Implementation of LSTM Neural Networks for Predicting Competition in Telecommunications Markets

Diego Armando Giral-Ramírez, dagiralr@udistrital.edu.co
Luis Fernando Pedraza-Martínez, lfpedrazam@udistrital.edu.co
Cesar Augusto Hernández-Suarez, cahernandezs@udistrital.edu.co

Universidad Distrital Francisco José de Caldas

April 2024

About me

DIEGO ARMANDO GIRAL-RAMÍREZ was born in Bogotá, Colombia. He received a bachelor's and master's degrees in electrical engineering. He is currently pursuing a Ph.D. degree in engineering with Universidad Distrital Francisco José de Caldas, Colombia.

He is an assistant professor of electrical engineering programs at Universidad Distrital Francisco José de Caldas (Bogotá, Colombia). His research interests include mathematical optimization, cognitive radio networks, power systems, automation, and intelligent systems.

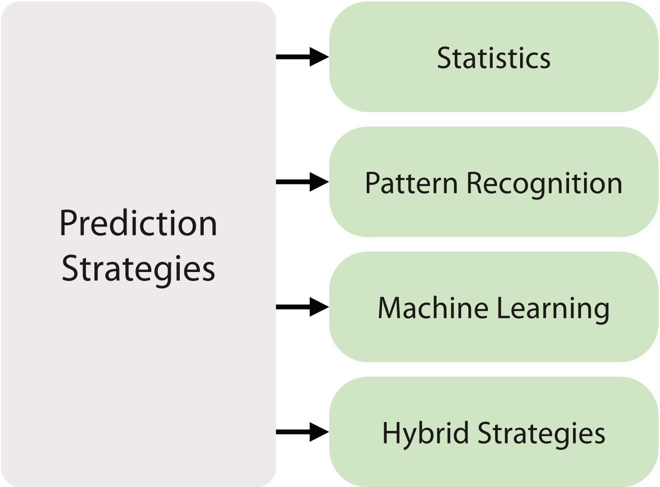
I invite you to know the
"Universidad Distrital Francisco José de Caldas"

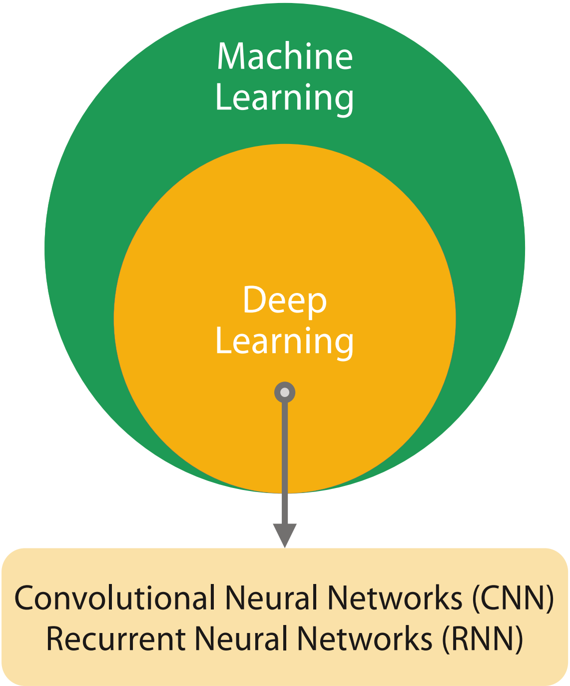
Telecommunications services market

The telecommunications services market operates in increasingly flexible and adaptable environments to meet customer needs, leading to a rise in data sales volume and becoming a robust source of revenue for service providers.

Research has shown that an operator's monopolization of spectrum not only reduces competition in the market but also has a direct negative impact on users and the sector's overall dynamics. Therefore, spectrum management strategies should aim to prevent unnecessary spectrum accumulation. Competition analysis in telecommunications markets and its corresponding prediction are crucial in spectrum management. These elements are essential for improving competitiveness, reducing the digital divide, facilitating regional development, and identifying potential investments.

