1. Introduction

The Master of Science in Artificial Intelligence (MSc AI) is a two-year intensive graduate programme offered by the School of Computer Science and Information Technology at the University of Juba. This programme seeks to educate students in the innovative use of artificial intelligence to create practical solutions in a wide variety of application areas. Imagine using intelligent machines to solve real-world challenges in healthcare, agriculture, environmental protection, and more. This programme empowers you to make that vision a reality.

As artificial intelligence matures, there is a great need for students who can envision, design, plan, and deliver solutions that integrate AI technologies such as deep learning, natural language processing, robotics, and big data analytics into new applications. This programme stresses both intrapreneurship and entrepreneurship, and encourages students to develop ideas for startups and for introduction to established companies.

The curriculum is designed for students who have a strong background in computer science with an interest in an in-depth study of AI to enable them to develop real-world applications, especially in areas to which AI has not yet been applied. The integrated curriculum includes coursework and team projects leading to a full-semester master dissertation.

This programme offers four exciting specialisations to match your interests:

- **Computer Vision**: See the world through the eyes of AI. Learn to develop systems that can analyse images and videos, leading to advancements in medical diagnosis, autonomous vehicles, and security systems.
- **Machine Learning**: Unleash the power of data. Master algorithms that can learn from experience, enabling intelligent applications like personalised recommendations, fraud detection, and even weather forecasting.
- **Intelligent Robotics**: Become the architect of the future. Design and build robots equipped with perception, control, and decision-making capabilities. Imagine robots assisting in surgery, exploring hazardous environments, or revolutionising manufacturing.
- **Edge Computing and Data Analytics**: Be the bridge between data and intelligence. Learn to analyse data collected from sensors and devices at the "edge" of the network, enabling real-time decision-making and optimising resource use.

2. Justification

The establishment of a Master of Science in Artificial Intelligence (MSc AI) at the University of Juba (UoJ) holds immense potential for South Sudan's development and aligns strategically with the university's mission to provide innovative, relevant and excellence education. The benefits of an MSc AI programme include:

2.1 Addressing National Priorities:

- **Economic Growt**h: AI has the potential to revolutionise various sectors in South Sudan, such as agriculture (precision farming, disease prediction), healthcare

(diagnostics, drug discovery), and finance (fraud detection, risk management). An MSc AI programme would equip graduates to develop and implement AI solutions, fostering economic diversification and job creation.

- **Infrastructure Development:** AI can optimise logistics, maintenance, and resource management for critical infrastructure projects like power grids and transportation networks. The programme's graduates can contribute to building a more efficient and sustainable infrastructure.
- **Social Development**: AI can be harnessed for education (personalised learning), environmental monitoring (climate change analysis), and disaster management (early warning systems). The MSc AI would empower graduates to address social challenges and improve the lives of South Sudanese citizens.

2.2 **Leveraging the University's Strengths**:

- **Faculty Expertise**: UoJ has faculty members with backgrounds in computer science, data analysis, and mathematics who can be trained in AI specialisation. The MSc AI program can leverage this existing expertise and potentially attract new faculty with AI research experience.
- **Building on Existing Programmes**: The University already offers programmes in computer science, information technology, engineering, and mathematics. The MSc AI can build upon these programmes, creating a strong foundation for students and fostering interdisciplinary collaboration.
- **Data Availability**: Government agencies, NGOs, and private companies in South Sudan may be collecting data relevant to AI applications (e.g., weather patterns, and agricultural yields). The programme can establish partnerships for data access, enabling students to work on real-world projects.

2.3 **Regional and Global Relevance**:

- **Sub-Saharan Africa Focus**: The MSc AI at UoJ can position itself as a leader in AI education within Sub-Saharan Africa. It can attract students from across the region, fostering knowledge exchange and collaboration on AI solutions specific to African challenges.
- **Global AI Landscape**: As AI continues to evolve rapidly, the programme can establish connections with universities and research institutions worldwide. This fosters the exchange of knowledge, potential joint research projects, and faculty development opportunities.

2.4 **Addressing Ethical Considerations**:

- **Responsible AI Development:** The curriculum integrates courses on the ethical implications of AI, including bias, privacy, and security concerns. This ensures graduates develop and deploy AI solutions responsibly, considering the social and environmental context.
- **Focus on Explainable AI**: The programme can emphasize the development of explainable AI models, making them more transparent and trustworthy for users in South Sudan.

Establishing an MSc AI programme at the University of Juba is a timely and strategic decision. It equips graduates to address national development priorities, leverages the university's strengths, and positions UoJ as a regional AI education leader. By ensuring responsible AI development, the programme can contribute to a more prosperous and equitable future for South Sudan.

3. Programme Learning Objectives

The MSc AI programme at the University of Juba (UoJ) aims to achieve a variety of key objectives, fostering both individual development and national progress in South Sudan. These objectives include:

3.1 Building Expertise in AI Fundamentals:

- Equip graduates with a strong foundation in core AI concepts, including machine learning, deep learning, natural language processing, and computer vision.
- Foster an in-depth understanding of algorithms, data structures, and programming languages relevant to AI development.
- Provide students with the skills to analyse complex datasets and extract meaningful insights using AI techniques.

3.2 Cultivating Applied AI Skills:

- Train graduates to translate AI theory into practical applications that address real-world challenges in South Sudan.
- Develop their ability to design, implement, and evaluate AI solutions for various sectors like agriculture, healthcare, finance, and infrastructure.
- Equip students with the skills to collect, clean, and manage data responsibly for effective AI development.

3.3 Fostering Innovation and Entrepreneurship:

- Encourage graduates to think creatively and identify innovative applications of AI that can benefit South Sudan's development goals.
- Develop their entrepreneurial skills to translate AI solutions into viable businesses or social ventures.
- Provide opportunities for students to collaborate with stakeholders from industry and government to bring their AI ideas to life.

3.4 Promoting Responsible AI Development:

- Integrate ethical considerations into the curriculum, ensuring graduates understand the potential biases, privacy concerns, and societal implications of AI.
- Train students in developing fair, accountable, and transparent AI models that promote trust and social good.
- Equip graduates with the ability to assess the environmental impact of AI solutions and promote sustainable practices.

3.5 Building a Strong AI Community in South Sudan:

- Create a network of AI professionals through the MSc AI programme, fostering collaboration and knowledge exchange within the country.
- Position UoJ as a hub for AI research and development in South Sudan, attracting talent and investment in the field.

- Contribute to a national dialogue on the responsible use of AI for inclusive growth and sustainable development.

By achieving these objectives, the MSc AI programme at UoJ will empower graduates to become leaders in the field of AI and contribute significantly to South Sudan's progress in the technological age.

4. Programme Learning Outcomes

Upon successful completion of this programme, the graduates shall be able to:

- Demonstrate the capability of building expertise in AI fundamentals;
- Acquire knowledge and skills of applied AI;
- Have the capability of fostering innovation and entrepreneurship;
- Demonstrate the capability in promoting responsible AI development;
- Demonstrate understanding of building a strong AI community in South Sudan.

5. Vision

To become a national, regional and global centre of excellence in computing education and research particularly in artificial intelligence spectrum and strive to empower students with cutting-edge knowledge and skills, fostering innovation and ethical practice for socio-economic growth or benefit.

6. Mission

The mission of this programme is to:

- Provide students with strong fundamental concepts of artificial intelligence;
- Equip students with critical thinking and problem-solving techniques and skills through practical experience and real world issues;
- Promote culture of research, innovation and continuous learning among students and faculty;
- Foster ethical and responsible practices of artificial intelligence in addressing societal problems;
- Develop partnership and collaboration with industries and research institutions to contribute to the development of artificial intelligence technologies.

7. Core Values

Creativity and originality, innovation, excellence, commitment, integrity, diversity, teamwork, leadership, transparency and impact.

8. Admission Criteria

The MSc AI programme at the University of Juba (UoJ) seeks qualified and motivated students with a strong foundation in computer science and a passion for artificial intelligence. To ensure

student success and a thriving learning environment, the following admission criteria will be considered:

8.1 Educational Background:

- A Bachelor's degree in Computer Science, Information Technology, Engineering, Mathematics, or a closely related field from an accredited institution.
- A strong academic record with a minimum grade point average (GPA) requirement (to be specified, e.g., 3.0 on a 4.0 scale).
- Prior knowledge in computer science fundamentals, including algorithms, data structures, and programming languages (e.g., Python, Java).
- Prior works in mathematics, including linear algebra, calculus, and probability theory (highly recommended).

8.2 Statement of Purpose:

- A well-written statement of purpose (1-2 pages) outlining the applicant's:
  - Motivation for pursuing the MSc AI programme.
  - Specific areas of interest within AI (e.g., machine learning, computer vision).
  - Relevant prior experience in research, projects, or coursework related to AI (if any).
  - Future career aspirations in AI and how they align with South Sudan's development goals.

8.3 Letters of Recommendation:

- Two letters of recommendation from university professors familiar with the applicant's academic performance and potential in a field related to AI.

8.4 Additional Considerations:

- Applicants with a non-computer science background but demonstrate strong quantitative skills and relevant work experience in data analysis or programming may be considered on a case-by-case basis.
- The programme may prioritise applicants from South Sudan or the East African region, aiming to build a diverse and regionally impactful student body.
- The admissions committee may conduct interviews with shortlisted candidates to further assess their qualifications and suitability for the programme.

9. Selection Process:

Applications meeting the above criteria will be reviewed holistically by the admissions committee, considering all factors mentioned. Shortlisted candidates may be called for interviews. The final selection will be based on a comprehensive evaluation, ensuring the incoming cohort possesses the academic foundation, motivation, and diverse perspectives necessary for a successful and enriching learning experience in the MSc AI programme at UoJ.

10. Assessment

To receive the M.Sc. degree in AI, all students must take and complete 15 courses: 10 core and 5 specialisation courses. Student performance shall be evaluated following the university's

examination guidelines. In addition to these guidelines, the following criteria are also considered for assessment and grading:

11. Course Assessment

Each course will be assessed in two parts, contributing to a total of 100%.

- **Coursework and In-Class Tests (30%)**: This component will evaluate student's ongoing learning through assignments, projects, and in-class tests.
- **Semester Examinations (70%)**: These three-hour examinations will assess student's comprehensive understanding of the course material at the end of each semester.

12. Grading System

Each course shall be graded out of maximum marks of 100% and assigned appropriate letter grades and grade points (GP) as shown in table 1.

Table 1: Grading System

Marks (%)	Letter Grade	Grade Points	Classification
80-100	A	4.0	Excellent
70-79	B+	3.5	Very Good
60-69	B	3.0	Good
55-59	C+	2.5	Fairly Good
50-54	C	2.0	Pass Satisfactorily
Below 50	F	0.0	Fail

13. Academic Progression

The MSc AI programme conducts an academic progress review after each semester to monitor individual student progress toward graduation according to the University of Juba Graduate Studies Guidelines on Examination. Additionally, the following guidelines shall be observed:

- A student of MSc AI has to obtain a GPA of 2.00 or more at the end of year one to be promoted to year two

14. Faculty

The School of Computer Science and Information Technology has sufficient number of qualified faculty members with various areas of specialisation in computer science, information technology, cybersecurity, and artificial intelligence, and have competencies to cover all of the curriculum areas of the programme. This number of academic and teaching

assistants staff can smoothly run the programme successfully. The list of the academic and teaching assistant staff is attached in the appendix.

