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Improvement of the automated NLP system as a factor in improving the quality of marketing strategy formation

Abstract. Natural language processing in company marketing is transforming data analytics, offering new opportunities to understand customers and optimize strategies.

Introduction. Natural language processing simplifies processes such as sentiment analysis, segmentation, and ad targeting. It is important to consider data accuracy, security, and query management skills training for effective use of technology.

Problem statement. One of the main challenges in marketing analytics is the transformation of initial numerical data into understandable and useful conclusions for humans. The way to solve the problem are natural language processing technologies and generative artificial intelligence, which allow you to turn complex data into accessible and useful information for work.

Unresolved aspects. Traditional manual analysis of reviews in marketing analytics has long ceased to meet modern business requirements, because it requires huge human resources, which makes the process extremely costly. Natural language processing offers a solution to this problem through the use of algorithms capable of automatically analyzing the semantics of the text, determining the tone of statements, and isolating key topics from large data sets.

Purpose of the article. The purpose of this study is to develop a system of automated analysis of user reviews based on the developed effective methods and models for automated analysis of user reviews in the field of marketing of companies using natural speech processing technologies.

Main material. The paper describes the problem to be solved and formulates a scientific task; analyzes approaches, methods and models for solving research problems; sets research tasks, analyzes theoretical approaches to solving research problems; considers theoretical aspects of natural language processing; investigates various models and algorithms for analyzing feedback, and also conducts an experimental assessment of their effectiveness on real data; models, algorithms and analysis of their adequacy in solving research problems; methodological support for the organization of research is being improved.

Conclusions. The results of the study can be used to develop software solutions that will allow companies to better understand the needs of their customers, quickly respond to problems and improve the quality of their products and services.

Keywords: *natural language processing, marketing, automation of user feedback analysis, method, analysis, evaluation, business process.*

JEL: G21, G28, G 32, O33

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Introduction. In today's digital landscape, the amount of text data generated by users of products and services is skyrocketing. In particular, user reviews have become an integral element of the modern business ecosystem. The ability to effectively analyze these reviews has become a critical success factor for businesses looking to remain competitive. According to research, more than 90% of consumers read reviews online before buying, and 84% trust them as much as personal recommendations. Natural language processing in company marketing has the potential to transform data analytics by offering new opportunities to understand customers and optimize strategies. This simplifies processes such as sentiment analysis, segmentation, and ad direction. One of the main problems of marketing analytics is to refer to the initial numerical data and turn them into understandable and useful conclusions. In this case, natural language processing technologies and generative artificial intelligence, which turn complex numerical data into simple and useful information for work, will help. NLP models learn from large amounts of information from the Internet, including social media posts and news. The main purpose of using NLP and generative AI is to extract specific insights from marketing data based on the knowledge collected. Benefits of NLP for marketing data analysis: improving the decision-making process with the help of available information; increasing the efficiency of data analysis; Improving the accuracy of trend forecasting and understanding of customer needs. The integration of NLP into marketing analytics includes several stages: Goal Definition: A clear understanding of what tasks or problems you want to solve with NLP; Use of ready-made models: huge models that have already been studied on large amounts of data, this allows you to hold the capabilities of NLP without high training costs; Model adaptation: Off-the-shelf models often know general information from the internet, but not from your data, two approaches can be taken to avoid this: fine-tuning – the model learns from your company's data, or through intermediary solutions that link your data to the finished model; Testing and implementation: After setting up and integrating, it is necessary to test the system to ensure the accuracy and usefulness of the results obtained, and then implement them into daily work; Analysis and adjustments: Regular analysis of the results will help identify areas for improvement, adjust settings or methods for using the model. Application of NLP in marketing, which helps to improve brand strategy, personalize customer experience and optimize content for better interaction and visibility: sentiment analysis for brand perception; customer segmentation and personalization; content optimization and SEO. Working with NLP in marketing is a number of unique tasks, and one of the main ones is operational engineering. Traditional methods of analyzing reviews, based on manual processing, face many limitations. Analysts can effectively process only a limited number of texts, and the subjectivity of human interpretation leads to difficulties in establishing and maintaining contacts with other people, which is expressed in isolation and problems with mutual understanding (inconsistency). From a business perspective, user reviews provide invaluable information about: the strengths and weaknesses of a product or service; expectations and needs of customers; comparison with competitors; ideas for improvement and innovation; problems that need to be solved immediately. Using NLP to analyze user feedback is a complex task that includes a number of subtasks: text pre-processing; determination of tonality; coverage of key aspects and topics; classification of reviews into different categories; identification of emotional coloring; Generalization and generation of reports. These tasks require the use of various models and algorithms – from classical statistical methods to modern deep learning approaches using transformers and large language models (LLMs). The market for NLP-based feedback analysis solutions is growing rapidly. According to analysts, by 2026, the global text analysis software market will reach $16 billion, demonstrating an annual growth rate of more than 17%. This shows the growing interest of businesses in technologies capable of efficiently handling user feedback. However, despite significant advances in the field of NLP, automated analysis of user feedback still faces many problems. Among them are the polysemy of words, idiomatic expressions, sarcasm, variety of languages, spelling mistakes, jargon, and many other linguistic nuances that require a deep understanding of the context. Solving these problems requires a comprehensive approach that

combines the most modern NLP techniques with an understanding of the business context and specifics of a particular industry.