Some Characteristics

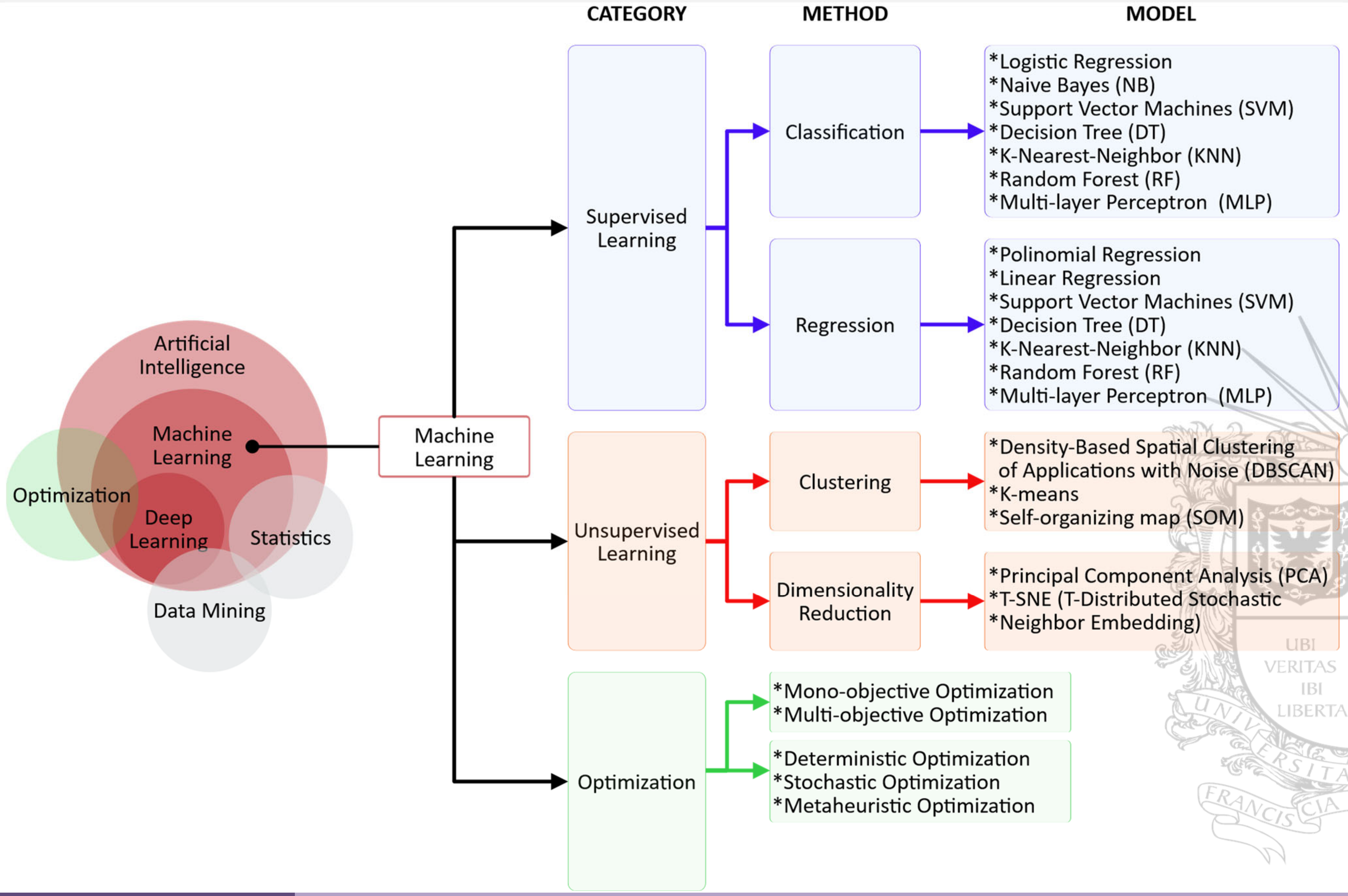




Machine Learning (ML) provides systems with the ability to learn. It focuses on developing algorithms capable of accessing data and using it to learn autonomously. Deep Learning (DL) is a branch of machine learning that employs artificial neural networks to model and solve problems. There are two main types of DL: Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN). Figure 2 depicts the subset of techniques based on ML and DL.

An RNN model allows processing and transforming a sequential data input into a specific sequential output. An LSTM processes input data by forming a loop with time steps and updates the state of the RNN. Essentially, an RNN extends its memory to learn from essential experiences that occurred long ago. The ability of LSTMs to handle temporal sequences, long-term dependencies, adaptability to changes, and management of complex data makes them an excellent strategy for predicting and forecasting the telecommunications market.

