Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence
B. Tech. Honors in Artificial Intelligence

Teaching Scheme and Syllabus

For

Bachelor of Technology

In

Artificial Intelligence

Honors in Artificial Intelligence

Department of Artificial Intelligence

Sardar Vallabhbhai National Institute of Technology

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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Honors in Artificial Intelligence

Sr. No.	Semester	Subject	Code	Schema	Credit
1	4	Advanced Algorithms	AI 212	3-1-0	4
2	5	Nature Inspired Computing and Optimization	AI311	3-0-2	4
3	6	Generative AI	AI312	3-0-2	4
4	7	Advanced Topics in Deep learning	AI411	3-1-0	4

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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Scheme	L	T	P	Credit
B. Tech. II (AI) Semester – IV **Advanced Algorithms** **AI 212**	**3**	**1**	**0**	**04**

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1. Course Outcomes (COs): **At the end of the course, students will be able to**	
CO1	Recognize the need to study algorithms in terms of time and space
CO2	Apply different data structures and algorithms to solve given problems.
CO3	ability to solve complex network flow and path optimization problems using advanced graph techniques
CO4	utilize computational geometry concepts to address real-world problems
CO5	identify problems that cannot be solved in polynomial time and develop solutions with mathematical bounds relative to the optimal solution

2.	**Syllabus**	
	INTRODUCTION	**(06 Hours)**
	Review of basic concepts: Sorting, Searching, Priority Queue, Complexity Analysis, Divide and Conquer Approach, Backtracking basic fundamental techniques, Recurrence relations, Substitution methods	
	DATA STRUCTURES	**(07 Hours)**
	Counting Sort, Radix Sort, Lower Bound on Sorting, Fibonacci Heaps, Red Black Trees, Segment tree and Fenwick tree	
	GREEDY ALGORITHMS	**(04 Hours)**
	Maximum Bipartite Cover Problem, Maximum Matching in an Un weighted Bipartite Graph, Egyptian Fraction, Convex Hull Problem, Cats and Rats Problem	
	DYNAMIC PROGRAMMING	**(08 Hours)**
	Bin-packing, Steiner trees, Minimum Edit Distance, Longest Palindromic Subsequence, Longest Palindromic Substring, Subset Sum Problem, Unique BST, Minimum Partition	

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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	ADVANCED GRAPH ALGORITHMS	**(06 Hours)**
	Network Flows and its Applications: Augmenting Path, Bottleneck Capacity, Residual Network, Flow Network, Ford-Fulkerson, Edmonds-Karp, Johnson's algorithm for sparse graphs, Max-flow Min-cut Theorem, Longest path problem: General Graph, Directed Acyclic Graph	
	COMPUTATIONAL GEOMETRY ALGORITHMS AND THEIR APPLICATIONS	**(06 Hours)**
	Visibility Graph, Convex Hull Algorithms, Voronoi Diagram, Sweep Line Algorithm, Closest Pair of Points Problem, Delaunay Triangulation	
	NP-COMPLETENESS AND APPROXIMATION ALGORITHMs	**(08 Hours)**
	Coping with NP-Hardness, Polynomial-time approximation, Set Cover Problem, Vertex Cover Problem, The Subset Sum Problem, Travelling Salesman Problem	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3. Tutorials:
1. Computation of time and space analysis of algorithms.
2. Problems on sorting and tree
3. Problems on greedy algorithms
4. Problems on dynamic programming
5. Solving problems using advanced graph algorithms
6. Problems on computational geometry-based algorithms
7. Providing the proof for NP-completeness problems and solving them

4. Books Recommended:

1. Cormen, Leiserson, Rivest, Stein, "Introduction to Algorithms", 3/E, MIT Press, 2009.
2. Ding-Zhu Du , Ker-I Ko , Xiaodong Hu, "Design and Analysis of Approximation Algorithms", 1/E, Springer, 2012.
3. Mark Berg, Otfried Cheong, Marc Kreveld, Mark Overmars, "Computational GeometryAlgorithms and Applications", 3/E, Springer, 2008.
4. Vijay V. Vazirani, "Approximation Algorithms", Springer, 1/E, 2003.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Artificial Intelligence
B. Tech. Honors in Artificial Intelligence

Scheme	L	T	P	Credit
B. Tech. II (AI) Semester-V **Nature Inspired Computing and Optimization** **AI311**	**3**	**0**	**2**	**04**

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Understand the fundamentals of optimization problems and the principles of nature-inspired computing techniques, including swam Intelligence and random works
CO2	Analyze and implement popular nature-inspired algorithms such as Particle Swarm Optimization, Ant Colony Optimization, and Cuckoo Search to solve complex optimization problems.
CO3	Explore advanced algorithms like Artificial Bee Colony Intelligent Water Drop, Egyptian Vulture, and Invasive Weed Optimization for application in diverse real-world domains
CO4	Develop and apply nature-inspired computing methods to address real-life optimization challenges, including industrial, environmental, and engineering applications.

