Impact of Leap Seconds on UTC and Prediction of Earth Orientation Parameter (UT1-UTC) using AI-ML Techniques

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The concept of the leap second was introduced in order to meet the necessity of celestial navigation to keep the discrepancy between solar time and atomic time as small as possible[1]. Alongside the numerous challenges related to the future of leap second, a new trend reversal in the UT1-UTC data is being observed. It clearly indicates that the Earth's rotation has been accelerating particularly and distinctly from 59000 MJD (31st May 2020) approximately. In fact, if we analyze UT1-UT1 (figure 1) at around MJD 51000 (mid of 1998), the acceleration became extremely evident and it has been persistently increasing since the last insertion of leap second, which was introduced at MJD 57753 (31st December 2016). Therefore, the Earth is rotating at a faster rate which may lead to the necessity of a negative leap second, which has never been implemented previously.

To predict and gain a deeper understanding of the anomalous patterns, the application of machine learning (ML) algorithms are utilized to estimate the Earth orientation parameter (EOP)(UT1-UTC), using data derived from the IERS database. In this study we have scientifically investigated the use of advanced machine learning techniques including regression models, neural networks with Long Short-Term Memory (LSTM) architecture, and time series forecasting methodologies like Prophet Library, a robust time series forecasting method that employs generalized additive models to capture annual, monthly, and daily seasonality patterns. The study aims to effectively capture and analyze the nuanced temporal trends concealed within the dataset. In order to project the future trend of UT1-UTC (after the reversal of trend) for the next 365 days, a prediction is modelled using EOP data available till date provided by IERS.[2]

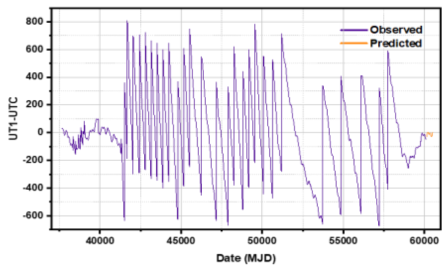

Fig. 1: UT1-UTC trend with leap seconds insertions. The data is obtained from Earth Orientation Centre.[2]

The LSTM model demonstrates accurate predictions with stacked LSTM layers, while the Prophet model captures seasonal patterns and handles outliers effectively. This study emphasize the scientific potential of machine learning models in precise timekeeping and Earth sciences, highlighting its ability to generate better forecasts and provide valuable insights into complex phenomena like UT1-UTC. ML models may help predict the insertion of leap second with better accuracy, reducing the need for frequent adjustments and ensuring a more stable time scale.

[1] R. A. Nelson, D. D. McCarthy, S. Malys, J. Levine, B. Guinot, H. F. Fliegel, R. L. Beard and T. Bartholomew, "The leap second: its history and possible future.", Metrologia, vol. 38(6), p. 509, 2001.

[2] https://eoc.obspm.fr/index.php?index=realtime&lang=en