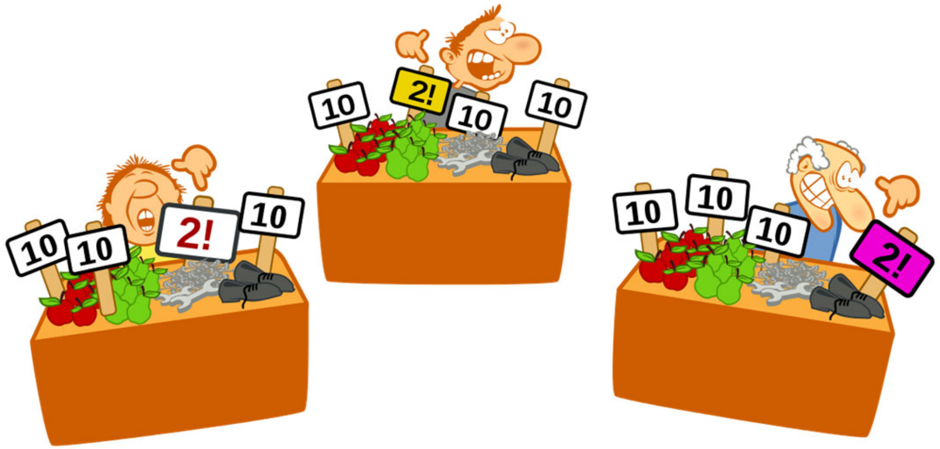
Some Characteristics

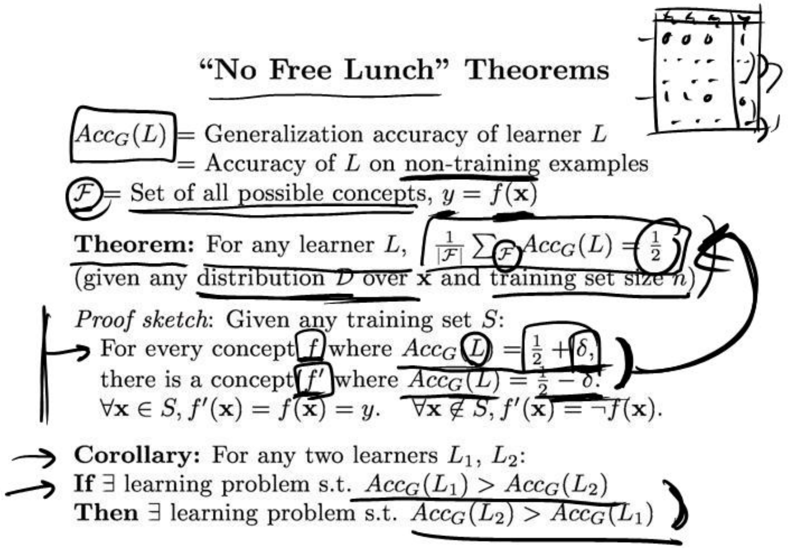


Some Characteristics

"No Free Lunch" Theorems

These theorems state that, for any optimization algorithm, any improvement in performance on one class of problems is offset by inferior performance on another class; that is, there is no universal optimal algorithm for all optimization problems.






Inicia sesión | Crea cuenta SUSCRÍBETE

El País

MARTES, 7 DE NOVIEMBRE DE 2023

Inicio Noticias Contenido Exclusivo Cali Opinión Deportes Clasificados Elecciones

Inicio › Columnistas › Artículo

OPINIÓN

En Colombia tampoco hay almuerzos gratis

El Congreso, actuando como contrapeso, puede y debe actuar, para moderar o mitigar los costos de este almuerzo

