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БИЗНЕС-ПРИЛОЖЕНИЯ МАШИННОГО ОБУЧЕНИЯ В СЕКТОРЕ РОЗНИЧНОЙ ТОРГОВЛИ В РАМКАХ КОНЦЕПЦИИ «ИНДУСТРИЯ 4.0»

***Аннотация**: в статье речь идёт о том, что в условиях современного бизнеса, характеризующегося стремительным технико-логическим прогрессом и меняющимися ожиданиями потребителей, актуальность различных аспектов бизнес-применения машинного обучения как одной из технологий "Индустрии 4.0" приобретает первостепенное значение.*

***Ключевые слова**: машинное обучение, розничная торговля, Индустрия 4.*

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BUSINESS APPLICATIONS OF MACHINE LEARNING IN THE RETAIL SECTOR WITHIN THE «INDUSTRY 4.0» CONCEPT

***Abstract**: the article states that in the landscape of contemporary business, marked by rapid technological advancements and evolving consumer expectations, the relevance of different aspects of business applications of the machine learning as one of the enabling technologies of «Industry 4.0» is paramount.*

***Keywords**: machine learning, retail sector, Industry 4.*

1. Introduction

The profound significance of this research topic emerges from several compelling factors. Firstly, Industry 4.0 serves as a catalyst for enhancing business efficiency, agility, and competitiveness. As organizations across various sectors seek to optimize operations, reduce costs, and offer innovative products and services, the integration of machine learning technologies becomes an imperative. Machine learning empowers businesses with the ability to extract valuable insights from vast volumes of data, thus enabling data-driven decision-making and the identification of trends and patterns that might otherwise remain overlooked or obscured.

Secondly, the global marketplace is increasingly characterized by hyper-competitive environments and heightened customer expectations. Industry 4.0 is not just about technological advancements but also about understanding and meeting these expectations. Customers' satisfaction with products and services is a central concern for businesses operating in this environment. The ability to gauge customer sentiments and emotions regarding products is essential for making data-driven decisions and tailoring offerings and customer service to align with individual needs and desires. Deep learning models for emotion recognition represent a pioneering frontier in this endeavor.

Furthermore, the implications of this research extend beyond individual businesses. In the broader context of the global economy, the successful adoption of Industry 4.0 practices and the integration of machine learning technology can yield substantial economic benefits. It fosters innovation, spurs job creation in emerging tech sectors, and positions businesses for sustained growth and relevance in a rapidly changing world.

At the heart of the Fourth Industrial Revolution (i.e., Industry 4.0) is Artificial Intelligence which revolutionizes business processes by harnessing the power of information. A plethora of newly-emerged technologies can be listed off as part of the aforementioned concept, such as Internet of Things (IoT), Cloud Computing, Simulation, etc. (see Fig. 1).

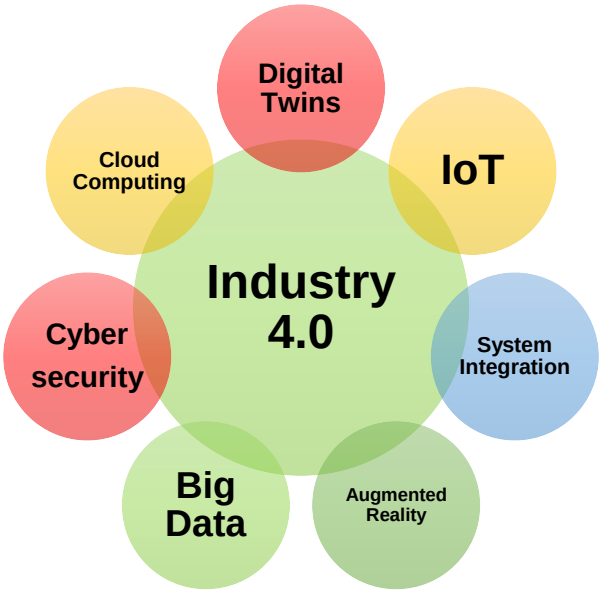

Fig. 1. Some Key Components of Industry 4.0.

These advanced technologies have been further automated and optimized with the incorporation of various Machine Learning (including Deep Learning) technologies. Specifically, DL (AI) algorithms hold the potential to be the main driver of growth of businesses, assisting in uncovering hidden and otherwise overlooked production patterns. In light of these considerations, this research assumes a central role in contributing to the ongoing discourse surrounding Industry 4.0 and its practical applications in the business landscape. By delving into the development and integration of deep learning models for emotion recognition within this context, this study seeks to advance the understanding of how these technologies can be harnessed to enhance business analytics, foster customer satisfaction, and drive growth.

As the following sections of this paper will detail, the pursuit of these objectives aligns seamlessly with the contemporary needs of businesses in the era of Industry 4.0, making this research topic both relevant and indispensable.

2. Problem Statement.

In the era of Industry 4.0, where automation and data-driven decision-making are paramount, there exists a distinct need for innovative solutions to address the challenge of evaluating and enhancing customer satisfaction within the retail sector. As businesses strive to remain competitive and customer-centric, the capability to discern customer emotions and sentiments in real-time is a compelling aspiration. However, a notable gap persists in the practical implementation of deep learning models for emotion recognition within physical retail environments, such as clothing stores.

Current market solutions often lack the sophistication and adaptability to effectively gauge customer satisfaction and preferences. This research is dedicated to a comprehensive examination of the practical implementation of machine learning technologies, with a primary focus on deep learning models, for the purpose of emotion recognition within the framework of Industry 4.0.

