Foundations of AI, Deep Learning, and Modern Architectures

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Special Focus on GenAI Agentic RAG

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Agenda – Foundations of AI for Oil & Gas

- In this session, we will understand how Artificial Intelligence evolved and why it is now practical for large industrial enterprises.
- By the end of this session, you will understand which AI architecture fits which industrial problem across upstream, midstream, downstream, and retail operations.

Agenda – Foundations of AI for Oil & Gas

- We will explore parallel computing and GPU acceleration, and how they enable large-scale AI training for applications such as seismic analysis and refinery optimization.
- We will study different neural network architectures including ANN, CNN, RNN, LSTM, and GNN, and understand where each is applicable in oil and gas operations.
- We will examine how Transformers revolutionized language understanding and enabled Large Language Models.

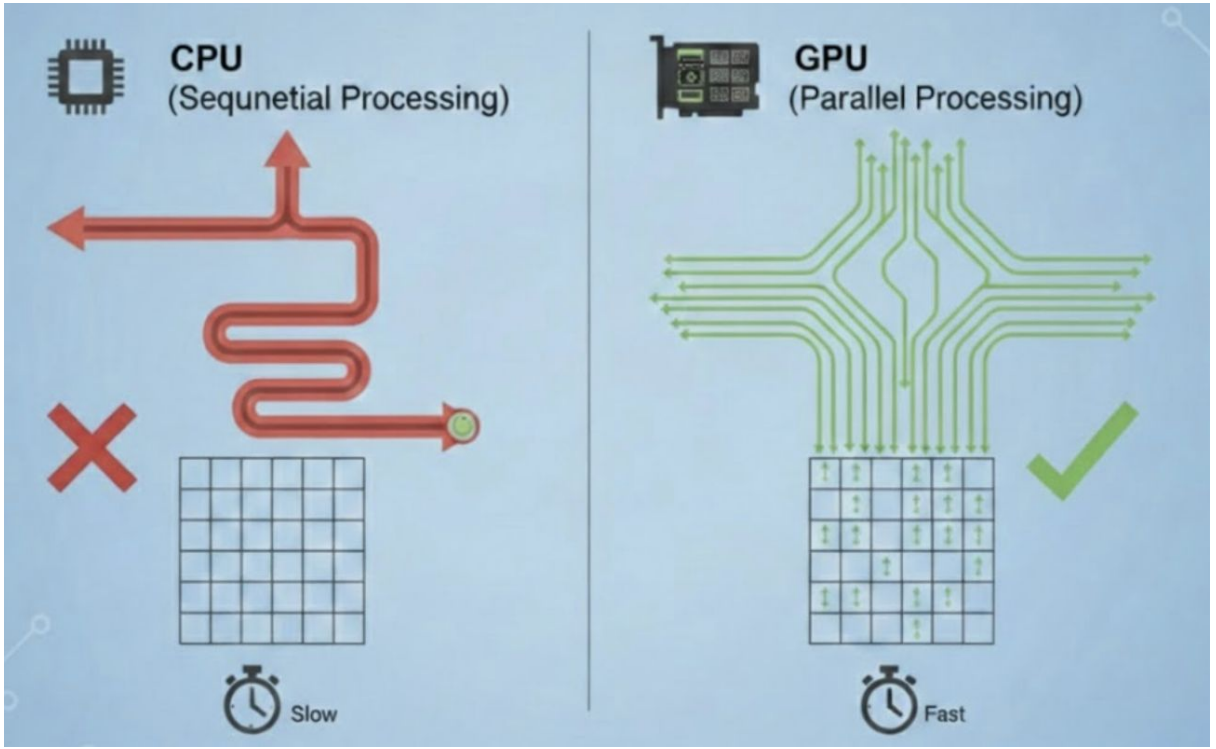
Why AI Is Transforming Oil & Gas

- Artificial Intelligence has become practical due to large operational datasets, affordable GPU computing, and advances in deep learning.
- Oil and gas companies generate massive data from refineries, drilling operations, pipelines, retail outlets, and supply chains.
- AI enables predictive maintenance of rotating equipment, optimization of refinery yields, demand forecasting for petrol and diesel, and real-time safety monitoring.
- These capabilities reduce downtime, improve margins, and enhance operational safety.

