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SEO AUDITING USING LARGE LANGUAGE MODELS AS A KEY UNIVERSITY MARKETING STRATEGY COMPONENT

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Purpose: Large Language Models (LLMs) are employed in a growing range of domains. They automatise processes and improve work efficiency. However, their application in website quality testing leaves a research gap. The paper aims to assess the capabilities and limitations of using selected LLM-based AI tools for SEO auditing as a critical component of a university's marketing strategy in a case study of a university website.
Design/methodology/approach: The paper reports a case study. The audited website belongs to a university where a new content management system (CMS) is deployed. At this stage, the audit minimises such adverse issues as deindexing and visibility loss. The SEO audit employed the following AI tools: ChatGPT, Microsoft Copilot, Gemini Google DeepMind, and Perplexity AI. Selected AI responses are quoted verbatim, while others have been synthesised. Some of them were subjected to semantic analysis.
Findings: LLM-based AI tools do not conduct an SEO audit in real time. LLMs can easily generate articles, abstracts, summaries, and other texts that may be used as input for meta tags or headings, such as H1. Therefore, LLMs can be useful for optimisation rather than quality assessment.
Originality/value: It is one of the first studies on the capabilities and limitations of Large Language Models regarding SEO audits presented with a case study of a university website.
Keywords: website quality, artificial intelligence, AI, LLM, GPT models, SEO audit, search engine optimisation.
Category of the paper: case study.

1. Introduction

Despite the dynamic expansion of AI, including Large Language Models (LLMs) and changes in how information is obtained (Strzelecki, 2024), search engine optimisation (SEO) remains critical for marketing strategies. This principle applies to various organisations, commercial and institutional both, including universities. SEO promotes continuous improvement of website and web application quality. The quality is evaluated through SEO audits, which may be done using AI tools (Chodak, 2024).

Traditional methods of assessing website quality are as effective as they are arduous (Król, Zdonek, 2020). AI tools could be useful in this regard thanks to their potential to streamline SEO audits and website optimisation. The paper offers an in-depth analysis of the application of selected AI tools for SEO audits. It focuses on the capabilities of Large Language Models regarding data analysis, process automation, and content optimisation. A better understanding of how AI can support SEO should help experts make sounder decisions and optimise websites more effectively, leading to higher search engine results page ranks and conversion rates.

Online platforms that make use of LLMs, such as ChatGPT, Microsoft Copilot, Gemini Google DeepMind, and Perplexity could automatise many SEO auditing processes, especially textual data analysis or content optimisation (Chodak, 2024). These tools process large datasets, which can provide more accurate and comprehensive analysis than traditional methods (Król, Zdonek, 2020). Moreover, machine learning algorithms allow AI models to learn from data available to them so they can identify patterns and regularities not accessible through basic analysis (Spitale, 2023). This raises the question of whether LLMs' characteristics show potential for revolutionising SEO and to what extent.

1.1. Aim and research gap

LLMs' possibilities are wide and growing. The technology is employed in a growing range of domains. It automatises processes and improves work efficiency. LLMs are becoming popular in marketing and advertising, e-commerce, education, medicine and health care, media and journalism, finance and banking, construction and architecture, entertainment and games, research, and the public sector and administration. Their application potential is still vigorously investigated. The literature review demonstrates that LLM research tends to focus on language model architecture and optimisation, security and ethics, and improvement of text generation and user interaction. The practical applications of LLMs and their potential social and economic impact are also investigated in depth (Cheng, 2023; Chodak, 2024; Lecler, 2023; Saka, 2023). In contrast, there are relatively few systematic analyses of LLM applications to improve SEO processes, such as website structural analysis, identification of technical errors, or content optimisation for search engines. This poses a certain research gap worth addressing.

