4	U, Ap	C, P
CO3	Perform Histogram Equalization	PO3, PO5	PSO8	Ap, An	C, P
CO4	Describe Otsu thresholding method	PO2, PO5	PSO4	U	C,P
CO5	Apply Fourier transform in images	PO3	PSO2	An	P
CO6	Illustrate the process of converting an analog image to digital image	PO1	PSO1	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.

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", Cengage Learning, 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: 3

COMPUTER VISION

Preamble: Image analysis and computer vision helps to analyse the images, gives a human perspective of the 3D world. It has applications in the areas robotics, augmented reality, inspection and autonomous vehicles. After the successful completion of this course, the students should be able to understand the different methods to analyse the images and the various aspects of computer vision. As part of this course the students will learn Python and OpenCV for processing the images and execute various computer vision algorithms.

Prerequisite: Image Processing, Linear algebra, Probability and Statistics

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain the fundamental theories and techniques of human vision with computer vision	PO4	PSO9	U	C, P
CO2	Explain the process of image formation in the camera	PO4	PSO8, PSO5	U, Ap	C
CO3	Explore the significance of morphological operations	PO5	PSO1	U	C,P
CO4	Apply different region properties in an image	PO1	PSO3	U	C,P
CO5	Apply different texture, color-based feature extraction methods used for computer vision	PO5	PSO9	U, Ap	C,P
CO6	Illustrate the working of Camera calibration system	PO3	PSO2	U, An,	C,P
CO7	Explain different methods to compute the motion of an object from 2D image sequences	PO6	PSO3	U	C, P
CO8	Explain the process of the depth information from stereo images	PO5	PSO5	U	C,F
CO9	Apply different types of morphological operations to an image	PO5	PSO9	U, A	C,P
CO10	Develop a computer-based system with vision capabilities	PO1	PSO11, PSO6	Cr	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

Cameras: Pinhole cameras, cameras with lenses, Human eye, Imaging and Image Representation- Imaging Devices, 3D structure from 2D images, Five frames of reference. *Binary image analysis*: Pixels and Neighborhoods, Applying masks to images, Counting the objects in an image, Connected components labeling. Binary image morphology, Region properties, Region adjacency graphs

MODULE II

Feature detection and matching: Points and patches, SIFT, Edges-Edge detection and linking, Lines-Hough transforms. Corner detection, Color and Shading: Color bases, Color histograms, Color segmentation, Shading.

Texture: Texture, Texels and Statistics, Texel based Texture Descriptions, Quantitative texture measures, Texture Segmentation.

MODULE III

Content based image retrieval: Image distance measures: Color similarity, Texture similarity, Shape similarity, Database organization.

Motion from 2D image sequences: Computing Motion Vectors, Using point correspondences, Computing paths of moving points, Detecting significant changes in video.

MODULE IV

Matching in 2D: Registration of 2D data, Representation of points, Affine mapping functions, 2D object recognition via Affine Mapping, Local Feature Focus method-Algorithm, Pose clustering Algorithm, Geometric hashing, 2D object recognition via Relational Matching.

MODULE V

Perceiving 3D from 2D images: intrinsic Images, Labeling of line drawings from blocks world, 3D cues available in 2D images, Perspective imaging model, Depth perception from Stereo-Establishing correspondences.

MODULE VI

3D sensing and Object pose Computation: 3D Affine transformations, Camera Model, Affine calibration matrix, Improved Camera calibration method, intrinsic camera parameters, extrinsic camera parameters, Pose estimation, 3D object reconstruction.

LEARNING RESOURCES

References

- Linda G. Shapiro, George C. Stockman, "Computer Vision", Prentice Hall, 1st Ed., 2001.
- Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 1st Ed., 2010.
- David A. Forsyth, Jean Ponce, "Computer Vision: A Modern Approach", 2nd Ed., 2011
- Simon J. D. Prince, "Computer Vision: Models, Learning, and Inference", Cambridge University Press, 1st Ed., 2012.
- Ramesh Jain, Rangachar Kasturi, Brian G. Schunck, "Machine Vision", McGraw-Hill, 1st Ed., 1995.
- Ranjay Krishna, "Computer Vision :Foundations and Applications "Stanford University.

Semester: 2	Course Code: CIC-CC-622	Credits: 3

DEEP LEARNING

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: Linear Algebra, Machine Learning

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Demonstrate the capability to articulate the basic concepts of deep learning	PO1	PSO6	U, Ap	C, P
CO2	Explain the basic concepts of convolutional neural networks and familiarize various pretrained models	PO2	PSO3	U	C
CO3	Implement and evaluate different deep learning models to perform real world applications	PO4	PSO2	U, Ap	C, P
CO4	Explain the processing of sequence data in different real-world applications	PO5	PSO9	U	C, P
CO5	Analyze the role of different generative adversarial networks in real world problems	PO2	PSO3	U, Ap	C, P
CO6	Illustrate attention mechanisms and transformers in deep learning	PO1	PSO2	U, An,	C, P
CO7	Implement the deep architectures using different deep learning libraries	PO4	PSO9	U,	C, P
CO8	Implement and analyze the performance of different deep learning architectures for solving various real-world problems	PO3	PSO6	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

Convolutional neural network: From fully connected layers to Convolutions, Convolutions for images, Convolutional layers, Feature map and receptive field, Padding and stride, Multiple input and multiple output channels, Pooling, Convolutional neural network (LeNet), AlexNet, VGGNet, Multibranch network-GoogleNet.

MODULE II

Recurrent neural network: Working with sequences, - Architecture, Types, Modern Recurrent Neural Networks Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU), Deep Recurrent Neural Networks, Bidirectional Recurrent Neural Networks, Recursive neural networks.

MODULE III

Unsupervised deep learning: Introduction, Auto encoders, Under complete auto encoders, Regularised autoencoders- sparse, stochastic, denoising, contractive, applications, variational auto encoders. Generative models-Generative Adversarial Network, types, GANs application.

MODULE IV

Attention mechanism and transformers, Queries, Keys, and Values, visualization, Attention pooling by similarity, kernels and data, Attention Pooling via Nadaraya-Watson Regression, Attention Scoring Functions- Dot Product Attention, Convenience Functions, Scaled Dot-Product Attention, Additive Attention, The Transformer architecture, Model, Transformers for vision.

MODULE V

TensorFlow: Implementing object classification and detection using CNN networks using any of deep libraries like Tensorflow, Keras, Caffe. Regularization - Dropout and Batch normalization, Optimization in deep learning, Gradient Descent, Momentum Optimizer, RMSProp, Adam optimizer.
Deep Generative models: Boltzmann Machines, Deep Belief Networks, deep Boltzmann Machines.

MODULE VI

Applications of deep architectures: Image captioning, word prediction. Flood forecasting, Natural language understanding, generating databases.

ASSESSMENT

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: 3

IMAGE AND DATA COMPRESSION

Preamble: This course aims to give a rigorous introduction into the fundamental concepts of data compression with strong emphasis on the mathematical techniques.

Prerequisite: Mathematical Foundations of Image Processing, Probability and Statistics

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Model and code the redundancy in a data	PO3	PSO2	An	C
CO2	Design a Huffman and Adaptive huffman codes for the data	PO2	PSO3, PSO4	E	P
CO3	Check whether a code is uniquely decidable or not	PO6	PSO4	An	P
CO4	Encode the data using adaptive dictionary-based algorithms including LZ77, LZ78, LZW	PO3	PSO2 PSO3	A	C, P
CO5	Explain Vector Quantization Technique	PO4	PSO2	U	C
CO6	Encode the data using BWT algorithm	PO1	PSO3	A	C, P
CO7	Analyze the working of JPEG compression algorithm	PO3	PSO2 PSO3	An	C
CO8	Compare Static quantization and Adaptive quantization techniques	PO5	PO5	An	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: Compression Techniques, Modeling and Coding, Mathematical Preliminaries for Lossless compression: Information Theory, Uniquely decodable codes, Prefix codes, Kraft-McMillan Inequality.