18 de mayo de 2023 Por: El País

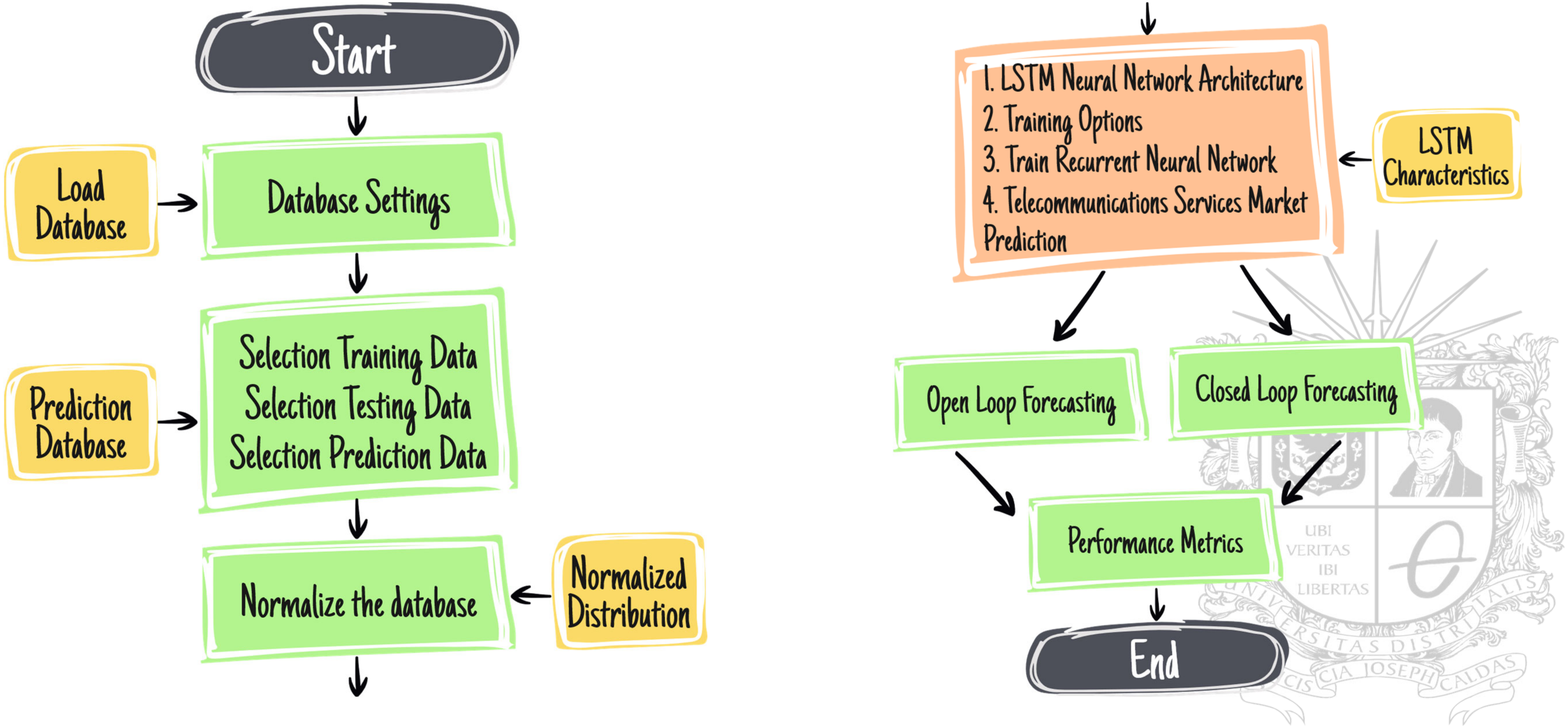
FRANCISCO JOSÉ DE CALDAS

Objective

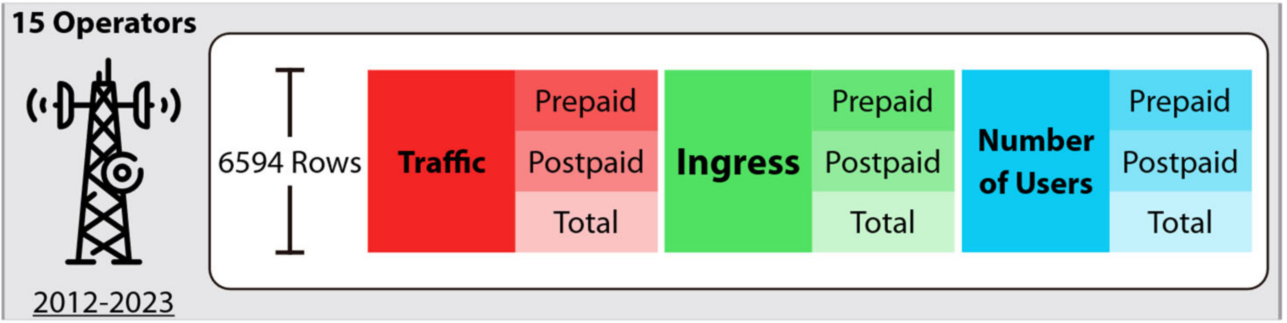
Objective

This investigation presents an artificial intelligence proposal to predict the number of users, traffic level, and operators' income in the telecommunications market. The objective is to use this prediction proposal to analyze competition in telecommunications markets.