2.	**Syllabus**	
	Preliminaries	**(06hours)**
	Introduction to Optimization Problems and nature inspired computing, swarm Intelligence, random walks, Particle swarm optimization	**(08hours)**
	Ant colony optimization, Cuckoo search algorithm, bat algorithm	**(08hours)**
	Artificial bee colony, Algorithm, intelligent water drop algorithm, Egyptian vulture algorithm	**(08hours)**
	Invasive weed optimization, glowworm swarm optimization, bacteria foraging flower pollination algorithm, firefly algorithm, dealing with constraints, multi-objective optimization, applications to real-life	**(08hours)**
	Flower pollination algorithm. firefly algorithm, dealing with constraints, multi-objective optimization, applications to real-life problems	**(07hours)**
	Practicals will be based on the coverage of the above topics separately	**(30hours)**
	Total Contact time: 45 Hours + 30 Hours =75Hours	

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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3.	**Practicals:**
1	Implement random walks to explore the search space for solving a basic optimization problem
2	Solve a benchmark optimization problem (i.e. Sphere Function) using PSO
3	Implement Cuckoo search algorithm(CSA) for optimizing the Rastrigin function. The Algorithm should employ Levy Flights for exploration and identify the minimum values of the Rastrigin function within a specified range
4	Implement a Cuckoo search Algorithm to optimize the sphere function visualize nest positions and their evaluation over iteration.
5	Develop a Brain storm optimization Algorithm to solve a complex function optimization problem
6	Implement a Bat Algorithm to optimize a Benachmark function Visualize the position and velocity update of bats over iterations. Analyze and discuss the performance of the algorithm.
7	Simulate the flower Pollination Algorithm(FPA) to solve a constrained optimization problem you will use this algorithm to optimize multivariate functions (e.g. Rastrigin, Ackley) while handling constraints that limit the feasible search space.
8	Apply the Flower Pollination Algorithm and Firefly Algorithm to solve a real-life optimization problem such as resource allocation, supply chain optimization, or production planning.

4. **Books Recommended:**

1. Discrete Problems in Nature-inspired Algorithms, A. Shukla, and R.Tiwari, CRC Press Galyor and Francis , 2018
2. Nature-inspired optimization Algorithms, Xin-She Yang, Science Direct 2021
3. Nature-inspired optimization Algorithms, Vasuki. A, Routledge, Taylor and Francis, 2020

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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B. Tech. Honors in Artificial Intelligence

Scheme	L	T	P	Credit
B. Tech. III (AI) Semester – VI **Generative AI** **AI312**	**3**	**0**	**2**	**04**

1. Course Outcomes (COs): **At the end of the course, students will be able to**	
CO1	Identify problems that could be solved using Generative AI.
CO2	Understand major components and key concepts of GANS, LLMs, and multi modal systems.
CO3	Understand recent advancements in Generative models.
CO4	Analyze and apply generative models for image, text, and speech generation tasks.
CO5	Design applications of generative models in Pytorch and Keras.

2.	**Syllabus**	
	Introduction to Generative AI	**(06 Hours)**
	Introduction to Generative models, Historical overview of generative models, Applications of generative AI: image and video generation, text generation, speech generation	
	Generative Adversarial Networks (GANs)	**(08 Hours)**
	Overview of GANs, Adversarial training, Variants of GANs: DCGANs, WGANs, WGAN-GP and LSGANs, Diffusion Models, Evaluation Metrics	
	Applications of GANs	**(06 Hours)**
	Image generation, style transfer, text generation, and data augmentation.	
	Large Language Models (LLMs)	**(10 Hours)**
	The transformer architecture, encoder-decoder and encoder-only models, decoder only models in LLMs, Pre-training and Fine-tuning LLMs, Generative Pre-trained Transformers (GPT), Prompt Engineering, Prompt Tuning, Instruction Tuning, Reinforcement Learning using Human Feedback (RLHF), Evaluation Metrics	
	Applications of LLMs	**(06 Hours)**

