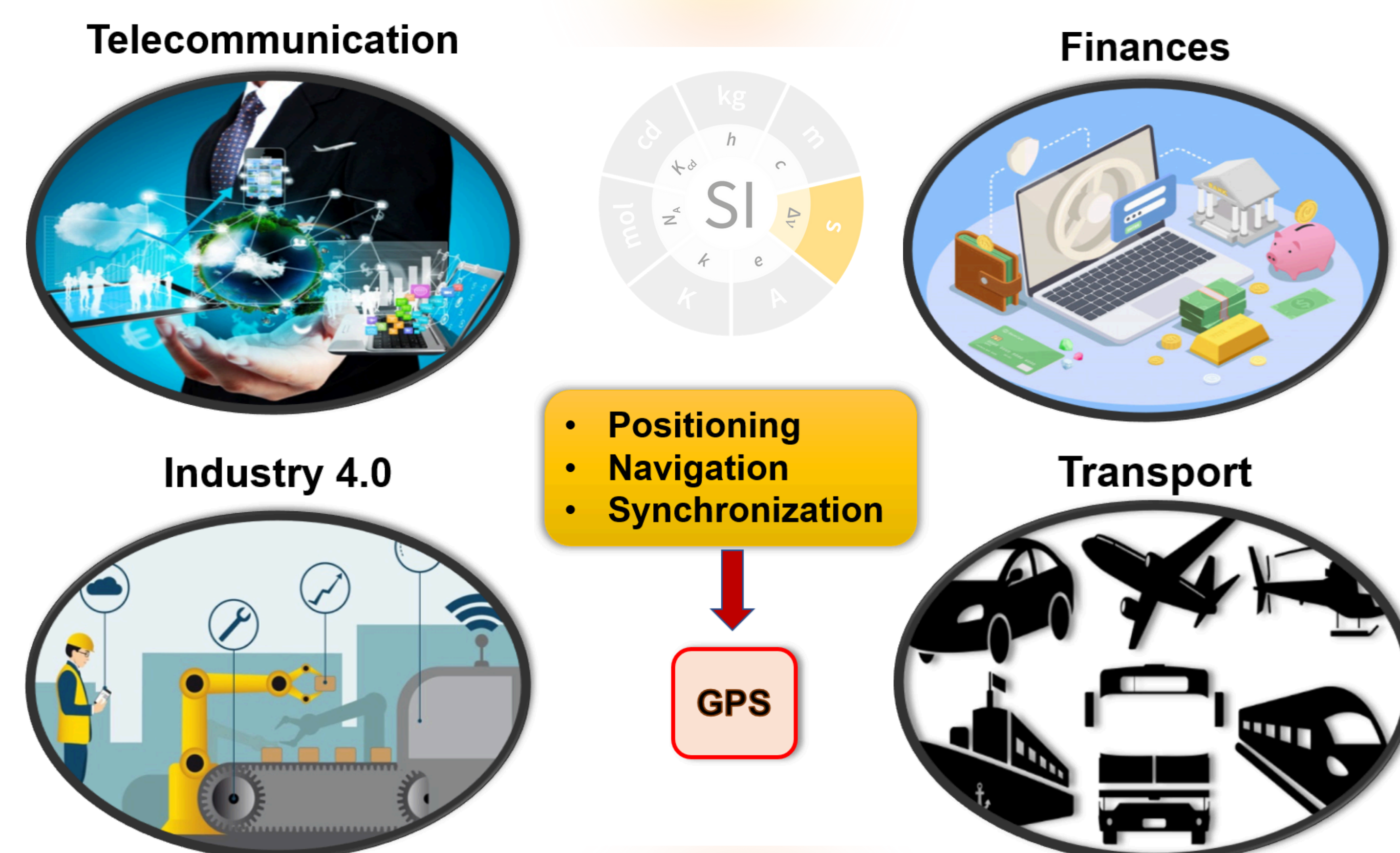


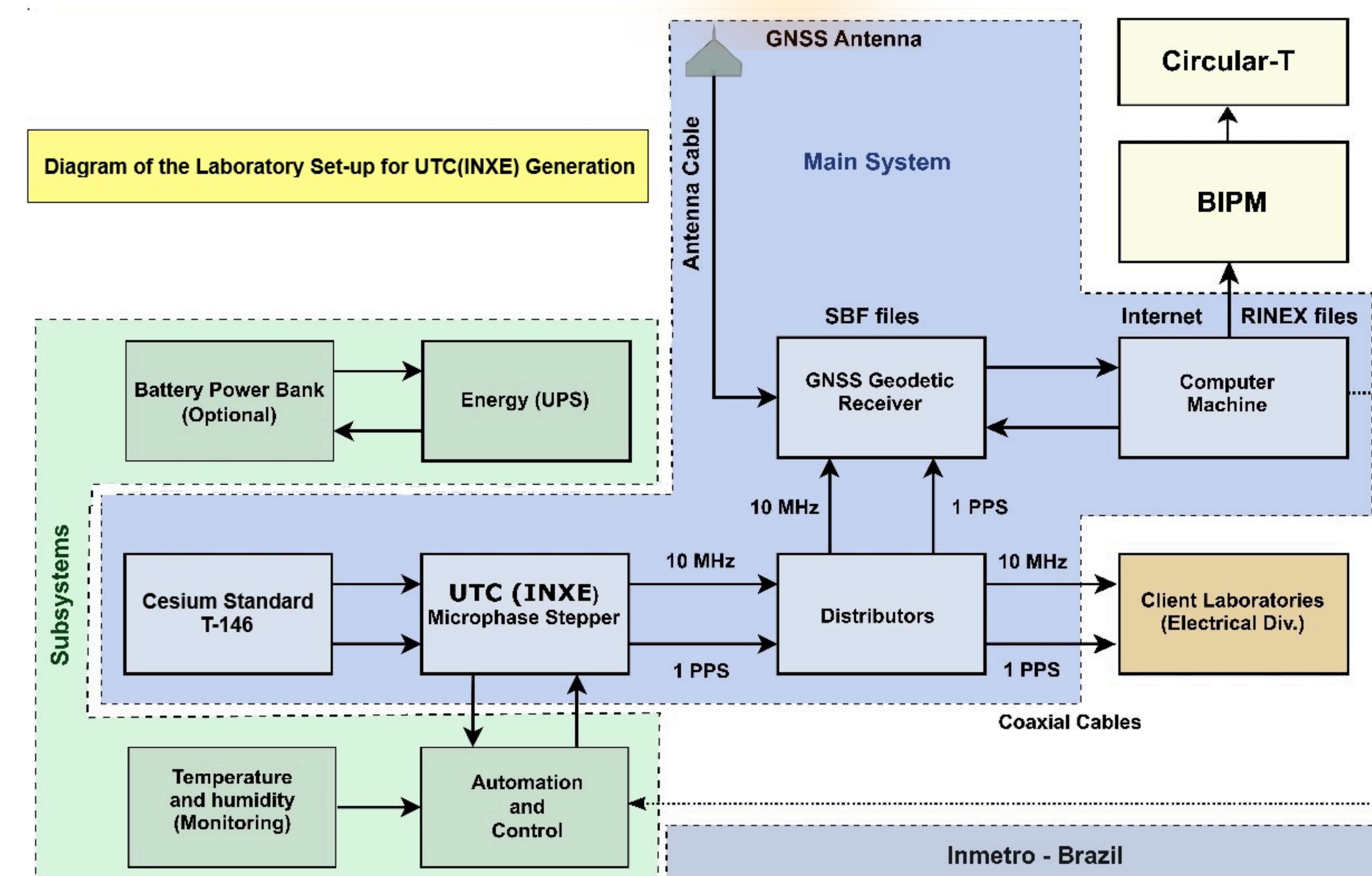
PERFORMANCE ANALYSIS OF THE UTC LOCAL TIME SCALE (INXE) USING ARTIFICIAL INTELLIGENCE ALGORITHMS