Methodology

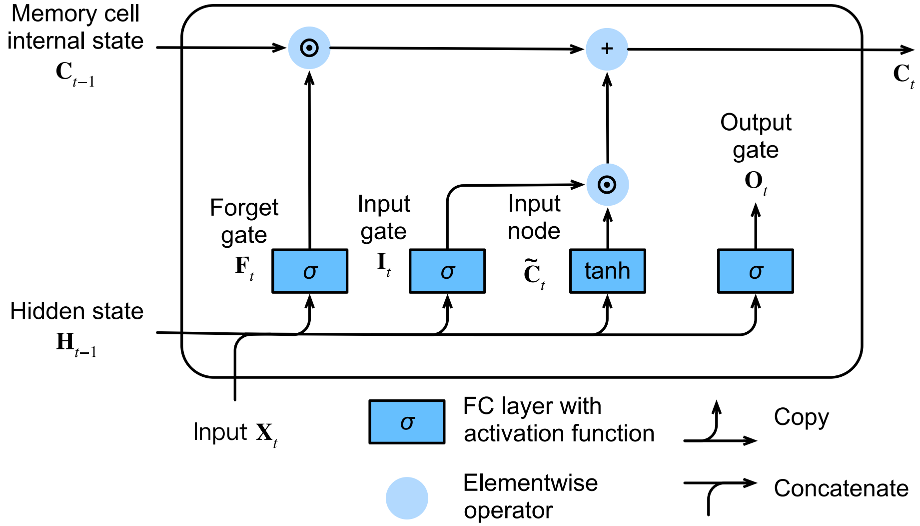


Methodology



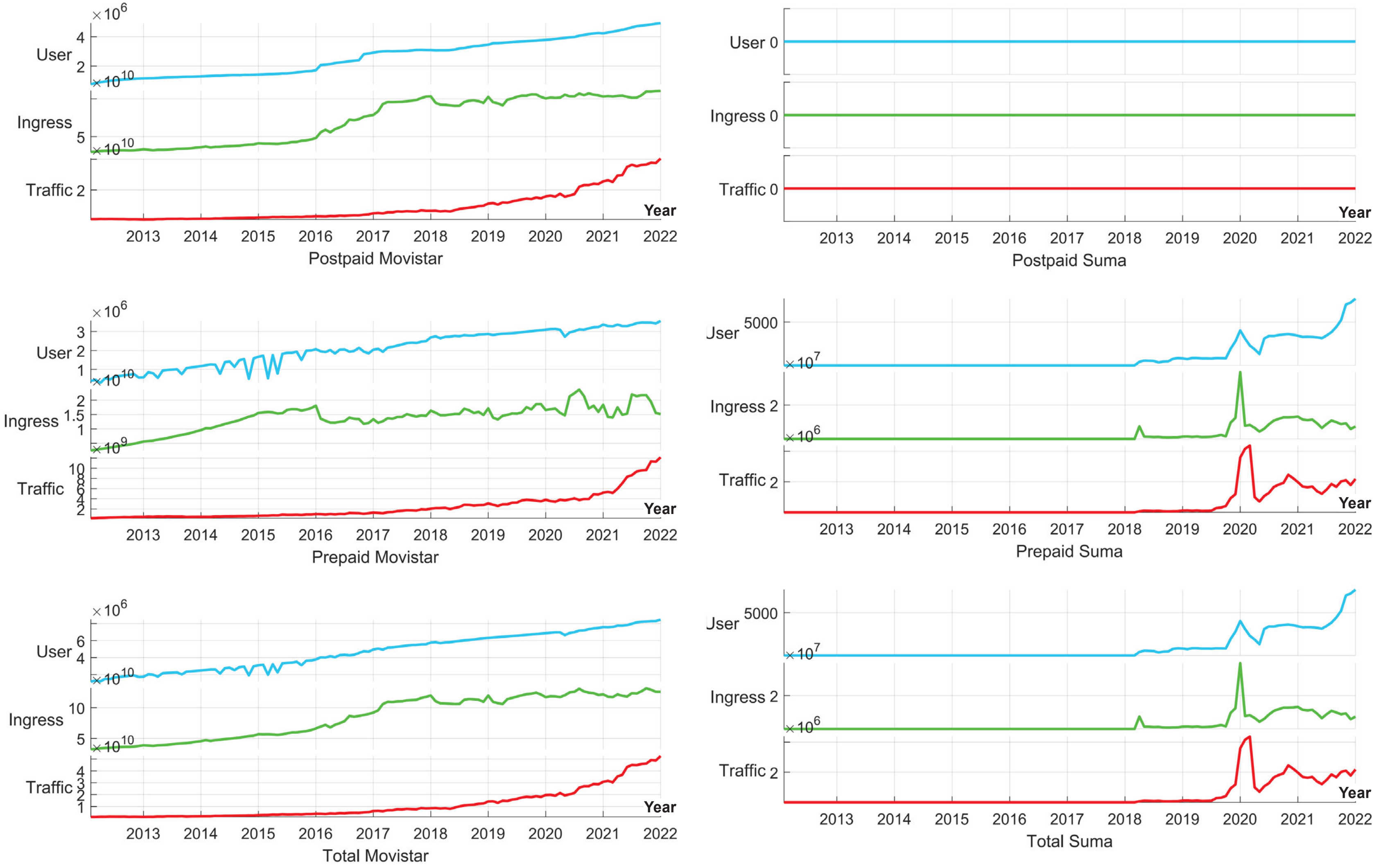
The database corresponds to the number of users, revenue, and traffic for fifteen network operators. The data is taken from the Commission of Regulation of Communications of the Republic of Colombia from 2012 to 2022.

