MS DATA SCIENCE

Course Catalogue

School of Electrical Engineering and Computer Science(SEECS)
National University of Science and Technology(NUST)
Sector H-12, Islamabad, Pakistan

ABOUT US

National University of Sciences and Technology, Islamabad, one of Pakistan's premier institutions, stands tall as a beacon of academic excellence, innovation, and research, nurturing bright minds across diverse disciplines.

The Department of Artificial Intelligence and Data Science (AI & DS) at NUST School of Electrical Engineering and Computer Science is at the forefront of cutting-edge research and education, driving innovation in AI and data science domains.

With a dynamic curriculum and world-class faculty, the department equips students with the skills and knowledge to tackle complex challenges and contribute meaningfully to the ever-evolving fields of artificial intelligence and data science.

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Department of Artificial Intelligence & Data Science

NUST - SEECS

TABLE OF CONTENTS

1. NUST

National University of Sciences and Technology (NUST) in Islamabad, Pakistan, is a premier institution renowned for its academic excellence and cutting-edge research. Established in 1991, NUST has consistently ranked among the top universities globally, featuring prominently in the QS World University Rankings. The university offers a wide array of undergraduate, graduate, and doctoral programs across various disciplines, fostering an environment of innovation and intellectual growth. With state-of-the-art facilities, a distinguished faculty, and a strong emphasis on industry linkages, NUST is dedicated to producing graduates who are well-prepared to meet the challenges of the modern world.

https://nust.edu.pk/

2. SEECS

The School of Electrical Engineering and Computer Science (SEECS) at the National University of Sciences and Technology (NUST) is a leading academic institution in Pakistan, known for its excellence in education and research. Located in Islamabad, SEECS offers a dynamic and interdisciplinary environment that nurtures innovation and critical thinking. The school provides a comprehensive range of undergraduate, graduate, and doctoral programs in fields such as Electrical Engineering, Software Engineering, Computer Science, Artificial Intelligence, and Data Science. With a commitment to cutting-edge research, industry collaboration, and professional ethics, SEECS equips its students with the skills and knowledge necessary to excel in their careers and contribute to technological advancements globally. The institution's state-of-the-art labs, distinguished faculty, and strong industry linkages ensure that students receive a holistic education that keeps them ahead of the innovation curve.

https://seecs.nust.edu.pk

3. DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

The Department of Artificial Intelligence and Data Science at NUST SEECS offers a diverse range of programs including BS in Artificial Intelligence, BS in Data Science, MS in Artificial Intelligence, MS in Data Science, and PhD in Artificial Intelligence. This department provides a comprehensive curriculum that covers both foundational and advanced topics in AI and data science, including machine learning, big data analytics, natural language processing, and data visualization.

The AI and Data Science department is committed to achieving academic and research excellence through a well-structured curriculum that emphasizes both theoretical understanding and practical application. Our curriculum is designed to foster innovation, creativity, and a strong focus on industry-relevant skills. We emphasize the importance of professional ethics and aim to equip our students with the knowledge and skills necessary to excel in their future careers.

The department is furnished with state-of-the-art labs and resources to ensure that students have access to the latest technologies and tools. Courses are regularly updated to include the latest developments in AI and data science, ensuring our students are always at the forefront of technological innovation. Additionally, internship opportunities are available to provide students with hands-on experience in real-world environments, bridging the gap between academic learning and practical application.

VISION AND MISSION

Vision

To be a globally recognized leader in education and research for Artificial Intelligence and Data Science, shaping intelligent systems that positively impact individuals and society.

Mission

Through rigorous education and cutting-edge research, in Artificial Intelligence and Data Science, we empower ethical innovators to build intelligent solutions that tackle real-world challenges, advance knowledge frontiers, and fuel sustainable progress for a better future.

OUR DISCIPLINES

Data Science

Our Data Science program offers a dynamic learning experience focused on practical application. Through hands-on projects, students delve into the intricacies of data manipulation and machine learning, gaining invaluable skills in analyzing and interpreting complex datasets. Additionally, our strong industry partnerships provide opportunities for internships and collaborative projects with leading companies, ensuring that students graduate with not only theoretical knowledge but also real-world experience, ready to excel in the rapidly evolving field of data science.

Artificial Intelligence

In our Artificial Intelligence program, students embark on a journey of innovation and discovery. They engage in cutting-edge research projects alongside esteemed faculty, exploring the frontiers of AI algorithms and applications. Complementing theoretical learning with experiential opportunities such as hackathons and industry projects, students acquire practical skills and insights into real-world AI scenarios, preparing them to be leaders in the ever-expanding realm of artificial intelligence.

OUR PROGRAMS

Undergraduate Programs

Bachelors of Data Science

Bachelors of Artificial Intelligence

Post Graduate Programs

Masters of Data Science

Masters of Artificial Intelligence

PHD in Artificial Intelligence

Research

Computer Vision

Natural Language Processing

Deep Learning

Robotics

4. MASTERS IN DATA SCIENCE (MSDS)

The Master's in Data Science program at NUST Islamabad, Pakistan, is a cutting-edge initiative designed to equip students with the skills and knowledge necessary to thrive in today's data-driven world. This interdisciplinary program blends theoretical foundations with practical applications, offering a comprehensive understanding of data science techniques, including machine learning, data mining, and statistical analysis. With a focus on real-world problem-solving and hands-on experience, students engage in projects that tackle complex challenges across various domains, preparing them for careers in industries ranging from finance and healthcare to technology and beyond. Led by experienced faculty and supported by state-of-the-art facilities, the program fosters innovation and collaboration, empowering graduates to make meaningful contributions to the field of data science.

