Deep recommender engine based on efficient product embeddings neural pipeline

Andrei Ionut DAMIAN
University POLITEHNICA of Bucharest
Bucharest, Romania
damian@cloudifier.net

Laurentiu Gheorghe PICIU
University POLITEHNICA of Bucharest
Bucharest, Romania
laurentiupiciu@gmail.com

Nicolae TAPUS
University POLITEHNICA of Bucharest
Bucharest, Romania
ntapus@cs.pub.ro

Bogdan DUMITRESCU
Hight-Tech System&Software
Bucharest, Romania
bogdan.dumitrescu@htss.ro

Abstract — **Predictive analytics systems are currently one of the most important areas of research and development within the Artificial Intelligence domain and particularly in Machine Learning. One of the "holy grails" of predictive analytics is the research and development of the "perfect" recommendation system. In our paper we propose an advanced pipeline model for the multi-task objective of determining complementarity, similarity and sales prediction using deep neural models applied to big-data sequential transaction systems. Our highly parallelized hybrid pipeline consists of both unsupervised and supervised models, used for the objectives of generating semantic product embeddings and predicting sales, respectively. This paper will argue that our system surpasses known and classical approaches to this particular problem. Our experimentation and benchmarking has been done using very large pharma-industry retailer Big Data stream.**

Keywords — **recommender systems; efficient embeddings; machine learning; deep learning; big-data; high-performance computing, GPU computing.**

I. INTRODUCTION

Recommender systems are by far one of the most important areas where machine learning in conjunction with Big Data are applied with proven success. The goal is to find what is likely to be of interest to a certain customer or group of customers and to provide personalized services to them. The interest in this area is very high because finding the "perfect" recommendation system is crucial and will allow retailers to structure their offer including sales strategy and marketing campaigns very well in order to optimize consumers choices.

This paper proposes a state-of-the-art deep neural model for the multi-task objective of determining product complementarity/similarity and sales prediction. The pharmaceutical industry has been proposed as an experimental environment in our research. As a result, we used the advantage of a Big-Data sequential transaction system provided by a successful pharma retailer.

Our work presents a way to extend capabilities of recommender systems by learning low-dimensional vector space representation of products – or product embeddings - used in the following stages stage for sales prediction. We will compare our system with classical approaches to this particular problem (Collaborative Filtering*, Non-Negative Matrix Factorization*) and we will benchmark the results in order to demonstrate that our pipeline is better.

Semantically, our pipeline can be divided in two separate general models with end-to-end learning capabilities: the early stage of product semantic analysis and later stage of product sales regression. The key point within the initial stages of our pipeline system is learning product feature vector embeddings for each customer. Our work is analogous to Word2Vec* and Doc2Vec* approaches which are used to learn linguistic regularities and semantic information for natural language processing. The general approach within the initial stage is based on analysing each sequence from the transactions database, choosing *n* products around a target product *T* in the same way a NLP system would analyse text semantics. The result will reveal that the embeddings generate clusters of complementary and similar products. As a result, through this approach we can identify a set of *k* items that will be of interest to a certain customer. Moreover, besides the product similarity, the resulting embeddings will bring to light an important aspect: if a product is not available anymore, it can be replaced with other two products whose embeddings sum will be very close to the initial product feature vector. Simultaneously, our system is able to generate product similarities and complementarities based on discrete time-series such as seasons.

In order to finish the pipeline, our work includes also a deep neural model which uses the feature vectors and predicts the sales. As we said, this is a crucial aspect for all companies if they want to set up an efficient marketing campaign.

To summarize, our work will include:

- Analysis and benchmarking against *Collaborative Filtering* algorithm implemented in high-performance computing environment
- Analysis and benchmarking against *Non-Negative Matrix Factorization* algorithm implemented in high-performance computing environment
- Our proposed P2E (Product-to-Embeddings) model
- Our proposed deep neural model for final stages of sales prediction