The Test-Validation technique is employed for the training, validation, and testing process, distributing the data in proportions of 70%, 20%, and 10%, respectively.



Given that LSTM networks incorporate memory units that allow them to learn when to forget previous hidden states explicitly and when to update hidden states with new information, the LSTM architecture is illustrated in Figure 4. Figure 4 illustrates the data in the input gate, forget gate, output gate, memory cell internal state, and hidden state.

Results



The implementation was carried out on an Intel(R) Core(TM) i7-7700HQ 2.8GHz processor with 24 GB of RAM running the Microsoft Windows 10 64-bit operating system using MATLAB version R2023b.

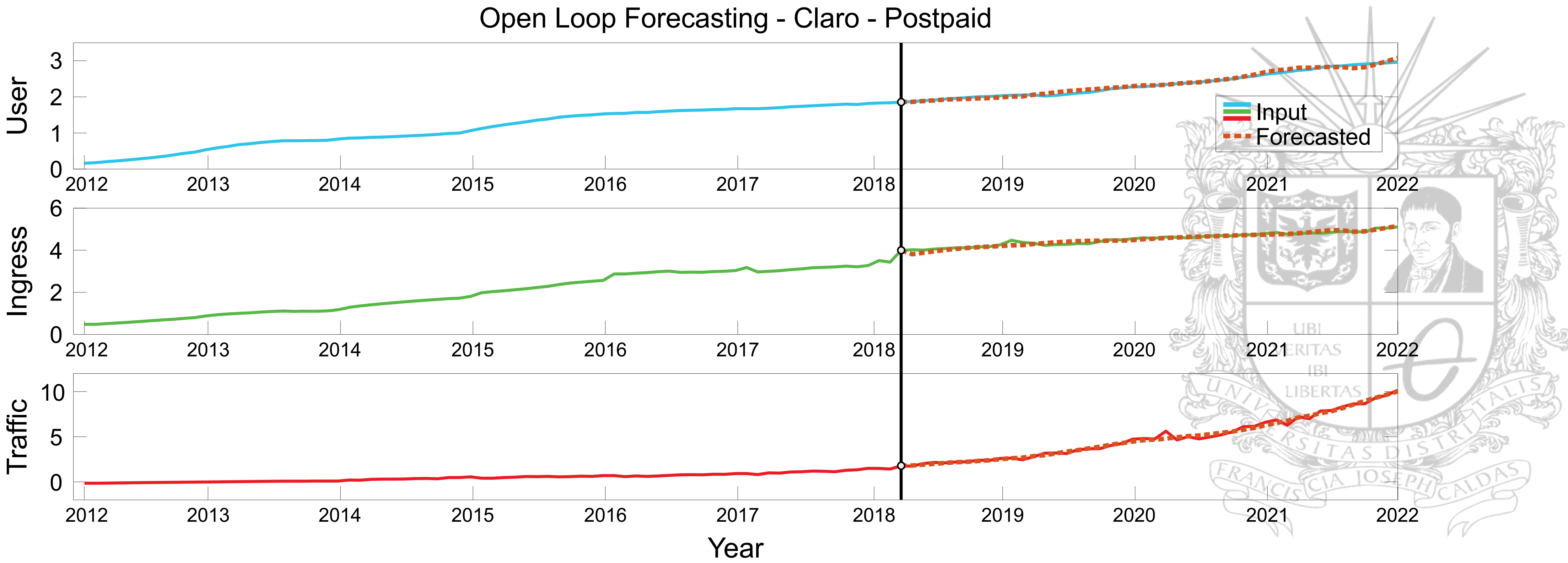
Figures show the information corresponding to two of the five companies that predict telecommunications markets.