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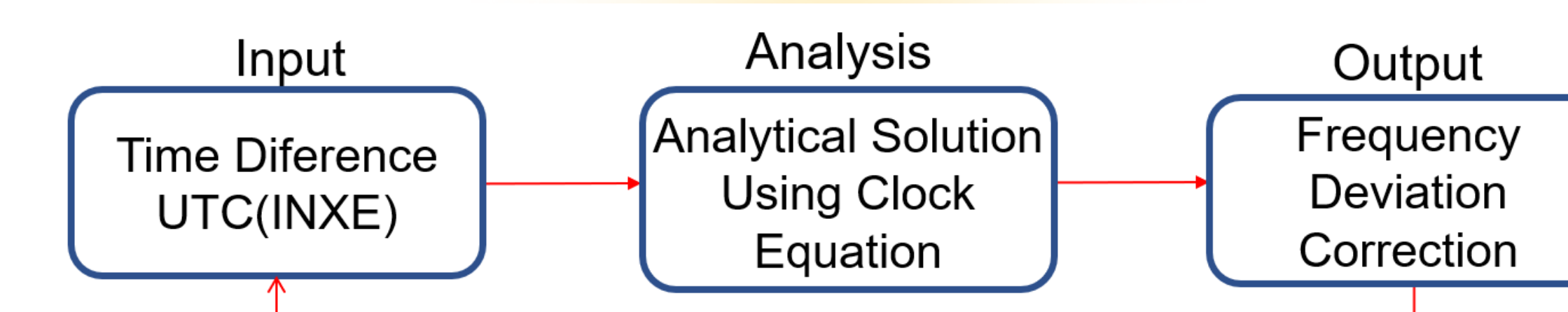
INTRODUCTION