4.1. Core Courses

i. CS-871 Machine Learning

"CS-871 Machine Learning" offers a comprehensive exploration of fundamental concepts and advanced techniques in the field of machine learning. Starting with an introduction to the course and essential mathematical foundations, students delve into the core principles of machine learning as function approximation. The course covers a wide array of topics including Linear Regression, Gradient Descent, Logistic Regression, Decision Trees, KNNs, Parson Window, Kernel Methods, Support Vector Machines, Bayesian Analysis, Bayesian Networks, Model Selection, Feature Engineering, Regularization, and Experimental Design. Moreover, students gain insights into Dimensionality Reduction techniques, Perceptron, Back propagation, Gradient Descent optimization, Clustering Techniques, and Reinforcement Learning. Throughout the course, emphasis is placed on both theoretical understanding and practical application, culminating in a hands-on project where students can apply their acquired knowledge to real-world scenarios. By the end of this course, students will possess a solid foundation in machine learning principles and techniques, equipping them with the skills necessary to tackle complex problems in various domains.

Ii. CS-807 Statistical and Mathematical Methods for Data Science

The course "CS-807 Statistical and Mathematical Methods for Data Science" provides a comprehensive foundation in the essential mathematical and statistical concepts crucial for data science practitioners. Through an exploration of probability theory, students will grasp the fundamental rules governing uncertainty and randomness, laying the groundwork for understanding the behavior of random variables and probability distributions, both discrete and continuous. Building upon this probabilistic framework, the course delves into statistical inference techniques, empowering students to draw meaningful conclusions from data. Moreover, students will gain proficiency in linear algebra, including systems of algebraic linear equations, matrices, eigenvalues, and eigenspaces, essential for the manipulation and analysis of data structures. Additionally, the course covers advanced topics such as projections, principal component analysis (PCA), and singular value decomposition (SVD), providing students with powerful tools for dimensionality reduction and feature extraction in data analysis and machine learning tasks. By mastering these mathematical and statistical methods, students will acquire a solid foundation to tackle complex data science challenges effectively.

iii. CS-808 Tools and Techniques for Data Science

CS-808, "Tools and Techniques for Data Science," offers a comprehensive exploration of the foundational principles and practical methodologies essential for navigating the dynamic field of data science. Students will delve into the entire data science lifecycle, from formulating pertinent questions to deploying predictive models and visualizing insights. The course covers various data types and datasets, emphasizing data quality assessment and pre-processing

techniques such as aggregation and dimensionality reduction. Through hands-on sessions, learners will master the Python Data Science Stack, including libraries like NumPy, Pandas, and Matplotlib, along with fundamental concepts of relational algebra and SQL for data manipulation. Additionally, students will acquire proficiency in data scraping and wrangling methodologies, descriptive and exploratory data analysis, text analysis techniques, and the basics of prediction and inference algorithms using Scikit Learn. Furthermore, the course addresses crucial concepts such as the bias-variance tradeoff, model evaluation metrics, and introduces students to the Map-Reduce paradigm, providing a holistic understanding of contemporary data science tools and practices.

4.2. Specialized Electives

i. CS-825 Information Retrieval

CS-825 Information Retrieval delves into the fundamental principles and techniques essential for effective information retrieval systems. The course begins with an exploration of the foundational concepts, including Boolean retrieval and term vocabulary, providing students with a solid grounding in the theoretical underpinnings of the field. Moving forward, the course progresses into more advanced topics such as the Vector Space Model, Query Expansion, and Language Model Based Retrieval, equipping students with the tools to understand and implement modern retrieval algorithms. Evaluation methodologies in Information Retrieval are thoroughly examined, ensuring students can assess the performance of retrieval systems accurately. Additionally, the course covers practical applications including Text Classification and Text Clustering, essential for organizing and categorizing large volumes of text data. Furthermore, students gain insights into Web Search Basics, Web Crawling, and Link Analysis, crucial components of web search engines. Through a combination of theoretical exploration and hands-on exercises, students emerge from CS-825 equipped with the knowledge and skills to design, evaluate, and optimize information retrieval systems effectively.

ii. CS-836 Advanced Distributed Computing

CS-836 Advanced Distributed Computing offers a comprehensive exploration of distributed systems, delving into their fundamental principles, architectures, and the myriad of challenges they present. From understanding the evolution of peer-to-peer systems to mastering advanced algorithms like Lamport Logical Time and Paxos for achieving distributed consensus, students will gain a deep insight into the intricate workings of distributed computing. Practical skills are honed through hands-on experience with network simulation tools like OMNeT++ and an introduction to cutting-edge technologies such as opportunistic distributed vehicular networks and cloud computing. Furthermore, the course covers critical topics including fault tolerance, distributed transactions, and consistency in distributed systems, preparing students to tackle real-world challenges in designing and implementing scalable, resilient, and efficient distributed applications. With a focus on both theoretical foundations and practical applications, CS-836 equips students with the knowledge and skills needed to excel in the rapidly evolving field of distributed computing.