15. Facilities

- **Lecture Halls**

Due to the scarcity of class rooms for teaching in the University for each School to use independently, the School of Computer Science and Information Technology does not own many lecture halls but being assigned by the preparatory college for use at a specified interval of time. Based on this criterion, the School of Computer Science and Information Technology can run its programme properly to attain student outcomes.

- **Offices**

The School of Computer Science and Information Technology has insufficient number of offices that can accommodate the academic and teaching assistant staff for the lectures preparation and carrying out their research activities, respectively. Currently, most of the instructors do not have offices at the school.

- **Laboratory**

At the moment, the School of Computer Science and Information Technology has a computer laboratory that can accommodate all students of this new programme for carrying out their practicals successfully. Any course in the curriculum that involves practicals will be carries out effectively.

- **Library**

The School of Computer Science and Information Technology is currently preparing a small library using the references used for drafting the course content of each course in the Department of Artificial Intelligence. In addition, the main University library can be of help to the Department of Artificial Intelligence.

- **Equipment**

Most of the facilities mentioned above are furnished. The offices are equipped with furniture, laboratory is equipped with computers and printers, library is equipped with recent published textbooks, and lecture halls are equipped with desks, tables and writing boards (black, green or white), respectively.

16. Environment

The facilities such as classrooms, offices, laboratories, library and other teaching facilities are almost being adequately equipped to provide conducive learning environment in order to fulfil programme objectives as well as student outcomes. Other activities such as collaborative projects or research with organisations or industries are to be put in place to support the scholarly activities of both faculty and students.

17. Support and Financial Resources

The School of Computer Science and Information Technology does not possess the financial resources to fulfil its mission for the attainment of the student outcomes of its own but entirely depends on the main administration of the University. It is a necessity for the School to have sufficient resources to attract and retain well qualified staff and also to provide them with chances for continued development in education as well as career growth. Therefore, the budgetary planning process of the School must include the acquisition, repair, maintenance and replacement of physical facilities and equipment appropriate for the programme, and to provide conducive environment in which student outcomes can be achieved.

18. Management Structure

The School of Computer Science and Information Technology is a established school with proper line governance structures such as dean, deputy dean, heads of departments, examination officer, registrar, assistant registrar, administrator, assistant administrator, clerk, and secretary of the dean for the formulation and implementation of polices that enable the programme to fulfil its mission as well as student outcomes. Therefore, the operation of the Department of Artificial Intelligence will base on the existing line management structures of the School.

19. Course Coding System

Based on University of Juba calendar (Blue book) coding system, the courses are coded by three letters indicating College or School, name of the College or School and the field of study as well as three digits showing the academic year, semester of that year, and the course number in that semester. Thereafter, the course name or course title is indicted followed by the course credit hours which is split into lecture hours, practical or tutorial hours, respectively. E.g. SCC 611 is expressed as S= school, C= name of the school (Computer Science and Information Technology), C= core course (AI); 6= academic year (first year), 1= semester one of the academic year(First year), and

1=first course in first year semester one, SCC 621 is expressed as: the first three letters are similar to the first case, 6=academic year (first year), 2= semester two of this academic year, 1= course number in this semester of the academic year and so on.

20. Credit Hours

As shown in the tables for the courses in each semester, the total credit hours for a course is split into lecture hours, practical and tutorial hours, respectively. Therefore, the total credit hours for the courses offered in this programme including a final year research project leading to a dissertation is sixty three (63) hours.

21. Teaching and Learning Methods

The teaching and learning in this Department shall be delivered through:

- Lectures
- Discussion and Dialogue
- Practical Demonstration
- Group Learning (Cooperative Learning)
- Problem Solving (Problem-based Learning)
- Investigation and Presentation

Course Structure

Year One

Semester One

S/No	Course Code	Course Title	Course Hours	Hours Per Week	
				Theory	Practical
1	SCC 611	Introduction to AI	3	3	0
2	SCC 612	Machine Learning	3	2	3
3	SCC 613	Probability and Statistics for AI	3	3	0
4	SCC 614	Algorithms and Complexity	3	3	0
5	SCC 615	Python Programming	3	1	4
		Total	15	12	7

Semester Two

S/No	Course Code	Course Title	Course Hours	Hours Per Week	
				Theory	Practical
1	SCC 621	Deep Learning	3	2	3
2	SCC 622	Introduction to Computer Vision	3	2	3
3	SCC 623	Computer Graphics	3	2	1
4	SCC 624	Data Visualisation	3	2	2
5	SCC 625	Speech Processing	3	2	2
Total			15	10	11

Year Two

Semester One: Computer Vision Specialisation

S/No	Course Code	Course Title	Course Hours	Hours Per Week	
				Theory	Practical
1	SCV 711	Advanced Computer Vision	3	2	3
2	SCV 712	Image and Video Processing	3	2	3
3	SCC 713	Mobile Wearable Computing	3	2	1
4	SCC 714	User Design Experience	3	2	2
5	SCC 715	Natural Language Processing	3	2	2
6	SCC 716	Research Methodology	3	3	0
Total			18	13	11

Year Two **Semester One: Machine Learning Specialisation**

S/No	Course Code	Course Title	Course Hours	Hours Per Week	
				Theory	Practical
1	SCM 711	Advanced Machine Learning	3	2	3
2	SCM 712	Machine Learning Optimisation Techniques	3	2	3
3	SCC 713	Mobile Wearable Computing	3	2	1
4	SCC 714	User Design Experience	3	2	2
5	SCC 715	Natural Language Processing	3	2	2
6	SCC 716	Research Methodology	3	3	0
Total			18	13	11

Year Two **Semester One: Intelligent Robotics Specialisation**

S/No	Course Code	Course Title	Course Hours	Hours Per Week	
				Theory	Practical
1	SCR 711	Robot Learning and Control	3	2	3
2	SCR 712	Embedded Deep Learning	3	2	3
3	SCC 713	Mobile Wearable Computing	3	2	1
4	SCC 714	User Design Experience	3	2	2
5	SCC 715	Natural Language Processing	3	2	2
6	SCC 716	Research Methodology	3	3	0
Total			18	13	11

Year Two **Semester One: Edge Computing and Data Analytics Specialisation**

S/No	Course Code	Course Title	Course Hours	Hours Per Week	
				Theory	Practical
1	SCE 711	Edge Computing	3	2	3
2	SCE 712	Big Data Analytics	3	2	3
3	SCC 713	Mobile Wearable Computing	3	2	1
4	SCC 714	User Design Experience	3	2	2
5	SCC 715	Natural Language Processing	3	2	2
6	SCC 716	Research Methodology	3	3	0
Total			18	13	11

Capstone Project or Master Dissertation

The students pursuing master of science in artificial intelligence after successively completing year two semester one shall have option to choose either capstone project or dissertation for final completion of the programme. Hence, both choices require a comprehensive understanding of artificial intelligence fundamental concepts, research methodologies and practical implementation.

Year Two **Semester Two: Master Dissertation**

S/No	Course Code	Course Title	Course Hours	Hours Per Week	
				Theory	Practical
1		Master Dissertation	15	0	30
Total			15	0	30

Year Two **Semester Two**: **Capstone Project**

S/No	Course Code	Course Title	Course Hours	Hours Per Week	
				Theory	Practical
1		Capstone	3	0	6
		Total	3	0	6

Course Description

Year One

Semester One

SCC 611 Introduction to Artificial Intelligence 3(2, 3)

Course Description:

In this course, you will explore the core concepts, theories, and applications that define the AI field. The material will delve into the historical evolution of AI, examining groundbreaking milestones and exploring the various types of intelligent agents. The course equips you with a foundational understanding of problem-solving techniques, search algorithms, and knowledge representation methods used by AI systems. You will gain insights into the ethical considerations surrounding AI development and deployment, preparing you to navigate the responsible application of this powerful technology. Through engaging discussions, projects, and case studies, you will gain a comprehensive perspective on the immense potential and transformative impact of AI across various industries and scientific disciplines.

Course Objectives

The main objectives of this course are to:

- Grasp the fundamental concepts and history of Artificial Intelligence (AI).
- Understand the core areas of AI, including machine learning, computer vision, natural language processing, and robotics.
- Explore the capabilities and limitations of AI systems.
- Examine the real-world applications of AI across various industries.
- Discuss the ethical considerations and potential impact of AI on society

Course Content

- Introduction to AI :
    - Definition of AI, History and evolution of AI.
    - Types of intelligent agents and their capabilities.
    - Problem-solving techniques in AI (search algorithms, game playing)
- Machine Learning:
    - Supervised Learning: Concepts, algorithms (linear regression, decision trees).
    - Unsupervised Learning: Concepts, algorithms (clustering, dimensionality reduction).
    - Introduction to Deep Learning and its Applications.
- Knowledge Representation and Reasoning:
    - Techniques for representing knowledge (logic, semantic networks).
    - Reasoning methods for inferring new knowledge.
- Natural Language Processing:

    - Introduction to NLP tasks (text classification, sentiment analysis, machine translation).
    - Applications of NLP in various domains.
- Applications of AI:
    - Case studies of AI applications in different fields (e.g., healthcare, finance, robotics).
    - Exploring the impact of AI on society.
- Ethics and AI:
    - Bias and fairness in AI systems.
    - Transparency and explainability of AI decisions.
    - Responsible development and deployment of AI.

Learning Outcomes

Upon successful completion of this course, the student should be able to:

- Understand and describe the fundamental concepts and history of AI;
- Demonstrate understanding of core areas of AI such as machine learning, computer vision, natural language processing and robotics, respectively;
- Know the capabilities and limitation of AI systems;
- Demonstrate understanding of the application of AI in various industries;
- Understand and describe the ethical consideration and potential impact of AI on society.

Suggested References:

- Russell, Stuart and Norvig, Peter . ( ) Artificial Intelligence: A Modern Approach
- Introduction to Artificial Intelligence by Michael Wooldridge (strong emphasis on AI reasoning methods)
- Machine Learning: A Probabilistic Perspective by Kevin Murphy (focuses on the statistical and probabilistic foundations of AI)

Online Resources:

- Stanford University's CS229: Machine Learning by Andrew Ng (https://www.coursera.org/specializations/machine-learning-introduction) (covers fundamental machine learning concepts and algorithms)
- MIT OpenCourseWare: 6.S191 Introduction to Deep Learning by Lex Fridman (https://ocw.mit.edu/courses/6-s191-introduction-to-deep-learning-january-iap-2020/) (introduces deep learning architectures and applications)
- DeepMind's Deep Learning Course (https://deepmind.google/) (covers deep learning concepts and implementation with TensorFlow)

SCC 612 Machine Learning 3(2, 3)

Course Description:

The Machine Learning course serves as the cornerstone of the Master's in AI programme. This intensive course delves into the core concepts and algorithms that power intelligent systems. You will explore supervised learning techniques like linear regression and decision trees, along with unsupervised learning methods like dimensionality reduction and clustering. The course will equip you with the ability to evaluate and select appropriate models for various tasks, optimise their performance, and interpret their results. You will gain hands-on experience by working with real-world datasets and implementing machine learning algorithms using popular programming languages and frameworks like Python and TensorFlow. By the end of this course, you will be well-versed in the fundamental principles of machine learning, ready to tackle more advanced topics and applications in your chosen specialisation.

