ARTIFICIAL INTELLIGENCE
ENCT 305

Year/Part: III/I

Teaching Schedule				Examination Scheme						Total
				Theory			Practical			
L	T	P	Total	Assessment Marks	Final		Assessment Marks	Final		
					Duration (Hrs)	Marks		Duration (Hrs)	Marks	
3	1	1.5	5	40	3	60	25	0	0	125

Depth Codes

E-Explanation	C-Circuit	D-Definition	DM-Demonstration
DV-Derivation	DW-Drawing	P-Proof	I-Illustration
NUM-Numerical	PRG-Programming	S-State	ACT-Activity-based Learning
MP- Mini Project	EXP-Experiment	REV-Review / Recap	PS- Problem Solving
QA- Question Answer	Q- Quiz	ST- Surprise Test	MT-Mid Term Test

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
1	**Introduction**			**4**	**1**		**1,2**
	1.1. Definition, Foundation, History of AI	D, E	Definition of AI, Turing test, Reverse Turing Test, Total Turing test Foundation & History of AI	0.5			
	1.2. AI Tree: Branches and Interdisciplinary Nature	D, E	AI as a tree with branches and core concepts Applications in interdisciplinary areas	0.5			
	1.3. Definition and importance of Knowledge and Learning	D, I	Definition, importance and examples of Knowledge and Learning DIKW Pyramid Data, Information, Knowledge, Intelligence	0.5			
	1.4. Human intelligence and Machine intelligence	D, E	State of the Art What Humans and AI can do? Comparison based on various parameters	0.5			
	1.5. Intelligent Agents and Types	D, E, PS	Definition of Intelligent Agent, Block Diagram, explanation, factor considerations while selections an agent, exercises about different type of agents Definition, characteristics of Agentic AI and Autonomous Intelligence	2	1		
	Evaluation	QA, Q					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
2	**Problem Solving and Search**			**9**	**3**	**6**	**2,3,4,5**
	2.1. Formal problem definition: States, actions, transitions, well-defined problems	D, E, NUM	Definition of Problem-solving agent, States, State Space and Problem Space Problem Representation using Graph vs Tree Well-defined problems and solutions Example Problems	1	1		

	2.2. Constraint Satisfaction Problems: Node Consistency, Path Consistency, Backtracking	E, I, NUM	Defining CSPs; Constraint Propagation; Node Consistency, Path Consistency, Arch Consistency, Backtracking Search with examples (Fixed Examples topics: Cryptarithmetic, Map coloring, Eight Queens or mini-Sudoku) Variable Limitation--→ Easy/Medium	1			
	2.3. Search algorithms, Strategies, and Evaluations	D, E,	Search algorithms, Strategies, and Evaluations	0.5			
	2.4. Uninformed: BFS, DFS, Iterative Deepening	D, E, NUM	Definitions and Complexity of BFS, DFS, Iterative Deepening	1			
	2.5. Informed Search: Best First search, Greedy Search, A* algorithm	D, E, NUM	Definitions and Examples : Best First search, Greedy Search, A* algorithm	1	1		
	2.6. Adversarial search: Minimax algorithm, Alpha-beta pruning	D, E, NUM	Definitions, Algorithms and Example of Adversarial search: Minimax algorithm, Alpha-beta pruning	1			
	2.7. Local Search and Optimization: Hill climbing, Simulated Annealing	D, E, I	Definitions , Algorithms and Example of Hill climbing, Simulated Annealing	1.5			
	2.8. Evolutionary Optimization: Genetic Algorithm	D, E, NUM	Definitions , Algorithms and Example of Genetic Algorithm	1.5	1		
	Evaluation	QA, Q					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
3	**Knowledge Representation and Probabilistic Reasoning**			**7**	**2**	3	**5,6,7**
	3.1. Knowledge-based Agent	D, E, I	Definition of Knowledge-Based Agents; Example: The Wumpus World;	0.5			
	3.2. Knowledge Representation Techniques and Issues in Representation	D, E, I	Knowledge Engineering Approaches for Knowledge Representation Issues in Representation Path planning	1			
	3.3. Propositional & Predicate Logic	REV, E, NUM	Review of Propositional & Predicate Logic, Rules of Inference and Resolution Refutation Forward and Backward Chaining	1.5	2		
	3.4. Semantic networks and frames	D, E, NUM	GUI for Logic Definition of and Examples of Semantic networks and frames	0.5			
	3.5. Probabilistic Reasoning, Inference using Bayes' Theorem	E, DV, NUM	Review of Probability Definition and use-cases of Bayes theorem for Probabilistic Reasoning (Numerical)	1			
	3.6. Fuzzy logic: membership functions, fuzzy inference systems	D, E, I	Concept of Fuzzy Logic, Fuzzy Sets vs. Crisp Sets, Role of membership functions and Common Shapes Components of a Fuzzy Inference System (FIS). Applications	2			