The paper aims to assess the capabilities and limitations of using selected LLM-based AI tools for SEO auditing as a critical component of a university's marketing strategy in a case study of a university website. It addresses the following specific research questions: 1) To what extent are LLM-based AI tools useful for SEO auditing? and 2) How detailed are recommendations from an SEO audit generated by an LLM? The substantial deliverable of the paper is practical recommendations for using LLMs in SEO audits. The remainder of the paper is structured as follows. Section two contains potential capabilities and limitations of using Large Language Models in SEO audits and the research results to date. Section three presents the research methods, including a retrospective analysis of the study object, and outlines the research model and measurement tools. Section four offers the results discussed in the next section in the context of traditional SEO practices and the literature.

2. Background

2.1. Applicability of LLMs for SEO Auditing

Artificial intelligence (AI) is a generic term describing technologies and methods that allow machines to emulate intelligence and perform tasks requiring human abilities to understand, learn, and make decisions (Floridi, 2020). Large Language Models (LLMs) are sophisticated AI models for natural language processing (NLP) (Kalyan, 2023). LLMs are designed to understand and generate natural language (Spitale, 2023). In addition, such LLMs as GPT (Generative Pre-trained Transformer) are typical generative models. They are capable of creating new, original content, such as articles, dialogues, headings, titles, or programming or hypertext code from an input context called a prompt (Zhang, 2021). LLM advance is among the primary AI research and development areas. LLMs are constantly improved to create more precise and coherent content, but most of all, better understand human speech and text so that human-machine interactions can be elevated (Chodak, 2024). One example of such interactions is when a human (auditor) uses algorithms (‘machines’, in a sense) to assess the quality and position of ‘other algorithms’ (i.e. websites) in the global online ecosystem. The process is referred to as an SEO audit.

An SEO audit analyses and evaluates the quality of a website regarding its search engine optimisation. Its purpose is to flag problematic areas in need of optimisation. The end result is improved website visibility on the search engine results page (Edgar, 2023a). The literature analysis suggests that Large Language Models could be employed in SEO audits, particularly for content auditing, including textual element assessment (Cutler, 2023). Thanks to their ability to analyse text, generate content, and learn from large datasets, LLMs can potentially support search engine optimisation by generating content from input keywords, generating meta

description and meta title tags, and optimising existing content (Chodak, 2024). This means that LLMs can analyse existing text for search engine optimisation and suggest changes, such as new keywords and headings (H1-H3, for example) or inserting a call to action in the right place. Language models can also be useful for analysing reports and data from third-party test tools, such as the Google Search Console, Ahrefs, SEMrush, or Moz. They can synthesise and abridge large reports using simple language. All this shows that it is worth thoroughly analysing the capabilities and limitations of LLMs regarding SEO auditing.

2.2. Related work

In the digital era, university websites are critical for academic communication and reaching out to potential students. A well-optimised university website has a better potential to rank high on search engine results pages. In turn, good university visibility on search engine results pages supports its brand, recognition at home and abroad, and availability of research outcomes. It may also affect candidate application. As shown in the literature, search engine optimisation of university websites has become an indispensable part of marketing strategies.

The literature review indicates a growing role of search engines as a university enrolment tool. Research shows that search engine optimisation significantly improves university visibility on search engine results pages (Iddris, 2018). Shahzad et al. (2018) analysed various SEO techniques employed on university websites. They demonstrated that content optimisation, right keywords, and improved performance boost organic traffic, which is critical for university visibility on search engine results pages. Dolai (2023) investigated the impact of SEO on user engagement. He demonstrated that technical optimisation (Technical SEO), including optimisation of the URL and user experience (UX), affects search engine results page rank and conversion rate. Giannakoulopoulos et al. (2019) examined how SEO influences university website accessibility and search engine results page rank. They concluded that optimisation per W3C guidelines improves UX and SEO. Vállez and Ventura (2020) established that Local SEO boosts the number of university candidates from specific regions. Elsayed (2017) investigated search engine optimisation challenges relevant to university websites. He has shown that university portals are usually extensive, which calls for sophisticated SEO strategies, such as careful internal linking and meta tag optimisation. Cassar and Caruana (2023) demonstrated that multi-lingual content and optimisation of university websites for international search engines drive the number of international students up. Moreover, according to Al-Ananbeh et al. (2012), search engine-optimised websites with easily accessible content and user-friendly interfaces have a higher user retention rate. Shafaei and Taheri (2024) analysed selected SEO characteristics, such as optimising headings (H1, H2, etc.), removing duplicate content, and improving loading speed. The efforts were shown to affect indexing and search engine results page rank. Elbadrawy and Halim (2022) analysed search results and websites of selected universities. They discovered that those who had effectively used SEO techniques enjoyed increased organic traffic and higher search engine