Parallel Computing and GPU Acceleration

- Parallel computing divides large computational tasks into smaller tasks that run simultaneously.
- GPUs contain thousands of cores optimized for matrix and tensor operations used in deep learning.
- This computational power allows large AI models to be trained efficiently.
- In oil and gas, GPU computing supports seismic imaging, reservoir simulation, refinery process optimization, and large-scale time-series analysis.

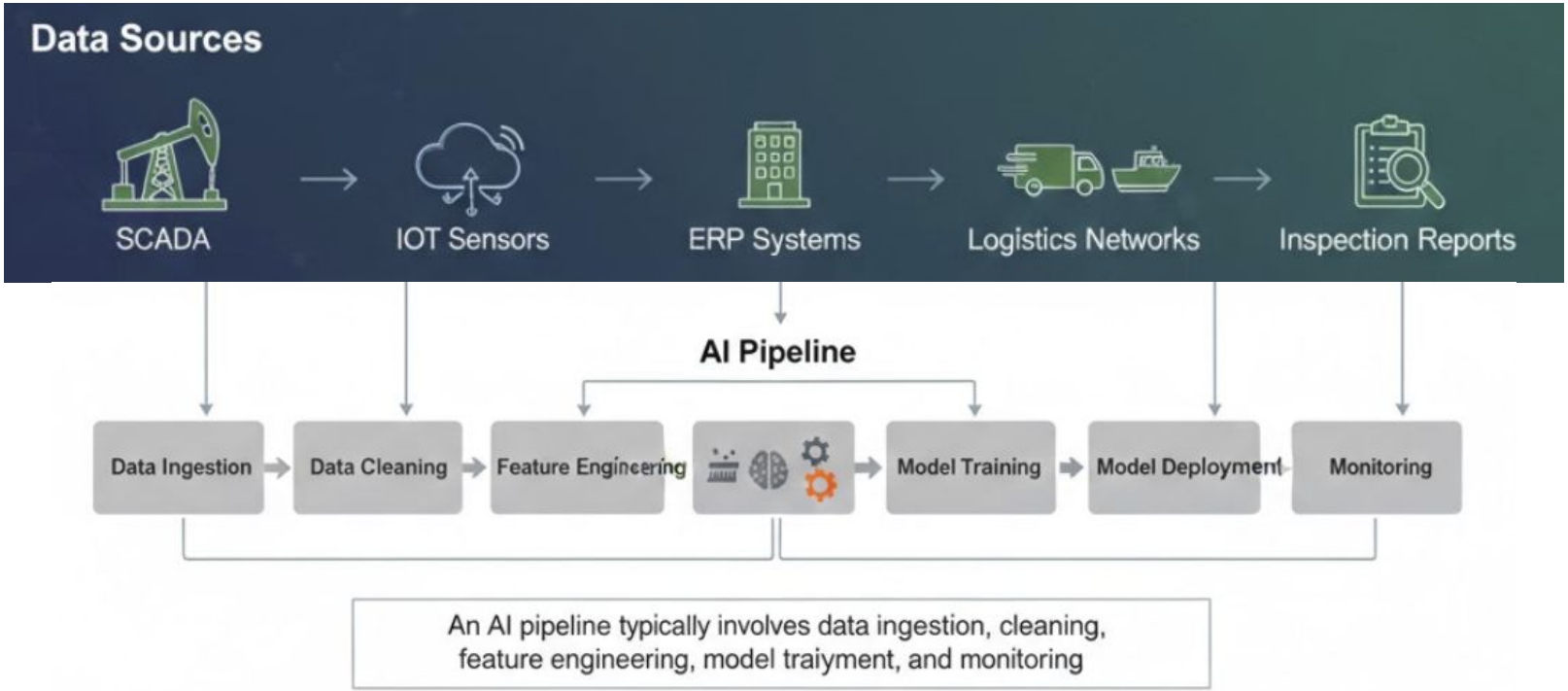
Parallel Computing and GPU Acceleration