Literature review. The article [1] is devoted to the topic of management of innovative marketing in modern conditions of a competitive market. As a result of the study, it was found that Ukrainian enterprises often ineffectively apply innovative marketing methods. The article discusses new marketing technologies that use elements of artificial intelligence and machine learning. The most common skills required for digital marketing are also identified: video editing, graphic design, coding, program creation, writing, software expertise, experience with SEO and SEM, software use and project management, data analysis, marketing automation, and more. The article pays special attention to the issue of privacy of customers' personal data, as it is an important aspect of digital marketing. Various technologies and ways to identify and protect users' personal data are being studied. The article [2] states that digital marketing helps to draw customers' attention to the company, brand, goods and services. The use of artificial intelligence technologies together with digital marketing allows you to improve the quality of customer service and better promote the brand. The article examines how artificial intelligence is impacting modern marketing strategies. It is important to note that it has significant advantages, but it also raises problems and ethical issues. The article draws attention to how artificial intelligence can be used to personalize communication to increase customer attention and loyalty. The final comment notes that artificial intelligence has an important future in marketing, while drawing attention to the need for a balanced approach – harnessing its capabilities together with ethical and operational concerns. The widespread application of artificial intelligence in digital marketing highlights its importance in today's world. The paper [3] shows that the creation of a marketing strategy of an enterprise is an important means for its effective development. With the help of SWOT analysis, the strengths and weaknesses of the enterprise, as well as market opportunities and threats, are identified and systematized. Based on this, the main directions of development of the marketing strategy have been identified, which will contribute to strengthening management, sales growth and increasing the competitiveness of the production enterprise. The article [4] discusses the concept of detecting emotions based on texts and highlights the main approaches used by researchers in the design of NLP text systems. The article also discusses some recent contemporary proposals in this area. Finally, the article presents some open questions and future directions for NLP research. The publication [5] confirms how NLP in marketing is transforming data analytics, offering new opportunities to understand customers and optimize strategies. This simplifies processes such as sentiment analysis, segmentation, and ad targeting. The publication [6] states that the main goal of natural language processing through NLP is to create systems that can interact seamlessly with humans, making technology more accessible and responsive to our daily communication needs. As NLP continues to evolve, it is transforming the way we interact with machines, opening up new possibilities for effective, effective and human communication, as well as defining some approaches to NLP, namely: controlled, uncontrolled, natural language understanding, natural language generation. The author [7] argues that, unlike artificial languages, natural languages have evolved as they move from generation to generation and are difficult to define with clear rules, and suggests considering natural language processing in a broad sense as encompassing any kind of computer manipulation of natural language. The author argues that on the one hand, it can be as simple as counting the frequency of words to compare different writing styles, on the other hand, NLP implies "understanding" full-fledged human statements, at least to the extent that useful answers can be given to them. The textbook [8] presents a comprehensive overview of the basic principles, models and methods of natural language processing (NLP), providing a theoretical basis and practical knowledge for using modern language technologies in solving engineering and analytical tasks. The publications [9] consider and define NLP, consider how NLP is related to artificial intelligence, how NLP helps people be more productive, how NLP helps improve the user experience, how NLP creates new analytical data, and also provide examples of natural language processing tasks.

Purpose, objectives and methods of research. In today's digital world, user feedback analysis has become a critical element for any business looking to improve the quality of its products and services. However, the scale and unstructured nature of this data pose significant challenges to traditional analysis. The main problem is the inefficiency and limitations of manual analysis of large volumes of text user reviews: exponential growth in data volumes; subjectivism and inconsistency of analysis; critical time costs; limited ability to detect hidden patterns; the increasing complexity of multilingual analysis; lack of standardization and subjectivity of assessments; Rising costs for review analytics. However, the application of NLP to analyze user feedback also faces a series of problems that need to be addressed: understanding context and ambiguity; identification of irony, sarcasm and hidden meanings; processing of unstructured and "noisy" text; multilingualism and cross-cultural aspects; adaptation to the specifics of the domain; assessment of the reliability of reviews and detection of false reviews; ethical issues and model bias. Based on the above and taking into account current trends and challenges in the field of NLP, the scientific task of this study is formulated as follows: development and evaluation of the effectiveness of a comprehensive system based on natural language processing methods and models for automated analysis of user feedback, which provides accurate sentiment detection, identification of key aspects and topics, identification of critical problems and opportunities for improvement, and also allows To conduct multilingual benchmarking of reviews in a time perspective, taking into account contextual and cultural features.