	Evaluation	QA, Q					
Unit	**Topic/ Sub topic**	**Depth Code**	**Description of Depth**	**Actual plan**			**Week**
				L	**T**	**P**	
4	**Machine Learning Fundamentals**			**10**	**5**	**6**	**7,8,9,10**
	4.1. Forms of Learning: Supervised, Unsupervised, Semi-Supervised, Reinforcement Learning	D, E, I	Definition of machine learning. Definition, Applications and Approaches for • Supervised Learning • Unsupervised Learning • Reinforcement Learning	1	1		
	4.2. Machine Learning Pipeline	E, I, NUM	Machine Learning Pipeline Data Wrangling Process General steps of data preprocessing Data cleaning, Handling missing values, Handling outliers Feature Selection/Engineering Model: Generative vs. Discriminative: Training and Validating Models Training, Testing, and Hyperparameter Tuning Training and validation loss	2.5			
	4.3. Overfitting, Underfitting, Bias-Variance Tradeoff	E, I	Overfitting, Underfitting, Bias-Variance Tradeoff	0.5			
	4.4. Regression & Classification with Linear Model	E, DV, NUM,MP, PRG	Univariate linear regression and Loss function minimization Multivariate linear regression Linear Regression vs Logistic Regression Linear classification with logistic regression	3	1		
	4.5. Classification using Decision Tree & Naive Bayes	E, NUM,MP, PRG	Training, Test and Algorithm for Decision Tree (Entropy/Gini) & Naive Bayes	2	2		
	4.6. Evaluation with Confusion Matrix	E, I, NUM	Classification Performance Measures; accuracy, Confusion matrix and derived metrics: Sensitivity (Recall), Specificity, Precision, F-score. ROC curve and AUC	1			
	Evaluation	QA, Q					

Unit	**Topic/ Sub topic**	**Depth Code**	**Description of Depth**	**Actual plan**			**Week**
				L	**T**	**P**	
5	**Neural Networks and Deep Learning Algorithms**			**6**	**2**	3	**11,12**
	5.1. Neural Networks: Structures and Activation Functions	D, E	Biological vs. Artificial Neurons: Analogy and differences. Right Brain/Left Brain A simple mathematical model for a neuron. Neural Networks: Structures Learning in NN. (Hebbian, Logic gates) Types of Activation Functions its purpose and Characteristics	1.5	1		
	5.2. Perceptron, Multilayer Perceptron, and Backpropagation	D, E, DV	Perceptron and its limitations. Single-layer feed-forward neural networks Architecture and function of a Multilayer Perceptron (MLP).	2	1		

			The Backpropagation algorithm and it's derivation				
	5.3. Introduction to Deep learning	D, E	ML Vs DL Deep Learning and its distinction from traditional Neural Networks. Building Blocks of Deep Neural Networks Forward and Backward Propagation Why Deep Representations? Vectorized Implementation. Getting your Matrix Dimensions Right Prerequisites for successful Deep Learning. https://medium.com/@tharangachaminda/neural-network-06-deep-l-layer-neural-network-d843c20b0f3c	1.5			
	5.4. Concepts on Recurrent and Generative Neural Networks	D, E	Introduction to CNN, Components Applications* Introduction to RNN, Components Applications (Recurrent Neurons and Recurrent Layer) * Introduction to GANs, Components Applications*	1			
	Evaluation	QA, Q					