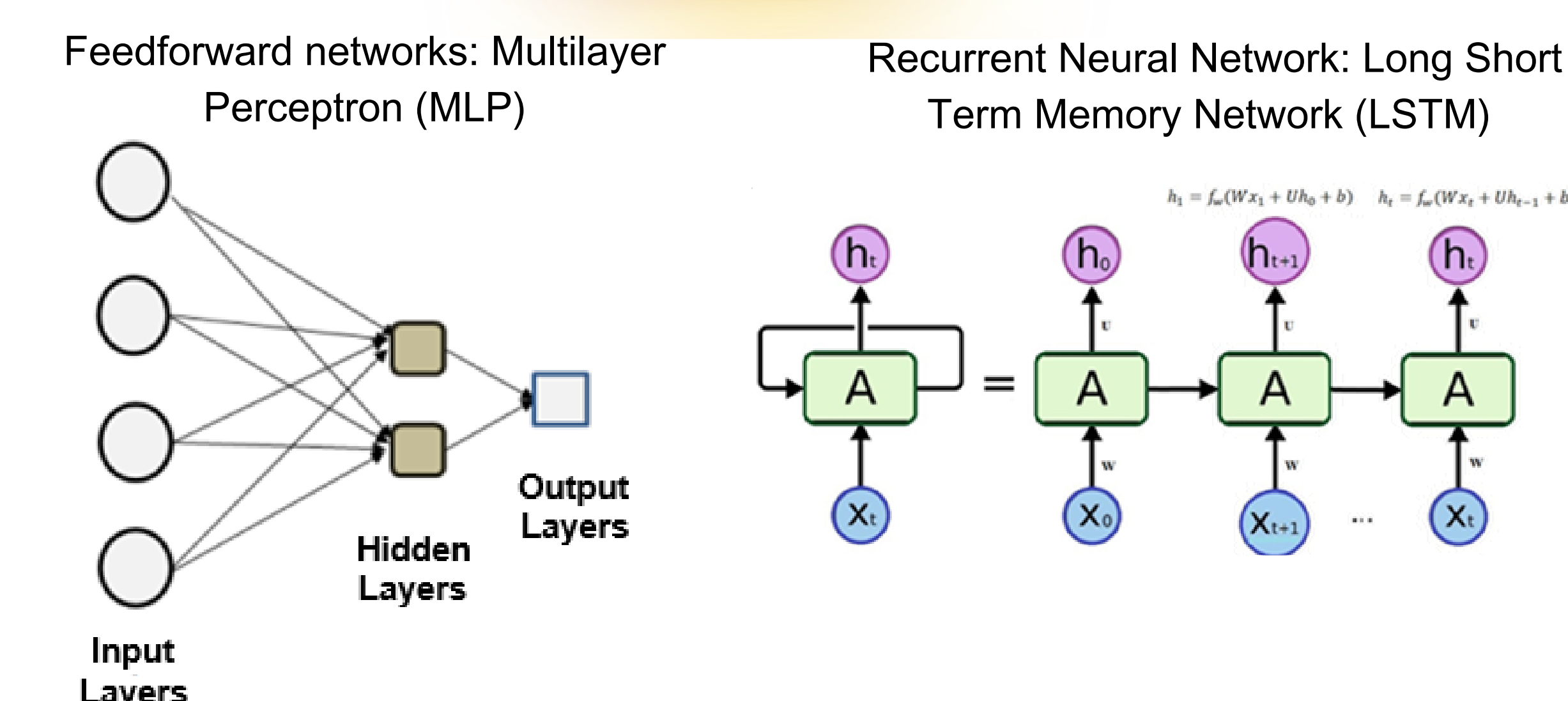
METHODS



1. The Local Time Scale Algorithm