Course Objectives

The main objectives of this course are to:

- Grasp the fundamental concepts of machine learning.
- Understand core machine learning algorithms for supervised and unsupervised learning.
- Gain proficiency in using Python for machine learning tasks.
- Be able to build and train basic machine learning models.
- Develop critical thinking skills to evaluate and interpret machine learning results

Course Content

- Introduction to Machine Learning:
    - Definition of Machine Learning.
    - Different types of Machine Learning (Supervised, Unsupervised, Reinforcement)
    - Machine Learning applications in various domains
    - The Machine Learning Workflow (Data Acquisition, Preprocessing, Model Training, Evaluation, Deployment)
- Supervised Learning:
    - Linear Regression: concepts, model fitting, evaluation
    - Classification: Logistic Regression, K-Nearest Neighbors, Decision Trees
    - Ensemble Methods: Random Forests, Support Vector Machines (SVM)
    - Model Selection and Regularization Techniques (e.g., cross-validation, L1/L2 regularization)
- Unsupervised Learning:
    - Dimensionality Reduction Techniques (Principal Component Analysis (PCA))
    - Clustering Algorithms (K-Means Clustering)
    - Introduction to Association Rule Learning
- Learning from Data:
    - Data Preprocessing Techniques (cleaning, normalisation, feature engineering)
    - Performance Evaluation Metrics (accuracy, precision, recall, F1 score)
    - Model Overfitting and Underfitting and Techniques to Address Them
- Advanced Topics :
    - Introduction to Deep Learning concepts (brief overview of Neural Networks)

- Reinforcement Learning: concepts and basic algorithms
- Applications of Machine Learning in specific domains (e.g., Recommender Systems, Natural Language Processing)

Learning Outcomes:

Upon successful completion of this course, the student should be able to:

- Demonstrate an understanding of the fundamental concepts of machine learning;
- Understand and describe the core machine learning algorithms for supervised and unsupervised learning;
- Show understanding in using Python for machine learning task;
- Demonstrate understanding in building and training basic machine learning models;
- Have knowledge in developing critical thinking skills to evaluate and interpret machine learning results.

Suggested References:

- "The Elements of Statistical Learning" by Trevor Hastie, Robert Tibshirani, and Jerome Friedman (Provides a strong theoretical foundation)
- "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy (Focuses on the probabilistic approach to machine learning)
- "Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow" Aurélien Géron (Balances theory with practical implementation using popular libraries)
- Ian Goodfellow, Yoshua Bengio, and Aaron Courville (2021) Deep Learning. (Focuses on deep learning techniques, a crucial subfield of machine learning)

Online Courses:

- Stanford University's Machine Learning Specialization on Coursera by Andrew Ng (A well-regarded introduction to machine learning with hands-on exercises)
- DeepLearning.AI Specialization on Coursera (Focuses on deep learning with TensorFlow/Keras)
- fast.ai Practical Deep Learning for Coders (https://course.fast.ai/) (Project-based approach using Python libraries)

SCC 613 Probability and Statistics for Artificial Intelligence (AI) 3(3, 0)

Course Description:

In the Probability and Statistics for AI course, you will explore the powerful duo of probability and statistics as essential tools for navigating the world of uncertainty inherent in AI. You will delve into the fundamentals of probability theory, learning how to quantify the likelihood of events and reason under conditions of incomplete information. Statistical methods will equip you to analyse data effectively, identify patterns and trends, and draw meaningful conclusions. This knowledge is crucial for tasks like evaluating the performance of machine learning models,

assessing the reliability of predictions, and making informed decisions based on AI outputs. By mastering these concepts, you will gain the ability to translate real-world problems into a probabilistic framework, enabling you to build robust and reliable AI systems.

Course Objectives

The main objectives of this course are to:

- Grasp the fundamental concepts of probability and statistics critical for AI applications.
- Quantify uncertainty in AI models and interpret results.
- Employ statistical methods to evaluate and improve AI performance.

Course Content

- Introduction to Probability:
  - Sets and Events
  - Axioms of Probability
  - Conditional Probability and Bayes' Theorem
  - Random Variables and Probability Distributions
- Descriptive Statistics:
  - Measures of Central Tendency (Mean, Median, Mode)
  - Measures of Dispersion (Variance, Standard Deviation)
  - Data Visualization Techniques (Histograms, Scatter Plots)
- Probability Distributions for AI:
  - Discrete Distributions (Bernoulli, Binomial, Poisson)
  - Continuous Distributions (Normal, Uniform, Exponential)
  - Central Limit Theorem
- Statistical Inference for AI:
  - Hypothesis Testing (Null and Alternative Hypothesis, p-values)
  - Confidence Intervals
  - Statistical Learning Theory (Bias-Variance Tradeoff)
- Machine Learning Applications:
  - Maximum Likelihood Estimation (MLE)
  - Maximum A Posteriori Estimation (MAP)
  - Evaluation Metrics for Machine Learning Models (Accuracy, Precision, Recall)
- Applications and Case Studies:
  - Case studies demonstrating the use of probability and statistics in real-world AI applications (e.g., computer vision, natural language processing, recommender systems)

Learning Outcomes:

Upon successful completion of this course, the student should be able to:

- Demonstrate complete understanding of the fundamental concepts of probability and statistics critical for AI applications;
- Possess an ability to quantify uncertainty in AI models and interpret results;

- Demonstrate understanding in employing statistical methods to evaluate and improve AI performance.

Suggested References

- "Introduction to Probability and Statistics" by Sheldon M. Ross (Highly Regarded)
- "Probability and Statistics" by Fushing Hsieh, Deepayan Chakrabarti, and Sreeram Sundararajan (Strong on Applications)
- "The Elements of Statistical Learning" by Trevor Hastie, Robert Tibshirani, and Jerome Friedman (Advanced, Covers Machine Learning Applications)
- "Probabilistic Machine Learning: An Introduction" by Kevin P Murphy (Focuses on Probabilistic Methods in Machine Learning)

Online Resources:

- "https://www.coursera.org/learn/machine-learning-probability-and-statistics" by University of Alberta (Interactive and Well-Structured)
- "https://www.edx.org/learn/algorithms/stanford-university-algorithms-design-and-analysis-part-2" by Daphne Koller (Advanced, by Stanford University)
- https://ocw.mit.edu/courses/res-6-012-introduction-to-probability-spring-2018/ (Lectures and Materials from MIT)
- https://www.khanacademy.org/math/statistics-probability (Free Tutorials and Practice Problems)

SCC 614 Algorithms and Complexity 3(2, 3)

Course Description:
In the Algorithms and Complexity course, you will delve into the intricate world of designing and analysing efficient algorithms – the heart of intelligent systems. You will explore various algorithm design paradigms like dynamic programming, greedy algorithms, and divide-and-conquer, learning how to break down complex problems into manageable steps. By analysing the time and space complexity of algorithms, you will gain a critical understanding of their efficiency and resource requirements. This knowledge will be instrumental in selecting the most appropriate algorithms for tackling specific AI problems and ensuring your systems operate optimally in real-world scenarios. Through practical assignments and projects, you will solidify your grasp of algorithm design and analysis, empowering you to create efficient and scalable AI solutions.

Course Objectives

The main objectives of this course are to:

- Understand fundamental algorithm design techniques.
- Analyse algorithm efficiency using time and space complexity.
- Apply appropriate algorithms to solve various computational problems.
- Develop problem-solving skills for designing new algorithms.

Course Content

- Introduction to Algorithms

    - Definition of algorithms
    - Algorithm properties (correctness, efficiency)
    - Basic algorithmic concepts (brute-force search, recursion)
- Data Structures and Algorithms
    - Common data structures (arrays, linked lists, stacks, queues, trees, graphs)
    - Algorithm design paradigms (greedy algorithms, divide-and-conquer, dynamic programming)
    - Analysing time and space complexity (Big O notation)
- Advanced Algorithmic Techniques
    - Network flow algorithms (Ford-Fulkerson, Edmonds-Karp)
    - Linear programming and applications
    - NP-completeness and intractable problems
- Algorithm Design and Analysis
    - Problem-solving strategies for algorithm design
    - Analysing trade-offs between time and space complexity
    - Case studies of practical algorithms
- Advanced Topics
    - Approximation algorithms
    - Randomised algorithms
    - Parallel and distributed algorithms

Learning Outcomes:

Upon successful completion of this course, the student should be able to:

- Demonstrate understanding of fundamental concepts of algorithm design techniques;
- Acquire the capability in analysing algorithms efficiency using time and space complexity;
- Show understanding of applying appropriate algorithms to solve various computational problems;
- Acquire capability in developing problem solving skills for designing new algorithms.

Suggested References

- Introduction to Algorithms by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein [Introduction to Algorithms by Cormen et al.]. This is a classic and widely used textbook that covers a broad range of algorithms and their analysis.
- The Algorithm Design Manual by Steven S. Skiena [The Algorithm Design Manual by Skiena]. This book focuses on practical algorithm design techniques and problem-solving strategies.
- Algorithm Design by Jon Kleinberg and Eva Tardos [Algorithm Design by Kleinberg and Tardos]. This text offers a more theoretical approach to algorithms and complexity analysis.

Online Resources:

- Massachusetts Institute of Technology (MIT) OpenCourseware: Introduction to Algorithms (https://ocw.mit.edu/courses/6-006-introduction-to-algorithms-spring-2020/). This free course by Professor Charles Leiserson provides video lectures, lecture notes, and problem sets.
- Stanford University: Introduction to Algorithms (https://web.stanford.edu/class/cs109/). This course by Professor Tim Roughgarden offers video lectures and problem sets.
- Coursera: Algorithms, Part 1 and 2 by Princeton University (https://www.coursera.org/learn/algorithms-part1). This specialization by Professor Kevin Wayne covers fundamental algorithms, data structures, and graph theory.

SCC 615 Python Programming 3(1, 4)

Course Description:
The Python Programming course within the Master of Science in Artificial Intelligence programme equips you with the essential programming skills needed to succeed in your AI endeavours. This course delves into the core functionalities of Python, a versatile and widely used language in the AI field. You will gain proficiency in data structures, algorithms, and control flow, enabling you to manipulate and analyse data effectively. The course will also cover object-oriented programming (OOP) principles, crucial for building modular and reusable AI systems. Additionally, you will be introduced to popular Python libraries specifically designed for scientific computing and machine learning, such as NumPy, Pandas, and scikit-learn. By the course's end, you will be able to confidently write Python code to implement AI algorithms, analyze datasets, and build intelligent applications.

Course Objectives

The main objectives of this course are to:

- Learn the fundamentals of Python syntax and data structures.
- Gain experience in writing Python programs to solve problems.
- Be introduced to key Python libraries for common applications.

Course Content

- Introduction to Python:
  - Description of Python and it popular.
  - Setting up your Python development environment.
  - Basic syntax: variables, data types (numbers, strings, booleans), operators.
- Control Flow:
  - Conditional statements (if/else)
  - Loops (for, while)

    - Using functions to break down complex problems.
- Data Structures:
    - Lists, tuples, dictionaries
    - How to store, access, and manipulate data.
- Input and Output:
    - Working with user input and file I/O.
    - Printing formatted output.
- Modules and Libraries:
    - Introduction to importing and using modules for common tasks.
    - Examples: math, string manipulation, data analysis libraries (e.g. NumPy, pandas)
- Object-Oriented Programming (OOP):
    - Classes and objects
    - Encapsulation and inheritance

Learning Outcomes:

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

- Understand and describe fundamental concepts of Python syntax and date structure;
- Acquire capability in writing Python program to solve problems;
- Demonstrate understanding of key Python libraries for common applications.

