ITAI 1370
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Review of Artificial Intelligence, Related Technologies, and Applications

This portfolio provides a review of the key themes, concepts, and technologies throughout the course in assignments, labs and via the midterm glossary, focusing on the history of AI, core machine learning concepts, specific applications, and related technologies like computer graphics and humor generation. In the overview of assignments, I reference assignments by the assignment number A01, A02, L01, etc... and will include all works as a zipped file with the assignments in pdf format for ease of reference. I am also including a mind map of the core concepts.

1. The History and Evolution of Artificial Intelligence

The sources detail artificial intelligence's long history by tracing its origins from ancient myths and philosophical discussions to today's technological advances. Important people along with crucial events have driven this progression. "A01.pdf" stresses that understanding AI's historical development is essential to grasp its present importance while shaping future directions. AI evolved from philosophical ideas into a defining force that shapes modern society.

The document identifies key influential figures who shaped AI development.

• Alan Turing: Alan Turing laid the groundwork for theoretical computer science and invented the Turing Test which determines if a machine's intelligent behavior matches human intelligence. (A01.pdf, MidtermGlossary.pdf)

• John McCarthy: John McCarthy created the term "artificial intelligence" and organized the Dartmouth Conference which became a landmark moment in AI history. (A01.pdf)

• Marvin Minsky: Marvin Minsky established the MIT AI Laboratory and gained recognition as one of the most influential researchers in artificial intelligence. (A01.pdf)

• Geoffrey Hinton: Geoffrey Hinton received recognition for his trailblazing research in neural networks and deep learning that reshaped modern artificial intelligence. (A01.pdf)

Alan Turing proposed the Turing Test in 1950 which serves as a practical definition of intelligence by measuring whether a human can identify computer-generated responses from human responses. (MidtermGlossary.pdf)

2. Essential principles of Machine Learning and Neural Networks form the cornerstone of modern Artificial Intelligence.

Multiple resources explore the essential concepts of Machine Learning (ML) and Neural Networks (NNs) which serve as the foundation of current artificial intelligence.

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• Machine Learning: Machine learning represents the process where computers learn to perform tasks by recognizing patterns and utilizing predictive algorithms to analyze new data. Machine Learning needs "vast quantities of data and extensive processing capabilities" and typically depends on specialized hardware like GPUs. Machine Learning requires mathematical algorithms which pre-exist to teach computers how to process data. (MidtermGlossary.pdf)

• Deep Learning (DL): Deep Learning represents a branch of machine learning which employs neural networks with multiple layers known as deep neural networks. Deep learning algorithms model human brain functions to achieve superior performance in image and speech recognition tasks. Deep learning demands large volumes of quality annotated data together with substantial GPU resources. (MidtermGlossary.pdf)

• Neural Networks (NNs): Neural Networks serve as brain-inspired models which generate "weights and biases through a specific process." Interconnected nodes called "neurons" make up networks that execute information processing tasks. (L01.pdf)

• Input Layer: Raw data enters the first layer where it remains unchanged. The number of neurons within the network corresponds to the number of input features. (A07.pdf)

• Hidden Layers: Hidden layers function by applying weights and biases to data inputs to identify basic patterns. Activation functions allow neural networks to process non-linear information which aids in feature extraction. As networks increase in hidden layers they become deeper and more powerful. (A07.pdf)

• Output Layer: The output layer represents the final neural network layer which generates predictions or classification results. The output layer uses an activation function to transform processed data into predictions or classifications. (A07.pdf)

• Key Neural Network Architectures: Convolutional Neural Networks (CNNs) process structured grid data such as images by identifying patterns through the use of filters. Facial recognition systems utilize these technologies. (L01.pdf)

• Recurrent Neural Networks (RNNs): Architectures designed to handle sequential data. (A06.pdf)

• Long Short-Term Memory (LSTM) Networks: Long Short-Term Memory (LSTM) Networks represent a category of RNN built to capture long-term dependencies which makes them ideal for time-series analysis and forecasting tasks. Language models perform text prediction and translation tasks using Long Short-Term Memory networks (LSTMs). (L01.pdf)

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- Generative Adversarial Networks (GANs): Generative Adversarial Networks (GANs) utilize a dual structure consisting of a generator and a discriminator to create synthetic data that appears realistic. (L01.pdf, MidtermGlossary.pdf) GANs can generate realistic images. (L01.pdf)

- Transformers: Transformers represent advanced AI models that demonstrate exceptional abilities to comprehend data context through analysis of data relationships particularly in language processing. Transformers have transformed NLP tasks because they eliminate the need for sequential data processing. (MidtermGlossary.pdf)

- Learning Approaches: Supervised Learning techniques allow models to learn mappings between inputs and outputs through labeled data which provides example input-output pairs. This approach uses features to foresee a precise label while enabling straightforward assessment of model effectiveness. (MidtermGlossary.pdf)

- Unsupervised Learning: Models identify hidden structures within data that does not contain predefined labels. The approach examines structural patterns and unusual characteristics which results in indirect assessments. (MidtermGlossary.pdf)

