Mathematical Foundations of Artificial Intelligence

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Introduction

This poster template is modified from the original FSU Mathematics template by Rafiq Islam[1] for Nanjing University AI School presentations[2].
Artificial Intelligence encompasses the development of systems that can perform tasks requiring human intelligence, including learning, reasoning, perception, and decision-making.

Mathematical Foundations

The core of modern AI lies in mathematical optimization and linear algebra. The fundamental neural network forward propagation is:

$$a^{(l)} = \sigma(W^{(l)} a^{(l-1)} + b^{(l)})$$

where σ is the activation function, $W^{(l)}$ are weight matrices, and $b^{(l)}$ are bias vectors.
Backpropagation uses gradient descent to minimize the loss function:

$$\theta \leftarrow \theta - \eta \nabla_\theta J(\theta)$$

Neural Network Architecture

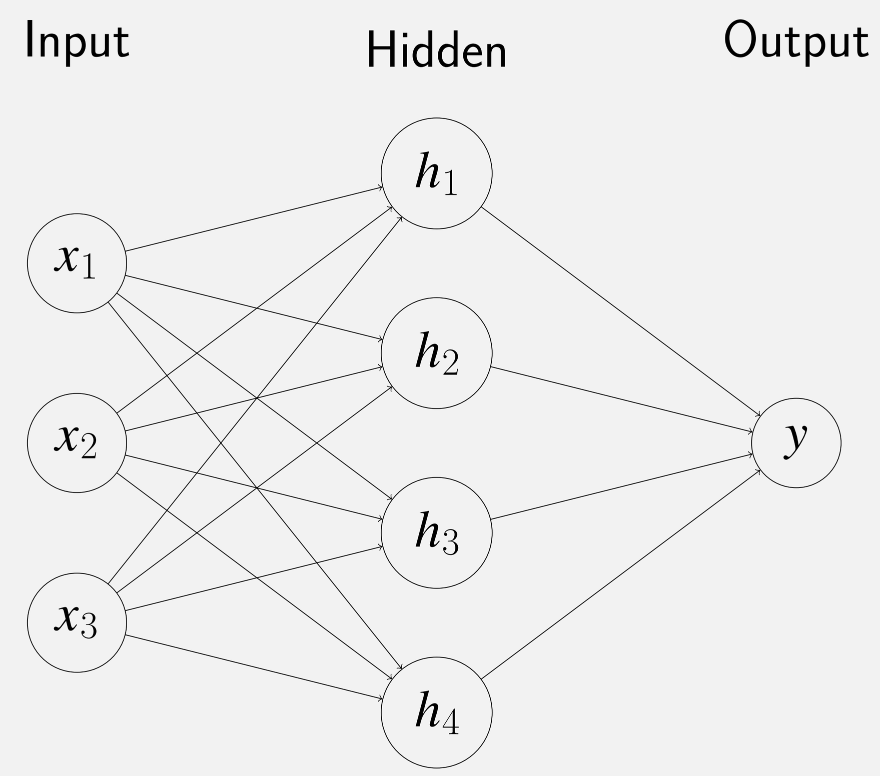


图 1: Basic Neural Network Architecture

Research Objectives

- Develop advanced deep learning architectures
- Improve natural language understanding capabilities
- Enhance computer vision systems for real-world applications
- 推动人工智能理论创新 (Advancing AI theoretical innovation)

Why Artificial Intelligence?

Artificial Intelligence is revolutionizing multiple industries and creating new possibilities:

- Healthcare: Early disease detection and personalized treatment
- Transportation: Autonomous vehicles and smart traffic systems
- Education: Adaptive learning platforms and intelligent tutoring

Methodology

Our research methodology follows a systematic approach:

1. Problem formulation and mathematical modeling
2. Data collection and preprocessing
3. Algorithm design and implementation
4. Experimental evaluation and performance analysis
5. Theoretical analysis and generalization studies

AI Research Areas

图 2: NJU LAMDA Research Team (Photo credit: LAMDA)

- Machine Learning and Deep Learning
- Natural Language Processing
- Computer Vision and Robotics
- Knowledge Representation and Reasoning

Performance Comparison

Model	Accuracy	Precision	Recall
CNN	94.2%	93.8%	94.5%
RNN	91.5%	90.2%	92.1%
Transformer	96.8%	96.5%	97.1%
Traditional ML	87.3%	86.1%	88.2%

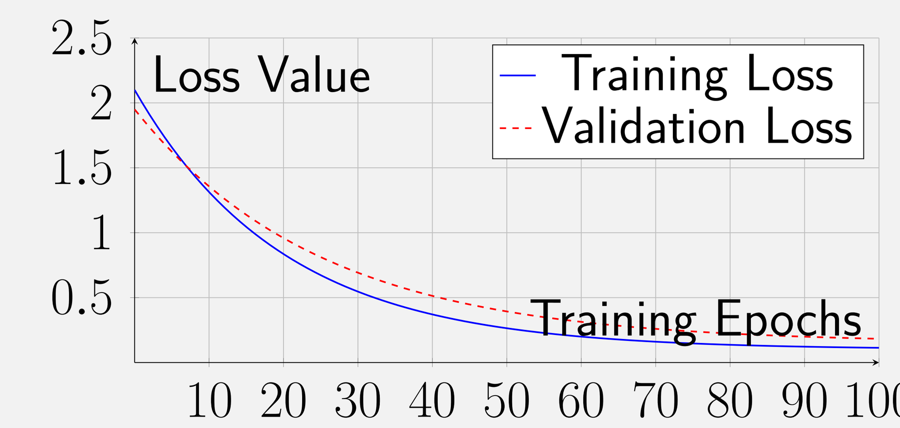
表 1: Performance comparison of different AI models on benchmark datasets

Theoretical Foundations

The mathematical foundation of deep learning involves optimization theory and linear algebra. The learning process minimizes the loss function:

$$\min_\theta \frac{1}{N} \sum_{i=1}^{N} \mathcal{L}(f_\theta(x_i), y_i) + \lambda R(\theta) \tag{1}$$

where $\mathcal{L}$ is the loss function, $R(\theta)$ is the regularization term, and λ controls regularization strength.



This visualization shows typical learning curves where both training and validation losses decrease over epochs, indicating successful model convergence.

Conclusion and Future Work

- Deep learning models demonstrate superior performance across various tasks
- Transformer architectures excel in natural language processing
- Continued research needed for explainable and trustworthy AI
- Future directions include multimodal learning and AI safety

References

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