iii. CS-866 Information Visualization

CS-866 Information Visualization is a postgraduate-level course designed to explore the principles, techniques, and applications of visualizing complex data sets and information. Students will delve into the theoretical foundations of perception, cognition, and design to understand how to effectively represent data visually. Through hands-on exercises and projects, they will learn to use various visualization tools and libraries to create interactive and informative visualizations. Topics include data preprocessing, visualization design principles, interaction techniques, multidimensional data visualization, and evaluation methods. This course equips students with the skills needed to analyze, interpret, and communicate insights from large and diverse data sets through compelling visual representations. Prerequisites: Proficiency in programming and familiarity with basic data structures and algorithms.

iv. CS-878 Deep Learning

CS-878 Deep Learning delves into the core principles and advanced techniques of artificial neural networks, providing a comprehensive understanding of their architecture, training methodologies, and applications. Students will explore the fundamental concepts behind perceptron's and multi-layer perceptron's, mastering the intricacies of back propagation and optimization algorithms essential for efficient training. The course extends into Convolutional Neural Networks (CNNs), examining their components and specialized operations like dilated and transposed convolutions, crucial for tasks such as object detection and semantic segmentation. Additionally, students will delve into Natural Language Processing (NLP) techniques, including word embedding and sequence modeling with RNNs, GRUs, and LSTMs. Advanced topics such as machine translation with Seq2Seq models, transformer architectures with self-attention mechanisms, and generative models like Auto encoders and GANs will also be explored. Moreover, the course emphasizes the importance of identifying and mitigating biases in data and AI models as well as strategies for achieving interpretability and explain ability in deep neural networks.

v. CS-895 Big Data Analytics

CS-895 Big Data Analytics provides a comprehensive exploration of the rapidly evolving field of big data analytics and its practical applications. The course begins with an overview of big data analytics, highlighting its significance and impact across various industries. Students delve into the transition from traditional data analytics to the big data paradigm, addressing the technological gaps and challenges. The curriculum covers essential big data algorithms, including frequent item set mining, finding similar items, classification, and clustering problems, equipping students with the tools to analyze vast datasets effectively. A focus on big data technologies such as platform storage, Hadoop, and Apache Spark enables students to gain hands-on experience in processing and analyzing massive amounts of data efficiently. Advanced topics include designing data-intensive systems and exploring cutting-edge applications like recommender systems, text analytics, and healthcare applications. Through a blend of theory and practical application, students develop the skills necessary to tackle complex data challenges in today's data-driven world.

vi. CS-875 Natural Language Processing

CS-875 Natural Language Processing offers a comprehensive exploration of the fundamental principles and advanced techniques in the field of NLP. Through a structured curriculum, students delve into the intricacies of language modeling, tagging, and parsing using a variety of models such as Hidden Markov Models, Log-Linear Models, and Probabilistic Context-free Grammars. The course further delves into advanced topics like lexicalized context-free grammars and history-based parsing, providing a robust understanding of syntactic and semantic analysis in natural language. Students also explore modern approaches such as Feedforward Neural Networks, Recurrent Networks, and LSTMs, leveraging them for tasks like tagging, dependency parsing, and statistical machine translation. Additionally, the course covers key methods for word representation including Word Embeddings and Word2Vec, as well as cutting-edge techniques like Transformers and Large Language Models (LLMs). By the end of the course, students gain a solid foundation in NLP theory and practical applications, equipping them with the skills to tackle real-world language processing challenges.

4.3 General Electives

i. CS-820 Advanced Database Concepts

CS-820 Advanced Database Concepts delves into the intricate framework of modern database systems, equipping students with a comprehensive understanding of fundamental principles and advanced techniques. Beginning with a thorough exploration of database basics, including disk storage and basic file structures, the course progresses into the realm of indexing structures and query processing, providing a solid foundation for optimizing database performance. Through an in-depth study of physical database design and tuning, students learn to craft efficient data storage solutions tailored to specific

organizational needs. Transaction management and concurrency control techniques are examined to ensure data integrity and consistency in multi-user environments. Furthermore, the course delves into database recovery techniques, essential for maintaining system robustness. With a focus on emerging trends, such as informational retrieval, semi-structured data models, and NoSQL databases, students are prepared to tackle the complexities of contemporary data management challenges. By the end of this course, students will possess the knowledge and skills necessary to design, implement, and optimize robust database systems capable of meeting the demands of modern enterprises.

ii. CS-807 Statistical and Mathematical Methods for Data Science

The course "CS-807 Statistical and Mathematical Methods for Data Science" provides a comprehensive introduction to the fundamental concepts and techniques essential for navigating the dynamic field of data science. Through a structured curriculum, students delve into the data science lifecycle, understanding its intricacies from asking the right questions to building predictive models and generating meaningful visualizations. Emphasizing data quality and preprocessing, students learn to handle various types of data and address common challenges such as measurement errors and data collection issues. Practical skills in Python data science stack, relational algebra, SQL, and data scraping are honed to manipulate and analyze data effectively. Additionally, the course covers foundational statistical and probabilistic methods, equipping students with the knowledge to make informed decisions and derive insights from complex datasets. With a focus on both supervised and unsupervised learning algorithms, students gain proficiency in model evaluation techniques and the essential bias-variance tradeoff. By the course's conclusion, students emerge equipped with a robust toolkit to tackle real-world data challenges and contribute to the burgeoning field of data science.

iii. CS-821 Distributed Databases

CS-821 Distributed Databases explores advanced concepts in distributed database systems for postgraduate students. The course delves into topics such as distributed data management, replication strategies, concurrency control, fault tolerance, and scalability. Students will analyze distributed query processing techniques, transaction management models, and consistency protocols. Through case studies and real-world examples, they will gain insights into the design, implementation, and optimization of distributed databases in modern applications. Additionally, emerging trends like blockchain integration, edge computing, and big data analytics in distributed environments will be discussed. By the end of the course, students will be equipped with the knowledge and skills to design, deploy, and manage distributed database systems effectively, addressing the complexities and challenges of distributed computing architectures.