Big Data and AI Pipeline in Oil & Gas

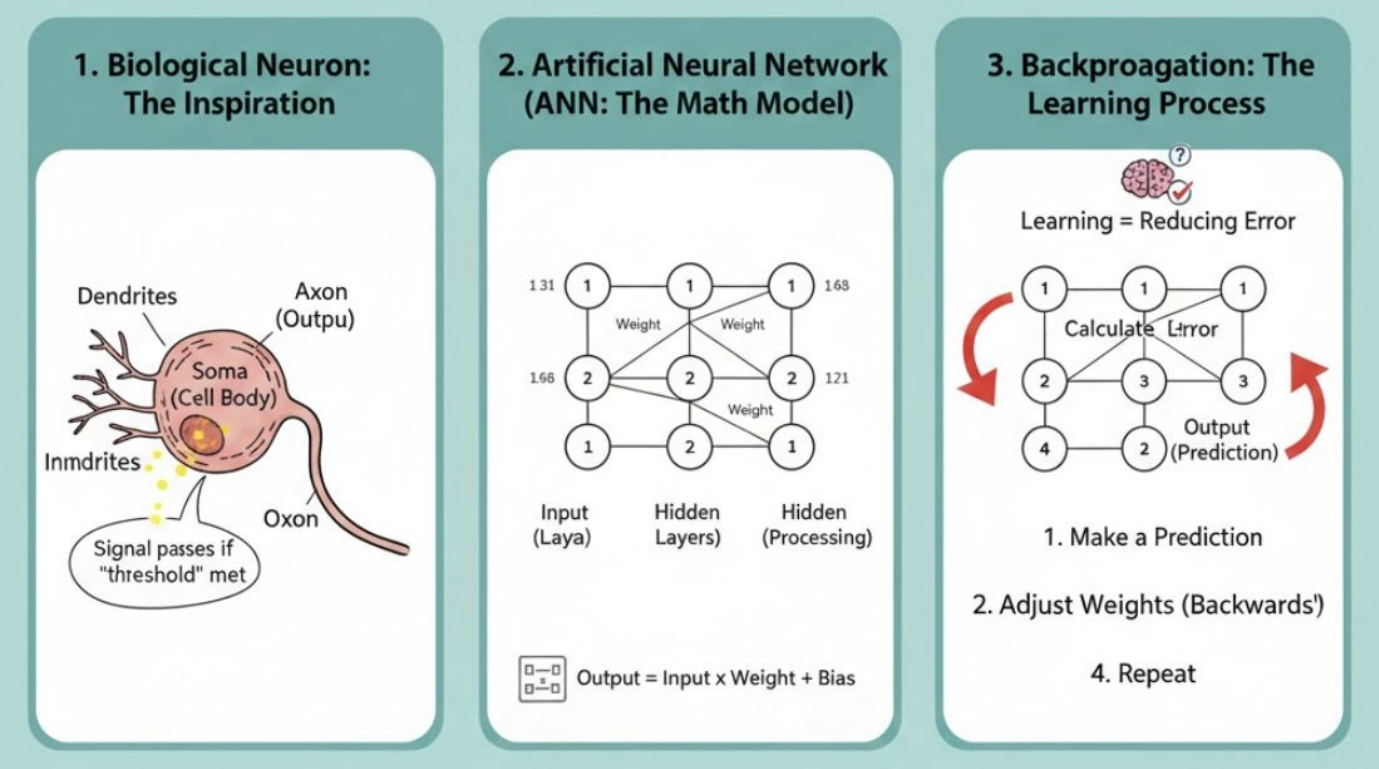
- Oil and gas enterprises generate structured and unstructured data from SCADA systems, IoT sensors, ERP systems, logistics networks, and inspection reports.
- An AI pipeline typically involves data ingestion, cleaning, feature engineering, model training, deployment, and monitoring.
- For example, refinery temperature and pressure data can be used to predict equipment failure.
- Retail sales and regional consumption patterns can be used to forecast fuel demand across depots.