MODULE II

Huffman Coding, Adaptive Huffman Coding, Arithmetic Coding: Coding a sequence, Generating a binary code.
Dictionary Techniques: Static Dictionary, Digram coding, Adaptive Dictionary, LZ77, LZ78, LZW algorithms.

MODULE III

Context-based Compression: Prediction with partial match (ppm), Burrows-Wheeler Transform (BWT), JPEG compression, Run-Length Coding .

MODULE IV

Scalar and Vector Quantization: Quantization: Quantization problem, Uniform Quantizer, Lloyd- Max Quantizer, LBG Algorithm, Tree Structured and Structured Vector Quantizers.

MODULE V

Image Compression: Compression model- Lossless compression methods- Huffman coding- Run length coding- Lempel Ziv Welch coding- Arithmetic coding.

MODULE VI

Lossy Compression Methods: Block Truncation Coding- Vector Quantization- Model based and Fractal Compression- Differential Predictive Coding- Wavelet Compression.

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: 2	Course Code: CIC-CC-624	Credits: 3

DEEP LEARNING LABORATORY

Preamble: Aim of this course is to understand the implementation procedures for deep learning algorithms using Java/Python programs. Students are expected to apply appropriate vision and signal data sets in to the designed deep learning algorithms to solve real-world problems.

Prerequisite: Programming Skills, Deep Learning.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Implement the deep learning concepts and algorithms in any programming language.	PO2	PSO2, PSO4	U, Ap	C, P
CO2	Understand fundamental concepts and methods of deep learning by implementing the deep learning methods in computer vision and pattern recognition applications.	PO1	PSO2, PSO3	U, Ap	C, P
CO3	Design and implement convolutional neural networks to solve real world computer vision and image processing problems.	PO3	PSO4, PSO9	Ap	C, P
CO4	Apply the pretrained models and fine tune the parameters for solving the problems.	PO4	PSO10	Ap	C, P
CO5	Perform different pre-processing operations on structured or unstructured data	PO5	PSO3, PSO1	U, Ap	C, P
CO6	Implement, train, and validate deep architectures.	PO2	PSO4, PSO8	Ap	C, P
CO7	Illustrate the role of deep architectures to solve image processing problems.	PO4	PSO10	Ap	C, P
CO8	Interpret the deep model results and analyze the performance of the model.	PO3	PSO11	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.

Deep Architecture Cycle

- Familiarizing Tensorflow, Keras, Caffe.
- Recurrent networks
- Convolutional Neural Network
- Computer vision problems using deep architectures
- Transfer Learning

Unsupervised Deep Architecture cycle

- Auto encoders
- Variational Auto encoders
- Understanding of GAN

Real world problem solving cycle

- Deep architecture for solving real world problems
- Natural language Processing
- Image Processing applications
- NLP using LSTM
- Image Classification/ Segmentation
- 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. Evaluation matrices that have to be projected as out will also be given.

ASSESSMENT

Basic Laboratory programs: 30 marks
The programming exercises marked as basic level, to provide practical awareness for the main objective of the course.

Mini Project/Case Study Evaluation: 50 marks
At the advanced level, advanced programming exercises are given to understand the application level of the course.

End Semester Viva: 20 marks
The students have to attend a viva voce examination, where the knowledge in the different courses undergone in the semester and presentation skill of the students are evaluated systematically.

Laboratory Record

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

Semester: 2	Course Code: CIC-DE-625(i)	Credits: 3

COMPUTATIONAL GEOMETRY

Preamble: Computational Geometry focuses on developing algorithms and data structures for solving geometric problems and analyzing geometric data. Computational Geometry is a multidisciplinary field that encompasses mathematics, computer science, and engineering. By learning these concepts and algorithms, student should be able to solve complex geometric problems, design efficient algorithms for geometric computations, and develop applications in various domains such as computer graphics, robotics and computer-aided design.

Prerequisite: Data Structures and Algorithms, Programming concepts

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain fundamental geometry representations	PO4	PSO2	U	C
CO2	Explain and apply basic concepts from Polygons and Triangulations	PO2	PSO4	U,A	P
CO3	Analyze the 3D graphics programming and understand its limitations	PO1	PSO3	An	P
CO4	Implement and evaluate basic geometry processing algorithms, such as smoothing, remeshing, deformation, and constructive solid geometry	PO5	PSO4	A	P
CO5	Perform PCA based shape synthesis	PO5	PSO4	A	P
CO6	Discuss surface reconstruction techniques	PO3	PSO2	U	C
CO7	Explain the deformation types including Volume-based Deformation, Multi-Scale Deformation, Free-Form Deformation	PO4	PSO2	U	F

(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: Digital Models- Geometry representation - Polygons and Triangulations - polygonal Jordan Curve - Art Gallery problem- Point Sets- Convex hull construction-Voronoi Diagrams.

MODULE II

Mesh Data Structures- Face-Based Data Structures- Edge-Based Data Structures – Half edge-Based Data Structure Directed-Edge Data Structure- 3D Graphics Programming- Introduction to open inventor tool- Mesh Comparison- Distance- Geodesic distance- Diffusion distance- Shape descriptors- Sampling - Shape correspondence.

MODULE III

Surface reconstruction- Explicit representation- Implicit representation- Implicit function- Implicit reconstruction- Marching Squares algorithm- Marching cubes algorithm- Signed

distance function- KD tree for NN- Scientific visualization - Direct scalar field visualization- Vector field visualization- Information visualization.

MODULE IV

Mesh Generation - Shape Synthesis- Part based shape synthesis- PCA based shape synthesis- PCA Computation - PCA application- Eigen vector decomposition -Active shape model - Shape from Silhouette- Mesh Processing- Mesh smoothing- Remeshing- Subdivision surfaces- Subdivision curves.

MODULE V

Mesh parameterization- Texture Mapping - Parameterization types- Linear Parameterization Methods- Disk Parameterization - Fixed-Boundary Parameterization - Free-Boundary Parameterization - MDS-based Parameterization - Parameterization Refinement- Parameterization of Closed Meshes - Spherical Parameterization- Sphere Generation Method - Parameterization Distortion.

MODULE VI

Shape Registration - Rigid vs Non-rigid- Rigid Alignment via PCA- Eigen decomposition of Covariance Matrix- Rigid Alignment Transformations- Rigid Alignment via ICP- Rigid Alignment via RANSAC - Mesh Deformation- Deformation Types- Volume-based Deformation- Multi-Scale Deformation- Free-Form Deformation (FFD)- Interpolation- Skinning- Shell-based Deformation- Physically based deformation.

LEARNING RESOURCES

References

- Polygon Mesh Processing, Mario Botsch, Leif Kobbelt, Mark Pauly, Pierre Alliez, Bruno Lévy , 2010
- Computer Graphics: Geometric Modeling, course by L. Guibas (Stanford)
- Digital Geometry Processing, course by Hao Li
- Digital Geometry Processing, course by Mirela Ben-Chen
- Geometric Modeling course by TamalDey and the associated course notes (Ohio State University).

Online Resources

- http://staff.ustc.edu.cn/~fuxm/course/2017_Spring_DGP/index.html
- http://user.ceng.metu.edu.tr/~ys/ceng789-dgp/
- https://www.cs.ubc.ca/~sheffa/dgp/
- https://www.cse.iitb.ac.in/~cs749/spr2017/

Semester: 2	Course Code: CIC-DE-625(ii)	Credits: 3

PRINCIPLES OF GIS AND REMOTE SENSING

Preamble: GIS and Remote Sensing provide powerful tools for analyzing and visualizing geospatial data, enabling the students to gain valuable insights into the geographical information system. The integration of GIS with other technologies, such as artificial intelligence and machine learning, has a great impact for data analysis and decision making.