results page rank. Their conclusions were corroborated by Supraba and Jati (2021). Therefore, the literature review shows that SEO is critical for university website optimisation. It affects their search engine results page rank, which determines the number of visitors, brand recognition, and enrolment effectiveness.

3. Materials and methods

3.1. Research object

The audited object is the website of the University of Agriculture in Kraków (UAK). The website was selected for the study because the deployment of a new content management system (CMS) coincided with the study. The process was commenced in 2024. The new CMS replaced a system used from 2010 to 2024, which is relatively long (Fig. 1). The system has become deprecated despite upgrades due to the emergence of new technologies. It was replaced with a new one, 'Platforma multiportalowa WEB360' (OPTeam).

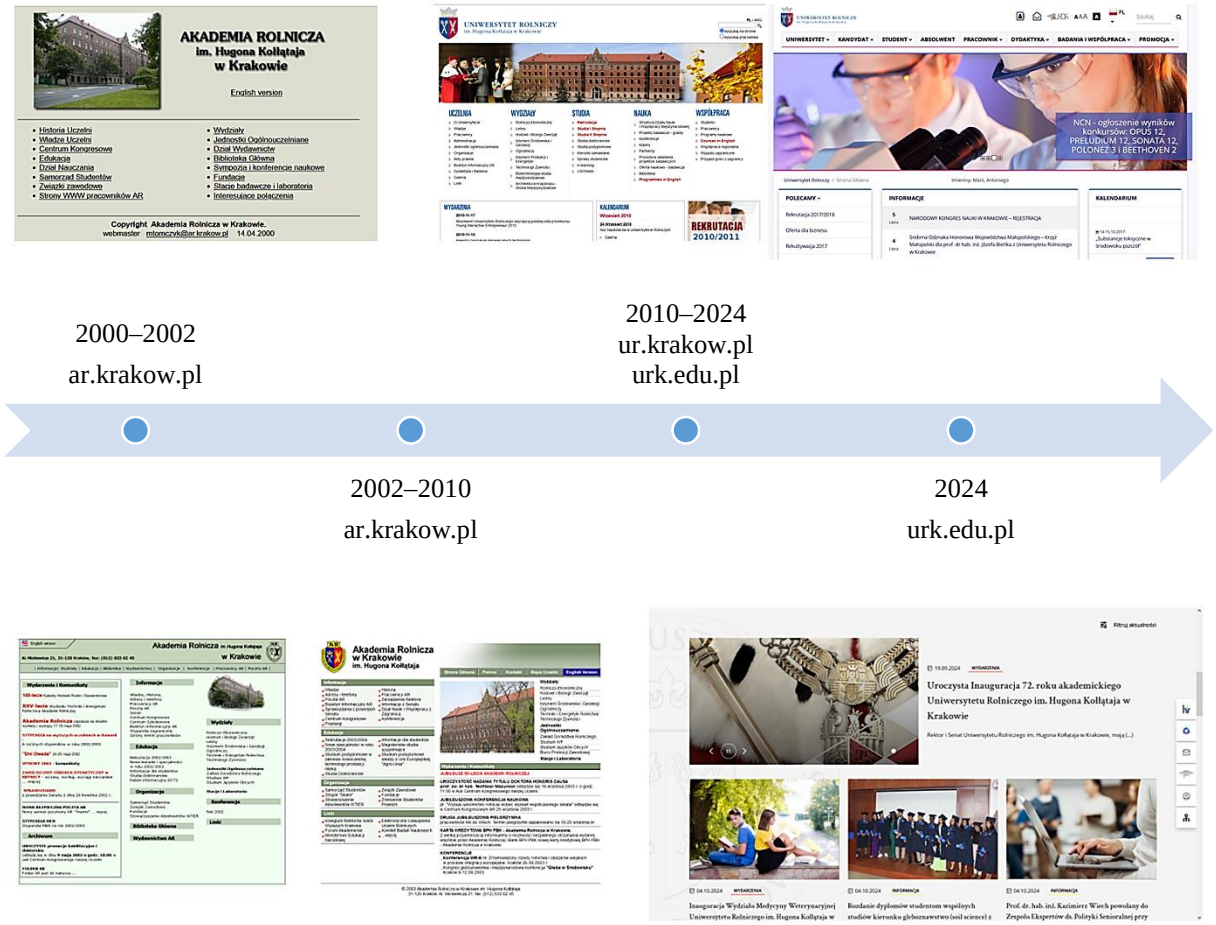

Figure 1. Evolution of the graphic design of URK's website.

Source: original work based on the Internet Archive.

The University of Agriculture in Kraków's website has a long history. It has changed substantially between 2000 and 2024. Its first digital copies date back to 1998. They are available from the Internet Archive's Wayback Machine. However, they are incomplete due to missing graphics. The first complete copy is from April 2000. It is a website of the university under its previous name, Academy of Agriculture (HTML 4.0 Transitional). Content posting involved replacing files on the server via an FTP client (File Transfer Protocol). The first CMS (XHTML 1.0 Transitional) was implemented in 2010. It was used until 2024 with a few upgrades. A new multiportal CMS (HTML5) was deployed in 2024.

An SEO audit conducted when a new CMS is introduced helps avoid potential technical problems and fully utilise the new system. SEO audits are recommended at this stage because they can improve the quality of the new system regarding URL structure, performance, responsiveness (adaptation to mobile devices), UX usability, functionality, internal linking structure (no broken links), and content (Król, Zdonek, 2020). Any shortcomings detected during deployment can be handled before release for use and indexation. This minimises the potential adverse consequence of introducing a new CMS, deindexing, which could possibly lead to reduced search engine results page rank. Moreover, an SEO audit can help flag problems caused by content migration, which may also harm indexation.