Big Data and AI Pipeline in Oil & Gas



Big Data and AI Pipeline in Oil & Gas

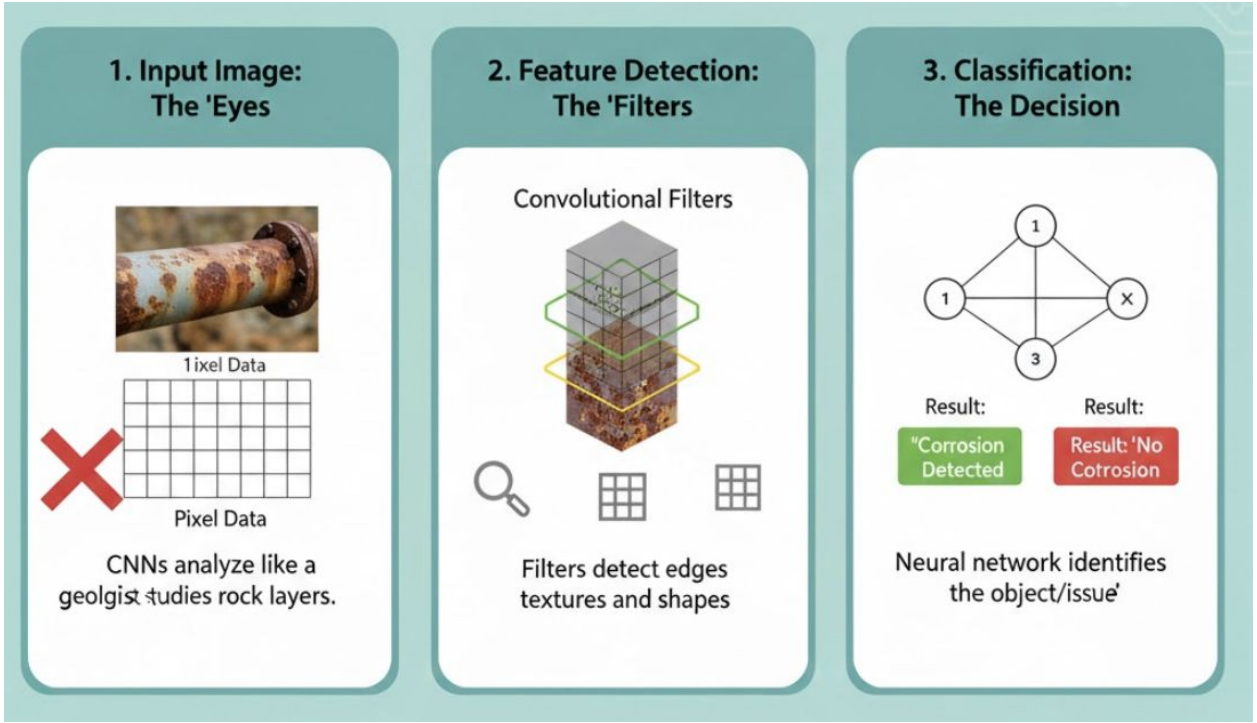
Artificial Neural Networks (ANN)



Artificial Neural Networks (ANN)

- Artificial Neural Networks consist of layers of interconnected neurons that learn patterns from data.
- They adjust internal weights through backpropagation to minimize prediction error.
- In oil and gas, ANNs can predict crude blending ratios to optimize refinery output.
- They can also estimate fuel consumption patterns based on historical demand and macroeconomic indicators.
- Demo: https://github.com/insAnalytics/ANN_ong_equipment_failure