- Reinforcement Learning: Using reinforcement learning agents discover optimal actions that help them collect maximum rewards from their environment. (L01.pdf) Autonomous robots apply reinforcement learning. (L01.pdf)

- Training Neural Networks: During forward propagation the network receives inputs and sequentially processes them through each layer to determine the final output. (A07.pdf)

- Activation Functions: Activation functions create non-linear operations so the model can understand complex data patterns via functions like ReLU and Sigmoid. (A07.pdf)

- Loss Function: The loss function calculates the deviation between predicted outputs and actual results using methods such as Mean Squared Error or Cross-Entropy Loss. (A07.pdf)

- Backpropagation: Backpropagation functions as a supervised learning approach which teaches neural networks to minimize errors by modifying network connection weights. The procedure involves calculating the loss function gradient before using gradient descent to modify the network weights. (A07.pdf)

- Gradient Descent: The optimization algorithm functions to reduce the loss function by repeatedly modifying model parameters. (A07.pdf)

- Feedback Loop: The learning process involves detecting errors to calculate their signals and adjusting neural connections to achieve better performance in future tasks. (A07.pdf)

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3. Data serves as a crucial element for both artificial intelligence and machine learning systems.

Data serves as the essential element for AI and ML technologies because it works as both fuel for machine learning systems and instructional content for algorithm training. (MidtermGlossary.pdf)

• Big Data: Big data consists of extensive complex datasets that need special tools for their capture storage management and analysis. The management of big data faces difficulties due to its volume as well as variety and velocity and must also maintain accuracy and usefulness. Deep learning models demonstrate strong capabilities to identify intricate patterns within extensive data sets. (MidtermGlossary.pdf)

• Small Data: Traditional methods can handle datasets that have been created for specific problems. (MidtermGlossary.pdf)

• Data Cleaning: Data engineering requires careful handling of missing values together with outlier detection and feature scaling. (A06.pdf)

• Dark Data: Data that organizations collect but fail to analyze can negatively impact model performance while creating missed business opportunities. (MidtermGlossary.pdf)

• Categorical Data: Data examples such as gender and nationality represent ordinal data when ordered or nominal data when unordered. The ability to distinguish between data types helps in selecting proper machine learning models. (MidtermGlossary.pdf)

• Features (in ML): Observations used to form predictions. The process of identifying relevant features plays a critical role in the construction of ML models. (MidtermGlossary.pdf)

• Label (in ML): The output you wish to predict during supervised learning training is commonly referred to as the target label. (MidtermGlossary.pdf)

• Data Augmentation: Deep learning models for small datasets improve their performance through artificial data augmentation techniques. (MidtermGlossary.pdf)

4. Natural Language Processing (NLP)

Natural Language Processing (NLP) functions as a field of artificial intelligence that provides computers the ability to both understand and generate human language. Virtual assistants and chatbots depend on this functionality. (L01.pdf)

• Transformers: Transformers represent advanced models for NLP tasks because they function optimally in understanding context. (MidtermGlossary.pdf)

• Text Processing Steps (illustrated with "Alice in Wonderland" excerpt in A10.pdf): The cleaning process involves transforming all text to lowercase and eliminating punctuation marks as well as numbers and special characters.

• Tokenization: Breaking text into individual words or tokens.

• Stop Word Removal: The stop word removal process removes common words such as "and," "the," "is," and others to highlight important words.

• Stemming/Lemmatization: Extracting the root meaning of words. Lemmatization retains contextual meaning which proves vital for analyzing sentence structure.

• Part-of-Speech (POS) Tagging: POS Tagging helps to understand word functions which enables context-sensitive interpretations.

• Vectorization (TF-IDF): Text tokens must be transformed into numerical formats for effective machine processing.

5. Computer Graphics and Rendering

The advancement of computer graphics development receives special attention through the analysis of rendering technique evolution. (MidtermGlossary.pdf)

• Rendering: Rendering generates 2D images from 3D models through texture application and management of lighting effects and shadows. (MidtermGlossary.pdf)

• Ray Tracing: Ray tracing functions as a computer graphics technique that simulates light-object interactions to produce lifelike visual representations. The system monitors the trajectory of light rays while accounting for reflective surfaces and refractive materials together with shadow generation. Video games and movies use ray tracing for realistic visuals while architecture and medical imaging fields also apply it for professional purposes and scientific applications benefit from its techniques. (A04.pdf)

• Invention of Ray Tracing: Introduced in 1968 by Arthur Appel. (L04.pdf)

• Real-Time Ray Tracing: NVIDIA RTX Graphics Cards (2018) enabled real-time ray tracing to deliver realistic lighting effects and reflections in live video game environments. (A04.pdf, L04.pdf)

• Phong Shading Model (1975): A technique for realistic rendering of surfaces. (L04.pdf)

• Pixar's RenderMan (1988): Pixar's RenderMan represents rendering software that generates high-quality images and plays an essential role in animated film productions. (L04.pdf)