Table 1. Average time spent on manual analysis of reviews of varying complexity

Type of response	Average length (words)	Time to analyze (min)	Number of reviews per working day (8 hours)	Number of analysts per 1000 reviews/day
Short	10-30	1-2	240-480	2-4
Medium	31-100	2-4	120-240	4-8
Long	101-300	4-8	60-120	8-16
Detailed	>300	8-15	30-60	16-33

Source: built by the author

Unlike existing studies that focus on specific aspects of review analysis, this work offers an integrated approach that combines state-of-the-art NLP techniques to solve the entire complex of problems related to automated analysis of user reviews. Particular attention is paid to the adaptability of the system to different domains and languages, as well as its ability to provide high accuracy of analysis in the face of limited training data. Solving this scientific problem is of great practical importance for business, as it will allow companies to: quickly identify problematic aspects of products and services, even with large volumes of feedback; make informed decisions on improving products based on objective analysis; to effectively allocate resources to the most critical areas of development; increase customer satisfaction through prompt response to their needs; gain a competitive advantage through a deeper understanding of the market and consumers; significantly reduce the cost of analyzing reviews while improving the quality of results; proactively identify new trends and opportunities based on the analysis of large data sets. Table 2 presents a comparison of the effectiveness of different approaches for key feedback analysis tasks based on recent research. Successfully integrating a feedback analysis system into business processes requires not only choosing the right technologies, but also understanding the business context and needs of a particular organization. According to McKinsey, companies that effectively use user feedback analytics demonstrate 15-20% higher customer retention rates and 10-15% higher average revenue per customer [7]. The most successful implementations of review analysis are characterized by several key features. First, they provide integration with existing systems such as CRMs, customer support systems, and analytics platforms. This allows you to combine data from different sources

and gain a comprehensive understanding of customer needs and problems. Second, effective feedback analysis systems provide results in an understandable and actionable format. They not only generate statistical reports, but also highlight specific problems that need attention and provide recommendations for solving them. This is especially important for users who do not have technical training, but make strategic decisions based on the results of the analysis.

Table 2. Comparison of the effectiveness of different approaches of key review tasks

Method	Sentiment Analysis (F1)	Topic Detection (NMI)	Cross-Lingualism	Speed (Feedback/sec)	Need for Data for Learning	Explainability
Vocabulary Methods	0.65-0.70	N/A	Low	500-700	Minimum	High
ML with manual signs	0.75-0.85	0.50-0.65	Low	100-300		Medium
CNN/RNN	0.82-0.88	0.60-0.70	Medium	50-100	High	Low
BERT/RoBERTa	0.88-0.92	0.65-0.75	Medium-High	20-50	High	Low-Medium
LLM + Few-shot	0.90-0.95	0.70-0.80	High	5-15	Minimum	Average
Specialized models	0.92-0.96	0.75-0.85	Medium-high	20-40	Medium-high	Medium-high

Source: built by the author

Thirdly, successful review analysis systems provide full-cycle automation – from collecting and analyzing reviews to generating insights and recommendations. This allows you to significantly reduce the time from receiving feedback to responding to it, which is critically important in today's fast-changing business environment. Summarizing the analysis of approaches, methods and models for automating the analysis of user feedback, several key conclusions can be drawn. The modern landscape of feedback analysis technologies is represented by a wide range of methods – from simple dictionary approaches to complex neural network architectures and large language models. The choice of a specific method depends on many factors: the volume and quality of the available data, the specifics of the domain, the requirements for processing speed, the required level of accuracy and interpretation of the results. Transformer models, especially the specialized domain versions of BERT and RoBERTa, demonstrate the best ratio of accuracy, speed, and resource intensity for most practical feedback analysis tasks. They provide high accuracy in understanding the context and nuances of language, which is critical for correctly interpreting user feedback. Large language models with few-shot training open up new opportunities for the rapid implementation of feedback analysis systems in new domains and for new products. They are especially valuable in situations with limited training data or when you need to quickly adapt to new types of feedback. Aspect-oriented sentiment analysis is the most informative approach for businesses, as it allows you to gain a detailed understanding of the strengths and weaknesses of products or services. The combination of ABSA with topic and aspect detection techniques provides the most complete picture of user feedback. Multilingual models provide better results for multilingual analysis compared to the translation + analysis approach, especially when understanding cultural and linguistic nuances is important. These models are becoming increasingly important in a globalized business environment. The optimal solution for most business problems is a combination of different methods, which allows you to ensure high accuracy, efficiency and adaptability of the feedback analysis system. This approach allows you to use the advantages of each method and minimize their limitations. Based on the analysis of the problems and existing approaches to