Prerequisite: Image Processing.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the basic concepts of Remote Sensing and Digital Image Processing and its application	PO1	PSO1, PSO3	U, A	C, P
CO2	Identify the distinctive characteristics of GIS models.	PO6	PSO4	U, A	C ,P
CO3	Examine the nature of system using the concept of Digital Terrain Modeling and data analysis.	PO3	PSO7	An	C, P
CO4	Understand the theoretical working of Remote sensing system Classification.	PO1	PSO4	A	P
CO5	Acquire knowledge of different missions & their utility in areas of Remote sensing and GIS.	PO6	PSO11	A	P, C
CO6	Apply remote sensing in different thematic studies	PO3	PSO7	A	C, P
CO7	Describe the standard methods used in Digital image processing for sensors.	PO1	PSO4	A	P, C
CO8	Apply numerical methods to obtain approximate solutions to various problems in Remote Sensing and GIS such as Ground Truthing, Integration etc.	PO6	PSO3	A	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 GIS: Evolution of GIS, Components of GIS, Basic Geographic concepts, GIS Applications GIS data models- Computer database structures for managing data-GIS model for multiple maps, Maps and GIS- Classes of Maps, Mapping process, Geographic coordinate system of earth.

MODULE II

Digital representation of the geographic data: Raster data, vector data and Object-oriented data representation, Raster based GIS data processing, Vector based GIS data processing, Digital Photogrammetry, Global Positioning System, Data quality and data standards.

MODULE III

Principles of Remote Sensing: Principles of electromagnetic remote sensing, Remote sensing system Classification. Image characteristics of remote sensing systems, extraction of metric information from remotely sensed images, Integration of GIS and remote sensing.

MODULE IV

Digital Terrain Modeling: Approaches to digital terrain data, Acquisition of digital terrain data and – Data Analysis, Processing and Visualization- Applications of digital terrain models. Data Analysis and Modeling- descriptive statistics- Trend surface analysis_ network analysis- GIS modeling.

MODULE V

Image registration and Multi Image fusion, Image Rectification, Thematic Classification- Classification Process, Feature Extraction, Training the Classifier, Sub pixel Classification, Hyper spectral Image analysis.

MODULE VI

Ground Truthing and Remote Sensing Applications: Importance of Ground Truthing in Remote Sensing, Ground Truth Radiometer (GTR), Radiometric Calibration, Digital and Analog Methods, Spectral Response Patterns: Soil, Vegetation, Rocks and Water, RS Applications in Agriculture, Forestry, Land cover/Land use, RS Applications in Water resources and Earth Science.

LEARNING RESOURCES

References

- Chor Pang Lo, Albert K. W. Yeung," Concepts and techniques of geographic information systems", Prentice Hall, 2002.
- Michael N. Demers," Fundamentals of Geographic Information Systems", 3rd Ed, John Wiley & Sons, 1999.
- Robert A. Schowengerdt, "Remote Sensing: Models and Methods for Image Processing", Academic Press, 2007.
- Victor Mesev, "Integration of GIS and Remote Sensing (Mastering GIS: Technol, Applications & Management)", John Wiley & Sons, 2007.
- Heywood Ian, "An Introduction to Geographical Information Systems", 3rd Edition, Pearson Education India, 2010.

Semester: 2	Course Code: CIC-DE-625(iii)	Credits: 3

AUTOMATIC ACOUSTIC AND SPEECH RECOGNITION

Preamble: Automatic Acoustic Speech Recognition (ASR) is a rapidly evolving field that lies at the intersection of computer science, signal processing, and linguistics. ASR technology plays a crucial role in various applications, including voice assistants, transcription systems, speaker recognition, and more. This course delves into the fundamental concepts and advanced methodologies used in ASR, equipping you with the necessary knowledge to understand, design, and evaluate speech recognition systems.

Prerequisite: Digital Signal Processing, Image Computing

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the theoretical foundations and key components of Acoustic features in Speech Recognition.	PO5	PSO9	U, A	C, P
CO2	Apply various feature extraction techniques, such as Mel-frequency cepstral coefficients (MFCCs) and filter banks, to process speech signals.	PO2	PSO4	U, A	C, P
CO3	Implement and evaluate acoustic models, such as Hidden Markov Models (HMMs) and deep neural networks (DNNs), for speech recognition tasks.	PO3	PSO8	An, E	C, P
CO4	Explain various feature extraction techniques used in speech processing.	PO2	PSO4	U, Ap	C, P
CO5	Understand the mathematical foundations and algorithms employed in speech recognition systems	PO6	PSO3	U	C
CO6	Familiarize with popular ASR tools and frameworks	PO3	PSO3	U	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 speech processing: Historical of speech processing – Applications, Speech Production: Acoustic theory of speech production.

Representations of speech waveform: Sampling speech signals, Basics of quantization, Delta modulation, Differential PCM.

Speech Analysis: Short-Time Speech Analysis, Time domain analysis (Short time energy, short time zero crossing Rate, ACF). Formulation of linear prediction problem in Time Domain – Basic Principle – Auto correlation method – Covariance method –Pitch detection using LPC parameters – Formant analysis – VELP – CELP.

MODULE II

Speech coding, speech enhancement, Language Identification -*Signal Processing Models of Audio Perception*: Basic anatomy of hearing System, Auditory Filter Banks.

Psycho-acoustic analysis: Critical band structure, Absolute threshold of hearing, Simultaneous Masking, Temporal Masking, Quantization Noise Shaping, MPEG psycho-acoustic model.
Homomorphic Systems for Convolution: Properties of the complex cepstrum, Computational considerations, Complex cepstrum of speech, Pitch Detection, Formant Estimation, Homomorphic Vocoder.

MODULE III
Acoustic Speech feature Enhancement: Nature of interfering sounds, Speech enhancement techniques: Single microphone approach- spectral subtraction, Enhancement by re-synthesis, Comb filter, Wiener filter, Multi microphone Approach, Analysis and Synthesis of pole-zero speech models – Time-Dependent Processing, All-Pole modeling of deterministic signals, Linear prediction analysis of stochastic speech sounds, Synthesis based on all-pole modeling. Short-time fourier transform analysis and synthesis - Short-time analysis and synthesis, Signal estimation from the modified STFT, Time-scale modification and enhancement of speech.

MODULE IV
Speech Analysis: acoustic features, Feature Extraction and Pattern Comparison Techniques, Speech distortion measures – mathematical and perceptual – Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral distortion using a warped frequency scale, LPC, PLP and MFCC Coefficients, Time alignment and normalization – Dynamic time warping, Multiple time – alignment paths. Cholesky method – Durbin's Recursive algorithm – lattice formation and solutions.

MODULE V
Automatic Speech Recognition (ASR): Speech recognition architecture- Types of speech recognition-Issues in speech recognition - Performance evaluation of SR systems. *Speech recognition methodologies*: Acoustic-phonetic approach, Pattern recognition approach-Template based approach-Dynamic time warping- Hidden Markov Model (HMM) -Vector Quantization – Support Vector Machine (SVM), Sequential data models.

MODULE VI
Speaker identification and verification, Voice response system.
Speech Synthesis: Text-to-Speech Synthesis- Concatenative and waveform synthesis methods, subword units for TTS, intelligibility and naturalness – role of prosody, Applications and present status, Smoothing algorithm for speech, Deep Learning Sequential prediction model for Speech, Recurrent Neural Networks (RNN), Long Short Term Memory (LSTM).