• Programmable Shaders (2001): Programmable Shaders give developers the power to craft unique programs that control the graphics pipeline and create sophisticated visual effects. (L04.pdf)

• Path Tracing (2020s): The visual timeline references Path Tracing as a rendering technique. (L04.pdf)

• Cloud Rendering: Allows for scalable, high-performance rendering capabilities. (MidtermGlossary.pdf)

• GPU Engine: Software applications that utilize GPU power to perform tasks beyond visual rendering processes. (MidtermGlossary.pdf)

• Eco-Friendly Rendering Practices: The trend towards eco-friendly rendering practices gains momentum through the implementation of energy-efficient algorithms and the use of renewable energy sources. (MidtermGlossary.pdf)

6. Applications of AI and Related Technologies

The sources identify multiple sectors where AI and similar technologies have practical applications.

• Search Engines: Google emerged from the need to effectively find meaningful data online by focusing on delivering "relevant and high-quality search results." The PageRank algorithm stood out as a major breakthrough because it used inbound links to determine web page rankings. Google seeks to arrange all global information so it can be accessed by everyone and provide useful content. (A02.pdf)

• Autonomous Systems: Self-driving vehicles and drones demonstrate how automated technology is transforming industrial sectors and everyday life. (A01.pdf)

• Image Recognition: Security systems leverage this technology to detect and identify individuals within video surveillance footage. (L01.pdf)

• Natural Language Processing (NLP): Powers virtual assistants and chatbots. (L01.pdf)

• Recommendation Systems: Personalized recommendation algorithms function as the backbone of Netflix, YouTube, and Amazon. (A07.pdf)

• Fraud Detection: Detects unusual patterns in transactions. (A07.pdf)

• Healthcare: The healthcare application supports medical professionals by enabling disease diagnosis and treatment customization alongside predictions of patient outcomes. (A07.pdf)

• Computational Humor: Research focuses on developing AI systems capable of producing humorous content.

• HAHAcronym: The HAHAcronym system creates funny acronyms through the use of linguistic templates and semantic connections. The system demonstrates strengths in fast processing and grammatical accuracy yet struggles with creating unpredictable content and producing advanced humor. (L05.pdf)

• STANDUP: The interactive STANDUP system helps children with communication issues by using pun-based riddles. The tool provides an interactive riddle creation feature which produces riddles of varying difficulty levels but struggles with generating complex riddles and engaging users while working with limited vocabulary options. (L05.pdf)

• JAPE: JAPE represents a computational system that creates pun-based jokes through rule-based methods along with lexical databases and established joke frameworks. This system achieved early success but failed to grasp the full complexity of humor. (L05.pdf)

• BERT-Based Humor Detection: The approach uses cutting-edge NLP models to achieve high accuracy in humor identification in text but needs large amounts of training data. (L05.pdf)

7. Ethical and Social Implications of AI

Sources emphasize that ethical and social consequences must be evaluated in AI systems. AI's past developments require us to evaluate the ethical implications of intelligent machines. The future relevance of emotional connections between users and AI digital assistants emerges as a crucial point of consideration. The narrative in "A12.pdf" presents the "promise and pitfalls of AI" through an insightful examination of its use in crime prediction.

8. Knowledge Representation and Data Management

AI systems depend on knowledge representation and data management as essential components.

• Knowledge Representation: AI systems require the organization and storage of information and world relationships for effective reasoning and decision-making. (L01.pdf)

• Knowledge Graph: Semantic networks serve as knowledge bases that represent relationships between actual entities instead of just text strings while including limitations on their connections. Google launched their Knowledge Graph in 2012. Knowledge Graphs enable ML models to access additional features and generate synthetic labeled data while transforming ML data into a more machine-readable format. (MidtermGlossary.pdf)

• Semantic Network: Semantic networks function as knowledge bases for conceptual relationships in networks which served as early foundations for today's neural networks. (MidtermGlossary.pdf)

• Semantic Web: The Semantic Web is designed to help machines interpret web information through structured data linkages. ML performance receives improvements through the addition of new features and enhanced interpretability while decreasing the need for labeled data. (MidtermGlossary.pdf)

• Ontology: Ontology serves as a model for grouping entities and their attributes as well as their interconnections which are frequently associated with taxonomic structures. (MidtermGlossary.pdf)

9. Personal Narratives and Believability

Personal stories in "A08.pdf" enable readers to understand narrative construction and how believable stories are created. Realistic actions such as Richard's father maintaining control during a hunting incident reveal the authenticity of storytelling. The credibility of narratives depends on "how characters behaved and reacted throughout the narratives."

Conclusion:

The combination of assignments, labs and midterm work provides students an extensive introduction to artificial intelligence's wide-ranging elements. The learning materials provide a complete examination of artificial intelligence including its historical development and fundamental machine learning principles as well as neural network foundations and demonstrate practical uses in diverse fields together with technologies such as computer graphics and natural language processing. Ethical and social aspects of AI technology emerge as essential elements when developing and deploying intelligent machines in the future. Personal narratives offer distinctive viewpoints on storytelling while revealing what makes a story believable.