automating the analysis of user feedback, key challenges and promising areas of research have been identified. A clear statement of research tasks will allow you to structure further work and focus on the most relevant aspects of the problem. The main goal of this study is to develop and evaluate the effectiveness of a comprehensive system of automated analysis of user feedback based on modern methods of natural language processing, which will provide high accuracy in identifying sentiment, key aspects and topics, the ability to work with feedback in different languages and effectively integrate into the business processes of organizations of various sizes. To achieve this goal, it is necessary to solve the following specific tasks: development of effective methods for pre-processing user feedback; research and comparative analysis of modern models of classification of reaction tones, which involves adaptation and evaluation of the effectiveness of various NLP models for analyzing the mood of reactions – from classical approaches to machine learning to modern transformer architectures and large language models; development of a method of aspect-oriented sentiment analysis for different domains, which is aimed at developing an approach that will allow not only to determine the general tone of response, but also to identify specific aspects of products or services and the corresponding tone in relation to each of them; creation of effective methods for identifying topics and key aspects in the feedback corpus, which includes the development and evaluation of methods for automatically identifying the main topics discussed in detailed reviews, and highlighting key aspects of products or services; development of an approach to multilingual feedback analysis, which focuses on creating methods that will allow you to effectively analyze reviews in different languages without significant loss of accuracy and while preserving linguistic and cultural characteristics; creation of methods for interpreting and visualizing the results of the analysis of feedback, which includes the development of approaches to ensure the clarity of the analysis results and their effective visualization for end users; development and evaluation of a comprehensive system of automated analysis of feedback, which provides for the combination of developed methods and models into a single system that will provide a full cycle of feedback analysis – from collection and pre-processing to the generation of insights and recommendations; experimental assessment of the effectiveness of the developed methods on real data, which includes conducting complex experiments to assess the effectiveness of the developed methods and the system as a whole on real sets of reviews from different domains and in different languages. To solve the tasks, a comprehensive methodological approach will be used, which combines methods of machine learning, deep learning, natural language processing and data analysis. The study will be carried out in several stages: analytical stage, at which a detailed analysis of existing methods and models, their advantages and limitations will be carried out; the design and development stage, at which specific methods and models will be developed to solve the tasks; experimental stage, which includes conducting experiments in order to assess the effectiveness of the developed methods and models; analytical and generalizing stage, at which the results of experiments will be analyzed, patterns will be identified and conclusions will be formulated regarding the effectiveness of the developed methods and models.

Research results. Automated analysis of user feedback relies on a solid theoretical foundation of natural language processing, machine learning, and artificial intelligence techniques. Pre-processing of text data is a fundamental stage in the process of analyzing user feedback and largely determines the effectiveness of post-processing. At the heart of text preprocessing is the theory of tokenization, which defines the principles of splitting text into smaller units – tokens. In the context of analyzing user feedback, tokenization faces a number of specific challenges. Various theoretical approaches have been developed to address these problems, including statistical methods, dictionary-based approaches, and, most recently, subword tokenization techniques. Based on the analysis, the following conclusions can be drawn about the adequacy of various models and algorithms for the tasks of automated analysis of user feedback: for the analysis of moods, the most adequate are transformer models, additionally trained on data from a specific subject area, which provide an optimal balance between accuracy and computational efficiency; for aspect-oriented

analysis of moods, it is recommended to use combined models that simultaneously identify aspects and determine their tonality; To identify topics and aspects, it is advisable to combine classical algorithms of thematic modeling with neural network approaches, using the advantages of each method; for multilingual analysis, it is optimal to use specialized multilingual models with additional adaptation to the specifics of domains and languages; To ensure scalability and high performance of the automated feedback analysis system, it is recommended to implement a multi-level architecture using models of varying complexity at different levels. Overall, hybrid approaches that combine the strengths of different models and algorithms, providing an optimal balance between accuracy, computational efficiency, scalability, and interpretation, are the most adequate for comprehensively solving the problems of automated analysis of user feedback. In Table 3 summarizes the key methods of sentiment analysis and their theoretical foundations.

Table 3. Methods of sentiment analysis and identification of aspects

Method	Theoretical background	Key principle
Dictionary methods	Lexicography and affect theory	The tonality of a text is calculated as the sum of the tonalities of individual words
Machine Learning with	a Teacher Theory of Learning from Labeled Data	Optimization of the Classification Function on Labeled Data
Deep Learning	Neural Network Theory	Automatic Learning of Hierarchical Representations of Text
ABSA	Multitasking Learning	Simultaneous Identification of Aspects and Sentiment Analysis of Them
Thematic	modeling Probabilistic modeling	Presentation of documents as a mixture of topics, and topics as distributions of words

Source: built by the author

The considered theoretical foundations provide an understanding of the principles of operation of various methods and models, their capabilities and limitations, which is a prerequisite for the effective implementation of the system of automated feedback analysis and the development of innovative approaches in this area.