iv. CS-808 Tools and Techniques for Data Science

CS-808 Tools and Techniques for Data Science offers a comprehensive exploration into the foundational principles and practical methodologies essential for navigating the dynamic landscape of data science. Throughout the course, students delve into the intricacies of the data science lifecycle and process, learning to formulate precise inquiries, acquire pertinent data, and glean actionable insights through predictive modeling and visualization techniques. The curriculum spans the spectrum of data types and datasets, elucidating strategies for assessing and enhancing data quality. From data pre-processing stages to algebraic and probabilistic interpretations, students gain proficiency in leveraging Python's robust data science stack, relational algebra, and SQL for effective data manipulation and analysis. Additionally, the course equips learners with essential skills in data scraping, wrangling, and exploratory analysis, paving the way for proficiency in text analysis and prediction algorithms. By elucidating concepts like bias-variance tradeoff and model evaluation metrics, students develop a nuanced understanding of predictive modeling paradigms and the Map-Reduce framework, ensuring readiness to tackle real-world data challenges with confidence and competence.

v. CS 816 Statistical Machine Learning

CS-816 Statistical Machine Learning delves into advanced techniques for modeling and analyzing complex data sets. The course explores a wide array of topics including density estimation, clustering, and principal component analysis. Students will study various model types, ranging from parametric to semi-parametric and non-parametric models, and learn to utilize basis functions, manifold embedding, and kernel methods for efficient data representation. Additionally, the course covers deterministic and stochastic optimization strategies, addressing issues such as over fitting, regularization, and validation techniques crucial for model robustness. Through in-depth discussions on LASSO, sparse representation, joint optimization, k-SVD, and dictionary learning, students will gain practical insights into solving real-world problems in machine learning and data analysis. With a focus on both theoretical foundations and practical applications, CS-816 equips students with the skills necessary to tackle challenges in modern statistical machine learning domains.

vi. CS-823: Advanced Topics in Databases

CS-823: Advanced Topics in Databases is a postgraduate-level course designed to delve into cutting-edge concepts and emerging trends in database systems. It explores advanced database management techniques, including distributed databases, NoSQL databases, and big data analytics. Topics covered include advanced query processing and optimization, transaction management, data mining, and stream processing. Students will examine current research papers and industry practices to gain insights into the latest developments in database technology. The course emphasizes hands-on experience through practical assignments and projects, enabling students to apply theoretical knowledge to real-world database challenges. By the end of the course, students will be equipped with the skills and knowledge necessary to tackle complex database problems and contribute to advancements in the field.

vii. CS-834 Scientific Computing

CS-834 Scientific Computing is a postgraduate-level course designed to equip students with the essential computational tools and techniques required for solving complex scientific problems. The course focuses on numerical algorithms, parallel computing, and high-performance computing (HPC) methodologies relevant to scientific research and data analysis. Topics covered include numerical methods for differential equations, optimization algorithms, Monte Carlo simulations, and data-intensive computing techniques. Through theoretical lectures and hands-on programming assignments, students will develop proficiency in implementing and analyzing scientific algorithms using programming languages such as Python, MATLAB, and C/C++. By the end of the course, students will have the skills to tackle real-world scientific challenges efficiently and effectively using computational approaches.

viii. CS-853 Formal Methods

CS-853 Formal Methods is an advanced postgraduate-level course that introduces students to formal techniques for software specification, verification, and validation. The course covers mathematical foundations, formal languages, and automated tools used in the rigorous analysis of software systems. Topics include formal logic, model checking, theorem proving, temporal logic, and abstraction techniques. Through theoretical lectures and practical exercises, students develop skills in specifying system requirements formally, verifying system properties, and detecting potential design flaws early in the software development process. Emphasis is placed on understanding the theoretical underpinnings of formal methods and applying them to real-world software engineering problems. By the end of the course, students will be equipped with the knowledge and tools necessary to ensure the correctness and reliability of complex software systems.

ix. CS-861 Advanced Computer Graphics

CS-861 Advanced Computer Graphics is a postgraduate-level course designed to delve into advanced topics in computer graphics. Building upon foundational knowledge, this course explores cutting-edge techniques and algorithms used in rendering, animation, and simulation. Topics include advanced rendering techniques such as ray tracing and global illumination, realistic materials and shaders, advanced animation methods, physically-based simulation, and virtual reality (VR) technologies. Through theoretical study, practical implementation, and hands-on projects, students will gain proficiency in designing and implementing complex computer graphics systems. Emphasis is placed on understanding the underlying principles, optimizing performance, and exploring current research trends in the field. By the end of the course, students will be equipped with the skills and knowledge necessary to tackle challenges in the rapidly evolving field of computer graphic

x. CS-864 Scientific Visualization

CS-864 Scientific Visualization is a postgraduate-level course designed to explore advanced techniques and methodologies in the field of scientific visualization. The course delves into the principles and practices of representing complex scientific data visually, enabling students to effectively analyze and communicate insights from various domains such as physics, biology, engineering, and medicine. Through hands-on projects and case studies, students will gain proficiency in utilizing cutting-edge tools and software for visualizing large-scale datasets, understanding visualization algorithms, and designing interactive visual interfaces. Topics include volume rendering, flow visualization, information visualization, virtual reality applications, and emerging trends in scientific visualization research. By the end of the course, students will have the skills to create compelling visualizations that facilitate scientific discovery and communication in interdisciplinary research environment

