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INDUSTRY 4.0 TECHNOLOGIES: MACHINE LEARNING AND THE CUSTOMER RELATIONSHIPS MANAGEMENT

Abstract*: the Fourth Industrial Revolution represents the latest transformation of means of production in the history of humanity. These innovations are built upon preceding technical progress, starting from the creation of the network itself, its evolution from static to social through the introduction of blogs, wikis, and web services, further enriching it with semantic data to facilitate inter-machine interaction, and culminating in its current state. This work provides an overview of the most interesting methods and approaches in applying artificial intelligence within Industry 4.0 to address the optimization of customer relationship management systems.*

Keywords*: Industry 4, enabling technologies, machine learning, CRM.*

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ТЕХНОЛОГИИ ИНДУСТРИИ 4.0: МАШИННОЕ ОБУЧЕНИЕ И УПРАВЛЕНИЕ ВЗАИМООТНОШЕНИЯМИ С КЛИЕНТАМИ

Аннотация*: четвертая промышленная революция представляет собой последнюю трансформацию средств производства в истории человечества. Эти инновации основаны на предшествующем техническом прогрессе, начиная с создания самой сети, ее эволюции от статической к социальной через внед-*

рение блогов, вики и веб-сервисов, дальнейшего обогащения ее семантическими данными для облегчения межмашинного взаимодействия и заканчивая ее текущим состоянием. В статье представлен обзор наиболее интересных методов и подходов в применении искусственного интеллекта в рамках индустрии 4.0 для решения задач оптимизации систем управления взаимоотношениями с клиентами.

***Ключевые слова**: Индустрия 4.0, стимулирующие технологии, машинное обучение, CRM.*

Introduction

CRM originated from the idea of relationship marketing and technical database innovations. Soon after, the digitization of sales processes followed, leading to the emergence of transactional task automation systems now characterized as CRM. CRM might have little to do with customers and instead manifests in automating processes and sales reporting with an internal focus. This emphasis on organizational aspects rather than on customers is one of several key differences between it and its predecessors, representing a structural aspect in our final structure.

Considering that CRM 1.0, CRM 2.0, and the preliminary conceptualization of CRM 3.0 result from various innovations underlying the evolution of the Internet from the late digital to the early informational age, we can assume that the conceptualization of CRM 4.0 will mirror aspects of the Internet. Technology 4.0: those very technologies we most associate with Industry 4.0. Similar to CRM 3.0, CRM 4.0 could primarily exist as an industry framework, still not fully explored in academic literature.

General structure and CRM functioning

In this chapter, a general framework for implementing machine learning methods in data-driven CRM applications is described. The proposed overview aims to facilitate customer segmentation, market basket analysis, customer-oriented classification, and customer-centric forecasting through the use of relevant supervised or unsu-

pervised machine learning methods. The general Machine Learning framework consists of the following main stages:

- problem formulation;
- data preparation and preprocessing;
- implementation of ML algorithms;
- evaluation of results or models based on one or multiple metrics;
- result interpretation.

Each of these steps will be detailed in the following subsections. Problem formulation, involving defining the objective and understanding domain requirements, is the initial step in every machine learning application.

The second stage of data preparation and preprocessing involves handling, cleaning, and transforming raw data, selecting important features, etc., to build and evaluate models. If a specific problem requires a supervised learning approach, model construction is a crucial step, forming a predictive model aligned with business requirements. Model evaluation measures the effectiveness of the model. For problems involving uncovering unknown patterns in data or conducting exploratory analysis and automatic data structure determination, unsupervised machine learning algorithms are implemented, and the obtained results are interpreted.

As a first step, it's crucial to articulate the problem, setting the direction for subsequent steps. In this context, the goal should align with CRM policies and strategies, and companies must decide what actions to take to achieve this goal. Subsequently, an appropriate machine learning method is determined, along with specific algorithms based on the chosen CRM application. For example, a company aiming to profile customers and identify its target group may require customer segmentation, a typical unsupervised learning problem. For such tasks, cluster analysis is applied, one of the most popular and widely used machine learning methods in CRM. Finally, one of the most frequently used clustering algorithms is selected. Another unsupervised problem for a company might involve discovering combinations of items often found

together in sales transactions. This is an unsupervised learning problem requiring market basket analysis using association rule mining.

Other scenarios might involve predicting whether the next online session of a particular customer will result in a purchase or predicting the number of copies of a music album that will be sold next month. Both are supervised learning tasks. The only difference between these two tasks lies in the types of predicted targets. The first example requires customer-oriented classification, while customer-oriented forecasting suits the second one. Classification methods are used for the first task, while regression methods are suitable for the second.

After articulating the problem and determining the suitable machine learning technique on this phase, the next step is the understanding and preparing data for application. Thus, the first step involves defining the level of data granularity/detail. The chosen problem plays a vital role in this process. For example, predicting the number of copies of a music album to be sold next month requires aggregated historical transaction data of all customers. On the other hand, a customer's past purchase transactions are necessary for predicting whether the next online purchase will occur. This type of data includes individual-level data containing information about specific customer behavior.

The second step involves defining the set of features necessary for applying machine learning methods. This is related to the problem itself and thus requires some understanding of which features potentially influence the selected problem. Moreover, this process varies across different industries and business sectors. One way to approach this process is seeking input from domain experts. In this sense, CRM experts can choose an appropriate set of features according to the available data. Another way to determine the feature set is reviewing past literature and studying commonly used features. In literature, various subsets of features have been used in machine learning methods for many CRM applications. For example, features of the RFM model, such as Recency (R), Frequency (F), and Monetary value (M), are effectively used in customer segmentation applications. Thus, different versions of RFM model

features are frequently and successfully utilized for understanding and analyzing customer behavior characteristics in customer segmentation applications in literature.

Conclusions

The contribution presents a technological perspective of CRM within the context of digital disruption and technologies underlying the evolution of the Internet: a process that has occurred throughout the digital revolution and the second IT revolution (i.e., the 4th industrial revolution). To develop this viewpoint, we delved into academic and industry literature to provide an explanation of CRM in comparison to other breakthrough innovations. Subsequently, we positioned the current state of CRM within the context of the latest manifestation of the information age.

References

1. Amnu H. (2017), Customer Relationship Management and Machine Learning technology for Identifying the Customer, JOIV International Journal on Informatics Visualization 1(4):12 DOI:10.30630/joiv.1.1.10;

2. Chagas B.N.R; Viana, J.A.N., Reinhold O., Lobato F., Jacob A.F.L., Rainer A. (2018), Current Applications of Machine Learning Techniques in CRM: A Literature Review and Practical Implications 2018 IEEE/WIC/ACM International Conference on Web Intelligence (WI).

3. Singh, N., Singh, P. & Gupta, M. (2020) An inclusive survey on machine learning for CRM: a paradigm shift. Decision, n. 47, https://doi.org/10.1007/s40622-020–00261-7.