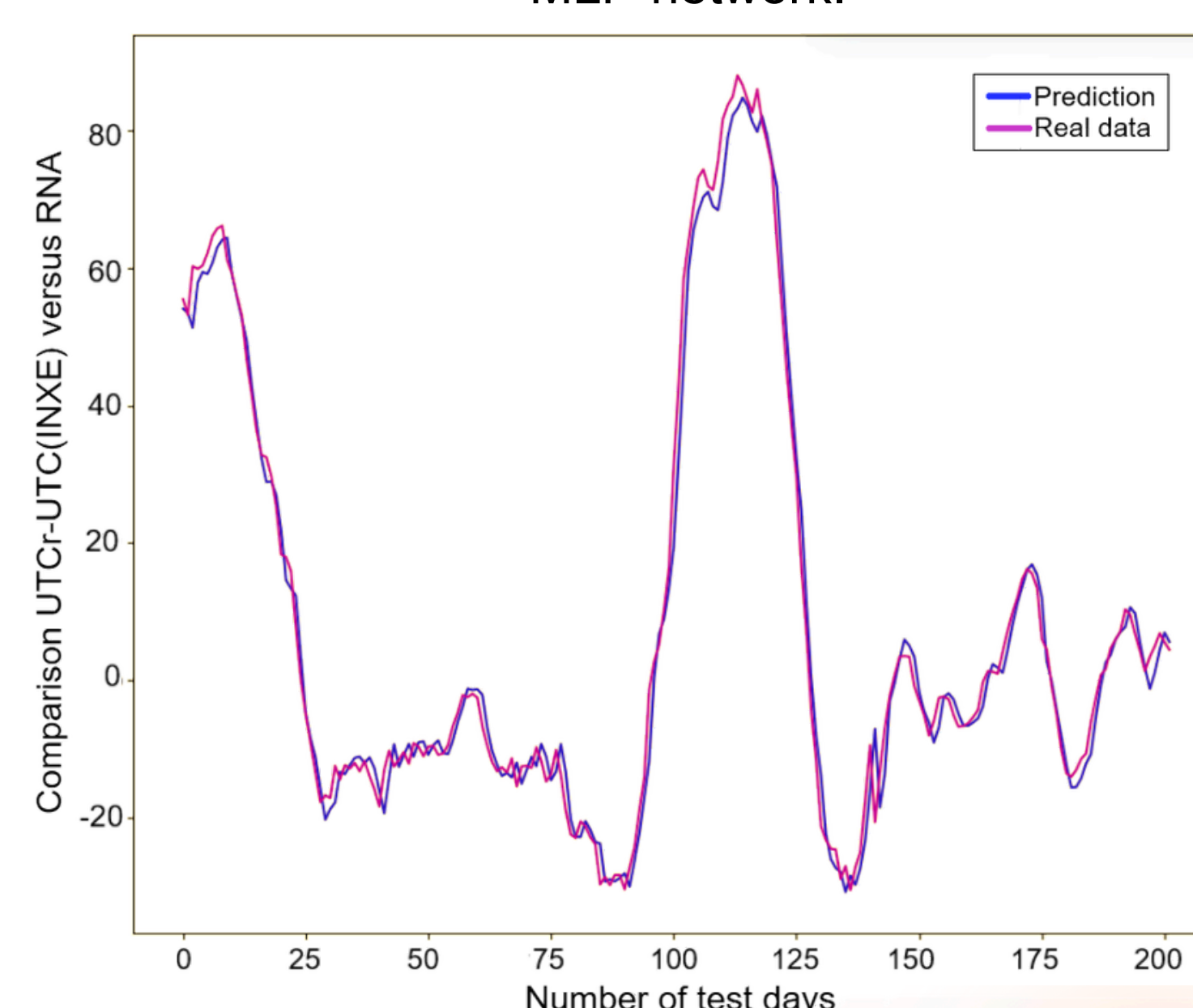


2. The Neural Network Algorithm