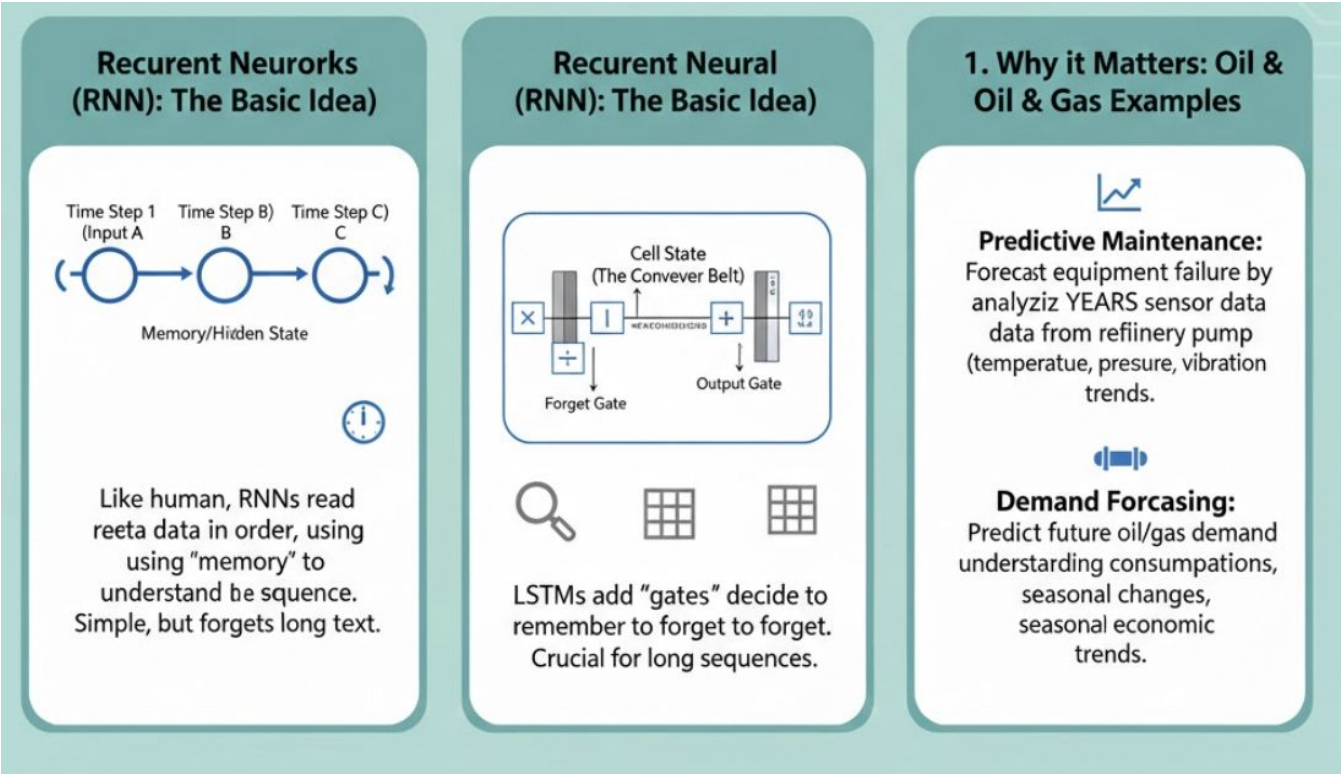
AI for Vision



Convolutional Neural Networks (CNN)

- Convolutional Neural Networks are designed for image and spatial data processing.
- They automatically detect features such as edges, textures, and anomalies.
- In oil and gas operations, CNNs are used for pipeline corrosion detection, refinery safety monitoring, and flame detection systems.
- They reduce manual inspection effort and enhance early hazard detection.
- Demo: https://github.com/insAnalytics/CNN_ong_pipeline_corrosion

AI for Sequential Data

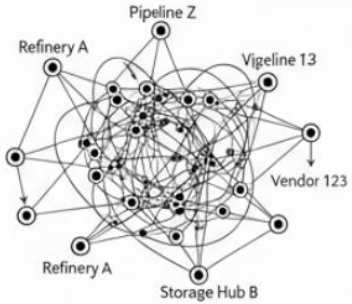


Recurrent Neural Networks (RNN) and LSTM

- Recurrent Neural Networks process sequential data such as time-series signals and text.
- LSTM networks retain important long-term dependencies using gating mechanisms.
- In oil and gas, LSTMs can forecast daily fuel demand across regions and predict pressure fluctuations in pipelines.
- They can also analyze sequential maintenance logs to identify early warning signs.
- Demo: https://github.com/insAnalytics/RNN_ong_demand_pred

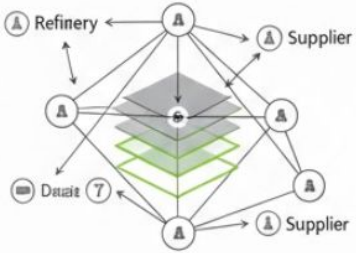
AI for Relationships (Networks)

1. The Challenge: Complexx Systems



Oil & Gas is web of connections: facilities, facilities, supplers, and logistics. Traditional AI struggles with this "equipment failure.