Unit	**Topic/ Sub topic**	**Depth Code**	**Description of Depth**	**Actual plan**			**Week**
				L	**T**	**P**	
6	**AI Applications**			**7**	**2**	3	**13,14, 15**
	6.1. Expert Systems: Characteristics, Architecture, Development and Various Applications	D, E	Definition, characteristics, Architecture and components of Expert Systems Pros and Cons Development Phases. Applications	1			
	6.2. NLP: Level of Analysis and Application	D, E, MP, PRG	Levels of analysis in NLP with examples Phonological/Morphological Analysis. Lexical Analysis, Syntactic Analysis, Semantic Analysis and Pragmatic Analysis, Discourse Analysis Challenges in NLP applications Embeddings & Modern NLP models.*	2.5	1		
	6.3. Robotics & Computer Vision: Fundamental, Components and Applications	D, I, E, MP, PRG	Robotics and its fundamental components. Robot Classifications Computer Graphics/Image Processing Computer Vision Computer Vision (CV) and its core concepts. Image Filtering/Enhancement, Feature Extraction (Edges), Object Detection and Recognition. Discuss the applications of Robotics and Computer Vision. Robotics: Industrial automation, surgical assistance, space exploration. CV: Autonomous vehicles, facial recognition, medical imaging analysis, quality control.	2.5	1		

			Use of Deep Learning *				
	6.4. VLSI testing, fault diagnosis, and sustainable systems	D, E	VLSI Design & Testing: Need for automated test pattern generation Using ML/DL to predict and locate faults efficiently. Concept of sustainable AI systems. Using AI to optimize energy grids, predict climate change, and improve resource efficiency. Energy Consumption of training large models and potential for "Green AI" practices.	1			
	Evaluation	QA, Q					

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual plan			Week
				L	T	P	
7	**AI Ethics and Recent Trends**			**2**			**15**
	7.1. Responsible AI: Bias, Fairness, Explainability	D, E	Definition of Responsible AI and its core pillars. Framework for developing and deploying AI Concepts of bias and fairness in AI. Introduction to Explainable AI (XAI).	0.5			
	7.2. Ethical & Societal Considerations	D, E, ACT	Ethical dilemmas posed by AI i.e. Job Displacement/Automation, Misuse of AI etc. Societal impact and governance of AI and Regulatory Frameworks Activity includes: Policy/Regulatory Framework Review and Presentation	0.5			
	7.3. Privacy & Security in AI	D, E	Privacy risks associated with AI. Data Privacy, Data Anonymization, Inference Attacks e.tc. Introduction to AI Security threats e.g.: Adversarial Attacks, Poisoning etc. and Defense Strategies	0.5			
	7.4. Emerging Trends: Federated Learning, Embedded AI	D, E	Concept and benefits of Federated Learning Concept and benefits and impact of Embedded AI Discuss briefly other emerging trends.	0.5			
	Evaluation	QA, Q					

*Descriptive Notes Questions Only

Tutorial

The following tutorial activities (including but not limited to those listed) should be conducted to cover all the required content of this course.

- Design a simple agent model (vacuum cleaner, chess player).
- Formulate a route-finding problem using states, and transitions.
- Solve the Problem with uninformed strategies
- Apply the A* algorithm with the given heuristic values.
- Solve the minimax tree and demonstrate alpha–beta pruning
- Solve a CSP like Cryptarithmetic, Map coloring, Eight Queens or Mini-Sudoku.
- Perform one iteration of the Genetic Algorithm (selection, crossover, mutation).
- Represent facts using semantic networks and frames.
- Solving the problem related to linear and logistic regression.

