TECH STAR SUMMIT 2025

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Comparative Study of LSTM and CNN for Early Earthquake Detection Using Seismic Data

INTRODUCTION

- This research compares Long Short-Term Memory (LSTM) and Convolutional Neural Network (CNN) models for early earthquake detection using seismic data.
- Early earthquake prediction is critical to reducing damage and ensuring safety through timely alerts.
- The study uses time-series seismic signals to train deep learning models and improve detection accuracy.

Fig 1: Rescue people before Earthquake

MATERIALS AND METHODS

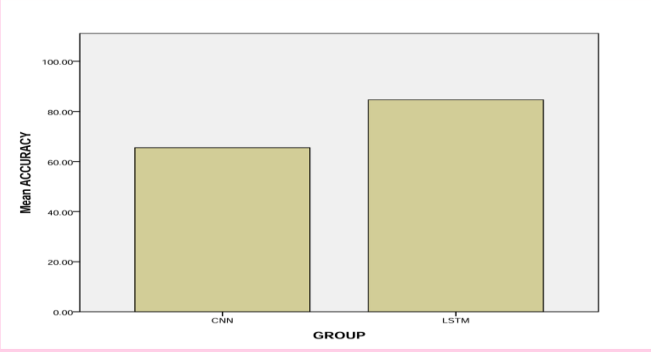
Data Collection : Seismic Waveforms from a public earthquake dataset → Preprocessing: Signal denoising, normalization and segmentation → LSTM :Used to capture temporal patterns in waveform sequences. / CNN: Applied to extract spatial features from transformed spectrograms of seismic data. → Training Phase & Testing → Evaluation Metrices

Fig.2: Flowchart for finding Accuracy using Seismic data in trained models

RESULTS

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
ACCURACY	LSTM	30	84.6090	2.90499	.53038
	CNN	30	65.5000	2.92138	.53337



- Comparison of accuracy prediction using LSTM and CNN. There are 30 samples for each algorithm.
- It specifies the accuracy levels of the LSTM and CNN algorithms for various inputs. CNN shows faster computation, while LSTM performs better in identifying temporal earthquake patterns

DISCUSSION AND CONCLUSION

- The Statistical analysis using paired T-tests shows a p-value of 0.001, confirming a significant performance difference between LSTM and CNN.
- LSTM effectively learns sequential patterns in seismic waves, making it more suitable for early detection. On Other hand, CNN, though efficient in spatial feature extraction, is less effective in capturing time dependencies.
- Conclusion: LSTM outperforms CNN in earthquake detection tasks using seismic data due to its memory-based learning capability.

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Comparative Study of LSTM and GRU for Early Earthquake Detection Using Seismic Data

INTRODUCTION

- This research investigates the effectiveness of Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) models in early earthquake detection using seismic data.
- Both LSTM and GRU are types of Recurrent Neural Networks (RNNs), capable of handling time-series data.
- The study focuses on model accuracy, training time, and sensitivity to seismic signal changes.