Each figure comprises information regarding the number of users, the total revenue, and traffic corresponding to each company. This information is available for prepaid and postpaid services.

Results

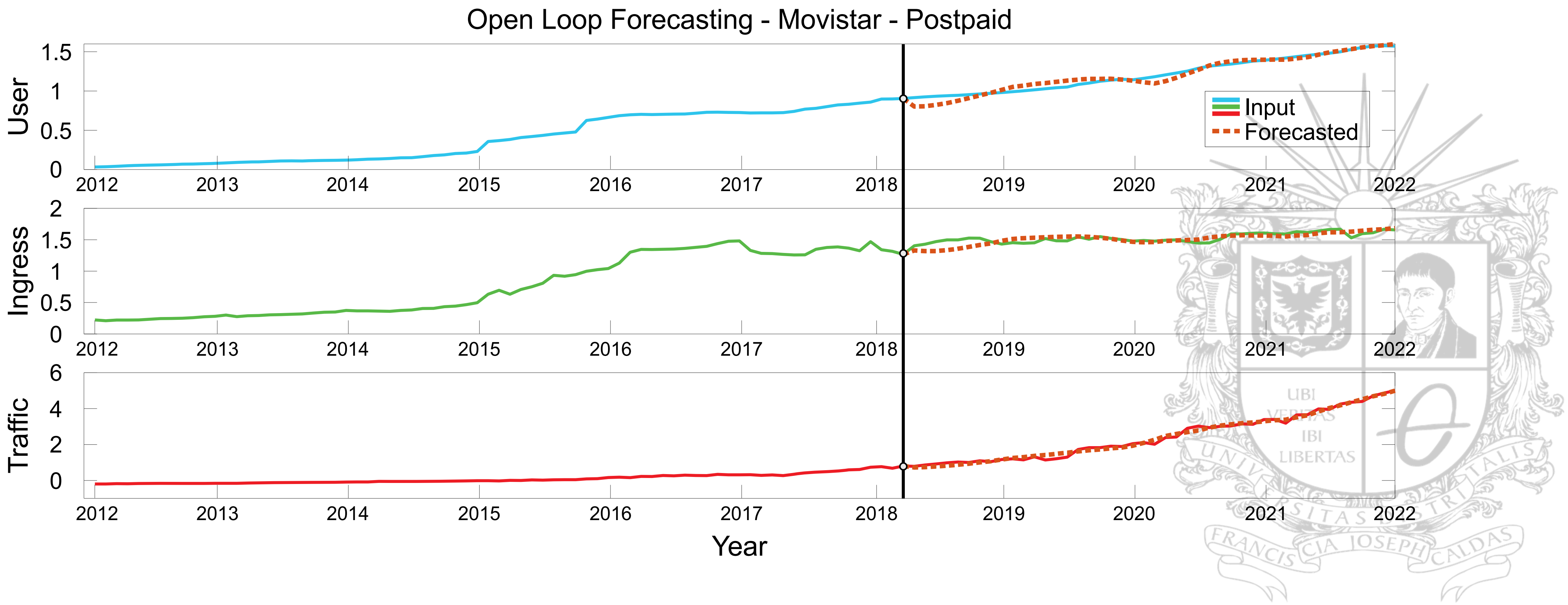
An open-loop methodology was employed for the prediction. The open-loop forecast allows for the prediction of the next time unit in a sequence using only input data. This methodology was chosen because it allows forecasts to be made when the actual values of the RNN are provided before making the next prediction.

The figure below shows the forecast behavior obtained for three of the fifteen analyzed companies. RMSE was used for each test sequence to assess accuracy, comparing predictions with actual values. The average RMSE obtained was 0.0776.