- Solving problems related to Bayes' theorem & Fuzzy Logic
- Understanding machine learning basics through model training, cross-validation, and performance evaluation.
- Apply the Naive Bayes theorem to classify an instance.
- Model Evaluation: Build a confusion matrix. Calculate Sensitivity, Specificity, Precision, Recall, and F1-score.
- Solve perceptron weight updates for a small dataset.
- Derive forward and backward propagation numerically for a 2-layer NN.
- Case study: Identify ethical risks in real-world AI use. Responsible AI in Nepal's context.

Practical

The following lab exercises (including but not limited to those listed) will give students hands-on experience in applying artificial intelligence and machine learning tools to solve real-world problems:

- Week 1: Knowledge-Based Agents & Search
- Week 2: Adversarial Search & CSP
- Week 3: Probabilistic Reasoning
- Week 4: Machine Learning – Supervised
- Week 5: Machine Learning – Unsupervised
- Week 6: Neural Networks Basics
- Week 7: Mini Project & AI Applications

References:

1. Stuart Russell & Peter Norvig, *Artificial Intelligence: A Modern Approach*, Pearson (4th edition)
2. Elaine Rich, Kevin Knight, Shivashankar B. Nair, *Artificial Intelligence, 3rd Edition*
3. Christopher Bishop, *Pattern Recognition and Machine Learning*, Springer

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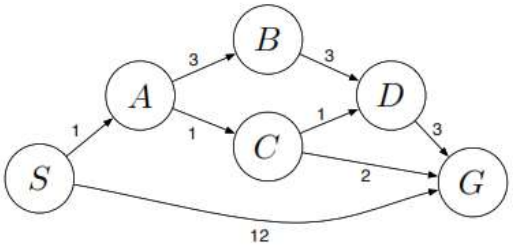
<table>
<tr><th>QN</th><th>Question</th><th>Marks</th><th>Unit</th></tr>
<tr><td>1.</td><td>What is Agentic AI? How Intelligent agent and Agent AI is contributing to Autonomous Intelligence?</td><td>1+4 =5</td><td>1</td></tr>
<tr><td>2.</td><td>Why A* is preferred over greedy search? For following graph, compute A* search. Assume start state is S and goal state is G.
 