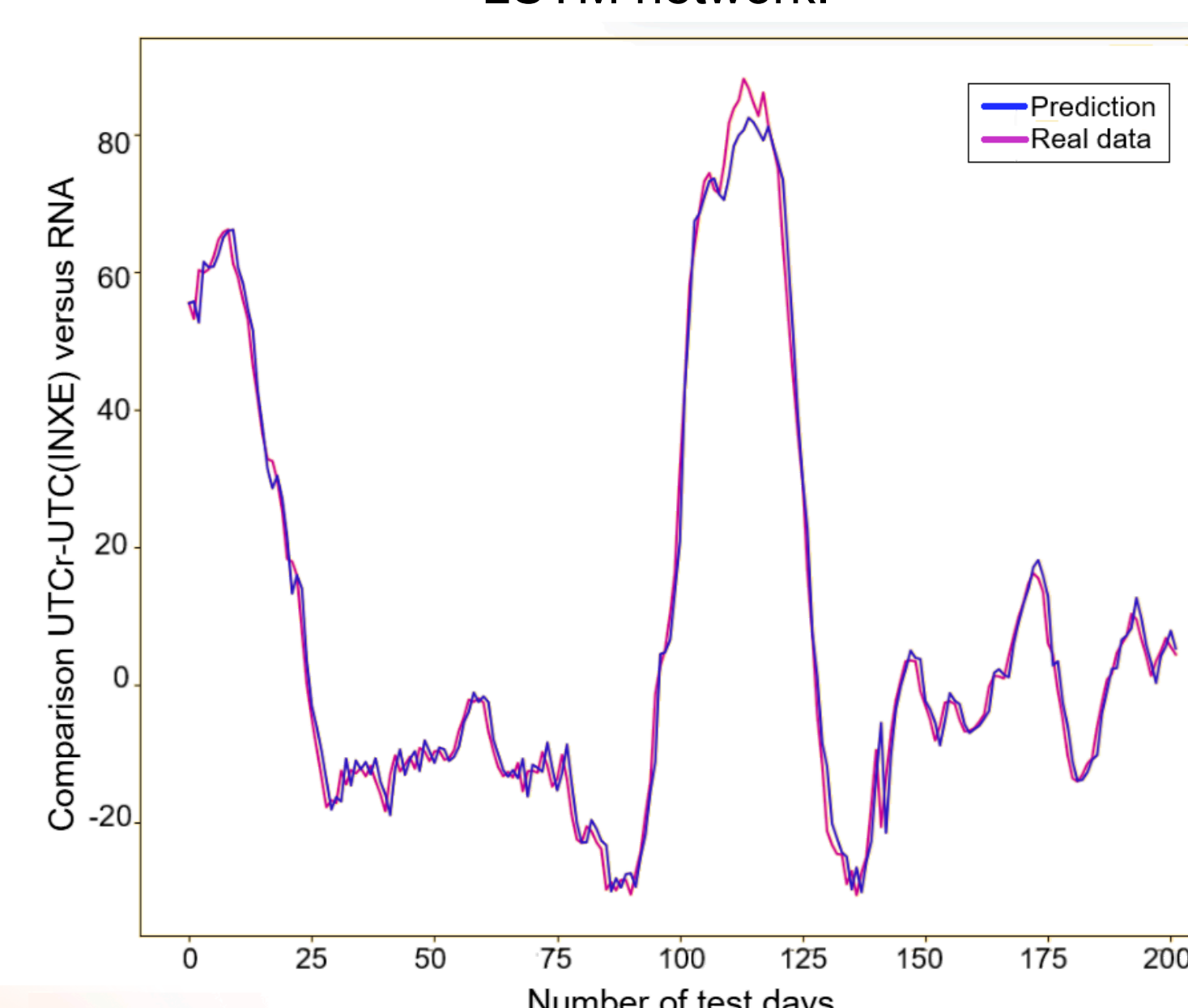


RESULTS

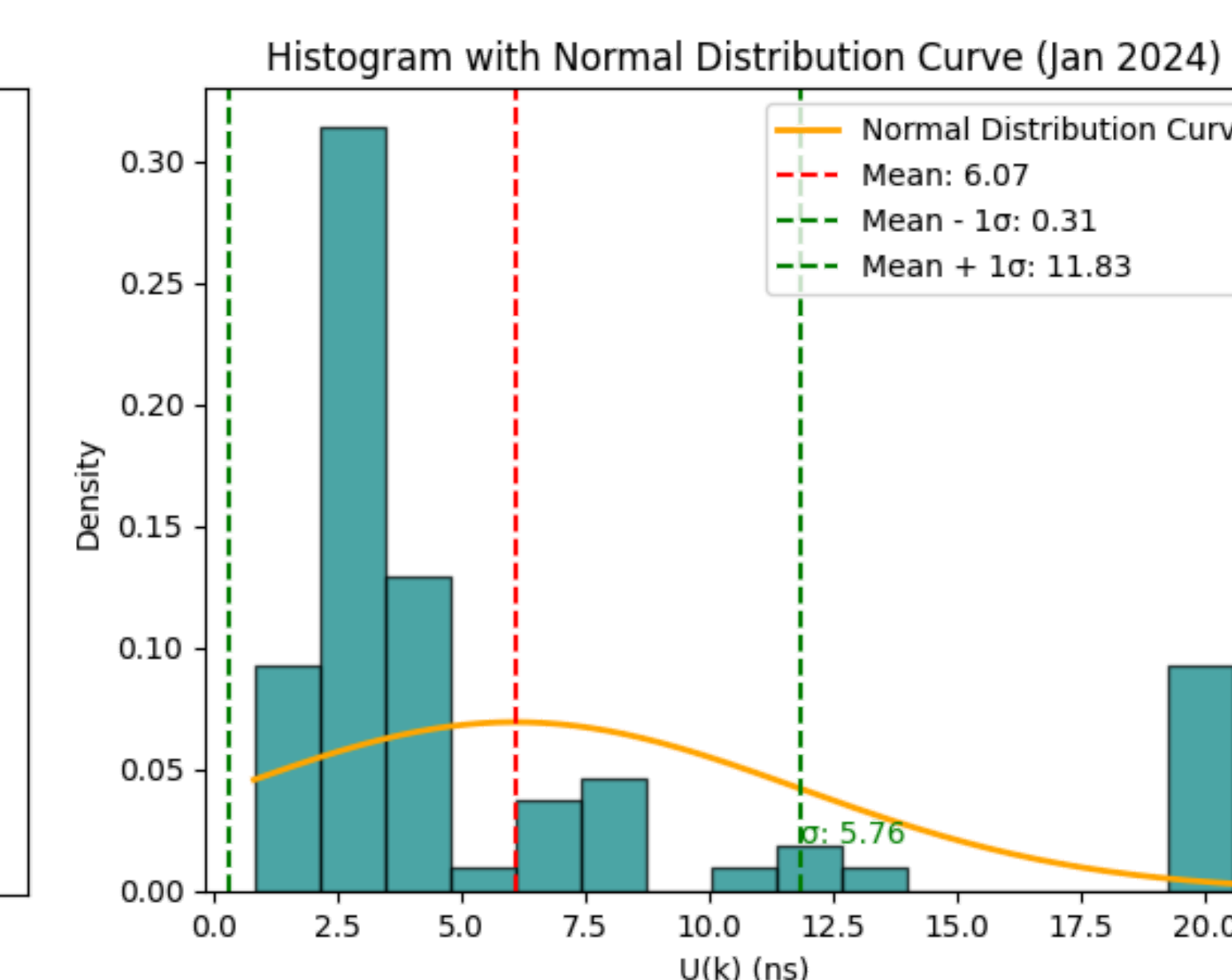