	Text generation, Machine Translation, Summarization, Question & Answering, Code generation, Text-to-SQL generation	
	Exploring Multi-Modal System	**(04 Hours)**
	Image and Video Captioning Systems, Visual Question & Answering, Multi-modal LLMs, Speech-to-Speech Machine Translation	
	Ethical Considerations in Generative AI	**(05 Hours)**
	Bias and fairness in generative models, Misinformation and deep fakes, Intellectual property rights and copyright issues, Responsible AI practices and guidelines	
	Practicals will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3. Practicals:
1. Introduction to Tensor Flow/ PyTorch
2. Implementing a Basic GAN and advanced GAN techniques
3. Image-to-Image Translation using Pix2Pix, Cycle GAN, Star GAN
4. Fine-tuning a Pre-trained LLM (BERT and its variants, GPT, BART, T5, BERT models for Indian languages)
5. Applications of LLMs: Machine Translation, Text Summarization, Question & Answering
6. Implementing an image captioning model using a pre-trained vision-language model
7. Integrating pre-trained ASR, Machine Translation, and TTS models for developing a Speech-to-Speech MT model
8. Exploring all the evaluation metrics for all the models
9. Implementing Bias Detection and Mitigation Models

4. Books Recommended:

1. *Deep Learning* by Ian Good fellow, Yoshua Bengio, and Aaron Courville
2. Natural Language Processing with Transformers, Lewis Tunstall, Leandro von Werra, Thomas Wolf
3. Build a Large Language Model (From Scratch), Sebastian Raschka

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Scheme	L	T	P	Credit
B. Tech. IV (AI) Semester-VII **Advanced Topics in Deep learning** **AI411**	**3**	**1**	**0**	**4**

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1. Course Outcomes (COs):

At the end of the course, students will be able to

CO1	Foundational Understanding of Advanced Deep Learning Concepts.
CO2	Application of Generative Models such as GAN, VAE, Diffusion models.
CO3	Mastery of Attention Models and Transformers.
CO4	3D Computer Vision Techniques tasks such as 3D object detection, reconstruction, and facial analysis.
CO5	Exploration of Cutting-Edge Research Trends.

2.	**Syllabus**	
	Exploring Auto encoders	**(06 Hours)**
	Autoencoder, Architecture Design of AE, Convolutional AE, Denoising Auroencoder, U-Net , YOLO, Applications and Integration AE, U-Net, and YOLO in real-world tasks.	
	Deep Generative Models	**(08 Hours)**
	Generative Adversarial Networks (GANs), Variational Auto encoders (VAE), Self-Attention Generative Adversarial Network, Progressive GAN, StyleGAN	
	Diffusion models	**(06 Hours)**
	Generative Modelling Through Denoising, Architecture Design of Diffusion Models, Training of Diffusion Models, Denoising Diffusion Probabilistic Models, Conditional diffusion models.	
	Text-to-Image Synthesis	**(04 Hours)**
	Latent diffusion process, CLIP, Stable Diffusion, Imagen, DALL-E, GLIDE, Dream Booth.	
	Deep Dive into Attention	**(04 Hours)**
	Attention Mechanism, Advantages of Attention, Architecture Design of Transformers, Vision Transformer, Swin-Transformer, attention in NLP, Reformer , T5 (Text-to-Text Transfer Transformer)	
	Deep Learning in 3D Computer Vision	**(08 Hours)**

	Introduction to 3D Computer Vision, Camera Models and Calibration, Stereo Vision, Structure from Motion (SFM), 3D representations (Point cloud, Surface mesh, implicit representation, Volumetric representation), Geometry Processing (Mesh operation, simplification, decimation, triangulation), Image formation (Camera Transformation, Rendering), 3D Reconstruction Techniques, 3D Object Detection and Recognition, 3D-CNNs, 3DGANs, Neural Radiance Fields (NeRF)	
	Innovations in Deep Learning	**(07 Hours)**
	Deep learning for multimodal systems, Speech recognition, Deep Fake detection, Adversarial Attack, Machine translation, Medical Imaging, Image and Video Analytics.	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3 Tutorial:	
1.	Case Study on Deep Learning Research Select a recent research paper from a top-tier conference (NeurIPS, CVPR, ICLR, etc.). Deliverable: A concise case study (3-4 pages).
2.	Mathematical Derivations for GAN, VAE, and Diffusion Models.
3.	Generative Models: Compare GANs, VAEs, and Diffusion Models in terms of architecture and application domains. *Deliverable:* Write a report (2-3 pages) including key insights from a recent paper or study.
4.	Theoretical Understanding: Explain the key differences between Self-Attention and Cross-Attention in transformer architectures. *Deliverable:* Submit a written explanation (2-3 pages).
5.	Hugging Face Resources: https://huggingface.co/learn
6.	Case Studies on a Multimodal System
7.	Top-tier conference Paper presentation (NeurIPS, CVPR, ECCV, ICCV, ICLR, IJCB etc.)
8.	Capstone Project

4 Books Recommended:

1. Dive into Deep Learning: Book by Aston Zhang, Zack C. Lipton, Mu Li, Alex J. Smola.
2. Hartley, R., & Zisserman, A. Multiple View Geometry in Computer Vision.
3. Ian Good fellow and Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press
4. Lewis Tunstall, Leandro von Werra, & Thomas Wolf, Natural Language Processing with Transformers