2. How GNNs See: The 'Relationship' Map



GNNs analyze data on * nodes and "betwen" and betwen of connections simanatulomesusly.

2. GNNs in Action: Oil Oil & Gas Examples

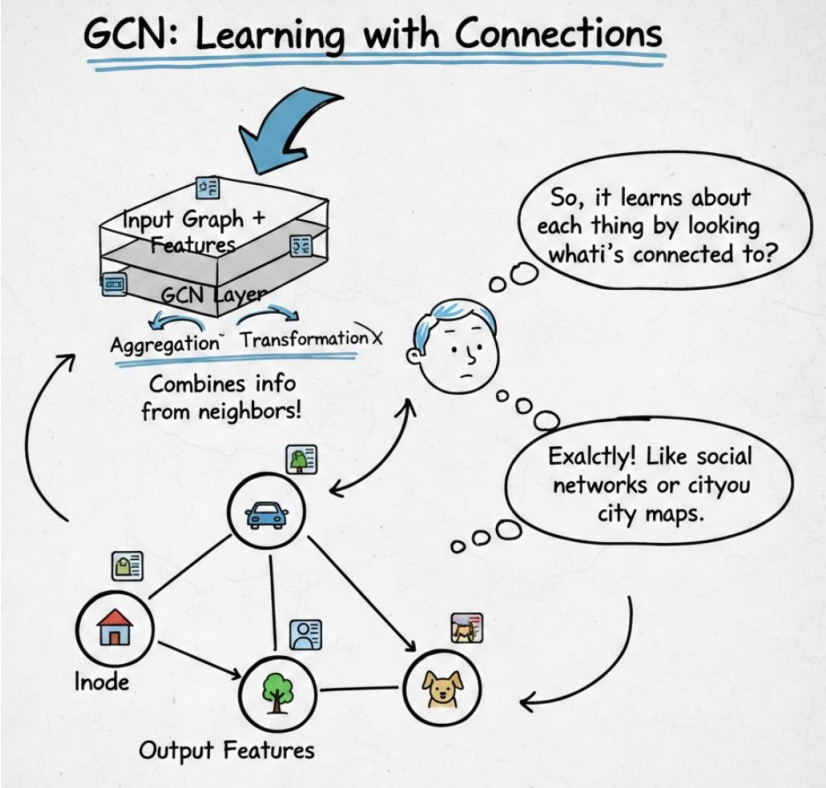
Supply Chain Opitinzation:
Predict bottpecckks, ae-route deliverres based to realme conditions

Tranker Route

Consumes

Pineline Chain Optinzatione
Predict cascade risks. If section section X fails, which otherr other secctions, wvis immegutely viiton impactet?

GCN (Graph Convolutional Network)