Discussion. Effective research in the field of automation of user feedback analysis requires careful planning, a structured approach and the use of appropriate techniques. Methodological aspects of the organization of scientific research, starting from the collection and preparation of data and ending with the evaluation of results and their interpretation. The methodical approach to data collection and preparation involves the implementation of a number of successive stages, each of which has its own characteristics and requirements. The methodological approach provides for the sequential implementation of the following stages: selection of the basic model architecture in accordance with a specific task; division of data into training and validation and test samples; The process of training and optimization of models includes: selection of the loss function in accordance with the set one; selection of an optimizer and determination of training parameters; regularization to prevent requalification; monitoring of the learning process and early stopping when reaching a plateau on a validation sample; search for optimal hyperparameters using grid search, random search, or Bayesian optimization. The methodological approach to assessing the effectiveness of feedback analysis models involves the use of a set of metrics adapted to specific tasks: for mood classification tasks, the main metrics are: F1-score – harmonious average accuracy and memorization; For aspect-oriented sentiment analysis, the assessment is carried out in two stages: assessment of the quality of identifying aspects; assessment of the accuracy of the classification of tonality in relation to correctly identified aspects; For thematic modeling problems, specific metrics are used, such as: consistency of the topic; Surprise; variety of topics; for multilingual model evaluation tasks, it is important to test in different languages and check the stability of the model; to

interpret the results, it should be carried out taking into account the context of the study and the characteristics of the data; to ensure the reliability of the results obtained, it is recommended to conduct statistical analysis; analysis of the sensitivity of models to changes in data and parameters; checking the stability of the results on different subsamples of data. The methodical approach to the organization of experiments involves adherence to a structured protocol. Each experiment must have a clearly defined goal and hypotheses that are tested. The documentation of the experiment should include: a description of the input data (source, scope, characteristics, method of pre-processing); detailed information about the model architecture and its parameters; description of the learning process (loss function, optimizer, learning speed, number of epochs); results of evaluation of validation and test samples against all relevant metrics; error analysis and interpretation of results; comparison with basic models and previous experiments. Methodological support for research in the field of automation of user feedback analysis is a comprehensive process that covers all stages from data collection to implementation of results. The developed methodological recommendations provide a structured approach to research, which allows you to obtain reliable and reproducible results. For a comprehensive assessment of various methods of automated analysis of user feedback and verification of theoretical results, a comprehensive experimental design was developed, covering four key tasks: general sentiment analysis, aspect-oriented sentiment analysis, identification of themes and aspects in reviews, and multilingual analysis. For each task, appropriate datasets, estimation techniques and comparison models were selected.

The following data sets were used in the experimental study:

1. For general sentiment analysis: Amazon Product Reviews (version 2024) – a subset of 500,000 reviews for different product categories (electronics, books, clothing, household goods); Yelp Open Dataset (2023-2025) – 300,000 restaurant and service industry reviews [3, 30]; IMDb Movie Reviews – 50,000 movie reviews.

2. For aspect-oriented sentiment analysis: SemEval-2024 ABSA – dataset with marked aspects and corresponding tonality; Restaurant Reviews Dataset – a specialized set of 25,000 restaurant reviews with aspect and tone markup; Tech Products Reviews – 35,000 tech device reviews with detailed aspect markup.

3. To identify themes and aspects: Hotel Reviews Corpus – 200,000 hotel reviews for thematic modeling; AppStore Reviews – 150,000 mobile app reviews; Product Discussion Forums – 100,000 texts from discussions of various products.

4. For multilingual analysis: MultiLing Sentiment Dataset – reviews in ten different languages (English, German, French, Spanish, Italian, Portuguese, Russian, Chinese, Japanese, Arabic); Cross-lingual E-commerce Reviews – a set of parallel product reviews in different languages.