xi. CS-872 Ontology Engineering

CS-872 Ontology Engineering is a postgraduate-level course designed to delve into the theoretical foundations and practical applications of ontology engineering. Students will explore techniques for designing, building, and managing ontologies, which are critical for knowledge representation and sharing in various domains such as semantic web, artificial intelligence, and data integration. The course covers topics including ontology languages, ontology development methodologies, ontology alignment and merging, ontology evaluation, and ontology-driven applications. Through hands-on exercises and projects, students will gain proficiency in ontology modeling tools and learn how to apply ontological principles to solve real-world problems in domains such as healthcare, e-commerce, and information retrieval. Prerequisites include a solid understanding of database systems, knowledge representation, and logics.

xii. CS 838 Geometric Deep Learning

CS 838 Geometric Deep Learning delves into the tools and techniques essential for studying and analyzing non-Euclidean data structures prevalent in various domains such as social networks, sensor networks, types of brain imaging, and 3D point structures. The course emphasizes the integration of structural and topological information into deep learning algorithms, enabling the extraction of meaningful insights from complex data representations. Students explore advanced topics including geometric deep learning on graphs and manifolds, spectral learning methods, and spectral analysis of manifolds. Additionally, the course covers spectral and spatial graph convolutions, along with techniques for evaluating their effectiveness. Representation learning on graphs is a focal point, facilitating the understanding of intricate relationships within data. Practical applications, including molecular modeling and learning, as well as 3D modeling and learning, provide real-world contexts for applying the learned concepts. Through hands-on exercises and theoretical discussions, students gain a comprehensive understanding of geometric deep learning principles and their applications in diverse fields.

xiii. CS 843 Generative Deep Models

Variation Auto encoders (VAEs) and their variants, equipping students with the tools to understand latent space representations and probabilistic modeling. Moving forward, students immerse themselves in the realm of Generative Adversarial Networks (GANs), learning about their architecture, training process, and applications in generating realistic data. From Conditional GANs to advancements like Style GAN, students dissect the strengths and limitations of GANs, exploring their impact on bias and ethical considerations. Additionally, the course delves into alternative approaches like Hopfield Networks, Boltzmann Machines, and Energy-based GANs, broadening students' understanding of generative modeling paradigms. Practical applications, including data augmentation, privacy preservation, and image-to-image translation, are explored using state-of-the-art techniques like Pix2Pix and Cycle GAN, empowering students to apply generative models creatively in real-world scenarios.

xiv. CS 827 Applied Game Theory

CS 827 Applied Game Theory delves into the fundamental principles of game theory and their practical applications in diverse domains, including real-world scenarios and computing. The course provides a comprehensive exploration of game theory's formal definitions, including the normal form, players, actions, payoffs, and strategies. It covers various solution concepts such as Nash Equilibrium, both in pure and mixed strategies, along with alternate solution methods like the iterative removal of strictly dominated strategies and minimax strategies. Extensive form games are examined, including perfect information games and their strategic implications through backward induction and subgame perfect equilibrium. Repeated games and multi-agent reinforcement learning are also discussed, highlighting concepts like stochastic games and Q-learning. The course extends into incomplete information games, coalition games, and mechanism design, offering students a holistic understanding of game theory's analytical power and its practical relevance in decision-making contexts.

xv. CS 843 Artificial Intelligence for Healthcare

"CS 843 Artificial Intelligence for Healthcare" is a dynamic course designed to equip students with the fundamental knowledge and practical skills necessary to apply artificial intelligence (AI) techniques in the field of healthcare, with a particular focus on medical image analysis. Covering a broad spectrum of topics, the course delves into essential concepts such as sequence alignments, tissue imaging, and computational pathology. Through a comprehensive curriculum, students will gain proficiency in handling and processing whole-slide images (WSIs), a critical aspect of modern medical diagnostics. Additionally, the course emphasizes the identification and classification of various cell types within cancerous WSIs, leveraging AI methodologies to enhance accuracy and efficiency. With a blend of theoretical foundations and hands-on experience, students will also explore advanced research topics in computational pathology, fostering a deeper understanding of cutting-edge AI applications in healthcare. Through this course, students will be empowered to contribute meaningfully to the intersection of AI and healthcare, driving innovation and improving patient outcomes.

xvi. CS867 Computer Vision

CS867 Computer Vision is an advanced course tailored to immerse students in the forefront of computer vision technologies. Delving beyond introductory principles, this course empowers learners with a comprehensive understanding of contemporary methodologies and techniques. Proficiency in Python programming, particularly with libraries such as OpenCV, PIL, NumPy, SciPy, Scikit-image, and Scikit-learn, is imperative, alongside a solid grasp of calculus, linear algebra, and basic probability and statistics. Essential skills in optimization, including comprehension of cost functions, loss functions, and gradients, are crucial for navigating the intricacies of computer vision algorithms. While prior exposure to deep learning is beneficial, this course accommodates students

with fundamental knowledge of neural networks and their applications in computer vision. Through a structured curriculum encompassing digital image processing concepts, participants will gain the necessary expertise to tackle real-world challenges and contribute to cutting-edge advancements in the field of computer vision.