Additional Considerations

- Hands-on coding exercises throughout the course to solidify learning.
- Projects applying Python concepts to solve real-world problems (optional).
- Introduction to debugging techniques for troubleshooting code.

Suggested References

- https://www.coursera.org/learn/python-data-analysis
- https://www.learnpython.org/ (Official Python Tutorial)
- https://github.com/wesm/pydata-book (Pandas Documentation)
- https://numpy.org/doc/ (NumPy Documentation)
- https://matplotlib.org/ (Matplotlib Documentation)

Semester Two

SCC 621 Deep Learning 3(2, 3)

Course Description:

The Deep Learning course will propel you into the heart of modern AI. You will explore artificial neural networks, the powerful learning algorithms that have revolutionized fields like computer vision, natural language processing, and robotics. By delving into architectures like convolutional neural networks (CNNs) and recurrent neural networks (RNNs), you will gain a deep understanding of how these models extract complex patterns from vast amounts of data. The course will equip you with the skills to design, train, and optimise deep learning models, allowing you to tackle real-world problems with cutting-edge techniques. In addition to the technical aspects, you will also explore the theoretical underpinnings of deep learning, fostering a critical understanding of its strengths, limitations, and potential biases

Course Objectives

The main objectives of this course are to:

- Understand the fundamental concepts of Deep Learning architectures (e.g., Neural Networks, Convolutional Neural Networks, Recurrent Neural Networks)
- Gain practical experience building and training Deep Learning models using popular libraries (e.g., TensorFlow, PyTorch)
- Apply Deep Learning techniques to solve real-world problems in areas like computer vision, natural language processing, and time series forecasting.
- Develop critical thinking skills to evaluate Deep Learning model performance and interpret results.

Course Content

- Introduction to Deep Learning:
    - Overview of Deep Learning and its Applications
    - Artificial Neural Networks (ANNs): Perceptrons, Multilayer Perceptrons (MLPs)
    - Gradient Descent and Backpropagation
- Deep Learning Architectures:
    - Convolutional Neural Networks (CNNs): for image recognition and computer vision
    - Recurrent Neural Networks (RNNs): for sequence data like text and time series
    - Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRUs): advanced RNNs for handling long sequences
- Deep Learning with Frameworks:
    - Introduction to popular Deep Learning frameworks (e.g., TensorFlow, PyTorch)
    - Building and training Deep Learning models using the chosen framework
    - Data preparation, preprocessing, and augmentation techniques
- Deep Learning Applications:
    - Computer Vision: Image classification, object detection, image segmentation
    - Natural Language Processing (NLP): Text classification, sentiment analysis, machine translation

    - Time Series Forecasting: Predicting future trends in data
- Deep Learning Best Practices:
    - Regularisation techniques to prevent overfitting
    - Hyperparameter tuning for optimal model performance
    - Evaluating Deep Learning models: Accuracy, precision, recall, F1-score
- Advanced Topics:
    - Generative Adversarial Networks (GANs)
    - Deep Reinforcement Learning
    - Deep Learning Ethics and Bias

Learning Outcomes:

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

- Understand and describe the fundamental concepts of Deep Learning architecture;
- Demonstrate a practical understanding in building and training Deep Learning models using popular libraries (TensorFlow, PyTorch);
- Acquire the capability of applying Deep Learning techniques to solve real world problems in areas like computer vision, natural language processing, and time series forecasting;
- Demonstrate understanding in developing critical thinking skills to evaluate Deep Learning models performance and interpret results.

Suggested References

- MIT Deep Learning (6.S191): http://introtodeeplearning.com/ (freely available online materials, covers core deep learning concepts with coding exercises)
- Stanford CS231n: Convolutional Neural Networks for Visual Recognition: https://cs231n.stanford.edu/ (lecture notes and assignments available online, focuses on computer vision applications)
- Deep Learning Specialization by DeepLearning.AI on Coursera: https://www.coursera.org/specializations/deep-learning (comprehensive program with coding projects in TensorFlow, covers various deep learning architectures and applications)
- Fast.ai Practical Deep Learning for Coders: https://course.fast.ai/ (practical approach, focuses on building deep learning models quickly with Python libraries)

Books:

- Ian Goodfellow, Yoshua Bengio, and Aaron Courville - Deep Learning: https://www.deeplearningbook.org/ (comprehensive textbook, in-depth explanation of deep learning theory and algorithms)
- Francois Chollet - Deep Learning with Python: https://www.amazon.com/Deep-Learning-Python-Francois-Chollet/dp/1617294438 (practical guide using Keras library, good for hands-on learning)

SCC 622 Introduction to Computer Vision 3(2, 3)

Course Description:

In the "Introduction to Computer Vision" course, you will embark on a fascinating exploration of how computers can see and understand the world around them. This course delves into the fundamental concepts and techniques for processing and analysing visual data, like images and videos. You will gain insights into image formation, filtering, and feature extraction – the building blocks for tasks like object detection, recognition, and segmentation. Furthermore, you will be introduced to core computer vision algorithms and explore their applications in various fields, from self-driving cars and medical imaging to robotics and augmented reality. This course serves as a springboard for further exploration within the computer vision specialisation, where you can delve deeper into advanced topics like 3D vision, deep learning for computer vision, and specific applications tailored to your interests.

Course Objectives

The main objectives of this course are to:

- Grasp the fundamental concepts of computer vision and its applications in various fields.
- Understand techniques for image processing and analysis relevant to computer vision.
- Gain practical experience using Python libraries like OpenCV for basic computer vision tasks.
- Develop a foundation for further exploration in computer vision and related areas of machine learning.

Course Content:

- Introduction:
    - Definition and importance of computer vision.
    - Real-world applications of computer vision (self-driving cars, robotics, etc.).
- Image Fundamentals:
    - Image formation and properties (pixels, color channels, etc.).
    - Different image representations (grayscale, RGB, etc.).
- Image Processing Techniques:
    - Basic operations (filtering, noise reduction, edge detection).
    - Image transformations (geometric transformations, color space conversions).
    - Introduction to image segmentation (partitioning an image).
- Feature Detection and Extraction:
    - Identifying and extracting distinctive characteristics from images.
    - Common feature types (corners, edges, blobs).
- Introduction to Machine Learning for Computer Vision:
    - Supervised learning concepts for image classification and object detection.
    - Building a simple image classifier using Python libraries (e.g., OpenCV).
- Applications and Future Directions:
    - Exploring computer vision applications in various domains (medical imaging, AR/VR).
    - Introduction to advanced topics (deep learning for computer vision).

Learning Outcomes:

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

- Demonstrate complete understanding of the fundamental principles of computer vision and its application to various fields;
- Understand and describe techniques for image processing and analysis relevant to computer vision;
- Demonstrate practical understanding of using Python libraries such as OpenC'V for computer vision tasks;
- Acquire the capability of developing foundation for further exploration in computer visio and related areas of machine learning.

Suggested References

- https://www.coursera.org/learn/introduction-computer-vision-watson-opencv
- https://cs231n.stanford.edu/

SCC 623 Computer Graphics 3(2, 3)

Course Description:

The Computer Graphics course within the Master of Science in AI programme delves into the fascinating world of creating and manipulating visual content using computational methods. You will explore the mathematical principles behind image formation, rendering techniques used to create realistic visuals, and 3D modeling for constructing virtual environments. The course will equip you with the knowledge to understand how computers generate the graphics you see in movies, video games, and other interactive applications. Furthermore, you will gain insights into how computer graphics can be leveraged within the realm of AI, such as for building realistic simulations for training AI models or developing advanced visualisation tools for analysing complex data sets.

Course Objectives

The main objectives of this course are to:

- Understand the fundamental principles of computer graphics.
- Gain proficiency in modeling, rendering, and animation techniques.
- Apply mathematical concepts to create realistic and visually appealing graphics.
- Develop problem-solving skills in a computer graphics context.

Course Content

- Introduction:
  - Overview of computer graphics applications (games, animation, VFX)
  - Graphics pipeline (modeling, animation, rendering, output)
- 2D Fundamentals:
  - Point, line, and polygon representation
  - Geometric transformations (translation, rotation, scaling)

    - Rasterisation and vector graphics
- 3D Modeling:
    - Polygon meshes and other primitives
    - Modeling techniques (procedural, sculpting, parametric)
    - Texturing and materials
- 3D Transformations:
    - Viewing transformations (camera position, orientation)
    - Projections (orthographic, perspective)
    - Object hierarchies and animation
- Lighting and Shading:
    - Light models (ambient, point light, directional light)
    - Material properties (diffuse, specular, reflection)
    - Shading algorithms (Phong shading, ray tracing)
- Rendering:
    - Rasterisation and ray tracing techniques
    - Anti-aliasing and visual effects
    - Optimisation and performance considerations
- Animation:
    - Keyframe animation and interpolation techniques
    - Motion physics and inverse kinematics
    - Character animation principles
- Applications:
    - Case studies in game development, animation, and VFX
    - Introduction to graphics APIs (OpenGL, Vulkan)

Learning Outcomes:
Upon successful completion of this course, the students shall be able to:

- Understand and describe the fundamental concepts of computer graphics;
- Demonstrate understanding in modelling, rendering and animation techniques;
- Acquire the capability in applying mathematical principles to create realistic and visually appealing graphics;
- Show the capability in developing problem solving skills in computer graphics context.

Suggested References

- Fundamentals of Computer Graphics by Richard S. Wright Jr., http://www.computo-visual.org/Graficacion/Biblioteca/Shirley.FundamentalsComputerGraphics.pdf
- Computer Graphics Programming in OpenGL with C++ by V. Scott Gordon, https://www.amazon.com/Computer-Graphics-Programming-OpenGL-C/dp/1683922212
- https://www.siggraph.org/ (Association for Computing Machinery's Special Interest Group on Computer Graphics and Interactive Techniques) - a professional society dedicated to computer graphics research and education.

SCC 624 Data Visualisation 3(2, 3)

Course Description:
In the Data Visualisation course, you will explore the art and science of effectively communicating complex AI results. You will delve into design principles for creating clear, informative, and engaging visualisations. The course will equip you with the skills to translate raw data into compelling charts, graphs, and dashboards. You will gain hands-on experience with industry-standard data visualisation tools, allowing you to present your findings to both technical and non-technical audiences. By mastering data visualisation, you will not only enhance your ability to analyse data but also ensure your insights have maximum impact within your field and beyond.

Course Objectives

The main objectives of this course are to:

- Understand the fundamental principles of data visualisation for effective communication.
- Learn how to choose appropriate chart types for different data and goals.
- Gain proficiency in data visualisation tools (e.g., Tableau, Python libraries).
- Develop skills to create clear, concise, and visually appealing data visualisations.
- Apply data visualisation techniques to real-world data analysis and storytelling.