<table>
<tr><th>State</th><th>h_1</th></tr>
<tr><td>S</td><td>5</td></tr>
<tr><td>A</td><td>3</td></tr>
<tr><td>B</td><td>6</td></tr>
<tr><td>C</td><td>2</td></tr>
<tr><td>D</td><td>3</td></tr>
<tr><td>G</td><td>0</td></tr>
</table></td><td>2+4=6</td><td>2</td></tr>
<tr><td>3.</td><td>A diagnostic AI system uses the following rules:
• If battery voltage is low AND starter is inactive → car won't start
• If fuel level is low AND battery voltage is normal → engine cranks but doesn't start
• If car won't start AND engine cranks slowly → battery problem
Facts given:
• Battery voltage is low
• Starter is inactive
• Engine cranks slowly
Using forward chaining, prove whether the system concludes a battery problem.</td><td>6</td><td>2</td></tr>
<tr><td>4.</td><td>How is inference carried out using Bayes' theorem? In a study of pleas and prison sentences, it is found that 45% of the subjects studied were sent to prison. Among those sent to prison, 40% chose to plead guilty. Among those not sent to prison, 55% chose to plead guilty.
a) If one of the study subjects is randomly selected, find the probability of getting someone who was not sent to prison.
b) If a study subject is randomly selected and it is then found that the subject entered a guilty plea, find the probability that this person was not sent to prison.</td><td>2+4=6</td><td>3</td></tr>
<tr><td>5.</td><td>When do we use Naive Bayesian classifier? The data samples are described by attributes age, income, student, and credit. The class label attribute, buys, tells whether the person buys a computer, has two distinct values, yes (class C1) and no (class C2).
Using the Naive Bayesian classifier, classify sample X = (age = youth, income = medium, student = yes, credit = fair)
<table>
<tr><th>RID</th><th>age</th><th>income</th><th>student</th><th>credit</th><th>C_i: buy</th></tr>
<tr><td>1</td><td>youth</td><td>high</td><td>no</td><td>fair</td><td>C_2: no</td></tr>
<tr><td>2</td><td>youth</td><td>high</td><td>no</td><td>excellent</td><td>C_2: no</td></tr>
<tr><td>3</td><td>middle-aged</td><td>high</td><td>no</td><td>fair</td><td>C_1: yes</td></tr>
<tr><td>4</td><td>senior</td><td>medium</td><td>no</td><td>fair</td><td>C_1: yes</td></tr>
<tr><td>5</td><td>senior</td><td>low</td><td>yes</td><td>fair</td><td>C_1: yes</td></tr>
<tr><td>6</td><td>senior</td><td>low</td><td>yes</td><td>excellent</td><td>C_2: no</td></tr>
<tr><td>7</td><td>middle-aged</td><td>low</td><td>yes</td><td>excellent</td><td>C_1: yes</td></tr>
<tr><td>8</td><td>youth</td><td>medium</td><td>no</td><td>fair</td><td>C_2: no</td></tr>
<tr><td>9</td><td>youth</td><td>low</td><td>yes</td><td>fair</td><td>C_1: yes</td></tr>
<tr><td>10</td><td>senior</td><td>medium</td><td>yes</td><td>fair</td><td>C_1: yes</td></tr>
<tr><td>11</td><td>youth</td><td>medium</td><td>yes</td><td>excellent</td><td>C_1: yes</td></tr>
<tr><td>12</td><td>middle-aged</td><td>medium</td><td>no</td><td>excellent</td><td>C_1: yes</td></tr>
<tr><td>13</td><td>middle-aged</td><td>high</td><td>yes</td><td>fair</td><td>C_1: yes</td></tr>
<tr><td>14</td><td>senior</td><td>medium</td><td>no</td><td>excellent</td><td>C_2: no</td></tr>
</table></td><td>2+2+2=6</td><td>4</td></tr>
</table>

<table>
<tr>
<td>6.</td>
<td>Describe the machine learning pipeline with an example. Discuss preprocessing, splitting, training, model tuning, and final evaluation.
OR
Discuss the different approaches for validating a classifier with calculating the accuracy of this Covid case test data. A confusion matrix for covid testing classifier is as follows:
<table>
<tr><td colspan="2"></td><td>Predicted Covid Cases</td><td></td></tr>
<tr><td colspan="2"></td><td>True</td><td>False</td></tr>
<tr><td rowspan="2">Actual Covid Cases</td><td>True</td><td>456</td><td>52</td></tr>
<tr><td>False</td><td>78</td><td>11569</td></tr>
</table>
Is accuracy sufficient to indicate the performance of this classifier? Justify with calculations and comparison of other parameters like precision , recall and F-1 scores.</td>
<td>3+3=6

2+4=6</td>
<td>4</td>
</tr>
<tr>
<td>7.</td>
<td>“Deep learning models sometimes outperform traditional computer vision methods” What are the key factors responsible for this?
Why Generative Neural Networks is popular? Describe briefly its components</td>
<td>3

4</td>
<td>5</td>
</tr>
<tr>
<td>8.</td>
<td>When do we use back propagation algorithm? Perform derivation for backward propagation to minimize the error.</td>
<td>1+5</td>
<td>5</td>
</tr>
<tr>
<td>9.</td>
<td>Compare and contrast
i. NLU Vs NLG
ii. Machine learning vs Federated learning</td>
<td>(3*2)
=6</td>
<td>6,7</td>
</tr>
<tr>
<td>10.</td>
<td>Write short notes on the following: -
iii. Fuzzy Logic
iv. Responsible AI</td>
<td>(3*2)
=6</td>
<td>3,7</td>
</tr>
</table>

Note: *Number of questions and distribution of marks are indicative only.*