xvii. CS-885 Data Security & Privacy

CS-885 Data Security & Privacy is a postgraduate-level course designed to provide students with advanced knowledge and skills in protecting data and ensuring privacy in modern computing environments. The course covers a wide range of topics, including cryptographic techniques, access control mechanisms, network security, privacy-preserving data mining, and legal and ethical aspects of data protection. Through lectures, case studies, and hands-on assignments, students will explore strategies for securing data at rest, in transit, and during processing, as well as mitigating risks associated with data breaches and unauthorized access. By the end of the course, students will be equipped with the expertise to design, implement, and manage robust data security and privacy solutions in various domains, including healthcare, finance, and e-commerce.

xviii. STAT-901 Advanced Probability & Statistics

This postgraduate-level course delves into advanced topics in probability theory and statistical inference, equipping students with the tools necessary to tackle complex statistical problems encountered in research and industry. Building upon foundational knowledge, students explore advanced probability distributions, stochastic processes, and multivariate statistical analysis. The course covers topics such as Bayesian inference, non-parametric methods, advanced regression models, and time series analysis. Emphasis is placed on theoretical understanding, practical application, and computational techniques using statistical software. Through lectures, problem-solving sessions, and projects, students develop proficiency in analyzing and interpreting complex datasets, making informed decisions based on statistical evidence, and contributing to cutting-edge research in various fields. Prerequisite: Undergraduate coursework in probability and statistics or instructor's approval.

xix. CS-890 Advanced Data Science

CS-890 Advanced Data Science is a postgraduate-level course designed to delve into the advanced techniques and methodologies used in contemporary data science applications. Building upon foundational concepts, this course explores cutting-edge topics such as deep learning, natural language processing, and advanced statistical analysis. Students will gain hands-on experience with state-of-the-art tools and frameworks for large-scale data analysis and predictive modeling. Emphasis is placed on developing practical skills for tackling real-world data science challenges, including feature engineering, model evaluation, and interpretation of results. Through lectures, discussions, and project-based learning, students will be equipped with the expertise necessary to navigate complex data landscapes and extract valuable insights for informed decision-making.

xx. CS-897 Advanced Topics in Computing

CS-897 Advanced Topics in Computing is designed for postgraduate students seeking a deeper understanding of cutting-edge concepts and emerging trends in the field of computer science. This course explores advanced topics spanning various sub-disciplines, including artificial intelligence, machine learning, distributed systems, cybersecurity, and data science. Students delve into complex theoretical frameworks, contemporary research findings, and practical applications through a combination of lectures, seminars, and hands-on projects. Emphasis is placed on critical analysis, problem-solving, and the exploration

of innovative solutions to real-world challenges. By the end of the course, students will have acquired advanced knowledge and skills to navigate the forefront of computing technology and contribute to advancements in research, industry, and academics.

xxi. CS-893 Advanced Computer Vision

CS-893 Advanced Computer Vision offers postgraduate students an intensive exploration of advanced topics in computer vision, focusing on cutting-edge research and practical applications. Students delve into sophisticated techniques for image analysis, understanding, and interpretation, with an emphasis on deep learning approaches. The course covers advanced image processing algorithms, feature extraction, object detection and recognition, semantic segmentation, and image synthesis. Additionally, students engage with recent developments in areas such as generative adversarial networks (GANs), convolutional neural networks (CNNs), and recurrent neural networks (RNNs) applied to computer vision tasks. Through theoretical study, hands-on projects, and discussion of contemporary research papers, students gain expertise in tackling complex challenges in computer vision and contribute to the advancement of this rapidly evolving field.

xxii. CS-839 explores the principles, algorithms

CS-839 explores the principles, algorithms, and technologies underlying parallel and distributed simulation systems. Postgraduate students delve into advanced topics such as parallel discrete event simulation, synchronization techniques, load balancing, and scalability in distributed environments. The course covers foundational concepts in parallel computing and simulation, including parallel programming models, distributed system architectures, and simulation methodologies. Through theoretical study and practical exercises, students gain insights into designing and implementing parallel and distributed simulation algorithms for various application domains, such as network simulations, large-scale scientific simulations, and real-time systems. Emphasis is placed on understanding the trade-offs involved in parallel and distributed simulation design, performance optimization strategies, and emerging trends in the field. Prerequisite: Proficiency in programming and basic knowledge of parallel computing concepts.

xxiii. CS-873 Semantic Web

CS-873 Semantic Web is an advanced postgraduate-level course that explores the principles, technologies, and applications of the Semantic Web. This course delves into the foundational concepts of knowledge representation, ontology engineering, and semantic web standards such as RDF, OWL, and SPARQL. Students will gain hands-on experience in designing and developing semantic web applications using ontology modeling tools and semantic web frameworks. Topics include semantic data integration, reasoning techniques, linked data principles, and semantic web services. Through case studies and practical assignments, students will analyze real-world applications of the Semantic Web in domains such as healthcare, e-commerce, and knowledge management. By the end of the course, students will have the knowledge and skills to design, implement, and evaluate semantic web solutions to address complex information challenges in various domains.

xxiv. CS-831 Parallel Computing

CS-831 Parallel Computing is a postgraduate-level course that delves into the principles and techniques essential for designing and implementing high-performance parallel computing systems. This course explores advanced topics in parallel computing, including parallel algorithms, parallel programming models, and distributed computing architectures. Students will examine various parallel computing paradigms, such as shared-memory and distributed-memory systems, GPU computing, and cluster computing. Through hands-on programming assignments and projects, students will gain practical experience

in parallel algorithm design and optimization, parallel programming using frameworks like MPI and OpenMP, and performance evaluation of parallel applications. Additionally, the course will cover emerging trends in parallel computing, including heterogeneous computing, deep learning on parallel architectures, and cloud-based parallelism. Overall, CS-831 equips students with the knowledge and skills to tackle complex computational problems efficiently using parallel computing technologies.