Course Content:

- Introduction to Data Visualisation:
    - Importance and benefits of data visualisation
    - The perception of visual information
    - Core principles of design (e.g., hierarchy, contrast, color)
- Data Exploration and Preparation:
    - Data cleaning and manipulation techniques
    - Identifying patterns and trends in data
    - Choosing the right data for visualisation
- Chart Types and Design:
    - Common chart types (bar charts, line charts, pie charts, etc.)
    - When to use each chart type effectively
    - Best practices for chart design (e.g., axis labeling, legends)
- Data Visualisation Tools:
    - Introduction to popular data visualisation software (e.g., Tableau, Excel) or libraries (e.g., Python libraries)
    - Hands-on practice creating visualisations with chosen tool
- Data Storytelling:
    - Using data visualisation to communicate insights
    - Designing dashboards for effective data presentation
    - Considering audience and context
- Advanced Techniques and Applications:
    - Interactive visualisations
    - Data visualisation for specific domains (e.g., business, science)
    - Ethical considerations in data visualisation
- Course Project:

- Apply learned skills to create data visualisations for a chosen dataset
- Present findings and explain design decisions

Learning Outcomes:

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

- Demonstrate understanding of the fundamental concepts of data visualisation for effective communication;
- Shoe understanding of how to choose an appropriate chart types for different data and goals;
- Acquire capability in data visualisation tools;
- Demonstrate understanding in developing skills to create clear, concise, and visually appealing data visualisation;
- Acquire the capability in applying data visualisation techniques to real world data analysis and storytelling.

Suggested References

- "Data Visualisation with Tableau" by University of California, Davis Available on Coursera: certain MOOC platforms might require a subscription
- "Data Visualisation with Python" by IBM Available on Coursera: certain MOOC platforms might require a subscription
- "The Functional Art: Essential Design Elements of Information Graphics" by Alberto Cairo (book)

SCC 625 Speech Processing 3(2, 3)

Course Description:
The Speech Processing course delves into the fascinating world of human-computer interaction through spoken language. You will explore the science behind speech production, perception, and recognition, gaining insights into how computers can understand and generate human speech. This course equips you with powerful techniques for tasks like automatic speech recognition, speaker identification, and text-to-speech synthesis. By delving into signal processing methods, machine learning algorithms, and deep learning architectures, you will gain the ability to analyse and model speech data, paving the way for real-world applications in areas like virtual assistants, voice-controlled interfaces, and intelligent tutoring systems.

Course Objectives

The main objectives of this course are to:

- Grasp the fundamentals of speech production and perception mechanisms.
- Understand how speech signals are represented and analysed digitally.
- Explore techniques for speech feature extraction and analysis.
- Gain exposure to machine learning applications in speech processing.

- Develop practical skills in speech processing through programming assignments and projects.

Course Content:

- Introduction to Speech Processing:
  - Applications of speech processing (speech recognition, synthesis, etc.)
  - Anatomy and physiology of speech production
  - Basic acoustics of speech signals
- Digital Speech Signals:
  - Sampling and quantisation
  - Time-domain and frequency-domain analysis
  - Linear prediction analysis
- Feature Extraction and Speech Recognition:
  - Mel-frequency cepstral coefficients (MFCCs)
  - Hidden Markov Models (HMMs) for speech recognition
  - Introduction to deep learning for speech recognition
- Speech Synthesis:
  - Articulatory synthesis
  - Parametric synthesis
  - Text-to-speech systems
- Speech Enhancement and Coding:
  - Noise reduction techniques
  - Speech coding standards (e.g., MP3)
- Advanced Topics:
  - Speaker recognition
  - Spoken language understanding
  - Emotion recognition in speech

Learning Outcomes:

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

- Demonstrate complete understanding of the fundamental concepts of speech production and perception mechanisms;
- Understand and describe how speech signals are represented and analysed digitally;
- Demonstrate comprehensive understanding of the techniques for speech feature extraction and analysis;
- Understand and describe how machine learning is applied to speech processing;
- Acquire the capability in developing practical skills in speech processing through programming assignments and projects.

Suggested References:

- Jurafsky, Daniel, and James H. Martin. Speech and Language Processing (3rd ed.). Pearson, 2019. [This is a classic textbook on the subject]

- Lee, Hyundong. Automatic Speech Recognition: The Modern Approach. Springer, 2015. [A technical resource focusing on speech recognition]
- Stanford CS229N: https://cs229.stanford.edu/ (Lectures cover speech and language processing topics)

Year Two

Semester One

SCC 713 Mobile Wearable Computing 3(2, 3)

Course Description:
The Wearable Computing course delves into the exciting intersection of AI and wearable technologies. You will explore the design principles and functionalities of wearable devices, from smartwatches and fitness trackers to augmented reality glasses. The course will examine how AI algorithms are embedded within these devices to personalise user experiences, analyse physiological data, and enable seamless interaction with the environment. You will gain insights into the technical challenges and ethical considerations surrounding wearable computing, preparing you to contribute to the responsible development and application of this rapidly evolving technology.

Course Objectives

The main objectives of this course are to:

- Understand the fundamentals of mobile and wearable computing devices.
- Analyse the hardware and software components of wearable systems.
- Develop applications for wearable devices.
- Critically evaluate the challenges and opportunities of wearable technology.

Course Content:

- Introduction to Mobile and Wearable Computing:
    - Definition and history of wearable computing
    - Applications of wearable devices (e.g., healthcare, fitness, entertainment)
    - Comparison of mobile and wearable platforms
- Hardware Platforms for Wearables:
    - Sensors (accelerometers, gyroscopes, biometrics)
    - Processing units and memory
    - Displays and user interfaces
    - Power consumption and battery life
- Software Development for Wearables:
    - Operating systems for wearables (e.g., Android Wear, watchOS)
    - Programming languages and tools
    - User interface design for small screens
    - Sensor data collection and processing
- Mobile-Wearable Integration:
    - Communication protocols (Bluetooth, Wi-Fi)
    - Data synchronisation and management
    - Security and privacy considerations
- The Future of Wearable Computing:
    - Emerging trends and technologies (e.g., augmented reality, artificial intelligence)
    - Ethical considerations and societal impact
    - The future of wearable applications

Learning Outcomes:

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

- Demonstrate understanding of the fundamental concepts of Mobile and Wearable Computing devices;
- Acquire the capability of analysing hardware and software components of wearable systems;
- Have ability to develop applications for wearable devices;
- Demonstrate comprehensive understanding of critical evaluation of the challenges and opportunities of wearable technology.

Suggested References

- "Mobile and Wearable Computing: Principles and Practices" by Ashok Verma (or a similar recent textbook)
- Online Courses:
  - Udacity - Intro to Wearable Development [Resource 1]
  - Coursera - Wearable Technology Specialization [Resource 2]
- Research Papers:
  - Recent research papers on wearable technology applications in specific fields (e.g., healthcare, sports)

SCC 714 User Design Experience 3(2,3)

Course Description:
In the ever-evolving landscape of AI, the User Design Experience (UXD) course bridges the gap between cutting-edge technology and human needs. You will explore how to design intuitive and engaging interactions for AI-powered systems. This course equips you to understand user behaviour, conduct usability testing, and translate user research into actionable design principles. You will learn how to design interfaces that are clear, efficient, and cater to diverse user groups. By integrating user-centered design principles with your AI knowledge, you will gain the ability to create AI products that are not only powerful but also user-friendly and ethically responsible.

Course Objectives

The main objectives of this course are to:

- Understand the core principles of user-centered design.
- Apply UX design methodologies to create intuitive and user-friendly experiences.
- Conduct user research to understand user needs and pain points.
- Develop design skills using industry-standard tools and techniques.
- Create and iterate on prototypes to test and refine user experiences.

Course Content

- Introduction to UX Design

    - Define UX Design?
    - User-centered design principles
    - Benefits of good UX design
    - Understanding user needs and behavior (https://www.interaction-design.org/templates/persona-template)

- UX Design Process
    - Design Thinking framework
    - User research methods (surveys, interviews, user testing)
    - Information architecture and sitemaps
    - User interface (UI) design principles

- Design Tools and Techniques
    - Introduction to design software (e.g., Figma, Sketch)
    - Wireframing and prototyping
    - Usability testing and data analysis

- Interaction Design and Accessibility
    - User flows and task analysis
    - Designing for different user types and accessibility
    - Microinteractions and visual design

- Prototyping and Iteration
    - Prototyping techniques (low-fidelity, high-fidelity)
    - User testing and feedback loop
    - Iteration and refinement of designs

- Design for Specific Platforms
    - User experience considerations for web, mobile, and desktop applications
    - Designing for specific user journeys

- UX Design Portfolio and Career
    - Building a UX design portfolio
    - Presenting UX design work
    - Career paths in UX design

- Additional Considerations:
    - Guest lectures from UX professionals
    - Case studies of successful UX design projects
    - Hands-on workshops and group projects

Learning Outcomes:

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

- Understand and explain the core principles of user centred design;

- Demonstrate understanding in applying UX design methodology to create intuitive and user friendly experience;
- Develop understanding to conduct user research to understand user needs and pain points;
- Acquire the capability of developing design skills using industry standard tools and techniques;
- Demonstrate understanding to create and iterate on prototypes to test and refine user experience.

Suggested References

- Interaction Design Foundation: "https://www.interaction-design.org/" (Provides a strong foundation in UX design principles)
- Nielsen Norman Group: "https://www.nngroup.com/" (Offers resources on UX design for AI)
- "Designing for AI" by Sarah Horton and Dr. Whitney Quesenbery (Book specifically focused on UX design for AI)

SCC 715 Natural Language Processing 3(2, 3)

Course Description:

The Natural Language Processing (NLP) course delves into the fascinating world of enabling computers to understand and manipulate human language. You will explore techniques for machines to process and analyse text data, including tasks like sentiment analysis, topic modeling, and machine translation. The course will equip you with the fundamental algorithms and tools used in NLP, such as natural language understanding, text classification, and language generation. By exploring real-world applications of NLP in chatbots, machine translation systems, and text summarisation, you will gain a practical understanding of how NLP is revolutionising human-computer interaction.

Course Objectives

The main objectives of this course are to:

- Understand the fundamental concepts and techniques in Natural Language Processing (NLP).
- Gain practical experience with NLP tools and libraries.
- Apply NLP techniques to real-world applications like text classification, sentiment analysis, and machine translation.
- Develop critical thinking skills to evaluate the strengths and limitations of NLP models.

Course Content

- Introduction to NLP :
    - Definition of NLP, Applications and challenges.
    - Text representation: Bag-of-Words, TF-IDF, Word Embeddings.
    - Language Fundamentals: Morphology, Syntax, Semantics.
- Text Preprocessing:
    - Tokenization, Normalisation, Stemming, Lemmatisation.

    - Regular Expressions for text manipulation.
    - Text Cleaning and Handling Missing Data.'
- Machine Learning for NLP:
    - Supervised Learning: Classifiers for NLP tasks.
    - Unsupervised Learning: Clustering for topic modeling.
    - Evaluation Metrics for NLP models (Accuracy, Precision, Recall, F1 Score).
- Applications of NLP:
    - Text Classification: Sentiment Analysis, Spam Detection.
    - Named Entity Recognition (NER): Identifying People, Places, Organisations.
    - Machine Translation: Automatic translation between languages.
    - Chatbots and Conversational AI.
- Deep Learning for NLP:
    - Introduction to Neural Networks (RNNs, LSTMs).
    - Word Embeddings with Word2Vec and GloVe.
    - State-of-the-art NLP models (BERT, transformers).
- NLP in Practice:
    - Working with NLP libraries (e.g., spaCy, NLTK, TensorFlow).
    - Building and training NLP models for specific tasks.
    - Case studies and project presentations.
- Ethical Considerations in NLP:
    - Bias in NLP models and datasets.
    - Explainability and interpretability of NLP results.
    - Fairness and social impact of NLP applications.