LEARNING RESOURCES

References

- Daniel Jurafsky, James H.Martin, "Speech and Language Processing", Prentice Hall, 2008.
- L. R. Rabiner, R. W. Schaffer, "Digital Processing of Speech signals", Prentice Hall, 1978.
- Jacob Benesty, M. Mohan Sondhi, Yiteng Huang "Springer handbook of speech Processing", Springer, 2007.
- Lawrence Rabinerand Biing-Hwang Juang, "Fundamentals of Speech Recognition", Pearson Education, 2003.
- Ben Gold and Nelson Morgan," Speech and Audio Signal Processing", John Wiley and Sons Inc. , Singapore, 2004.

Semester: 2	Course Code: CIC-DE-625(iv)	Credits: 3

MEDICAL IMAGE ANALYSIS AND PROCESSING

Preamble: Medical image processing, which combines medical informatics, neuro-informatics, and bioinformatics, has emerged as a key area of innovation in contemporary health care, learn the principles of digital imaging. The course covers subjects including image segmentation, registration, statistical modeling, visualization, and applications of computational tools for medical imaging. Examples of medical imaging techniques covered in the course include X-ray, computed tomography, magnetic resonance imaging, and nuclear imaging.

Prerequisite: Machine Learning, Image Computing

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Demonstrate subject specific knowledge and understanding in theoretical and practical aspects of medical image analysis and processing	PO1	PSO3	U	C, P
CO2	Gain critical insight into challenges underpinning image analysis, including image enhancement and compensating for artefacts	PO2	PSO6	An, Ap	C, P
CO3	Develop specialized skills to interpret medical images critically and to communicate the findings to a range of audiences	PO4	PSO3, PSO7	An, Ap	C, P
CO4	Execute registration techniques in medical images	PO3	PSO7	An, Ap	P, M
CO5	Examine image texture analysis and models in medical images	PO2	PSO5	An, Ap	P, C
CO6	Execute the texture analysis and models on specific modalities	PO4	PSO3	An, Ap	P
CO7	Appraise various machine learning architectures and algorithms used in image segmentation, clustering and classification through case study on specific areas	PO1	PSO1	U, Ev	C, P
CO8	Discuss the image analysis using Deep learning models and generation of synthetic data	PO4	PSO12	An, 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

Introduction: Medical imaging modalities and image analysis software - Objectives of biomedical image analysis – Computer aided diagnosis, Nature of medical images- X-ray imaging – Tomography – Nuclear medicine imaging – SPECT imaging – Positron imaging tomography – Ultrasonography – Magnetic resonance imaging. Removal of artifacts – Space domain filters – Frequency domain filters – Optimal filtering – Adaptive filters.

MODULE II

Image enhancement – Gray level transforms – Histogram transformation – Convolution mask operators – Contrast enhancement. Detection of regions of interest – Thresholding and binarization – Detection of isolated lines and points – Edge detection – Region growing.

MODULE III

Introduction to medical imaging: Basic image processing techniques- Feature extraction, segmentation, systematic evaluation and validation on datasets- Machine learning based approaches for segmentation and classification.

MODULE IV

Image registration: Rigid models, Non-Rigid models- Image registration-Application- Image segmentation - Statistical shape model- PDE based methods-application- Computer Aided Diagnosis.

MODULE V

Analysis of shape and texture – Representation of shapes and contours – Shape factors – Models for generation of texture – Statistical analysis of texture – Fractal analysis – Fourier domain analysis of texture – Segmentation and structural analysis of texture. Pattern classification and diagnostic decision – Measures of diagnostic accuracy.

MODULE VI

Applications: Contrast enhancement of mammograms – Detection of calcifications by region growing – Shape and texture analysis of tumors- Case studies on some recent advances in analysis of retinal, CT, MRI, ultrasound and histology images- Deep Learning for Medical image analysis – 3D Convolutional Neural Networks- Generative models for synthetic data.

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: 2	Course Code:CIC-DE-626(i)	Credits: 3

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.	PO3	PSO4	U	C, P
CO2	Analyze and evaluate the importance of personal data its privacy and security.	PO5	PSO12	An	C, P
CO3	Identify the role of human in security systems with an emphasis o n ethics, social engineering vulnerabilities and training.	PO1	PSO12	U	C, P
CO4	Evaluate the digital payment system security and remedial measures against digital payment frauds using modern cryptographic techniques.	PO6	PSO12 , PSO4	E	P, M
CO5	Develop a deeper understanding and familiarity with various types of cyber-attacks, cybercrimes, vulnerabilities and remedies thereto.	PO1	PSO10	Cr	P, C
CO6	Generalize the impact based on the Risk assessment, plan suitable security controls, audit and compliance in network security.	PO3	PSO10	U	P
CO7	Analyze and evaluate the security aspects of social media platforms and ethical aspects associated with use of social media.	PO3	PSO12	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.	PO6	PSO12	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

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

Introduction to 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 SteuartComputer Forensics and Investigations,Cengage Learning, India Edition, 2016.
- Network Security Essentials: Applications and Standards,William Stallings.
- John R.Vacca,Computer Forensics, Cengage Learning, 2005.
- NinaGodbole, SunitBelapureCyber security, Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Wiley publications.

Semester: 2	Course Code:CIC-DE-626(ii)	Credits: 3

BIOINFORMATICS

Preamble: Bioinformatics is an interdisciplinary course that explores the application of computational and statistical techniques in biological research and data analysis. This course provides students with a comprehensive understanding of the fundamental principles, tools, and methods used in bioinformatics. Students will learn how to acquire, analyze, and interpret biological data, including genomic sequences, gene expression data, and protein structures. The course is designed on developing practical skills in using bioinformatics tools and resources to solve biological problems

Prerequisite: Algorithms, Fundamentals of Life Science

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Describe the basic concepts of Bioinformatics with an emphasis on structure, function and synthesis of biomolecules	PO3	PSO3	U	C, P
CO2	Identify biological data formats and databases, retrieve bio-sequences, and align bio-sequences to identify similarity	PO5	PSO10	Ap	C, P
CO3	Employ similarity searching tools and algorithms to align sequences to highlight the similarity, and describe the structure of genes	PO2	PSO3,PSO4	U, Ap	C ,P
CO4	Demonstrate Protein Structure, visualize protein structure using tools, and explain how proteins interact	PO4	PSO5	Ap	P, M
CO5	Explain the fundamental aspects of Systems Biology, Computational Modelling and properties of models	PO1	PSO11	U	P, C
CO6	Study algorithms in computational Biology	PO1	PSO3	Ap,	P
CO7	Describe the basic concepts of Bioinformatics with an emphasis on structure, function and synthesis of biomolecules	PO2	PSO3	Ap, Ev	C, P
CO8	RNA sequence analysis	PO4	PSO1	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

Introduction to Bioinformatics: Introduction to bioinformatics, Nature & Scope of Bioinformatics, DNA, RNA, and Protein: The Central Dogma, Messenger RNA, tRNA, rRNA, Genetic code, Gene Structure and Control, Transcription, translation

MODULE II

Introduction to bio sequences and analysis: Introduction to Biological Databases, NCBI, Genbank, Bio sequence formats- FASTA, Sequence alignment- Global Alignment and Local Alignment, Dot Matrix Method, Dynamic Programming Method, Gap Penalties, Amino Acid Scoring Matrices - PAM and BLOSUM

MODULE III

*Sequence alignment***:** local, global, pairwise, multiple, sequence alignment, scoring methods. Needleman and Wunsch algorithm, global and local alignments. Protein and RNA structure prediction, polypeptic composition, secondary and tertiary structure, algorithms for modelling RNA and protein folding

MODULE IV

Proteomics: Protein Structure, Ramachandran Plot, Hierarchies of Protein Structure, Determination of Protein three-dimensional structure, protein structure database-PDB, Protein structure visualization, introduction to Protein protein interaction, STRING database