xxv. CS-833 Cloud Computing

CS-833 Cloud Computing introduces students to the dynamic landscape of cloud computing, covering foundational concepts, essential technologies, and advanced architectures. The course delves into the fundamental principles of cloud computing, exploring its characteristics, delivery models (IaaS, PaaS, SaaS), and deployment options (public, private, hybrid, community). Students will gain a comprehensive understanding of cloud enabling technologies such as virtualization, web services, and multitenant architectures, alongside infrastructure and management mechanisms crucial for effective cloud operations. Through hands-on exercises and case studies, students will learn to build, manage, and optimize cloud environments, including IaaS, PaaS, and SaaS deployments. Additionally, the course addresses critical topics in cloud security, machine learning integration, and the latest developments in the field, equipping students with the knowledge and skills to navigate and innovate in the ever-evolving realm of cloud computing.

xxvi. IT-863 Internet of Things

The course "IT-863 Internet of Things" provides a comprehensive overview of the rapidly evolving field of IoT, exploring its significance, architecture, and diverse applications. Students delve into the fundamental concepts behind IoT, understanding its pivotal role in modern technology landscapes. From sensing to actuation, and from embedded systems to networking standards, participants gain hands-on experience with platforms like Arduino, Raspberry Pi, and Nvidia Nano Jetson. Through engaging lectures, industry guest lectures, and practical demonstrations, students explore real-world IoT implementations across various verticals such as smart cities, healthcare, and agriculture. Moreover, the course delves into advanced topics including cloud computing, edge computing, and big data analytics, elucidating the intersection of IoT with machine learning and data security. Through project assignments and presentations, students apply their knowledge to tackle contemporary IoT challenges, preparing them for impactful contributions to this dynamic field.

xxvii. CS-875 Natural Language Processing

CS-875 Natural Language Processing offers a comprehensive exploration of the fundamental principles and advanced techniques in the field of NLP. Through a structured curriculum, students delve into the intricacies of language modeling, tagging, and parsing using a variety of models such as Hidden Markov Models, Log-Linear Models, and Probabilistic Context-free Grammars. The course further delves into advanced topics like lexicalized context-free grammars and history-based parsing, providing a robust understanding of syntactic and semantic analysis in natural language. Students also explore modern approaches such as Feedforward Neural Networks, Recurrent Networks, and LSTMs, leveraging them for tasks like tagging, dependency parsing, and statistical machine translation. Additionally, the course covers key methods for word representation including Word Embeddings and Word2Vec, as well as cutting-edge techniques like Transformers and Large Language Models (LLMs). By the end of the course, students gain a solid foundation in NLP theory and practical applications, equipping them with the skills to tackle real-world language processing challenges.

xxviii. CS-889 Applied Artificial Intelligence

CS-889 Applied Artificial Intelligence delves into the intricate realm of artificial intelligence, offering a comprehensive exploration of cutting-edge techniques and emerging trends. The course commences with an insightful overview, transitioning seamlessly into crucial discussions on identifying and addressing bias within AI systems. Students will gain a profound understanding of uncertainty estimation in deep learning, distinguishing between epistemic and aleatoric uncertainties, alongside exploring probabilistic approaches such as Bayesian Neural Networks and Evidential Deep Learning. Statistical measures essential for deep learning models are extensively covered, including entropy, cross-entropy, and KL-divergence. A significant emphasis is placed on the concept of Explainable AI, elucidating inherently interpretable models and advanced techniques like LIME, SHAP, and counterfactual explanations. Moreover, students will delve into the modern era of statistics, uncovering the foundations of why deep learning flourishes. With a focus on deep unsupervised and self-supervised learning, alongside intriguing topics like machine unlearning and new frontiers in deep learning, this course equips students with the tools and knowledge to navigate the dynamic landscape of artificial intelligence.

xxix. CS-870 Social Web Mining

CS-870, Social Web Mining, delves into the intricate realm of extracting valuable insights from the vast landscape of the internet. This comprehensive course navigates through various methodologies essential for understanding and harnessing the power of social networks and web data. Through a combination of theory and practical applications, students will explore key concepts such as web crawling, indexing, and text analysis, laying the groundwork for comprehensive understanding. Link analysis and ranking algorithms offer insights into the interconnected nature of the web, while clustering and community algorithms provide tools for uncovering patterns within this complex network. Additionally, topics like web growth models and social tagging shed light on the evolving dynamics of online platforms. By the end of the course, students will possess the skills to extract meaningful information from social media and web sources, enabling them to make informed decisions in diverse domains ranging from business to social sciences.

xxx. CS-871 Advanced Machine Learning

CS-871 Advanced Machine Learning offers a comprehensive exploration of fundamental concepts and advanced techniques in machine learning tailored for postgraduate-level students. Beginning with essential mathematical foundations, students delve into core principles such as function approximation. The course covers Linear Regression, Gradient Descent, Logistic Regression, Decision Trees, KNNs, Parzen Window, Kernel Methods, Support Vector Machines, Bayesian Analysis, Bayesian Networks, Model Selection, Feature Engineering, and Regularization. Advanced topics include Dimensionality Reduction, Perceptron, Backpropagation, Gradient Descent optimization, Clustering Techniques, and Reinforcement Learning. Emphasis is placed on both theoretical understanding and practical application, culminating in a hands-on project applying learned concepts to real-world scenarios. Upon completion, students will possess a robust foundation in machine learning principles, empowering them to tackle complex problems across diverse domains.