Learning Outcomes:

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

- Understand and describe the fundamental concepts and techniques in Natural Language Processing;
- Acquire the capability of practical skills with Natural Language Processing tools and libraries;
- Demonstrate understanding in applying Natural Language Processing techniques to real world applications like text classification, statement analysis, and machine translation;
- Possess an ability to develop critical thinking skills to evaluate the strength and limitation of Natural language Processing models.

Suggested References

- Jurafsky, Daniel, and James H. Martin. *Speech and Language Processing* (3rd Edition). Prentice Hall, 2019. (Classic NLP textbook)
- https://web.stanford.edu/class/cs224n/ (Stanford's CS224n course, a popular online resource)

SCC 716 Research Methodology

Course Description

This course provides introductory research methodology concepts and applications to students. It further provides techniques to avoid plagiarism, concepts of intellectual property, industrial property, importance of intellectual property right in global economy.

Course Objectives

- Provides thorough knowledge of research, journal articles and proposal writing.
- Introduces basic concepts on plagiarism issues and ethics.
- Provides information about Intellectual Property Right (IPR).

Course Content

- Introduction to Research: Objectives, Motivation, Ingredients for Research (Creativity), Types of Research, Phase of Research or Research Process, Criteria of good Research, Research methods versus Research methodology.
- Literature Survey and Literature Review: Background Research, Resources for Literature Survey, How to read Scientific Papers, White Papers, and Patent, Recording and summarising the Findings, Formulation of Problem Statement, Scope and Significance of Research Problem, Research Proposal.
- Research Design: Definition, Necessity of Research Design, Parameters of a Research Design, Approaches of Research Design, Types of Research Design.
- Interpretation and report writing, Presenting and Publishing the Research Findings: Types of Publications, Body of Research Papers, Reports, Dissertations and Theses, Content of Research Paper, Reports, Dissertations, and Theses, Selecting Journal for publication, Journal Ranking and Journal Metrics, Citation index, Databases, search engine, Author Identifier, Presenting Research Papers, Reports, Dissertations and Theses.
- Plagiarism: Types, Plagiarism in computer Science and its Consequences, Plagiarism Polices, Techniques to Avoid Plagiarism.
- Intellectual Property Right (IPR): Forms (Patent, Copyright, Trademark, etc.), Intellectual Property, Industrial Property, Importance of IPR in Global Economy, Role of IP in Technology Transfer, Philosophy of IPR, IPR as Instrument for Development.

Learning Outcomes

Upon successful completion of this course, the student should be able to:

- Understand and explain research and research problem formulation.
- Equip with knowledge and skills for analysing research related information and follow research ethics.
- Understand the difference between literature survey and literature review.
- Understand and describe research design.
- Understand that the world of today is controlled by computers, information technology, but tomorrow world will be ruled by ideas, concepts and creativity.

- Demonstrate an understanding on IPR protection provides an incentive to inventors for further research work and investment in Research and Development (R & D), which leads to creation of new and better products, and brings about economic growth and social benefits.

Suggested References

- Vinayak Bairagi and Mousami V. Munot, (2019) **Research Methodology A Practical and Scientific Approach**, USA: CRC Press,.
- Alexander M. Novikov and Dmitry A Novikov, (2013) **Research Methodology: From Philosophy of Science to Research Design**, USA: CRC Press,.
- Peter Pruzan, (2016) **Research Methodology: The Aims, Practices and Ethics of Science**, London: Springer,.

Year Two

Semester One

SCV 711 Advanced Computer Vision 2(2, 3)

Course Description:

The Advanced Computer Vision course delves deeper into the cutting-edge techniques and applications of computer vision. You will explore advanced topics like 3D scene understanding, where computers can perceive and reason about the spatial relationships within an environment. Additionally, the course will cover advanced object detection and recognition frameworks, enabling machines to identify and localize objects with greater accuracy and robustness. You will delve into deep learning architectures specifically designed for computer vision tasks, such as convolutional neural networks (CNNs) and generative models. By the end of this course, you will be equipped to tackle complex computer vision challenges, pushing the boundaries of how machines can "see" and interpret the world around them

Course Objectives:

The main objectives of this course are to:

- Deepen understanding of core computer vision techniques (image classification, object detection, segmentation)
- Master advanced approaches using deep learning and convolutional neural networks (CNNs)
- Gain expertise in applying these techniques to solve real-world computer vision problems
- Develop proficiency in building and customising deep learning models for specific tasks

Course Content

- Review of Fundamentals:
    - Image processing and analysis
    - Feature extraction and representation
    - Traditional computer vision algorithms
- Deep Learning for Computer Vision:
    - Introduction to convolutional neural networks (CNNs)
    - Architectures for image classification (VGG, ResNet)
    - Object detection frameworks (R-CNN, YOLO)
    - Semantic segmentation with deep learning (FCN, U-Net)
- Advanced Techniques:
    - Transfer learning for computer vision tasks
    - Attention mechanisms and their applications
    - Generative adversarial networks (GANs) for image generation
    - Domain adaptation for robust models
- Project and Applications:
    - Develop a deep learning project using a chosen computer vision technique
    - Explore applications in areas like self-driving cars, medical imaging, robotics

Learning Outcomes:

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

- Demonstrate deepen understanding of core computer vision and techniques;
- Understand and explain advanced approaches using deep learning and convolutional neural networks;
- Demonstrate expertise in applying these techniques to solve real world computer vision problems;
- Acquire proficiency in building and customising deep learning models for specific tasks.

Suggested References

- Computer Vision: Algorithms and Applications by Richard Szeliski [Richard Szeliski Computer Vision: Algorithms and Applications]
- Deep Learning for Computer Vision by Jason Brownlee [Jason Brownlee Deep Learning for Computer Vision]
- Computer Vision: Applications and Algorithms by Richard Hartley and Andrew Zisserman [Richard Hartley and Andrew Zisserman Computer Vision: Applications and Algorithms]

Online Resources:

- Stanford University's CS231n: Convolutional Neural Networks for Visual Recognition [Stanford CS231n Convolutional Neural Networks for Visual Recognition] (Lectures and assignments)
- DeepLearning.AI Specialization by Andrew Ng ([DeepLearning.AI Specialization by Andrew Ng]) on Coursera (Course includes Deep Learning for Computer Vision)
- OpenCV Courses ([OpenCV Courses Deep Learning Courses Computer Vision Courses]) - Offers various online courses on computer vision with a focus on practical applications.

SCV 712 Image and Video Processing 3(2, 3)

Course Description:

In the Image and Video Processing course, you will delve into the fascinating world of extracting meaning from visual data. You will explore the fundamental techniques for manipulating, analysing, and understanding images and videos. You will gain hands-on experience with image formation, filtering, segmentation, and feature extraction. You will explore powerful deep learning architectures specifically designed for computer vision tasks like object detection, image classification, and image generation. By the end of the course, you will be equipped to build intelligent systems that can "see" and interpret the visual world, with applications in areas like autonomous vehicles, medical imaging, and robotics.

Course Objectives

The main objectives of this course are to:

- Understand the fundamental principles of digital images and videos.
- Gain knowledge of image/video processing techniques for enhancement, restoration, and compression.
- Develop practical skills in applying processing algorithms using industry-standard tools.

Course Content

- Introduction:
  - The digital image and video revolution.
  - Applications in science, engineering, and media.
  - Human visual system and its relevance to processing.
- Digital Image Fundamentals:
  - Image acquisition and sampling.
  - Image representation (pixels, bit depth, color spaces).
  - Mathematical foundations (matrices, convolutions).
- Image Processing Techniques:
  - Enhancement (contrast, noise reduction, filtering).
  - Restoration (deblurring, inpainting, error correction).
  - Segmentation (object identification and separation).
- Video Processing Fundamentals:
  - Video representation (frames, motion vectors).
  - Video compression standards (e.g., MPEG).
  - Motion analysis and tracking.
- Applications:
  - Image/video editing and manipulation (e.g., Photoshop).
  - Medical imaging and diagnosis.
  - Computer vision and object recognition.
  - Autonomous vehicles and robotics.
- Tools and Programming:
  - Introduction to image processing libraries (e.g., OpenCV).
  - Practical exercises using software tools.
- Future Trends:
  - Deep learning and its impact on image/video processing.
  - Emerging applications in augmented reality and virtual reality

Learning Outcomes:

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

- Show comprehensive understanding of the fundamental principles of digital images and videos;
- Have knowledge of image or video processing techniques for enhancement, restoration and compression;
- Acquire practical skills in applying processing algorithms using industry standard tools.

Suggested References

- "Fundamentals of Digital Image and Video Processing" offered by Northwestern University (https://www.coursera.org/learn/digital) - This course covers the fundamentals of image and video processing with a focus on practical applications.
- "Self-Driving Car Engineer Nanodegree" (relevant sections) (https://www.udacity.com/course/self-driving-car-engineer-nanodegree--nd0013) - While not solely focused on image processing, this Nanodegree program includes modules on computer vision techniques crucial for self-driving cars, which can be a valuable addition to your learning.
- "Digital Image Processing" by Rafael C. Gonzalez and Richard E. Woods (Fourth Edition) - This widely used textbook provides a comprehensive introduction to image and video processing concepts, algorithms, and applications.
- "Computer Vision: Algorithms and Applications" by Richard Szeliski (Second Edition) - This text delves into computer vision with an emphasis on deep learning techniques for image and video tasks.

Year Two

Semester One

SCM 711 Advanced Machine Learning 3(2, 3)

Course Description:
The Advanced Machine Learning course delves deeper into the theoretical underpinnings and practical complexities of machine learning algorithms. You will explore advanced topics like reinforcement learning, where an agent learns through trial-and-error interactions with its environment. The course will also cover advanced optimisation techniques used to train complex models efficiently. Additionally, you will gain insights into the challenges of model interpretability and bias, equipping you with the tools to create robust and trustworthy machine-learning systems. This course serves as a springboard for your specialisation studies, allowing you to apply these advanced concepts to solve real-world problems in areas like computer vision, robotics, or natural language processing.

Course Objectives

The main objectives of this course are to:

- Grasp advanced machine learning concepts like Bayesian learning, graphical models, and reinforcement learning.
- Understand and implement deep learning architectures including convolutional neural networks (CNNs), recurrent neural networks (RNNs), and transformers.
- Develop expertise in model optimisation, hyperparameter tuning, and ensemble methods.
- Gain experience working with large datasets and utilising cloud-based machine learning platforms.
- Effectively evaluate and debug machine learning models for optimal performance.