MODULE V

*Systems Biology***:** Introduction to Systems Biology, Models and Modelling, Properties of models, Systems state and steady state, Variables, Parameters, and Constants in modelling, Purpose and Adequateness of Models, Advantages of Computational Modelling, Model Development, Network Versus Elements, Modularity, Robustness and Sensitivity, Data Integration

MODULE VI

RNA Secondary Structure: Definitions, scoring schemes, dynamic programming approaches. Motif Finding: Repeat finding. Promoter and enhancer recognition. Signal peptide recognition, Algorithms in computational biology for RNA sequences

LEARNING RESOURCES

References

- Zvelebil, Marketa J., and Jeremy O. Baum. "Understanding bioinformatics". Garland Science,2007.
- Xiong, Jin. "Essential bioinformatics", Cambridge University Press, 2006.
- Vinod Chandra S S, Amjesh R - "Bioinformatics for Beginers", Lambert Academic Publishers, UK, 2019.
- Shaik, Noor Ahmad, et al. "Essentials of Bioinformatics", Volume I. Springer, 2019

Semester: 2	Course Code: CIC-DE-626(iii)	Credits: 3

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	PSO1	A	P
CO2	Explain the management and analysis of robotics systems	PO4	PSO2	U	C
CO3	Illustrate the working of a robot understanding the concepts of electronics, programming and robotics	PO2	PSO3	A	P
CO4	Acquire basic Knowledge on Robots	PO5	PSO1	U	C
CO5	Ability to process end effectors and robotic controls.	PO3	PSO7	A	P
CO6	Analyze Robot Transformations and Sensors	PO4	PSO2	An	P
CO7	Able to understand Robot cell design and applications	PO3	PSO2, PSO8	A	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-626(iv)	Credits: 3

NATURAL LANGUAGE UNDERSTANDING

Preamble: Natural language understanding (NLU) is a subfield of artificial intelligence that deals with the ability of machines to process and comprehend natural language texts and speech. NLU is one of the most challenging and fascinating areas of research, as it involves not only syntactic and semantic analysis, but also pragmatic and discourse aspects of language use. The goal of this course is to analyze the computational models of language that you could write computer programs to perform various tasks involving natural language focusing on the computational aspects of language processing.

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	PO4	PSO2, PSO9	U	F, C
CO2	Exposure to the concepts of Probabilistic language modelling and its applications	PO3	PSO2, PSO9	U, Ap	F, C
CO3	Analyse the significance of BERT and GPT in natural language processing	PO1	PSO2, PSO9	An	P
CO4	Illustrate machine learning models LSTM and RNN	PO4	PSO2, PSO9	An, Ap	C, P
CO5	Implement transformer and advanced algorithms in language computing	PO5	PSO2, PSO9	An, Ap	C, P
CO6	Write programs to analyse the applications of text analysis.	PO3	PSO2, PSO9	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 Natural Language Processing and applications. Different levels of NLP; Text Normalization: Basic pre-processing, Word and sentence segmentation, Lemmatization, Stemming, Morphology; Language Models: n-gram models, smoothing techniques

MODULE II

Probabilistic language modelling and its applications. Markov models. N-grams. Estimating the probability of a word, and smoothing. Generative models of language. Their application to building an automatically-trained email spam filter

MODULE III

Information Theory- Information, Measuring it in bits. The "noisy channel model." The "Shannon game"-motivated by language! Entropy, cross-entropy, information gain. Its application to some language phenomena.

MODULE IV

Machine learning Models - RNN in language computing, Role of LSTM in advanced machine learning models for languages. Attention model - additive and multiplicative attention and its importance

MODULE V

Transformer and advanced algorithms in language computing: Prompting Pre-Trained Language Models, architecture and applications of BERT, architecture and evolution of GPT.

MODULE VI

Text analysis and its applications- author identification, language identification, Comparative analysis of word embedding with word2vec, BERT and GPT.

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

Semester: 2	Course Code: CIC-SE-4B2	Credits: 2

SCIENTIFIC WRITING

Preamble: Writing and communication skills are amongst the most important for any student/ researcher. This course aims to improve the scientific writing skills of students to become better scientific writers. The course focuses on understanding the steps of writing using structured writing exercises and apply principles of the scientific narrative and plain language movements, punctuation, grammar, sentence, paragraph, and document design to prepare scientific documents

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Develop research skills in a student	PO1	PSO8	Ap, An	C
CO2	Provide expertise in writing a research article	PO3	PSO12	Ap	C, P
CO3	Able to compare Copyright, Trademark and Patent	PO1	PSO6	An	C
CO4	Assess the quality of scientific publications	PO3	PSO8	An	C
CO5	Identify whether a journal is indexed in WoS and Scopus.	PO2	PSO3	U, An	C, P
CO6	Understand the best practices followed for performing research	PO5	PSO4	U, Ap	C
CO7	Prepare scientific papers using LaTeX	PO6	PSO8	An	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

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

MODULE II

Article level Metrics- H-index- i10- index- g index- Altmetrics - Google Scholar- Journal Level Metrics- Impact factor- SCImago Journal ranking, Scientometrics -Citations- ORCID ID, Journal Citation Report, SNIP, SJR, Cite Score.

MODULE III

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 IV

Paper Publication Process - Peer Review Process- Steps for publishing paper in a conference and journal- Plagiarism Checking software including Turnitin, Urkund. Publication: Steps for publication-– Identify whether a journal is indexed in WoS and Scopus.

MODULE V

Introduction to LateX- Creating a Title Page, Page Numbering and Headings, Modifying Text etc. Page Layout:References and Citation- Typesetting of journal articles and reports- Packages: Geometry, Hyperref, amsmath, amssymb- Classes: article

MODULE VI

Preparing research papers in LateX- Applications to Writing Resume, Writing question paper, Prepare articles/ research papers - Prepare References using reference management software including Mendeley- Prepare documents with creative common licences.

LEARNING RESOURCES

References

- 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,PatrickW.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: 3

RESEARCH METHODOLOGY

Preamble: This course introduces the procedures and techniques adopted by the research, methods for research design, data collection and discusses the methods used to analyze the data. The salient aspects of publication and patenting along with the crucial role of ethics in research is discussed.

Prerequisite: Nil.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Illustrate the basic outline of a research process.	PO1	PSO11	C	M
CO2	Critically analyze and prepare a literature review.	PO3	PSO11	An	C, P
CO3	Analyse the research articles and reports	PO4	PSO7, PSO11	An	C
CO4	Illustrate the categories of research methodologies	PO1	PSO11	An	P
CO5	Develop professional ethics and code of ethics in research	PO6	PSO7, PSO11	C	C, P
CO6	Formulate viable research problems	PO3	PSO7, PSO11	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

MODULE I

Introduction –Need for research- objectives and motivations in research- Significance of research - need for interaction between academic institutions, industrial and research establishments – research and innovation. Research Formulation- Identifying a research problem- literature review– confirming to a research problem based on literature review.

MODULE II

Data collection- Primary and Secondary data, data collection methods, data preprocessing, classification of data. Research design- Need for research design, Features of good research design, types of research designs.

MODULE III

Data analysis: Statistical techniques and choosing an appropriate statistical technique, Hypothesis, Hypothesis testing, Data processing software (e.g. SPSS etc.), statistical inference, Interpretation of results

MODULE IV

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

MODULE V

Research Ethics – Environmental impacts – Ethical issues - Intellectual Property Rights – Patents – legal formalities in filing patent in India – Copy right– Copyleft- Open access- Reproduction of published material-royalty- plagiarism – citation and acknowledgement.

MODULE VI

Analyse: Analyse the chosen papers to understand formulation of research methods and analytical and experimental methods used. Study of how different it is from previous works. Analyze the chosen papers and study the methods of data collection used. - Data Processing and Analysis strategies used– Study the tools used for analyzing the data.

