

Chapter 11

Time Series Forecasting in Retail Sales Using LSTM and Prophet

Clony Junior

IEETA, University of Aveiro, Portugal

Pedro Gusmão

IEETA, University of Aveiro, Portugal

José Moreira

DETI, University of Aveiro, Portugal

Ana Maria M. Tome

DETI, University of Aveiro, Portugal

ABSTRACT

Data science highlights fields of study and research such as time series, which, although widely explored in the past, gain new perspectives in the context of this discipline. This chapter presents two approaches to time series forecasting, long short-term memory (LSTM), a special kind of recurrent neural network (RNN), and Prophet, an open-source library developed by Facebook for time series forecasting. With a focus on developing forecasting processes by data mining or machine learning experts, LSTM uses gating mechanisms to deal with long-term dependencies, reducing the short-term memory effect inherent to the traditional RNN. On the other hand, Prophet encapsulates statistical and computational complexity to allow broad use of time series forecasting, prioritizing the expert's business knowledge through exploration and experimentation. Both approaches were applied to a retail time series. This case study comprises daily and half-hourly forecasts, and the performance of both methods was measured using the standard metrics.

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INTRODUCTION

The rise of data science as a discipline with application in very different fields drives many developments in data mining, machine learning (ML) or data visualization. One of the popular topics is time series (TS) forecasting, and the challenge is to find a model that fits a timely-ordered collection of past observations to estimate future values. Besides traditional statistical methods that have been used for a long time, new forecasting methods that include or are built entirely on ML techniques, such as decision trees, support vector machines and neural networks are being researched. However, TS forecasting is not an easy task. On one hand it requires in-depth knowledge of ML and statistical methods to use and optimize models of increasing complexity. On the other, domain knowledge is crucial for requirements elicitation, model selection, and results' interpretation. Typically, ML experts do not know the business in-depth, and domain experts do not understand ML. Therefore, how to combine the knowledge of professionals with these two profiles is an interesting question, which still needs answers.

The motivating case study in this work is the prediction of client visits in retail stores. TS forecasting in the field of retail mainly focuses on predicting products' demand using ARIMA, SVR, multilayer perceptron (MLP) and hidden Markov models (İşlek & Gunduz Oguducu, 2017; Maaß et al., 2014). However, the solutions used by current commercial systems to predict the number of visiting clients and sales are, for the most part, built on empirical methods. Thus, we present the methodologies of two recent and different TS forecasting approaches.

The first approach uses Long Short-Term Memory (LSTM), a special kind of Recurrent Neural Network (RNN) that can deal with long sequential data. Some ANN features are challenging to achieve using other TS forecasting approaches because ANNs are self-adaptive, support nonlinear models and deal with multivariate problems. LSTM can learn which temporal dependencies in the data should be kept and which should be forgotten while enforcing mechanisms to reduce short-term memory. The reason for choosing the LSTM, however, comes from its forecasting potential as there are studies that demonstrate clear superiority of LSTMs over classical models such as ARIMA, a classical model that is very much established in the TS forecasting scene (Kolarik & Rudorfer, 1994; Siami-Namini et al., 2019).

The second approach uses Prophet, an open-source library developed by Facebook for time series forecasting. Prophet uses a generalized additive model (Hastie & Tibshirani, 1987) to represent trend, seasonality and holidays. While LSTM forecasting models are solely developed by experts in data mining or ML, Prophet aims to use general-purpose methods to keep domain experts in the loop. This includes understanding the data and the problem, choosing and tuning the forecasting model, and validating the model using adequate metrics. These issues are explained and discussed by example in this chapter.

The target audience is practitioners and academics interested in understanding and implementing TS forecasting solutions. The case study consists in predicting the number of client visits in retail stores, but the contents and issues presented in this chapter are also of interest in other use cases. The focus is on presenting the methodology, issues, and possible solutions using two different approaches in TS forecasting and not on optimizing or comparing the forecasting models.

The chapter is organized in the following order: (1) background in time series forecasting using neural networks and deep learning (LSTM), and off-the-shelf tools for business scenarios (Prophet) ; (2) the data and case study; (3) methodology and the implementation of the case study using LSTM and Prophet; (4) illustrative results and discussion of the two implementation strategies; (5) conclusions and guidelines for future research.

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