Course Content

- Advanced Learning Algorithms:
    - Probabilistic Graphical Models
    - Bayesian Learning and Inference
    - Reinforcement Learning: Fundamentals and Applications
- Deep Learning Architectures:
    - Convolutional Neural Networks (CNNs) for Computer Vision
    - Recurrent Neural Networks (RNNs) for Sequential Data
    - Transformers for Natural Language Processing
- Model Optimisation and Evaluation:
    - Optimisation Techniques for Deep Learning
    - Hyperparameter Tuning Strategies
    - Ensemble Methods and Model Averaging
    - Model Evaluation Metrics and Techniques
- Large-Scale Machine Learning:
    - Working with Big Data for Machine Learning
    - Distributed and Parallel Computing for ML

    - Cloud-Based Machine Learning Platforms (e.g., Google Cloud AI Platform, Amazon SageMaker)
- Advanced Applications:
    - Generative Adversarial Networks (GANs)
    - Unsupervised Learning and Dimensionality Reduction
    - Explainable AI (XAI) Techniques

Learning Outcomes:
Upon successful completion of this course, the students shall be able **to:**

- Acquire advanced machine learning fundamental concepts such as Bayesian learning, graphical models, and reinsforcement learning;
- Understand, describe and implement deep learning architecture including convolutional neural networks, recurrent neural networks and transformers;
- Demonstrate expertise in model optimisation, hyperparameter tuning, and ensemble methods;
- Acquire experience in working with large datasets and utilising cloud based machine learning platforms;
- Demonstrate understanding in effectively evaluating and debugging machine learning models for optimal performance.

Suggested Reference

- Stanford CS229: Machine Learning (https://online.stanford.edu/courses/cs229-machine-learning) (Highly respected course with video lectures and assignments)
- Deep Learning Specialization by DeepLearning.AI on Coursera (https://www.coursera.org/specializations/deep-learning) (Popular specialization covering deep learning fundamentals)
- Advanced Machine Learning Specialization by University of Washington on edX (https://www.edx.org/learn/machine-learning) (Focuses on advanced topics like reinforcement learning and Bayesian methods)

SCM 712 Machine Learning Optimisation Techniques 3(2, 3)

Course Description:
In the Machine Learning Optimisation Techniques course, you will delve into the heart of what makes machine learning models tick: optimisation! This course equips you with the essential tools and algorithms to train and fine-tune your models for peak performance. You will explore core concepts like gradient descent and its variants, along with advanced optimisation techniques used in deep learning. The course will delve into the critical role of hyperparameter tuning in achieving optimal model performance. Through practical exercises and assignments, you will gain hands-on experience implementing these techniques to optimise machine learning models on real-world datasets. By the end of the course, you will be able to confidently navigate the optimisation landscape, ensuring your models learn effectively and deliver the best possible results.

Course Objectives

The main objectives of this course are to:

- Understand the role of optimisation in machine learning.
- Grasp core optimisation concepts like cost functions, gradients, and convergence.
- Explore various optimisation algorithms, including gradient descent and its variants.
- Apply optimisation techniques to practical machine learning problems.
- Gain proficiency in tuning hyperparameters for optimal model performance.

Course Content

- Introduction to Machine Learning Optimisation
    - Importance of optimisation in machine learning
    - Types of optimisation problems (constrained vs. unconstrained)
    - Cost functions and performance metrics
- Gradient Descent and Variants
    - Fundamentals of gradient descent
    - Stochastic gradient descent and mini-batch gradient descent
    - Momentum, RMSprop, Adam, and other optimisers
    - Learning rate tuning strategies
- Advanced Optimisation Techniques
    - Derivative-free optimisation methods (e.g., genetic algorithms)
    - Regularisation for preventing overfitting
    - Optimisation in Deep Learning
- Practical Applications and Case Studies
    - Applying optimisation techniques to different machine learning tasks (classification, regression, etc.)
    - Hyperparameter tuning with GridSearchCV and RandomizedSearchCV

- Practical considerations and challenges in optimisation

Learning Outcomes:

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

- Understand and describe the role of optimisation in machine learning;
- Acquire core optimisation fundamental concepts such as cost function gradient, and convergence;
- Demonstrate understanding of various optimisation algorithms, including gradient descent and its variants;
- Show understanding on how to apply optimisation techniques to practical machine learning problems;
- Acquire proficiency in tuning hyper parameters for optimal model performance.

Suggested References

- *Optimisation for Machine Learning*: https://edu.epfl.ch/coursebook/en/optimization-for-machine-learning-CS-439) by Yves Lucet (Provides a strong theoretical foundation)
- *Deep Learning* by Ian Goodfellow, Yoshua Bengio, and Aaron Courville (Chapter 8: Optimization) (Focuses on deep learning-specific optimization techniques)

- Online Resource: "A Survey of Optimization Methods from a Machine Learning Perspective" arXiv paper on optimization methods: https://arxiv.org/abs/1906.06821
- Blog: "ML Optimization Methods and Techniques" Blog on Machine Learning Optimization: https://iopscience.iop.org/article/10.1088/2632-2153/ab6432

Year Two

Semester One

SCR 712 Embedded Deep Learning 3(2, 3)

Course Description:

In the ever-evolving realm of AI, the course "Embedded Deep Learning" delves into a specialised area where powerful deep learning techniques are applied to resource-constrained devices like microcontrollers and single-board computers. This course equips you with the knowledge and skills to navigate the unique challenges of running complex algorithms on hardware with limited processing power and memory. You will explore specialised deep learning architectures optimised for efficiency, delve into techniques for model compression and quantisation, and gain hands-on experience implementing deep learning models on embedded platforms. By the course's end, you will be prepared to push the boundaries of intelligent systems at the edge, enabling real-world applications of AI in resource-limited environments.

Course Objectives

The main objectives of this course are to:

- Understand the fundamentals of machine learning and deep learning.
- Identify the challenges and considerations for running deep learning models on embedded systems.
- Apply deep learning concepts for tasks like image classification and object detection on microcontrollers.
- Develop and deploy TinyML models using frameworks like Edge Impulse.

Course Content

- Introduction to Machine Learning and Deep Learning:
    - Overview of machine learning concepts
    - Introduction to neural networks and deep learning
    - Limitations and ethical considerations of machine learning
- Machine Learning on Embedded Systems:
    - Hardware and software constraints of embedded devices
    - Introduction to TinyML
    - Machine learning frameworks for TinyML (e.g., Edge Impulse)
- Deep Learning for Embedded Systems:
    - Optimising deep learning models for resource-constrained devices
    - Image classification with Convolutional Neural Networks (CNNs)
    - Object detection with CNNs
    - Data collection and pre-processing for TinyML
- Developing and Deploying TinyML Models:
    - Using Edge Impulse for model development and deployment
    - Case studies and applications of TinyML

Learning Outcomes:

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

- Understand and explain the fundamentals of machine learning and deep learning;
- Acquire an ability of identifying challenges and considerations for running deep learning models on embedded systems;
- Demonstrate understanding in applying deep learning concepts for tasks like image classification and object detection on microcontrollers;
- Understand how to develop and deploy TinyML models using framework like edge impulse.

Suggested References

- Introduction to Embedded Machine Learning (https://www.coursera.org/learn/introduction-to-embedded-machine-learning) (Coursera): This course by Edge Impulse and partners offers a practical introduction to deploying machine learning models on microcontrollers, ideal for those new to the field.
- Computer Vision with Embedded Machine Learning (https://www.coursera.org/learn/introduction-to-embedded-machine-learning) (Coursera): Building upon the previous course, this option delves specifically into computer vision applications with embedded systems.
- Deep Learning Specialization by Andrew Ng (https://www.coursera.org/specializations/deep-learning) (Coursera): This comprehensive specialization by deep learning pioneer Andrew Ng covers various deep learning architectures and applications. While not explicitly embedded focused, the foundational knowledge is highly relevant.
- TensorFlow Micro: Getting Started with Microcontrollers (https://www.tensorflow.org/lite/microcontrollers) (TensorFlow): TensorFlow offers official tutorials and resources specifically geared towards deploying TensorFlow models on microcontrollers.

SCR 711 Robot Learning and Control 3(2, 3)

Course Description:

"Robot Learning and Control" delves into the exciting intersection of machine learning and robotics. This course equips you with the knowledge and skills to program robots to interact with the world autonomously and intelligently. You will explore various robot learning techniques, including reinforcement learning, where robots learn through trial and error, and imitation learning, where robots mimic human demonstrations. Additionally, the course covers robot control systems, focusing on algorithms that enable robots to move and manipulate objects with precision and agility. By the end, you will gain the ability to design and implement intelligent control strategies that bridge the gap between perception and action in robots, allowing them to operate effectively in dynamic environments.

Course Objectives

The main objectives of this course are to:

- Understand the basics of robot kinematics and dynamics
- Apply control algorithms to robots for motion planning and execution
- Implement machine learning techniques for robot perception and control
- Gain experience in robot programming and simulation

Course Content

- Introduction to Robotics:
  - Applications of robots
  - Robot anatomy and classifications
  - Kinematics: Modelling robot motion
- Robot Dynamics:
  - Modelling robot forces and torques
  - Lagrange equations and Newton-Euler methods
- Robot Control:
  - Feedback control systems (PID control)
  - Motion planning and trajectory control
  - Advanced control techniques
- Machine Learning for Robotics:
  - Robot perception using sensors
  - Supervised learning for robot control
  - Reinforcement learning for autonomous robots
- Robot Programming and Simulation:
  - Introduction to robot programming languages (e.g., Python with ROS)
  - Robot simulation tools (e.g., V-REP, Gazebo)
- (Optional) Final Project:
  - Design, simulate, and implement control algorithms for a specific robotic task

Learning Outcomes:
Upon successful completion of this course, the students shall be able to:

- Demonstrate understanding of the basics of robot kinematics and dynamics;
- Understand and describe how to apply control algorithms to robots for motion planning and excution;
- Understand, explain and implement machine learning techniques for robot perception and control;
- Acquire experience in robot programming simulation.

Suggested References

- Modern Robotics: Mechanics, Planning, and Control: https://link.springer.com/book/10.1007/978-1-84628-642-1 by Bruno Siciliano, Oussama Khatib
- Online Resources:

    - Coursera: Robotics Specialization: https://www.coursera.org/courses?query=robotics
    - Udacity: Intro to Robotics Nanodegree: https://www.udacity.com/course/robotics-software-engineer--nd209

- Stanford University: https://www.classcentral.com/course/udacity-introduction-to-artificial-intelligence-301 (Focuses on probabilistic inference, planning, and control with a robotics application)
- MIT OpenCourseware: https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/ (Covers robot kinematics, dynamics, and control)
- [Book] "Introduction to Autonomous Mobile Robots" by Roland Siegwart, Nour R. Nourbakhsh, and Gabriel Garnier (Provides a comprehensive introduction to robot control and planning)

Year Two

Semester One

SCE 711 Edge Computing 3(2, 3)

Course Description:
As the world gets smarter with AI, the need for intelligent processing at the "edge" of networks becomes ever more critical. This elective course in Edge Computing delves into the interplay between AI and distributed computing paradigms. You will explore the challenges and opportunities of deploying AI models on resource-constrained devices at the network's edge. The course will cover topics like model optimisation for low-power hardware, federated learning for decentralised training, and security considerations for edge AI implementations. By understanding these concepts, you'll gain the knowledge to create intelligent systems that operate efficiently with minimal latency and network bandwidth, unlocking the full potential of AI in real-world applications.

Course Objectives

The main objectives of this course are to:

- Understand the core concepts of edge computing and its benefits.
- Identify the key components of an edge computing architecture.
- Explore various applications of edge computing across different industries.
- Analyse the security and privacy considerations associated with edge computing.
- Gain insights into the future trends and potential of edge computing.