3.2. Research design and measurement tools

The SEO audit followed the black-box model, where the auditor is a third party or at least not a member of the design/deployment team. They evaluate the website's quality, ignorant of its internal structure and source code (Bau, 2010). The auditor focuses on external interactions and verifies whether the system aligns with the assessment model. Black-box model testing involves inputting data and analysing the results to identify errors and problematic components in need of optimisation. This approach is particularly useful for assessing the website and web application quality from the user's perspective (Boukhris, 2017).

The URK website was audited using selected AI tools (Table 1). The first one is ChatGPT, an LLM-based AI by OpenAI. GPT (Generative Pre-trained Transformer) is a series of AI models trained on large datasets to understand, generate, and process natural language. Different versions of GPT models vary in terms of their text-processing capabilities (Cutler, 2023). It is important for the present study to note that ChatGPT has the SEO Audit Tool (DIAP Media) dedicated to SEO auditing.

Table 1.
AI applications used in the AI SEO audit

Item	Tool	URL*
1	ChatGPT OpenAI SEO Audit Tool (DIAP Media)	https://chatgpt.com
2	Microsoft Copilot	https://copilot.microsoft.com
3	Gemini Google DeepMind	https://gemini.google.com
4	Perplexity AI	https://www.perplexity.ai

*Accessed 10.10.2024.

Microsoft Copilot is based on advanced language models, such as GPT, integrated with Microsoft software, Microsoft Dynamics applications, and GitHub. The primary objective of Copilot is to support users in different tasks, such as automation of document workflow, spreadsheets, code, and business data (Stratton, 2024). The tool provides assistance in Microsoft applications, offering tips, generating content, or automating tool-specific tasks.