LEARNING RESOURCES

References

- 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: 3

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, Programming.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Identify a research problem which is significant in the area of computer science	PO1	PSO2, PSO7	An, Ap	C,P
CO2	Analyze the literature survey in the selected topic as an individual	PO2	PSO5	An	C,P
CO3	Design the experiment with proper hypothesis	PO4	PSO12	Ap	C,P
CO4	Evaluate and interpret the experimental results.	PO5	PSO8, PSO5	An	P
CO5	Analyze effectiveness of the method based on quantitative and qualitative methods.	PO3	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, presentation and 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: 3

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 behavior. 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	PSO1	Ap	F
CO2	Explain about optimization problems and its types.	PO5	PSO3	Ap	C, P
CO3	Familiar with swarm based algorithm and its applications.	PO2	PSO10	U, Ap	C, P
CO4	Compare different Ant Colony Optimization algorithmic models.	PO5	PSO3, PSO4	Ap	C ,P
CO5	Compare different Artificial Bee Colony Optimization algorithmic models.	PO4	PSO5	App	P, M
CO6	Illustrate Particle swam optimization algorithm with an example.	PO1	PSO11	Ap, An, Ev	P, C
CO7	Compare different natural inspired computing algorithms.	PO3	PSO3	An	P
CO8	Explain about optimization problems and its types.	PO5	PSO3	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

S*elected 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: 3

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	PSO1	U, Ap	F,P
CO2	Discuss methods used to enhance and extract useful information from the medical images and biometric systems	PO3	PSO2	U, An	C,P
CO3	Apply biological signals in diagnosis, patient monitoring, and physiological investigation	PO5	PSO4	Ap	P
CO4	Understand Computer interpretation of remote sensing image data to process images	PO1	PSO4	U, Cr	C,P, M
CO5	Familiarize different image representations, geometric image enhancement techniques, image restoration and edge detection, segmentation and registration	PO5	PSO9	U,Ap	F, P
CO6	Understand video surveillance and pedestrian tracking	PO1	PSO5	U,Ap	C,P
CO7	Impart the knowledge to recognize humans and describe activities from information acquired by video cameras	PO5	PSO5	Cr	M
CO8	Discuss moving objects tracking by estimating positions over time	PO1	PSO8	U, Ap	C,P
CO9	Understand low level vision functions such as sensing and Preprocessing for Robotics	PO1	PSO10	U,Cr	P,M
CO10	Apply high level vision functions to emulate cognition	PO5	PSO10	U, Cr	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

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 – Panchromatic Image- 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, AndrewW Senior, 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.
- Yunqian Ma, Gang Qian, " Intelligent Video Surveillance: Systems and Technology" CRC Press, (Taylor & Francis Group), 2010.
- Fredrik Nilsson, Communications Axis, "Intelligent Network Video: Understanding
- Modern Video Surveillance Systems", CRC Press (Taylor & Francis Group), 2008.
- Robotics: Control, Sensing, Vision, and Intelligence , K.S. Fu, R.C.Gonzalez, CSG LEE

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

BRAIN COMPUTER INTERFACE

Preamble: Brain-computer interfaces (BCIs) allow their users to communicate or control external devices using brain signals rather than the brain's normal output pathways of peripheral nerves and muscles. BCI review the BCI-relevant signals from the human brain, and describe the functional components of BCIs. This course emphasis is on electroencephalogram (EEG) signals, which is the most common source for brain-computer interfaces and the kind of signals. It also covers the design principles of complex brain-controlled devices beyond recording brain signals, enhancing their signal-to-noise ratio, and decoding subjects' intents and cognitive states.

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Prerequisites: Pattern Recognition, Machine Learning

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the overview of a Brain-Computer Interface, related hardware and brain sensing devices (EEG, fMRI, etc.)	PO1	PSO7	U	C, P
CO2	Analyze and understand different brain activation patterns and potentials	PO1	PSO9	U, An, Ap	C, P
CO3	Use of different data processing methods and techniques for effective Brain-computer interfaces	PO2	PSO2, PSO5	An, Ap	C, P
CO4	Acquiring skill set in implementing Machine Learning and Artificial intelligence algorithms for Brain-computer interfaces	PO3	PSO2, PSO5	U, Ap	C, P
CO5	Understanding of Cognitive Neuroscience for implementing better Brain-computer interfaces	PO3	PSO7	U, Ev	C, P
CO6	Conduct case studies and analyze the results	PO3	PSO4	An, Ev	C, M
CO7	Research on open areas of Brain-Computer Interfaces	PO2	PSO11,PSO9	Ap, Ev	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

Introduction: Brain structure and function, Brain Computer Interface Types – Synchronous and Asynchronous -Invasive BCI -Partially Invasive BCI – Non Invasive BCI, Structure of BCI System, BCI Monitoring Hardware, EEG, EcoG, MEG, fMRI.

MODULE II

Brain activation patterns - Spikes, Oscillatory potential and ERD, Slow cortical potentials, Movement related potentials-Mu rhythms, motor imagery, Stimulus related potentials - Visual Evoked Potentials – P300 and Auditory Evoked Potentials, Potentials related to cognitive tasks

MODULE III *Data Processing* – Spike sorting, Frequency domain analysis, Wavelet analysis, Time domain analysis, Spatial filtering -Principal Component Analysis (PCA), Independent Component Analysis (ICA), Artefacts reduction, Feature Extraction - Phase synchronization and coherence.

MODULE IV *Peripheral and Central Nervous System*- brain structure, motor pathways, Cognitive functions of the brain, brain computer interface types, Electrophysiology, Neuropsychology and Neuro imaging methods in cognitive neuroscience.

MODULE V

Cognitive Neuroscience of Attention : Cognitive functions of the brain, Attention and perception; Attention and neglect, Frontal lobe functions, the multifaceted human attention system and its relationship with sensory and other cognitive systems, Behavioral outcomes of dysfunctions of attention, Research methodology used in measuring attention

MODULE VI

Case Studies - Invasive BCIs: decoding and tracking arm (hand) position, controlling prosthetic devices such as orthotic hands, Cursor and robotic control using multi electrode array implant, Cortical control of muscles via functional electrical stimulation. Noninvasive BCIs: P300 Mind Speller, Visual cognitive BCI, Emotion detection, Ethics of Brain Computer Interfacing

LEARNING RESOURCES

References

- Rajesh.P.N.Rao, "Brain-Computer Interfacing: An Introduction", Cambridge University Press, First edition, 2013.
- Jonathan Wolpaw, Elizabeth Winter Wolpaw, "Brain Computer Interfaces: Principles and practice", Oxford University Press, USA, Edition 1, January 2012.
- Guger C, Allison BZ, Gunduz A. Brain-computer interface research: a state-of-the-art summary Springer International Publishing; 2021.

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

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.	PO2	PSO6	U	F,C
CO2	Understand the concepts used in shape representation and description	PO1	PSO8	U	C
CO3	Analyse the importance of various object recognition methods	PO4	PSO10	An	C
CO4	Understand the basic video processing techniques	PO3	PSO5	U	C
CO5	Understand the algorithms available for performing analysis on video data and address the challenges.	PO1	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

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

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, condensation, particle, Bayesian filters, hidden Markov models, 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

References

- A. Murat Tekalp, Digital Video Processing (2 ed.), Prentice Hall, 2015.
- Milan Sonka, Vaclav Hlavac, Roger Boyle, Image Processing, Analysis and Machine Vision, Vikas Publishing House, 2003
- Forsyth, D. A., & Ponce, J. (2012). Computer Vision: A Modern Approach. Pearson.
- Szeliski, R. (2010). Computer Vision: Algorithms and Applications. Springer.
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- Jain, A. K., Flynn, P., & Ross, A. (2011). Handbook of Biometrics. Springer.
- Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.