All datasets have been pre-processed according to the methodology described earlier. This included: cleaning up HTML tags and special characters; normalization of text (lowercase casting, removal of duplicate spaces); tokenization; lemmatization using spaCy; removing stop words for thematic modeling tasks; saving emoticons and emojis as special tokens for sentiment analysis; processing abbreviations and slang using specialized dictionaries. To ensure the objectivity and statistical significance of the results, all experiments were conducted using cross-validation (5-fold), and the assessment was carried out according to a set of relevant metrics for each task. To model the problem of general sentiment analysis, several approaches have been implemented and evaluated, ranging from classical machine learning methods to modern transformer models. The task was to classify feedback into three classes: positive, negative and neutral. The results of experiments on the classification of the tonality of responses demonstrate a clear pattern: transformer models are significantly superior to classical approaches in terms of accuracy, but require more computing resources. The domain-adapted BERT performed the highest with an average F1-score of 0.93 across all datasets, which is 17 percentage points higher than the baseline Naive Bayesian (0.76). Additional experiments with the analysis of the impact of the volume of training data showed that transformer models are especially sensitive to the number of training

examples. With limited datasets (less than 5000 samples), the difference between classical ensemble methods and transformer models is significantly reduced, which confirms the importance of having large marked enclosures to fully unleash the potential of modern approaches. Aspect-oriented sentiment analysis (ABSA) presents a more complex task compared to general classification, since it requires not only the definition of tonality, but also the identification of specific aspects to which it relates. Within the framework of the experiments, two main approaches were implemented and compared: pipeline models and joint models. The experiments were conducted on three domains: restaurant reviews, technical product reviews, and hotel reviews. Specific aspects have been identified for each domain. Additional experiments were aimed at studying the ability of models to detect and classify tonality for different types of aspects. For each domain, 5 to 8 categories of aspects were identified, and the results were evaluated separately for each category. The results of experiments on aspect-oriented sentiment analysis demonstrate several important patterns: combined models that simultaneously solve the problem of identifying aspects and classifying their tonality show better results compared to sequential approaches. The RACL model showed the highest performance with an average F1-score ABSA of 0.85, which is 9 percentage points higher than the baseline BiLSTM-CRF + ATAE-LSTM sequential model (0.76); the performance of all models varies depending on the data domain, the highest scores are seen for restaurant reviews, where models reach an F1-score ABSA of up to 0.86, while for tech product reviews, the score is lower (up to 0.84). This can be attributed to the greater complexity and diversity of aspects in technical products; analysis of the effectiveness of models for different categories of aspects revealed significant differences. All models demonstrate the highest accuracy for aspects that are often found in reviews (for example, "Food" in restaurant reviews with an F1-score of up to 0.88), instead, rare aspects or those with a high difficulty of detection; similar to the problem of general sentiment analysis, more complex models demonstrate higher accuracy due to higher computational requirements, the RACL model, which has the highest precision, also has the largest size (750 MB) and the longest inference time (35 ms per sample); impact on different stages of ABSA. It is interesting to note that the improvement in the transition from sequential to combined models is most noticeable in the combined F1 ABSA metric, this suggests that the combined models make more effective use of the relationship between the tasks of identifying aspects and determining their tone. Pooled models, especially RACLs, demonstrate a better ability to cope with these challenges through collaborative learning for interrelated tasks and the use of contextual attention mechanisms. To assess the adequacy of the studies carried out, an integrated approach was applied, including quantitative and qualitative evaluation methods. To ensure the statistical significance of the results and avoid random patterns, a number of statistical validation methods were used. A five-fold cross-validation procedure made it possible to evaluate the performance of models on different subsets of data and minimize the impact of random distribution on training and test samples. The standard deviation of the results between the folds for all models is in the permissible range of 1-3%, which indicates the stability of the models and their ability to generalize. To confirm the statistical significance of the difference between the results of different models, a paired Bonferroni-corrected t-test was applied for multiple comparisons [1]. The results obtained confirm that the advantage of the domain-adapted BERT and the RACL model over other approaches is statistically significant ($p < 0.01$). An additional method of checking reliability was bootstrap oversampling, which confirmed the stability of the results obtained when changing the data distribution. 95% confidence intervals for the F1 metric of transformer models are within ±1.5%, which indicates a high reliability of estimates. An important aspect of assessing the adequacy of an experimental study is the analysis of the representativeness of the data sets used. To verify this aspect, a detailed analysis of the characteristics of the data and their correspondence to real use cases was carried out. The analysis of the distribution of sentiment classes revealed a certain imbalance in the data, which is typical for real user reviews – positive reviews dominate (55-60%), negative reviews make up 25-30%, and neutral reviews make up only 10-15%. To compensate for this imbalance, weighted loss functions