Gemini is a new series of Google DeepMind models formerly known as Google Brain. Gemini is integrated with the Google ecosystem, which means its functions are linked to Google services. This makes the tool potentially more effective in tasks requiring real-time access to online data (Saeidnia, 2023). Finally, Perplexity AI was designed to provide hyperlinks to relevant sources along with its responses. It is because this particular tool can search the Internet and offer information based on real-time data as opposed to language models that have only training data to help them (Deike, 2023).

4. Results

Each AI test tool was given at least two identical tasks. The first one was to conduct an SEO audit of https://urk.edu.pl. The other job was to generate content for the description meta tag. Selected AI responses are quoted verbatim, while others have been synthesised. Some responses were subjected to semantic analysis. The results are presented below.

4.1. ChatGPT case study

Prompt 1: Perform an SEO audit of the website at https://urk.edu.pl

Synthesised SEO Audit Tool responses: Although the prompt did not mention the owner of the audited website, the tool identified (URK) based on the content under the URL. All suggestions in the SEO audit report by ChatGPT were generic and universal, also those pertaining to responsiveness, performance, hyperlink quality, and UX. Recommendations in the audit summary were just as universal. All this suggests that the tool provided a general information panel with generic and universal SEO design recommendations rather than SEO audit results defined as outcomes of real-time measurements.

Prompt 2: Generate content example for the description meta tag for the website at https://urk.edu.pl

ChatGPT's response (content example): The University of Agriculture in Kraków offers a broad range of environmental, agricultural, and technical courses. Find out more about our programmes, enrolment, and research activity.

4.1.1. ChatGPT SEO Audit Tool (DIAP Media) Case Study

Prompt 1: Perform an SEO audit of the website at https://urk.edu.pl

The website could not be audited because it cannot be accessed due to directives in the robots.txt file. The directives in the file govern the website's availability to crawlers.

Prompt 2: Generate content example for the description meta tag for the website at https://urk.edu.pl

SEO Audit Tool's response (content example): The University of Agriculture in Kraków offers a broad selection of environmental, agricultural, and technical courses. Find out more about the educational, research, and international opportunities here. Check out the latest news on enrolment and events.

4.2. Microsoft Copilot case study

Prompt 1: Perform an SEO audit of the website at https://urk.edu.pl

Synthesised Copilot's responses: The tool drafted a list of activities, the 'action plan'. It included quality attributes to inspect during an SEO audit with respective test tools. However, the response was brief despite references to websites used to draft it. The structures and lengths of further responses followed a pattern.

Prompt 2: Generate content example for the description meta tag for the website at https://urk.edu.pl

Synthesised Copilot's responses: The tool provided not only the content (tag input) but the entire HTML code. Copilot claimed that the proposed meta description content was short and concise and offered key university details to attract potential candidates and improve the website's search engine results page rank. Proposed content: University of Agriculture in Kraków – we offer a broad selection of courses, modern research facilities, and a friendly environment. Join us and develop your future!

4.3. Gemini Google DeepMind case study

Prompt 1: Perform an SEO audit of the website at https://urk.edu.pl

Synthesised Gemini's responses: The tool reported that advanced SEO tools and detailed content analysis were necessary to conduct a comprehensive and detailed SEO audit. Gemini's audit results were based on a general analysis of available data. They can be a starting point for more in-depth tests.

Prompt 2: Conduct an audit of website content at https://urk.edu.pl

Synthesised Gemini's responses: The tool presented detailed characteristics of individual stages of the SEO audit. The list covered both the analytical (technical) step and conceptual activities (before practical action) to determine the optimisation goals and scope of the audit. Next, it listed the most commonly used content audit tools. The response's closing statement was that a complete content audit requires details of the owner's primary marketing goals,

the target of the content, and the budget. Consequently, Gemini's response seems the most exhaustive under the employed research design.

Prompt 3: Generate content example for the description meta tag for the website at https://urk.edu.pl

Synthesised Gemini's response 1: The tool responded that an incorrect (unclear) prompt was input. The problem lay in using a URL the tool was unable to resolve. The prompt was revised to: Generate a content example for the meta description tag for the website of the University of Agriculture in Kraków.