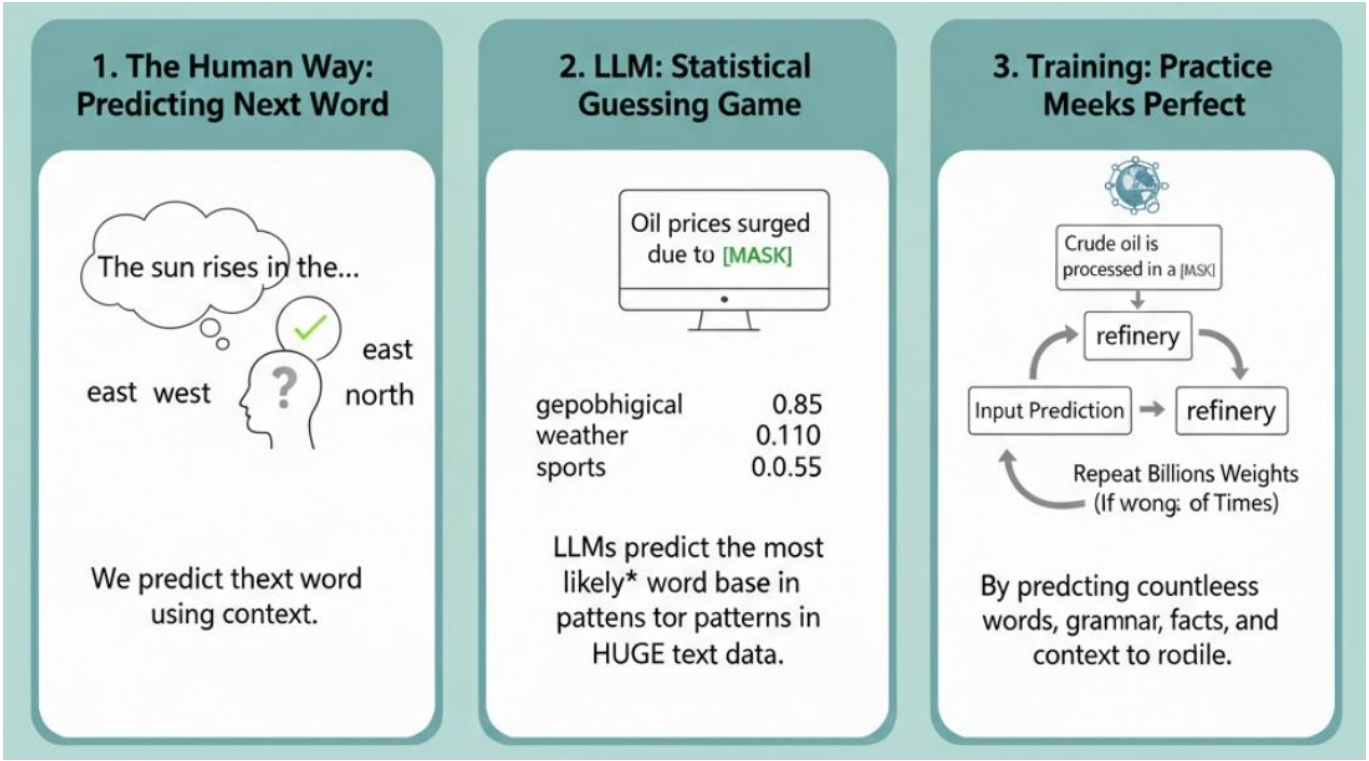
Graph Neural Networks (GNN)

- Graph Neural Networks analyze relationships between entities represented as nodes and edges.
- They model interconnected systems effectively.
- In oil and gas, GNNs can optimize supply chain networks linking refineries, depots, transporters, and retail outlets.
- They can also identify abnormal transaction patterns in fuel distribution networks.
- Demo: https://github.com/insAnalytics/GNN_ong_supply_chain

From NLP to Large Language Models

- Natural Language Processing enables machines to interpret and generate human language.
- Large Language Models are trained on massive datasets using transformer architectures.
- In oil and gas enterprises, LLMs can summarize incident reports, draft operational SOPs, answer employee queries, and compare regulatory clauses.
- They act as knowledge assistants across departments.