and class balancing techniques were used during model training. Analysis of the distribution of the length of reviews showed that the datasets cover a wide range – from short (5-10 words) to extended (more than 200 words) reviews, which corresponds to a variety of real-world scenarios. The models were evaluated separately on subsamples of different lengths of feedback to ensure their effectiveness for all types of inputs. Lexical diversity and specific features of responses (slang, emoticons, technical terms) are also adequately represented in the datasets, which is confirmed by frequency response analysis and lexical diversity assessment methods (TTR–Type–Token Ratio). To assess the representativeness of the data in terms of the diversity of topics and domains, the Topic Modeling (LDA) method was used, which found that the datasets cover all key topics and aspects of products in their respective domains. To ensure the validity of measurements and the objectivity of model evaluation, an analysis of the compliance of the selected metrics with the research tasks was carried out. For aspect-oriented tonality analysis, a combined metric was used, taking into account both the accuracy of identifying aspects and the correctness of determining their tonality. This metric better reflects the practical value of the models than individual metrics for each stage. Additionally, for a comprehensive evaluation of the models, metrics of the efficiency of the use of computing resources (training time, inference time, memory usage) were used, which are critical for practical application. An important aspect of the adequacy of experimental research is the consistency of the results obtained with theoretical predictions and data available in the literature. The results of the experiments confirm the theoretical provisions presented earlier, in particular: the superiority of transformer models over classical approaches in natural language comprehension problems is confirmed experimentally (F1-score 0.93 versus 0.76); the effectiveness of domain adaptation to improve the results of the analysis of specific texts is confirmed by higher indicators of domain-adapted BERT compared to the standard one; the theoretical assumption about the superiority of combined models over sequential models for aspect-oriented sentiment analysis is confirmed experimentally (F1-score ABSA 0.85 vs. 0.76); The dependence of model efficiency on the volume of training data is consistent with theoretical predictions – transformer models demonstrate greater sensitivity to the volume of data compared to classical approaches.

Table 4. Comparison of dataset characteristics with real user reviews

Characteristics	Experiment datasets	Real user reviews	Representativeness score
Class Distribution	60% / 25% / 15% (Positive/Negative/Neutral)	58% / 27% / 15%	High
Average Review Length	75 Words	68 Words	High
Lexical Diversity (TTR)	0.32	0.29	Medium-High
Share of reviews with emoticons	22%	25%	High
Share of reviews with spelling errors	35%	42%	Average
Domain Coverage	5 Major Domains	Multiple Domains	Medium-High

Source: built by the author

To objectively assess the adequacy of an experimental study, it is necessary to recognize its limitations and analyze their impact on the reliability and generalizability of the results. The main limitations of the study include: domain limitations – although the study covers several important domains (electronics, restaurants, movies, hotels), a number of specific areas (medical services, education, financial products) remained uncovered; language limitations – despite the inclusion of 10 languages in the multilingual experiment, the features of some rare languages and dialects were not taken into account; limitations of computing resources – for the largest transformer models (for example, RoBERTa-large), it was impossible to conduct a full cycle of hyperparameter optimization due to the limitations of available computing resources; Focus on textual data – the

study does not look at multimodal feedback that includes images or videos, which are becoming increasingly common in today's digital platforms. To evaluate the effect of these limitations on the reliability of the results, a series of additional experiments were conducted on smaller samples with different data configurations. The results show that the identified patterns persist when the composition of the data changes, which indicates the stability and generalizability of the conclusions obtained. The adequacy of the experimental study was also evaluated in terms of the practical applicability of the results obtained to solving real business problems. To assess the practical applicability, a pilot feedback analysis system based on domain-adapted BERT and the RACL model was developed, which was tested on real data from one of the e-commerce platforms. The system has demonstrated the ability to effectively analyze user feedback, identify problematic aspects of products, and track changes in user sentiment over time. Comparison of the automated analysis with the manual analysis carried out by a team of experts on a sample of 500 reviews showed high consistency of results (Cohen's kappa = 0.82 for sentiment classification and 0.79 for aspect detection). At the same time, the automated system processed reviews 120–150 times faster, which confirms its practical value. Based on a comprehensive analysis of statistical reliability, representativeness of data, validity of metrics and compliance with theoretical predictions, it can be concluded that the experimental study conducted is highly adequacy to solve the tasks. The main factors confirming the adequacy of the study: the use of a complex set of statistical methods to ensure the reliability of the results obtained; the use of representative data sets reflecting the diversity of real user reviews; selection of appropriate evaluation metrics that take into account all aspects of the model's effectiveness; consistency of experimental results with theoretical forecasts and existing studies; successful pilot implementation, confirming the practical applicability of the developed models. Thus, the conducted experimental study is sufficient to assess the effectiveness of various methods of automating the analysis of user feedback and develop practical recommendations for their implementation.