Synthesised Gemini's response 2: The tool drafted several meta description content examples in several categories. They were accompanied by suggestions for selecting the most suitable one.

4.4. Perplexity AI case study

Prompt 1: Perform an SEO audit of the website at https://urk.edu.pl

Perplexity AI's response: I cannot conduct an SEO audit for https://urk.edu.pl because I do not have access to SEO data analysis or tools for evaluating the website.

Prompt 2: What are the main SEO errors at urk.edu.pl?

Synthesised Perplexity AI's responses: The most important SEO errors at urk.edu.pl may include various aspects affecting its search engine visibility, such as low-quality content, incorrect keywords, not optimised meta tags, internal linking problems, and user experience (UX) shortcomings. When these errors are identified and addressed, the search engine results page rank of urk.edu.pl can be improved, driving up organic traffic.

Notes on the response: Note that the response to prompt 2 is worded with 'may include' instead of 'include'. It means that instead of results of actual measurements, the tool listed potential errors on the website based on analysis of relevant sources.

Prompt 3: What are the main linking errors at urk.edu.pl?

Synthesised Perplexity AI's responses: The website at urk.edu.pl may contain various linking errors that could be detrimental to SEO. Here are the most common ones: excess internal links, incorrect anchor texts, and broken links. When these errors are identified and addressed, the SEO effectiveness of urk.edu.pl may improve significantly, and the website's search engine visibility may be boosted.

Notes on the response: Note that the response to prompt 3 is worded with 'may contain various errors' instead of 'contains the following errors'. This means that the tool does not report the errors it identified. Instead, it merely provides general information about the most common linking errors.

5. Discussion

5.1. How ‘typical’ SEO auditing tools work

Tools employed in CEO audits use crawlers. These ‘virtual robots’ collect data, usually in real time and when requested. The process typically yields a synthetic score or quality indicator. The measurements are taken once, and their results represent the ‘here and now’ situation (Król, Zdonek, 2020). In contrast, such tools as Google Analytics collect user activity data on an ongoing basis (McGuirk, 2023). With such data, auditors can identify the most popular websites and the most effective keywords for long-term SEO. Still, Google Analytics data is usually available only to the website’s owner, editor, or administrator. Moreover, they are considered sensitive data (confidential trade secrets) in e-commerce. Some tools, such as SimilarWeb (Website Traffic Checker), can offer visitor statistics for third-party websites. Still, these are usually estimates based on sniffing, and their value is disputed (Król, Halva, 2017).

A comparative analysis and exhaustive SEO competitive analysis are possible for performance, content, responsiveness, usability, and hyperlinks (Edgar, 2023a). These aspects can be measured with easily available SEO tools that use crawlers. Simply put, crawlers search the website similarly to search engine robots (Kausar, 2013). They scan all available resources and collect various types of data on content, link structure, and metadata. After that, SEO tools generate a report of variable levels of detail on quality metrics, SEO problems, and recommended actions. These tools offer results that answer questions about the current state. Their functions can measure the potential for code minification or image file compression for optimised performance; they report how much and in what way files can be minified or compressed. However, such tools cannot generate ‘alternative content’ for textual components of the audited website. Performance audit follows a slightly different path. The tests involve two modes: desktop and mobile. The results come from laboratory tests (lab data) and a typical user environment (field data) (Edgar, 2023b).

5.2. SEO analyses with language models

The literature review shows that LLMs are most often used to obtain proposals for text input that could be published in various sections, components, or parts of the website. SEO auditing is a far less popular use of LLMs (Chodak, 2024). It may be due to their technical and logical structures, which set them apart from other natural language processing systems. How LLMs are designed and work is thanks to the latest achievements in artificial intelligence, such as transformer architecture, which allows them to understand and generate complex texts (Chang, 2024). Put simply and briefly, the logic of LLMs is based on machine learning, transformer architecture, probability, and semantic representation learning (Shanahan, 2024). These mechanisms allow LLMs to analyse relationships between words in an entire text instead

of just adjacent words. This way, LLMs can better understand sentences, especially in the case of complex contexts or ambiguous texts. It still remains text analysis, which means it does not measure technical attributes in real time, such as the measurement of browser loading time. Therefore, LLMs can be and, indeed, are most often used to aid optimisation after the results of an audit with typical SEO tools are known. LLMs can help interpret results (reports) from such tools.