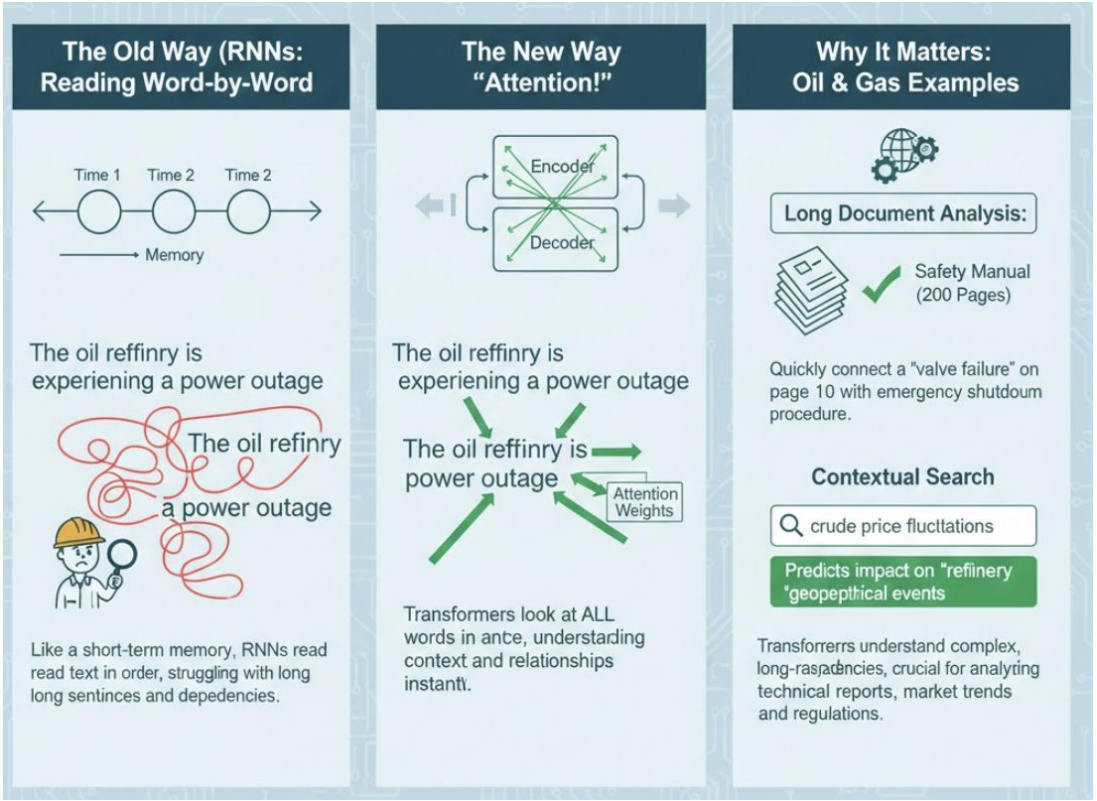
From NLP to Large Language Models



Transformers and Attention Mechanism

- Transformers use self-attention to understand relationships between words in a sequence.
- They process entire sequences in parallel, improving scalability and performance.
- This architecture forms the foundation of modern Large Language Models.
- In oil and gas, transformers enable automated analysis of contracts, environmental reports, compliance documents, and technical manuals.

Transformers and Attention Mechanism



Demo:
https://github.com/insAnalytics/LLM_ong_Gemini_demo

Comparative Analysis of LLMs: Free vs. Paid

Paid LLMs

Model	Multi-modal Capabilities	Monthly Subscription Fee	Best for...
GPT-5	Yes (Text, Image, Audio)	Starts at around ₹423.00 for "ChatGPT Go" (India-only) and goes up to ₹2,118.00 for "ChatGPT Plus" and higher for "Pro" and "Team" plans.	Complex, creative, multi-modal tasks, and advanced problem-solving.
Google Gemini 1.5 Pro	Yes (Text, Image, Audio, Video)	₹1,765.00 for "Gemini Advanced" which includes access to 1.5 Pro. Enterprise plans are higher.	Highly complex tasks requiring a massive context window (e.g., analyzing long documents or entire video files).
Claude 3	Yes (Text, Image)	Pricing is usage-based (per token) for API access. There are also subscription plans for individuals, like "Claude Pro" at ₹1,766.00/month.	Complex analysis and summarization of long documents with an emphasis on safe, harmless content.

Free LLMs

Model	Multi-modal Capabilities	Monthly Subscription Fee	Best for...
Meta Llama 3	Text	Free (open-source).	Fine-tuning for specific enterprise tasks; runs efficiently on-premise for privacy.
Google Gemma	Yes (Text, Image) for Gemma 3 models (4B, 12B, and 27B)	Free (open-source).	Efficient on-device AI for well-defined, high-volume tasks like sentiment analysis and entity extraction.

Summary

- Different neural architectures address different industrial data types such as images, time series, graphs, and text.
- GPU-powered parallel computing enables large-scale AI deployment.
- Transformers have enabled enterprise-grade language intelligence across oil and gas operations.

Q&A

Thank You

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