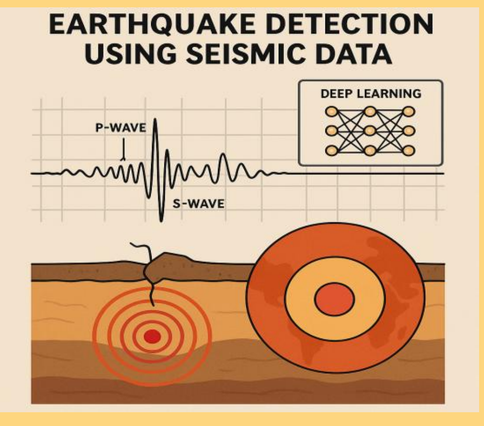


Fig 1: Earthquake detected by Seismic Data

MATERIALS AND METHODS

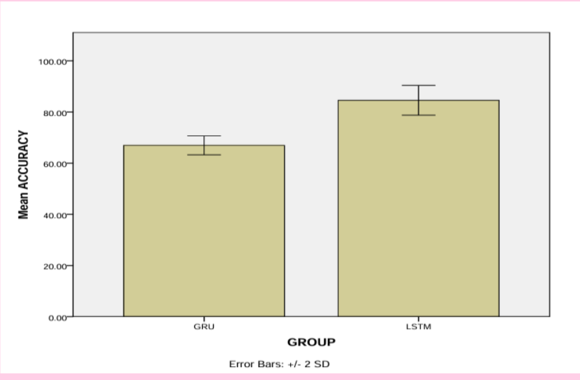
Seismic Dataset → Calculation of features and labels → Magnitude Prediction → LSTM / GRU; Magnitude Prediction → Model Evaluation (MSE,MAE,RMSE) → Earthquake detected

Fig.2: Seismic Data Analysis Pipeline

RESULTS

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
ACCURACY	LSTM	30	84.6090	2.90499	.53038
	GRU	30	66.9667	1.84733	.33728



- Comparison of accuracy prediction using LSTM and GRU. There are 30samples for each algorithm.
- LSTM shows higher accuracy but at the cost of longer training time.

DISCUSSION AND CONCLUSION

- Statistical analysis using a paired T-test revealed a p-value of 0.001, indicating a marginal difference in performance.
- LSTM provides better long-term memory capability, suitable for complex sequential data.
- GRU, while simpler, performs closely and requires fewer parameters.
- Conclusion: LSTM is slightly better in performance, but GRU offers a faster and lighter alternative for early earthquake detection tasks.

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Comparative Study of LSTM and Transformers for Early Earthquake Detection Using Seismic Data

INTRODUCTION

- This study explores the performance of LSTM and Transformer models in predicting early earthquake events using seismic time-series data.
- Transformers have revolutionized sequence modeling through attention mechanisms, showing promise in handling long-range dependencies.
- The goal is to assess which architecture LSTM or Transformer is more effective for timely and accurate earthquake prediction.

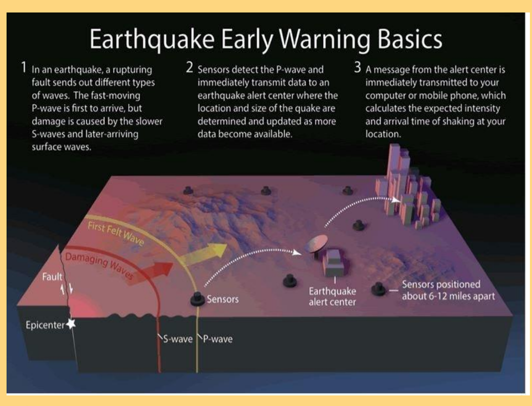


Fig 1: Sensors Give Early Warnings

MATERIALS AND METHODS

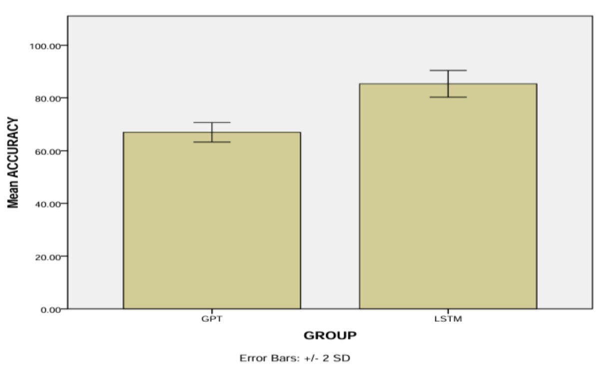
Seismic Time-Series Data #Waveform amplitude #timestamp → Preprocessing: Resampling, sequence alignment, and time-window slicing. → LSTM :Sequential processing of seismic data / Transformer: Attention mechanism applied to handle long sequences efficiently. → Feature Extraction Frequency & Statistical → Training Phase Magnitude > 3.5 → Evaluation Metrices

Fig.2:Methodology for Earthquake Prediction Using LSTM and Transformer Models

RESULTS

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
ACCURACY	LSTM	30	85.3617	2.53755	.46329
	GPT	30	66.9667	1.84733	.33728



- LSTM excelled in computational efficiency and faster training times, making it suitable for real-time or low-resource scenarios.
- However, Transformers require significantly more computational resources and longer training time, which may be a constraint in edge or embedded systems.