Conclusions. As a result of the study, all the goals and objectives were achieved, which made it possible to formulate the following conclusions. A theoretical study of natural language processing methods in the field of marketing demonstrated the evolution of approaches to text analysis - from simple dictionary methods to complex transformer architectures. Each of these approaches has its own advantages and limitations, and the choice of a specific method depends on the specifics of the task, available computing resources, requirements for accuracy and speed of analysis. Based on the experimental study, it was found that transformer models, in particular domain-adapted BERT, provide the highest accuracy of response sentiment analysis (F1-score up to 0.93), which is significantly superior to classical methods such as Naïve Bayes (F1-score 0.76) and XGBoost (F1-score 0.85). In the field of aspect-oriented tonal analysis, combined models have shown a significant advantage over sequential approaches, which simultaneously solve the problem of identifying aspects and classifying their tonality. The RACL model demonstrated the highest performance with an average F1 ABSA score of 0.85, which is 9 percentage points higher than the baseline BiLSTM-CRF + ATAE-LSTM sequential model (0.76). It has been established that the efficiency of all models significantly depends on the specifics of the subject area and the quality of preliminary data processing. Domain adaptation and additional training on specific data corpora greatly increase the accuracy of analysis, especially for specialized industries with their own terminology. The study confirmed that multilingual models such as XLM-RoBERTa provide efficient analysis of responses in different languages without significant loss of accuracy compared to models trained for specific languages. This is especially important for global companies that operate in different markets and receive feedback in many languages. Statistical validation of the results using cross-validation, bootstrapping and t-tests confirmed the reliability and statistical significance of the results obtained. 95% confidence intervals for the F1 metric of transformer models are within ±1.5%, which indicates high stability of the results. The developed pilot system of automated feedback analysis in the field of marketing of companies demonstrated high

consistency with the manual analysis of experts (Cohen kappa = 0.82 for sentiment classification and 0.79 for identifying aspects) at a much higher processing speed (120-150 times), which confirms the practical applicability of the proposed solutions. The cost-effectiveness of the implementation of automated feedback analysis systems is confirmed by a significant reduction in the time and human resources required to process feedback, as well as an increase in the quality of the insights received, which allows companies to make more informed decisions about the development of products and services. The practical significance of the results obtained lies in the possibility of using them to create effective systems for automated analysis of user feedback, which can be integrated into the business processes of companies of different sizes and industries. The novelty lies in the development of an original pilot system for automated analysis of user feedback, improvement and adaptation of the methodological approach to a specific task. Thus, the conducted research makes a significant contribution to the development of methods for automating the analysis of user reviews in the field of marketing companies based on natural language processing and creates the basis for further improvement of such systems.

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Удосконалення автоматизованої системи NLP, як фактор підвищення якості формування маркетингової стратегії

Анотація. Оброблення природної мови у сфері маркетингу компаній перетворює аналітику даних, пропонуючи нові можливості для розуміння клієнтів та оптимізації стратегій.

Вступна частина. Оброблення природної мови спрощує процеси, такі як аналіз настроїв, сегментація та направлення реклами. Важливо враховувати точність даних, безпеку та навчання навичок управління запитами для ефективного використання технологій.

Постановка проблеми. Однією з основних проблем у маркетинговій аналітиці є перетворення первісних числових даних у зрозумілі та корисні для людини висновки. Шляхом вирішення проблеми є технології оброблення природної мови та генеративний штучний інтелект, які дозволяють перетворювати складні дані на доступну та корисну для роботи інформацію.

Нерозв'язані аспекти. Традиційний ручний аналіз відгуків у маркетинговій аналітиці вже давно перестав відповідати сучасним вимогам бізнесу, тому що потребує величезних людських ресурсів, що робить процес надзвичайно затратним. Природна мовна обробка пропонує вирішення цієї проблеми через застосування алгоритмів, здатних автоматично аналізувати семантику тексту, визначати тональність висловлювань та виокремлювати ключові теми з великих масивів даних.

Мета статті. Метою даного дослідження є розроблення системи автоматизованого аналізу відгуків користувачів на основі розроблених ефективних методів та моделей для автоматизованого аналізу відгуків користувачів у сфері маркетингу компаній з використанням технологій природної мовної обробки.

Основний матеріал. У роботі проводиться опис проблеми, що вирішується, та формулюється наукове завдання; проводиться аналіз підходів, методів та моделей вирішення завдань дослідження; здійснюється постановка завдань дослідження, аналізуються теоретичні підходи, щодо розв'язання завдань дослідження; розглядаються теоретичні аспекти природної мовної обробки; досліджуються різні моделі та алгоритми для аналізу відгуків, а також проводиться експериментальна оцінка їх ефективності на реальних даних; досліджуються моделі, алгоритми та проводиться аналіз їх адекватності при розв'язанні завдань дослідження; удосконалюється методичне забезпечення, щодо організації проведення досліджень.

Висновки: Результати дослідження можуть бути використані для розроблення програмних рішень, що дозволять компаніям краще розуміти потреби своїх клієнтів, швидко реагувати на проблеми та підвищувати якість своїх продуктів і послуг.

Ключові слова: *природна мовна обробка, маркетинг, автоматизації аналізу відгуків користувачів, метод, аналіз, оцінка, бізнес-процес.*

JEL: G21, G28, G 32, O33

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