Semester: 3	Course Code:CIC-DE-634(i)	Credits: 3

THEORY OF FRACTALS AND APPLICATIONS

Preamble: The objective of this course is to familiarize the principal components of fractal geometry and how it can be exploited in characterizing images. An overview of general segmentation techniques discussed regarding texture classification. This course will help students to generate many different fractal types and how to calculate a fractal description of any region within an image.

Prerequisite: Image Processing

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Introduce the basic concept of fractals and its properties.	PO4	PSO 2	U	F
CO2	Impart the knowledge about the methods for calculating fractal dimension.	PO3	PSO2, PSO3	AP, An	F,C
CO3	Introduce the concepts of Diffusion Limited Aggregation and Cellular Automata.	PO2	PSO4	An	F
CO4	Familiarize with techniques to introduce random variation into fractals	PO5	PSO9	An	F
CO5	Provide the knowledge of Fractal and Texture Analysis.	PO3	PSO3	E	F,C
CO6	Discuss automatic means of providing texture features that agrees with human sensory perception	PO4	PSO9	An, Ap	F
CO7	Introduce practical method of segmenting images from the viewpoint of fractal geometry	PO5	PSO9	Ap,Cr	F
CO8	Understand the concept of Fractal Image Compression and introduce the mathematical modeling through IFS	PO5	PSO5, PSO12	U, Ap	F

(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 fractals: fractal geometry, properties of fractals, self similarity.Generation of Von Koch Curve, Koch Snowflake , Koch Star , Hilbert Curve , Sierpinskigasket, Cantor Set. Fractals and dimensions, methods of counting fractal dimension- walking divider, box counting, prism counting, fractional brownian motion. Similarity dimension, mass dimension, area-perimeter relation

MODULE II

Algebra of Dimensions-Union, Intersection, Product, Projection. Iterated Function Systems, IFS for Sierpinski Gasket, Sierpinski Carpet, Koch Curve, KochSnowflake. Lindermayer systems. Escape time fractals- Mandelbrot Set and Julia Sets.

MODULE III

Random fractals: fractional brownian motion, Cellular Automata, Applications of Cellular Automata. Diffusion-Limited Aggregation, Generating RandomFractal Terrain, Strange Attractors- Rossler Attractor, Lorenz Attractor

MODULE IV

Fractal and Texture Analysis- Image Segmentation problem- Texture and Fractal Geometry- Fractal Properties- Random Scaling Fractals- Stochastic differential equations of fractional order- Real life Fractional Brownian Motion

MODULE V

Fractal to Segment Images- Object Segmentation- Texture Segmentation-Edge Detection- Texture Parameters- Statistical Moments- Generalized Texture Measures-Fractal Segmentation- Extraction of Fractal Dimension

MODULE VI

Fractal image compression- Contractive Mapping- Iterated Function Systemand Collage Theorem, PIFS Compression- Color Considerations- Video Considerations-Fractal Texture Maps, Fractal Analysis, Fractal dimension, Fractional Brownian motion model, Fractal analysis of texture. Applications of fractal analysis

LEARNING RESOURCES

References

- Fractal Geometry in Digital Imaging, Martin J. Turner, Jonathan M. Blackledge,Patrick R. Andrews, Academic Press
- Fractal Image Compression: Theory and Application,YuvalFisher,Springer Science & Business Media, 2012
- Fractals Everywhere, Michael F. Barnsley, Hawley Rising, Morgan Kaufmann,
- Kenneth Falconer, "Fractal Geometry: Mathematical Foundations and Applications",2ndEd., Wiley, 2003.
- Nigel Lesmoir-Gordon, Ralph Edney, "Introducing Fractals: A Graphic Guide", TotemBooks, 2005.
- Benoit B. Mandelbrot, "Fractals and Chaos: The Mandelbrot Set and Beyond", 1st Ed.,Springer, 2004.
- Heinz-Otto Peitgen,HartmutJürgens, Dietmar Saupe, "Fractals for the Classroom: Part 1Introduction to Fractals and Chaos", Springer, 1991.
- Nigel Lesmoir-Gordon, Ralph Edney, "Introducing Fractal Geometry", Totem Books,2000.

Semester: 3	Course Code: CIC-DE-634(ii)	Credits: 3

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	PO1	PSO8	An	C,P
CO2	Illustrate the process of eye tracking and gaze detection	PO2	PSO3	U, Ap	C,P
CO3	Evaluate the impact of color models on visual perception	PO5	PSO4	E, An	C,P
CO4	Explain the methods of object recognition	PO3	PSO8	U	F,C
CO5	Analyze the relation between visual attention, emotions and color perception	PO3	PSO12	An	C,P
CO6	Apply Neuroimaging techniques including fMRI, EEG in visual cognition	PO5	PSO9	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- Gestalt principles 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 and Scene 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.Vision research, 51(13), 1538-1551.
- Goldstein, E. B., &Brockmole, J. R. (2017). Sensation and perception (10th ed.). Cengage Learning.
- Palmer, S. E. (1999). Vision science: Photons to phenomenology. MIT Press.
- Itti, L., & Koch, C. (2001). Computational modelling of visual attention. Nature Reviews Neuroscience, 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-634(iii)	Credits: 3

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	PSO8	U	F,C
CO2	To provide deep understanding of two-dimensional, three-dimensional transforms and video processing concepts	PO2	PSO3	U	F,C
CO3	Understand the Representation of video, principles and methods of motion estimation	PO5	PSO4	U	F,C
CO4	To provide deep understanding of two-dimensional, three-dimensional transforms and video processing concepts	PO3	PSO8	U	F,C
CO5	Know the different enhancement techniques in both spatial and frequency domains.	PO3	PSO12	U	F,C
CO6	To understand the video enhancement and restoration techniques.	PO5	PSO9	U	F,C
CO7	Understand the fundamentals of Image Compression.	PO5	PSO10	U	F,C
CO8	To strengthen the research skills of students in image and video processing	PO1	PSO11	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 Image Formation, 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- Matching Algorithm, Mesh based Motion Estimation, Global Motion Estimation, 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 III

Video Sampling and Interpolation- : Basic Linear Filtering with Applications to Image Enhancement-Computational Models of Early Human Vision- Motion Detection and Estimation- Optical Flow Methods- Motion Compensated Filtering.

MODULE IV

Video Enhancement and Restoration- Video Enhancement and Restoration- Video Quality Assessment- Restoration- Super-resolution

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

References

- Yao Wang, Joem Ostermann and Ya–quin Zhang, "Video processing and communication", 1 stEd., PH Int.
- M. Tekalp, "Digital Video Processing", Prentice Hall International.
- Handbook of Image and Video Processing, Bovik
- The Essential Guide to Video Processing, Bovik
- Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-VerlagLondon Limited 2011.

Semester: 3	Course Code:CIC-DE-634(iv)	Credits: 3

ADVANCED GRAPHICS AND ANIMATIONS

Preamble: This course focuses the advanced concepts and techniques of computer graphics and animations, focusing on the creation and manipulation of visually appealing and interactive digital content. Students will explore topics such as rendering algorithms, shading models, advanced animation techniques, and real-time graphics. Through hands-on projects and assignments, students will develop the necessary skills to design and implement sophisticated graphics and animations for various applications, including games, simulations, virtual reality, and visual effects.