DISCUSSION AND CONCLUSION

- A two-tailed T-test showed a p-value of 0.001, indicating a statistically significant improvement of Transformers over LSTM.
- Transformers, with their attention mechanism, effectively captured both short- and long-term dependencies. Although, LSTM computationally efficient, lagged slightly in long-range prediction accuracy.
- Conclusion: Transformers outperform LSTM in early earthquake detection, making them a strong candidate for real-time geophysical applications.

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Comparative Study of LSTM and XGBoost for Early Earthquake Detection Using Seismic Data

INTRODUCTION

- This study compares LSTM and eXtreme Gradient Boosting (XGBoost) for detecting earthquakes early using seismic signals.
- Early detection can help reduce casualties and infrastructure damage by triggering safety mechanisms in time.
- The aim is to assess which model better captures underlying seismic patterns for early and accurate predictions.

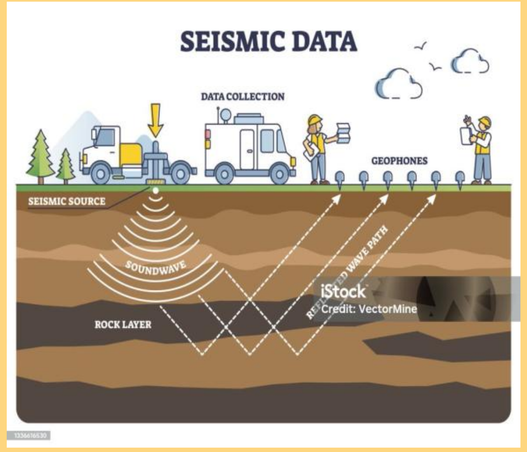


Fig 1: Seismic Data Collection

MATERIALS AND METHODS

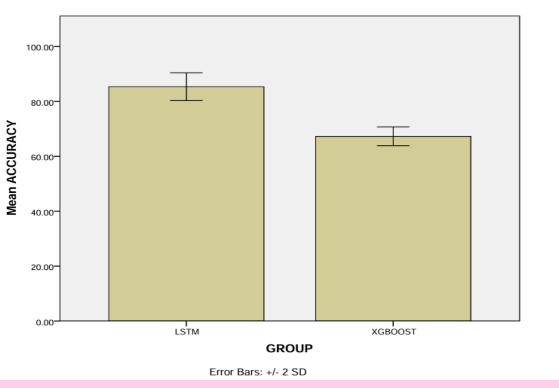
DATASET #Time Series #Amplitude Station Information Channel Type P-Wave/S-Wave Sampling Rate Signal Duration Noise Levels → Pre Processing & Feature Extraction (spectral entropy, STA/LTA ratio, waveform stats) → Label Encoding & Data Balancing / Apply SMOTE or under sampling if imbalanced → LSTM & XGBOOST → Evaluation & Predicted Output

Fig.2:Flowchart of Seismic Event Classification Framework Using XGBoost Algorithm.

RESULTS

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
ACCURACY	LSTM	30	85.3617	2.53755	.46329
	XGBOOST	30	67.3000	1.70496	.31128



- Comparison of accuracy prediction using LSTM and XGBOOST. There are 30 samples for each algorithm.
- LSTM captures sequential features effectively, whereas XGBoost may miss subtle time-based signals.

DISCUSSION AND CONCLUSION

- The independent sample T-test showed a p-value of 0.001, indicating a statistically significant performance difference between LSTM and XGBoost.
- LSTM is superior in modeling temporal seismic data for early prediction.
- XGBoost is advantageous for speed and explainability but less accurate in sequential anomaly detection.
- Conclusion: LSTM is better suited for early earthquake prediction from seismic data due to its ability to retain long-term dependencies.

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