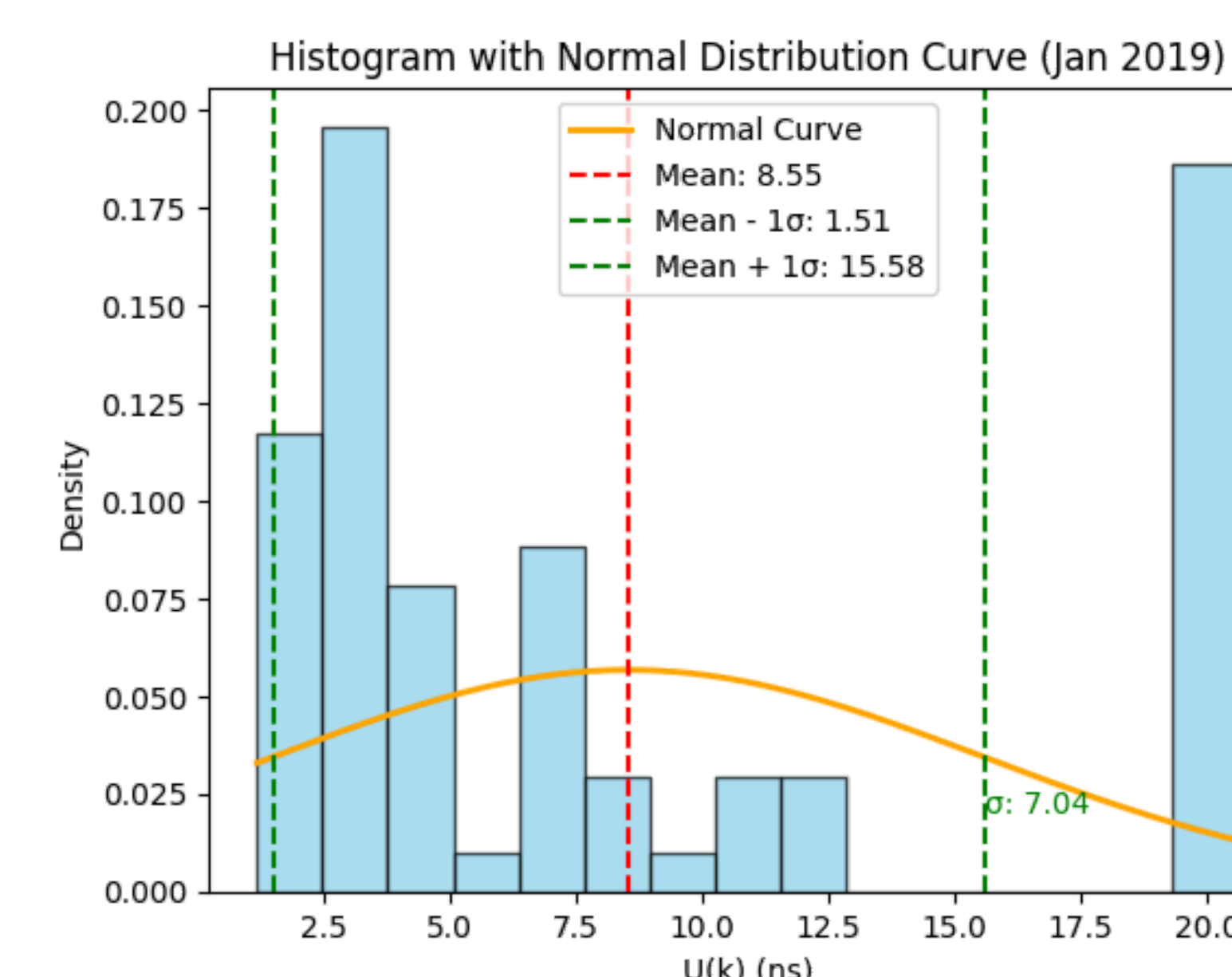
Comparison of Predictions after testing MLP network.