The present and past research shows that LLMs can be useful for SEO auditing, but their capabilities are limited in some areas. Such LLMs as ChatGPT, Microsoft Copilot, Gemini Google DeepMind, and Perplexity AI do not have access to analytical data and quality metrics that are necessary to thoroughly assess a website's quality (Król, Zdonek, 2020). LLMs are unable to browse websites to identify technical errors the way crawlers do it. Therefore, their capabilities to conduct sophisticated technical audits (Technical SEO), such as performance or link audits, are limited (Edgar, 2023a). Moreover, LLMs do not generate SEO reports based on the latest or real-time data because they have no access to input from SEO measurement tools. In light of the above, LLMs seem to be best suited for SEO optimisation rather than automated end-to-end SEO auditing. Still, they are continuously developed, and their analytical capabilities may expand significantly soon.

6. Summary

All the tools employed in this research use artificial intelligence algorithms to perform their tasks. Each is designed to interact with the user, who can ask questions or give prompts and receive responses or results in real time. Their signature quality is the conversational user interface. Although all the tools use artificial intelligence, their characteristics differ as they target different users. ChatGPT and Perplexity focus on generating texts, conducting general conversation, and responding to questions, whereas the SEO Audit Tool and Microsoft Copilot concentrate more on work optimisation and data analysis. In addition, ChatGPT and Perplexity are intended for general use, whereas the SEO Audit Tool and Microsoft Copilot target audiences specialising in specific domains.

The research shows that although LLMs have great potential for generating text for various website components, they cannot replace human creativity and critical thinking, which are indispensable in semantic analysis and SEO strategy building. LLMs provide valuable suggestions and tips, which, nevertheless, need to be verified and critically analysed to adapt them to the actual needs of the website. Still, LLMs' ability to automatise processes and generate text may improve SEO effectiveness, making the website more competitive in a rapidly changing online ecosystem. As AI algorithms grow more sophisticated, SEO may find LLMs critical to keep the competitive advantage and effectiveness of optimisation.

SEO is an essential part of the modern marketing strategy for universities. The right SEO techniques combined with result monitoring, also through regular SEO audits, can bring substantial benefits to universities. Effective SEO efforts can have tangible competitive gains, such as improved search engine visibility, brand image and recognition, and promotion and enrolment effectiveness.

6.1. Practical implications and limitations of the study

The study has demonstrated that LLM-based AI tools do not perform SEO audits. They have no analytical tools for investigating website content in real time. They can, however, list items to analyse during corrective activities. The study shows that LLMs can easily generate content for such elements as meta tags or headings (H1, for example). They can also be used to semantically analyse existing textual elements, such as articles, abstracts, summaries, and others, to be optimised. Therefore, a prompt for an LLM tool should be a request to generate textual content or optimise a specific component rather than perform a complete audit. Therefore, LLMs can be useful for optimisation but not quality assessment before optimisation.

The website administrator or editor sometimes blocks access to some server resources. They can also prevent third-parties from analysing the quality of their website. Therefore, it is not always possible to conduct an SEO audit. The primary reasons are security and performance optimisation (reduced server load and use) but also the intention to 'conceal' innovative design solutions. Consequently, many websites do not allow crawlers to inspect their content. The University of Agriculture's website is one of them. Its robots.txt file contains directives locking crawlers (GPT bots included) out of some sections of the website. This was confirmed by the tools used in the study.

Their responses also confirmed that most of them were generated by LLMs from estimations based on big data analysis rather than real-time measurements. They reported that the directives in the robots.txt file locked out crawlers when they attempted to perform a measurement and view the website's content.

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