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(Formerly Harcourt Butler Technological Institute, Kanpur)

Computer Science and Engineering Department, HBTU Kanpur

Expert Lecture Report on

Modeling Sequential Data: RNN, LSTM, an LLM
Organised by

Department of CSE, HBTU Kanpur on

Date : 29 November 2025

1. **Key Speaker:** Dr. [Name of Expert]
   Professor Prabhat Verma
   HBTU, Kanpur

Expertise: Deep Learning, Natural Language Processing, Sequential Modeling, Transformer Architectures

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2. Organizing Faculty

- Prof. Anita Yadav
- Dr. Prabhat Verma

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3. Participants

The lecture was attended by **100+ students** along with all faculty members of the Department of Computer Science & Engineering, HBTU Kanpur.

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4. Objectives of the Expert Lecture

- To introduce the concept of sequential and temporal data modeling
- To explain traditional and modern approaches for sequence prediction
- To highlight the evolution from Markov Models to RNNs, LSTMs, and Transformer-based LLMs
- To discuss limitations of earlier models and how modern architectures overcome them

- To expose students to real-world applications and industry workflows involving sequence models

5. Event Highlights

6. Key Discussion Points

- Importance of modeling temporal dependencies in data
- Limitations of probabilistic models like Markov Chains and HMMs
- Challenges of vanishing and exploding gradients in RNNs
- Role of gating mechanisms in LSTM networks
- Need for parallelization and scalability in deep learning models
- Emergence of self-attention and transformer architectures
- Foundations of Large Language Models (LLMs) such as GPT

7. Core Concepts Explained

7.1 Sequential and Temporal Data

Sequential data refers to data where order matters. Examples include:

- Text (word sequences)
- Speech signals
- Video frames
- Financial and sensor time-series

Understanding dependencies across time is crucial for accurate prediction and generation.

7.2 Markov Models and Hidden Markov Models (HMMs)

- Based on the Markov assumption (current state depends only on previous state)
- Effective for small, well-defined domains
- Limited scalability and representational power

7.3 Recurrent Neural Networks (RNNs)

- Introduce cyclic connections to maintain internal memory
- Suitable for variable-length sequences

- Suffer from vanishing and exploding gradient problems
- Weak performance on long-term dependencies

7.4 Long Short-Term Memory (LSTM)

- Extension of RNNs with memory cells
- Uses gates (input, forget, output) to regulate information flow
- Capable of learning long-term dependencies
- Limitations:
    - Encoding bottleneck
    - Sequential computation (slow training)
    - Limited parallelization

7.5 Self-Attention and Transformer Architecture

- Removes recurrence and convolution
- Uses self-attention to weigh importance of different tokens
- Multi-head attention captures diverse contextual relationships
- Enables parallel processing of sequences

7.6 Large Language Models (LLMs)

- Built on transformer architecture
- Examples: GPT, BERT, T5
- Capable of understanding context, semantics, and long-range dependencies
- Power modern NLP applications such as chatbots, summarization, and code generation

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8. Case Studies & Industry Workflows

Case Study 1: Natural Language Processing

- Task: Machine Translation
- Models Used: RNN → LSTM → Transformer
- Outcome: Transformers significantly improved translation quality and speed

Case Study 2: Speech Recognition

- Sequential acoustic signals modelled using LSTMs
- Attention-based models improved alignment between speech and text

Case Study 3: Financial Time-Series Forecasting

- LSTMs used for stock price prediction
- Transformers explored for long-horizon forecasting

Industry Workflow Example:

1. Data Collection (Text / Audio / Sensor Data)
2. Data Pre-processing & Tokenization
3. Model Selection (LSTM / Transformer)
4. Training with GPUs/TPUs
5. Evaluation & Fine-tuning
6. Deployment in Production Systems

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9. Learning Outcomes

After attending the lecture, participants were able to:

- Understand the evolution of sequence modeling techniques
- Identify strengths and limitations of RNNs, LSTMs, and Transformers
- Appreciate the role of attention mechanisms in modern AI
- Relate theoretical concepts to real-world applications

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10. Conclusion

The expert lecture provided a comprehensive overview of sequential data modeling, emphasizing the transition from traditional probabilistic models to modern transformer-based architectures. By connecting theory with industry practices, the session enriched participants' understanding of how Large Language Models are shaping the future of artificial intelligence.

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11. Acknowledgement

The organizing department sincerely thanks the expert speaker for sharing valuable insights and the participants for their active involvement, which made the lecture a great success.