xxxi. CS-882 Advanced Information Security

In CS-882 Advanced Information Security, students delve into the intricate realm of IoT (Internet of Things) and its security landscape. Through a comprehensive curriculum, learners gain insights into the fundamental principles of IoT security, exploring concerns and solutions within the context of a four-layer IoT architecture. The course delves into various security architectures, including the six-domain model, and examines the intricacies of RFID technology, addressing potential vulnerabilities such as relay attacks and the utilization of distance bounding protocols. Students also explore authentication mechanisms

for IoT nodes and security measures at both the perception and network layers. Additionally, the course introduces students to cloud computing paradigms (PaaS, SaaS, IaaS) and covers essential topics like single sign-on, federated identities, trust management, and key management within the IoT ecosystem. Privacy protection within IoT applications is thoroughly examined across two parts, culminating in project demonstrations to apply theoretical knowledge into practical scenarios.

xxxii. CS-865 Ubiquitous and Autonomic Computing

The Ubiquitous and Autonomic Computing course delves into the forefront of modern computing paradigms, exploring the integration of technology into every facet of our lives. Through a comprehensive overview, students gain insight into autonomic computing principles and their application in creating intelligent, self-managing systems. The course navigates through the landscape of Ubiquitous and Pervasive Computing, unraveling the complexities of Smart Cities and Smart Living concepts. It examines the role of technology in revolutionizing domains like agriculture through concepts like Smart Agriculture. Moreover, students explore the intricacies of Autonomic Cloud, Fog, and Edge Computing, essential for handling vast amounts of data in distributed environments. Through project proposals and presentations, students engage in hands-on exploration, fostering creativity in designing autonomic and pervasive systems. By the end, participants emerge equipped to navigate the ever-evolving landscape of technology, poised to contribute to the development of future computing solutions.

xxxiii. CS822 Data Warehousing and Data Mining

CS822 Data Warehousing and Data Mining is a comprehensive course delving into the fundamental principles and practical applications of data warehousing and data mining techniques. Through this course, students will explore the intricacies of data preprocessing, covering crucial aspects such as data summarization, cleaning, integration, transformation, reduction, and discretization, alongside concept hierarchy generation. They will gain insights into data warehouse architecture, multidimensional data models, OLAP technology, and data cube computation, laying a solid foundation for understanding complex data structures. Furthermore, students will dive into mining frequent patterns, associations, and correlations, as well as classification and prediction methods, including decision tree induction, support vector machines, and artificial neural networks. Cluster analysis techniques will also be explored, including partitioning, hierarchical, density-based, and model-based clustering, alongside outlier analysis. Through real-world case studies and hands-on exercises, students will emerge equipped with the knowledge and skills to tackle contemporary data challenges in diverse domains.

xxxiv. CS-862 Advanced Image Processing

CS-862 Advanced Image Processing delves into the intricate realm of image manipulation, equipping students with comprehensive knowledge and practical skills essential for modern image analysis and computer vision applications. Through a meticulously structured curriculum, students are introduced to fundamental concepts such as image sensing, sampling, and quantization, paving the way for a deeper understanding of image processing techniques. From spatial filtering to frequency domain analysis, the course navigates through a plethora of methodologies including morphological processing, edge detection, and feature extraction. Moreover, it explores contemporary advancements like deep learning and its profound impact on image analysis. Through a combination of theoretical lectures and hands-on exercises, students gain proficiency in implementing various algorithms and techniques for image enhancement, restoration, and feature detection. By the end of the semester, students showcase their mastery through project presentations, demonstrating their ability to tackle real-world image processing challenges with ingenuity and expertise.

xxxv. RM-898 Research Methodology

RM-898 Research Methodology is an essential course designed to equip students with the foundational skills and knowledge required for conducting rigorous academic research. Through a comprehensive curriculum, students will delve into the intricacies of research practices and management, emphasizing the importance of ethical considerations and effective project organization. The course guides students through the process of finding, critically evaluating, and synthesizing related literature, essential for building a strong theoretical framework. Furthermore, students will learn the art of crafting a compelling research proposal, covering key elements such as the introduction, review of literature, and research methodology. With guest lectures enriching the learning experience, students will explore various data sources, including both primary and secondary, and gain proficiency in utilizing tools for thesis writing and data analysis. Moreover, the course provides insights into publication platforms and culminates in project presentations and demos, fostering the development of effective communication and presentation skills crucial for academic and professional success.

xxxvi. CS-899 MS Thesis

CS-899 MS Thesis is a capstone course designed for postgraduate students pursuing a Master of Science degree in Computer Science. This course provides students with the opportunity to conduct original research in a specialized area of computer science under the guidance of a faculty advisor. Through this thesis work, students demonstrate their ability to critically analyze existing literature, formulate research questions, design experiments or theoretical models, collect and analyze data, and draw meaningful conclusions. The thesis document serves as a scholarly contribution to the field of computer science, showcasing the student's depth of knowledge, research skills, and ability to contribute novel insights to the academic community. Successful completion of CS-899 MS Thesis requires students to defend their thesis before a committee of faculty members, demonstrating mastery of their chosen research topic.