Course Content

- Introduction to Edge Computing
    - Definition of edge computing.
    - Traditional vs. edge computing architectures
    - Benefits and drawbacks of edge computing
    - The rise of Internet of Things (IoT) and its relation to edge computing
- Edge Computing Technologies and Devices
    - Edge devices and their capabilities (sensors, actuators, microcontrollers)
    - Network infrastructure for edge computing (fog computing, multi-access edge computing)
    - Communication protocols in edge networks
- Applications and Use Cases of Edge Computing
    - Edge computing in smart cities and transportation
    - Industrial automation and predictive maintenance
    - Retail and logistics applications
    - Media and entertainment use cases
- Security and Privacy in Edge Computing
    - Cybersecurity threats and vulnerabilities in edge networks
    - Secure data processing and transmission at the edge
    - Data privacy regulations and compliance

- The Future of Edge Computing
    - Emerging trends and advancements in edge technology
    - The impact of artificial intelligence (AI) and machine learning (ML) on edge computing
    - The future of edge computing across different industries

Learning Outcomes:
Upon successful completion of this course, the students shall be able to:

- Understand and describe the core concepts of edge computing and its benefits;
- Have capability of identifying key components of edge computing architecture;
- Demonstrate understanding of various applications of edge computing across different industries;
- Acquire the capability of analysing the security and privacy considerations associated with the edge computing;
- Demonstrate understanding of the insight into the future trends and potential of edge computing.

Suggested References

- Consider mentioning a relevant textbook, for instance: Ian Foster, Carlo Ghezzi, Aleksandar Konstantinovic, Markus Rothenberg, and Luis Felipe Velez-Pacheco. "https://shop.elsevier.com/books/intelligent-edge-computing-for-cyber-physical-applications/hemanth/978-0-323-99412-5".
- Additionally, you could reference online resources like the "AI Principles with Edge Computing" course offered on Coursera https://www.coursera.org/learn/ai-principles-with-edge-computing to showcase practical applications.

SCE 712 Big Data Analytics 3(2, 3)

Course Description:
This course provides a foundational understanding of big data concepts, technologies, and tools. You will explore the characteristics of big data (volume, velocity, variety, veracity), how it's managed and stored, and techniques for extracting valuable insights.

Course Objectives

The main objectives of this course are to:

- Understand the concepts and challenges of big data.
- Gain knowledge of big data processing tools and frameworks.
- Develop skills in data wrangling, analysis, and visualisation for big data.
- Learn to apply big data techniques to solve real-world problems.

Course Content

- Introduction to Big Data
  - Definition of big data (volume, variety, velocity, veracity)
  - Challenges of big data
  - Big data applications
- Big Data Processing Tools and Frameworks
  - Hadoop ecosystem (HDFS, YARN, MapReduce, Spark)
  - Cloud platforms for big data (AWS, Azure, GCP)
  - NoSQL databases for big data
- Data Wrangling for Big Data
  - Data ingestion and pre-processing techniques
  - Handling missing values and outliers
  - Data quality control
- Big Data Analytics Techniques
  - Big data analytics methodologies (descriptive, predictive, prescriptive)
  - Statistical analysis for big data
  - Machine learning for big data
- Big Data Visualisation
  - Techniques for visualising big data
  - Tools for creating interactive data visualisations
- Big Data Applications
  - Case studies in big data analytics (e.g., finance, healthcare, marketing)
  - Emerging trends in big data

Learning Outcomes:
Upon successful completion of this course, the students shall be able to:

- Thoroughly understand and explain the fundamental concepts and challenges of big data;
- Demonstrate comprehensive understanding of big data processing tools and frameworks;
- Acquire knowledge in developing skills in data wrangling, analysis, and visualisation for big data;
- Thoroughly understand how to apply big data techniques to solve real world problems.

Suggested References

- Books
  - "Big Data: A Revolution That Will Transform How We Live, Work, and Think" by Viktor Mayer-Schönberger and Kenneth Cukier
  - "Data Science for Business" by Foster Provost and Tom Fawcett
- Online Courses
  - "[Coursera Big Data Courses]"(https://www.coursera.org/specializations/big-data)
  - "[Udemy Big Data Courses]"(https://www.udemy.com/topic/big-data/)
- Websites
  - "[IBM Big Data & Analytics]"(https://www.ibm.com/analytics/big-data-analytics)
  - "[Machine Learning Crash Course Google]"(https://developers.google.com/machine-learning/crash-course)

Year Two

Semester Two

Master Dissertation

Course Description:

The Master dissertation is a semester-long course where a student will conduct original research exploring a specific topic within the field of Artificial Intelligence (AI) under the guidance of a faculty advisor. The research will involve in-depth research, analysis, and potentially the development of a novel approach or application related to AI. This path is ideal for students seeking a research career or Ph.D. studies.

Course Objectives

The main objectives of this course are to:

- Deepen understanding of a chosen AI subfield.
- Conduct a critical review of relevant literature.
- Develop a research question or hypothesis.
- Design and potentially implement an AI solution (depending on the chosen topic).
- Evaluate the effectiveness of the chosen approach (if applicable).
- Contribute to the advancement of knowledge in the chosen AI domain.
- Include any additional information, data, or code relevant to your research.

Course Outline:

- Introduction:
  - Briefly introduce AI and the chosen subfield.
  - Motivate the research topic and its significance.
  - State the research question or hypothesis.
- Literature Review:
  - Review existing research relevant to the chosen topic.
  - Identify key concepts, methodologies, and limitations.
  - Position your research within the existing body of knowledge.
- Methodology:
  - Describe the research approach (e.g., theoretical, empirical, etc.).
  - Specify the methods and techniques used (e.g., machine learning algorithms, data analysis techniques).
  - If applicable, describe the development process of your AI solution.
- Results and Analysis:
  - Present your research findings clearly and concisely.
  - Analyse the results of your research question or hypothesis.
  - Discuss the implications and limitations of your findings.
- Conclusion:
  - Summarise the key findings and their significance.
  - Discuss the broader implications of your research.
  - Suggest future research directions.

- References:
    - List all sources cited in your dissertation.
- Appendix (Optional):

Learning Outcomes:
Upon successful completion of this course, the students shall be able to:

- Demonstrate comprehensive understanding of the chosen topic in AI specialisation;
- Thoroughly demonstrate understanding on how to conduct a critical review of relevant literature;
- Show understanding on how to develop a research question or hypothesis;
- Acquire the capability of designing and potentially implementing an AI solution;
- Understand and explain how to evaluate the effectiveness of the chosen method;
- Comprehensively understand how to contribute to the advancement of knowledge in a chosen AI domain.

Suggested References

- Russell, S. J., & Norvig, P. (2021). Artificial intelligence: A modern approach (4th ed.). Pearson Education Limited.
- McCarthy, J., Minsky, M., Rochester, N., & Shannon, C. E. (1955). A proposal for research on artificial intelligence. http://jmc.stanford.edu/articles/dartmouth.html

Year Two

Semester Two

Capstone Project

Course Description:
The capstone project is designed to apply the knowledge and skills learned throughout the artificial intelligence course to a real-world problem. Students will develop and implement an AI solution using techniques like machine learning, deep learning, or natural language processing. This path is excellent for students seeking immediate industry employment.

Course Objectives:

The main objectives of this course are to:

- Design and develop an AI model to address a chosen problem.
- Collect, clean, and prepare data for the chosen AI model.
- Train and evaluate the performance of the AI model.
- Interpret and communicate the results of the AI model.
- Showcase the problem-solving and analytical skills acquired in the AI course.

Course Outline:

- Problem Definition and Data Acquisition:
    - Identify a real-world problem suitable for AI applications.
    - Research existing solutions and potential AI approaches.
    - Gather relevant data for model training and evaluation.
    - Preprocess and clean the data for effective use in the model.
- Model Development and Training:
    - Select appropriate AI techniques (e.g., machine learning algorithms, deep learning architectures) based on the problem and data.
    - Design and implement the AI model using chosen techniques and tools.
    - Train the model on the prepared data, potentially using techniques for hyperparameter tuning.
    - Monitor and evaluate the model's performance using relevant metrics.
- Evaluation and Refinement:
    - Analyse the model's performance, interpreting strengths, weaknesses, and potential biases.
    - Refine the model by adjusting hyperparameters, data preprocessing, or model architecture as needed.
    - Consider techniques to address overfitting or underfitting if encountered.
- Deployment and Communication:
    - Deploy the final model as a web application or integrate it into a larger system (if applicable).
    - Prepare a comprehensive report documenting the project journey, including:
        - Problem definition and chosen approach.
        - Data collection, processing, and exploration.
        - Model development, training, and evaluation.

        - Results, insights, and potential limitations.
    - Develop a presentation to effectively communicate the project's goals, methodology, and outcomes.

Learning Outcomes:

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

- Demonstrate understanding of designing and developing an AI model to address a chosen problem;
- Acquire the capability in collecting, cleaning and preparing data for the chosen AI model; Thoroughly understand how to train and evaluate the performance of the AI model;
- Demonstrate the capability of interpreting and communicating the results of AI model;
- Comprehensively understand and present ability for problem solving and analytical skills acquired in AI course.

Suggested References

- Specific references will depend on the chosen AI techniques and tools.
- General references on AI, machine learning, and deep learning can be found in textbooks and online resources.
- Look for course materials or instructor recommendations for relevant libraries and frameworks (e.g., scikit-learn, TensorFlow, PyTorch).

Appendix: Administrative Staff and Faculty members

Administrative Staff

- **Dean** **:** Dr. James Osuru Mark Amok
- **Deputy Dean** **:** Mr.Charles Amoli Taban
- **Registrar** **:** Mr Yanta Samuel Eyobo
- **Deputy Registrar** **:** Mr Eshag Emmanuel Richard
- **Administrator** **:** Mr John Wiskly Chicago
- **Assistant Administrator:** Ms Guyan Mahmoud

Heads of Departments

- **Computer Science** : Mr Lodu Bosco
- **Information Technology:** Dr Lily Abau Odwa
- **Cybersecurity** **:** Mr. Samuel Dut

Professors

- Dr John A. Akec, Vice Chancellor, University of Juba

Associate Professors

- Dr Lado Wani Kenyi (On Secondment)
- Dr Yak Deng Ater

Assistant Professors

- Mr Sebit Lagu
- Dr Moses Matur
- **Dr James Osuru Mark**
- **Dr Mohammed Elnour Abdalla**
- **Dr Khalid Hassan Mohammed Edris**
- **Dr Fakheraldin Abdaala**
- Dr Nazim Osman
- Dr Ahmed Mohammed
- Dr Lilly Abau Yosia

Lecturers

- Charles Taban Amoli
- David Lukudu Aggrey
- Manyok Chol David
- Richard Ring Kuach
- Francis Bambo
- Samuel Dut deng Akot
- Thon Kuir Biar Ayual

- Lodu Bosco John
- Peter Costa Marial

Teaching Assistants

- Taban Bosco Charles
- Anthony Ochira
- Anthony Taban Joseph
- Amuki Joseph Kesi
- Emmanuel Lomoro Samuel
- Kenyi Robert Alex
- Oheny Michael Hujang
- Mading Dau Awuol
- Khamis Cons Christopher
- Angelo Ajung
- Lino Chuol
- Riny Kornelio Koriom
- Majok Rin Kerjok