The research objectives encompass the following key aspects:

1. Evaluation of Deep Learning Architectures for Emotion Recognition in Visual Data:

1.1. Conduct a systematic assessment of deep learning model architectures tailored for emotion recognition, specifically in the analysis of images and/or videos within the Industry 4.0 context.

1.2. Scrutinize the performance, computational efficiency, and adaptability of different deep learning models (that have already been trained on similar type of data) when applied to visual data for emotion analysis.

1.3. Explore different methods of fine-tuning these models by adjusting the values of key hyperparameters and how this affects the performance thereof.

2. Hands-On Data Collection and Preprocessing for Visual Emotion Recognition:

2.1. Engage in the practical data collection processes, actively acquiring image and video datasets suitable for emotion recognition.

2.2. Execute the preprocessing procedures necessary to prepare visual data for model training, e.g., image augmentation and feature extraction.

3. Practical Model Enhancement through Fine-tuning and Training:

3.1. Investigate and execute the techniques and methodologies involved in the practical fine-tuning and training of deep learning models for optimized emotion recognition.

3.2. Engage in the practical use of pre-trained models as a foundation, and delve into transfer learning strategies to adapt models to Industry 4.0-specific requirements.

4. Cost Analysis and Return on Investment (*ROI*):

4.1. Undertake a practical financial assessment to determine the actual costs involved in implementing emotion recognition technology based on visual data within Industry 4.0.

4.2. Explore the potential benefits and ROI of adopting this technology, considering factors such as improved customer satisfaction, decision-making efficiency, and industrial process optimization.

5. Ethical Considerations in Visual Emotion Recognition:

5.1. Actively examine the ethical dimensions surrounding the practical utilization of visual emotion recognition technology in Industry 4.0.

5.2. Discuss practical concerns related to privacy, consent, and potential biases in the deployment of this technology, offering practical insights and recommendations to ensure responsible and ethically sound practices.

By elaborating on these key research objectives, this study endeavors to provide a thorough investigation into the practical implementation of deep learning models for emotion recognition within the Industry 4.0 paradigm, with a specific focus on visual data. This research seeks to illuminate the feasibility, benefits, ethical considerations, and overall practicality of implementing emotion recognition technology in an industry undergoing rapid digital transformation, emphasizing the hands-on and applied aspects of the research process.

The object of this paper is deep learning models trained for the recognition of human emotions within visual data, specifically when applied in real-time settings.

The subject of the research includes the algorithms developed and implemented within the framework of deep learning technologies. These algorithms play a pivotal role in the detection and enhancement of emotion recognition from static images and video streams, with a specific focus on their adaptation and application in retail settings.

3. *Methodological Steps*

1. Analysis and Synthesis of Scientific Literature

This method allows to do a comprehensive review and analysis of existing scientific articles and publications. It will also help identify and assess the suitability of current deep learning methods and algorithms for emotion recognition in visual data. Additionally, it will highlight any shortcomings and limitations in the existing models/architectures, with a specific focus on their relevance in real-time retail environments within the Industry 4.0 framework.

2. Calculation and Measurement:

Assessing the quality and performance of already existing deep learning models (pretrained ones with different architectures) designed for emotion recognition. It includes the quantitative evaluation of factors such as speed, accuracy, model size, and

their effectiveness in recognizing emotions in visual data. The primary focus is on measuring the technical attributes and capabilities of these models.

3. Quantification and Cost Analysis.

The emphasis shifts to the comprehensive analysis of the results obtained through experimentation. It encompasses the quantification of key performance metrics of the fine-tuned models and extends to the assessment of costs associated with data collection, model training, infrastructure, and potential returns on investment. The primary objective is to provide a detailed cost-benefit analysis, addressing the financial viability and overall practicality of implementing emotion recognition technology in Industry 4.0 retail settings.

4. Interpretation of Results and Cost-Benefit Evaluation:

As part of this method, the results obtained from the research will be analyzed, with a specific focus on interpreting these findings in the context of the research's overarching goal. The advantages and disadvantages of different methods and algorithms will be evaluated, with an emphasis on their practical applicability and cost-efficiency in retail environments. Within the context of this method, the trends in the field will be identified, and suggestions regarding potential directions for further research will be made.

All the experiments described and conducted within this research with Deep Learning models and various architectures will be carried out in Google Colab environment with the usage of various DL frameworks, including PyTorch, TensorFlow, etc.

References

1. Hernavs J. Deep learning in industry 4.0-brief overview / J. Hernavs // J. Prod. Eng. – 2018. – T. 21. №.2. – pp. 1–5.

2. Angelopoulos A. Tackling faults in the industry 4.0 era – a survey of machine-learning solutions and key aspects / A. Angelopoulos // Sensors. – 2019. – T. 20. №.1. – p. 109.

3. Rai R. Machine learning in manufacturing and industry 4.0 applications / R. Rai // International Journal of Production Research. – 2021. – T. 59. №.16. – pp. 4773–4778.

4. Wu C.D. Facial emotion recognition using deep learning / C.D. Wu, L.H. Chen // arXiv preprint arXiv:1910.11113. – 2019.

5. Tammina S. Transfer learning using vgg-16 with deep convolutional neural network for classifying images / S. Tammina // International Journal of Scientific and Research Publications (IJSRP). – 2019. – T. 9. №10. – pp. 143–150.

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