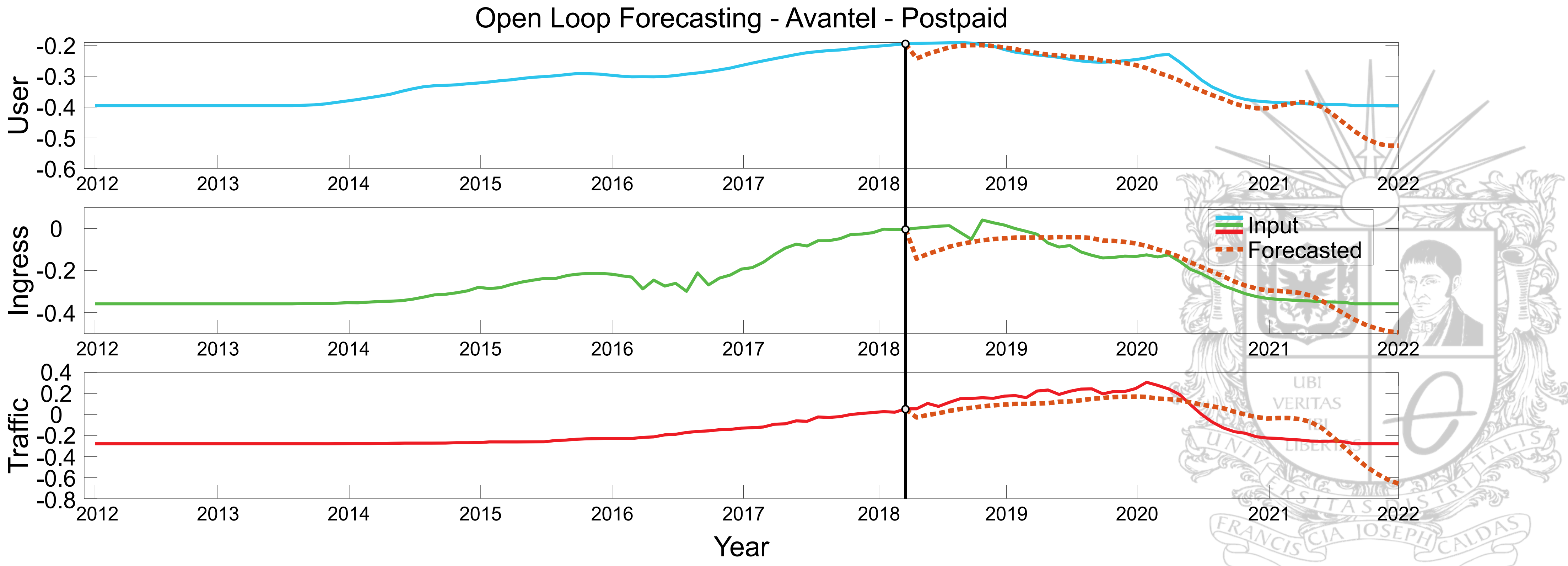
Results

The results of these three companies are presented according to their market behavior. CLARO is characterized by having a greater number of users than MOVISTAR, while Movistar has a greater number of users than AVANTEL. Additionally, it is essential to highlight that the RMS obtained in the prediction process for each company was at most 0.09.



Results

The solid line represents the actual market values, while the dashed line corresponds to the predicted information for the year 2022. To analyze the forecasted data, three companies were selected: one with a high level of market competition (CLARO), another with an intermediate level of competition (MOVISTAR), and one with a low level of competition (AVANTEL). All data presented in the figures is normalized.



Conclusions

This research implemented an LSTM network to predict the communications market. The results, with an RMSE index of 0.0776, demonstrate the accuracy of the implemented strategy. Using an LSTM network, with its ability to store temporal behaviors, proved to be an effective strategy for predicting market behavior.

Applying deep learning-based strategies, such as the LSTM network, emerges as a valuable tool to anticipate and adapt to the changing dynamics of the communications market, thus offering a promising perspective for future research and practical applications.

While our advances in prediction are promising, it's important to acknowledge that many questions remain to be resolved. Future work should build upon our findings and utilize advances in artificial intelligence and metaheuristic optimization to obtain even more accurate and reliable results. This involves developing scalable strategies that can handle heavier computational loads and efficiently address problems of greater complexity, paving the way for further advancements in market prediction.

$$
\begin{aligned}
&\min \quad f(x_i) \\
&\quad \textit{sujeto a} \\
&g_i(x) \le a_i, \quad i = 1,\ldots,m \\
&h_j(x) \le b_j, \quad j = 1,\ldots,q
\end{aligned}
$$

THE END