Prerequisite: Computer Graphics, Algorithms and Data Structures

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COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Introduce various Graphics Applications in real world scenario	PO1	PSO1	U	C
CO2	Familiar with image fundamentals and animations	PO3	PSO5	U,F	C
CO3	Identify more about 3D and Curve applications	PO1	PSO1	U	P
CO4	Applying efficient graphics technique to solve engineering problems	PO6	PSO10	Ap	F
CO5	Compare various graphics algorithm used in 2D and 3D	PO3	PSO12	An	P
CO6	Understand fundamentals of graphics used in various real life applications.	PO1	PSO5	U	C
CO7	Understand and identify the performance characteristics of graphics algorithms.	PO5	PSO1,PSO10	U	C
C08	Employ algorithm to model engineering problems.	PO1	PSO1	Ap	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

Three Dimensions: 3D geometry, primitives and transformations. Rotation about an arbitrary axis Parallel and perspective projection Viewing parameters 3D clipping and viewing transformation

MODULE II

Curves and Fractals: Polygon Meshes Parametric Cubic curves: B-spline, Bezier, Hermite. Parametric Bicubic Surfaces Quadric surfaces Fractals: fractal lines and surfaces Applications.

MODULE III

Solid Modeling: Representing solids -Regularized Boolean Set Operations Primitive Instancing Sweep and Boundary Representations Spatial-partitioning Representations Constructive Solid Geometry User Interface for Solid Modeling

MODULE IV

Achromatic and Colored Light: Achromatic light, Gamma correction, Halftone approximation, Chromatic Color CIE chromaticity diagram, Color models for Raster Graphics. Using Color in Computer Graphics

MODULE V

Hidden Lines and Surfaces: Algorithms for Visible-Line and Surface determination: zbuffer, List priority, Scan line, Area Subdivision, Ray Tracing

MODULE VI

Illumination and Shading Surface detail: shadows and Transparency Inter object Reflections Illumination Models Extended Light Sources Recursive Ray Tracing. Image based Rendering Introduction comparison with geometry based rendering. Animation - morphing character animation and facial animation

LEARNING RESOURCES

References

- Foley, J. D., van Dam, A., Feiner, S. K., & Hughes, J. F. (2013). Computer Graphics: Principles and Practice. Addison-Wesley Professional.
- Hearn, D., & Baker, M. P. (2014). Computer Graphics with OpenGL (4th ed.). Pearson.
- Hughes, J. F., & Duff, T. (2013). Computer Graphics: Principles and Practice in C (2nd ed). Pearson.
- Parent, R. (2012). Computer Animation: Algorithms and Techniques. Morgan Kaufmann.
- Watt, A., & Watt, M. (2008). Advanced Animation and Rendering Techniques. Addison-Wesley Professional.
- O'Brien, J. F. (2014). Introduction to Information Visualization: Transforming Data into Meaningful Information. Pearson.
- Perlin, K., & Hoffert, E. M. (1999). Advanced Animation and Rendering Techniques: Theory and Practice. ACM Press/Addison-Wesley Publishing Co.
- Parent, R. (2019). Computer Animation: Algorithms and Techniques (4th ed.). CRC Press.

Semester: 3	Course Code:CIC-SE-4B4	Credits: 3

CYBER ETHICS

Preamble: Cyber Ethics is an interdisciplinary course that explores the ethical issues and challenges arising from the use of technology, particularly in the context of cyberspace. The course examines the ethical implications of Net Neutrality, online behaviors, and digital interactions, with a focus on developing ethical decision-making skills in the digital realm.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Assess the role of technology, media, and social platforms in information warfare.	PO3	PSO10	An	C, P
CO2	Foster critical thinking and ethical decision-making skills in the context of autonomous weapon systems in warfare.	PO6	PSO10	Ap	C, P
CO3	Explore the role of technology and social media platforms in facilitating cyberbullying	PO3	PSO10	U	C,P
CO4	Analyze the relationship between net neutrality and freedom of expression, innovation, and digital equity.	PO5	PSO10	An	P, M
CO5	Explore the techniques and tools used for cyber intelligence gathering.	PO4	PSO10	U	P, C
CO6	Analyze case studies and real-world scenarios to apply ethical frameworks and principles.	PO6	PSO6	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

Net Neutrality: Introduction and key principles of net neutrality- Ethical considerations and values associated with net neutrality- Freedom of expression, privacy, and digital rights in the context of an open internet- Understanding the digital divide and its relationship to net neutrality

MODULE II

Warfare and use of autonomous weapons – Introduction to Autonomous Weapons Systems - Definition and characteristics of autonomous weapons systems- Ethical principles and frameworks relevant to autonomous weapons systems - Impact of AWS on human rights, civilian protection, and non-combatant immunity- Strategic implications and military advantages of AWS

MODULE III

Information Warfare **-** Introduction to Information Warfare- Types and objectives of information warfare - challenges- Cyber attacks and digital sabotage in information warfare - Role of traditional media, social media, and online platforms in information warfare - Strategies for countering information warfare and building societal resilience

MODULE IV

Cyber Space and intelligent gathering - Key concepts and terminology in cyber intelligence- Techniques and tools for cyber threat intelligence gathering- HUMINT and TECHINT methods for collecting and analyzing technical data - Forensics and malware analysis in cyber intelligence- Ethics of mass surveillance and targeted monitoring

MODULE V

Cyberbullying **-** Definition and characteristics of cyberbullying- cyberbullying and traditional bullying- Forms of Cyberbullying- Online harassment and verbal aggression- Cyberstalking and online threats- Digital exclusion and social manipulation- Technology and social media platforms in cyberbullying- digital citizenship and responsible online behavior- Ethical responsibilities of online platforms

MODULE VI

Applications: Impact of emerging technologies, such as 5G, Internet of Things (IoT), and cloud computing, on net neutrality - Artificial intelligence and machine learning in cyber intelligence - Best practices for addressing cyberbullying incidents

LEARNING RESOURCES

References

- Quinn, M. J. (2020). Ethics for the Information Age. Pearson.
- Spinello, R. A. (2019). Cyber ethics: Morality and Law in Cyberspace. Jones & Bartlett Learning.
- Reynolds, G. (2020). Ethics in Information Technology. Cengage Learning.
- Ess, C. (2017). Understanding Cyber ethics: From Theory to Practice. Routledge.
- Kaliski, B. S. (2018). Cyberethics: Social and Moral Issues in the Computer Age. Wiley.
- Johnson, D. G., & Miller, K. W. (2019). Computers, Ethics, and Society. Oxford University Press.
- Freitas, W. J. (2019). Ethics in a Computing Culture. Cengage Learning.

Semester: 3	Course Code:CIC-CC-641	Credits: 3

DISSERTATION AND VIVA-VOCE

Preamble: The Dissertation and Viva course is an advanced-level course designed to provide students 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 presentation on it.	PO2	PSO 4 PSO7	U,A	C,P
CO2	Investigate the related and recent works in the area of dissertation	PO5	PSO4	U,A	C,P
CO3	Apply critical thinking and design new strategies for the 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 research paper	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 innovative ideas/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 also be 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

Initial Review (Guide)
Weightage **10**

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.
Weightage **10**

Second Review (Internal)
Progress evaluation/ Implementation
Assessment is done based on Demonstration of project, presentation skills, performance in viva. Incorporation of suggestions, progress.
Weightage **20**

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.
Weightage **60**

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: 3	Course Code:CIC-SE-4B4	Credits: 3

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.	PO2	PSO2	U, Ap	C,P
CO2	Establish goals by working with supervision to define work objectives for the internship experience	PO5	PSO4	An,Ap	C, P
CO3	Demonstrate time and project management skills by completing the work objectives within the specified time limits	PO3	PSO2	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.	PO4	PSO11	An, Ap	P
CO5	Demonstrate the ability to effectively present ideas and solutions in the context of written, oral, and electronic media.	PO5	PSO12	U, An, Ap	C, P
CO6	Demonstrate and promote a proper work ethic.	PO3	PSO12	U, Ap	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

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 the job.

LEARNING RESOURCES

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