Comparison of Predictions after testing LSTM network.



The predictions of the MLP and LSTM networks for the first six months of 2023 show excellent convergence with the real data, indicating that the models have effectively learned the behavior of the UTC(INXE) scale. The training was conducted using data from 2019 to 2022.



After the receiver was calibrated and the proposal to implement a neural network for correction evaluation was introduced, it became possible to automate the algorithm using conventional statistical methods. This led to a significant reduction in UTC(INXE) uncertainty, decreasing from 20 ns in 2019 to 3.1 ns in 2024. As a result, the dispersion of the control algorithm decreased. Today, INMETRO is among the 57 countries with uncertainties below 5 ns.

CONCLUSIONS

	Results			
	Mean Square Error (ns ²)		Normalized Error(ns)	
	Training	Testing	Training	Testing
Laboratory 2022 (jan e jun)	-	1588,26	-	25100,14
MLP	15,22	12,35	0,35	0,19
LSTM	14,54	12,47	0,33	0,20

This study demonstrated the potential of artificial intelligence, specifically neural networks, to optimize the prediction of temporal deviations, identifying patterns not usually observed and potentially improving the stability of the UTC(INXE) scale in INMETRO. The AI-based methodology outperformed the traditional time correction algorithm method, offering insights for system improvement with greater accuracy and resilience, especially in scenarios with noisy data.

This approach reduces the reliance on manual corrections and paves the way for more reliable automation in time and frequency metrology processes. Implementing AI in UTC(INXE) scale adjustment brings clear practical benefits, including the reduction of significant errors and the ability to operate with greater consistency. The introduction of neural networks also allows exploring new models to process data more effectively, increasing control over the long-term stability of the system.

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