Enhancing Image SEO using Deep Learning Algorithms: A Research Approach

Marwa Amara

Department of Computer Sciences, Faculty of Sciences, Northern Border University, Saudi Arabia
marwa.amara@nbu.edu.sa (corresponding author)

Radhia Zaghdoud

Department of Computer Sciences, Faculty of Sciences, Northern Border University, Saudi Arabia
radhia.zaghdouud@nbu.edu.sa

Olfa Ben Rhaiem

Department of Computer Sciences, Faculty of Sciences, Northern Border University, Saudi Arabia
offa.moktar@nbu.edu.sa

Ebtihal Abdulmaeen Althubiti

Department of Computer Sciences, Faculty of Sciences, Northern Border University, Saudi Arabia
ebtihal.althubiti@nbu.edu.sa

ABSTRACT

Visual content influences profoundly user interactions and search engine rankings. Traditional SEO techniques, while foundational, often fall short in the swiftly changing search landscape. This paper presents a cutting-edge solution that leverages the power of deep learning and generative AI to redefine image SEO. Through the innovative integration of the AWS Rekognition's image analysis and ChatGPT's advanced natural language processing, we automate and refine the creation of alt-texts, ensuring they are not only precise, but also SEO-enriched. The result is a harmonious blend of technology and strategy that significantly boosts online content discoverability. Using a specific website as a test environment, the proposed methodology demonstrated a profound impact on SEO performance. Initially, no images on the webpage had alt-texts. After applying the AI-driven approach, all images were equipped with descriptive, SEO-optimized alt attributes, markedly improving their visibility in search engine results. These results underscore the effectiveness of integrating advanced AI technologies in SEO strategies, providing a scalable and effective framework for enhancing digital content accessibility and search engine rankings.

Keywords-image SEO; generative AI; alt text automation; deep learning

I. INTRODUCTION

Nowadays, visual content dominates web interactions and necessitates advanced optimization strategies [1]. Image Search Engine Optimization (SEO) has become essential for ensuring the visibility and engagement of online content. Visual resources are pivotal in capturing user engagement in today's digital environment, with their presence often determining the success or failure of user retention. The proficiency of search engines at indexing and displaying these images plays a critical role in influencing web traffic and maintaining user interest [1]. The application of Deep Learning (DL) techniques, as demonstrated in [2-5], showcases the versatility of these technologies in improving system efficiencies. This principle is central to our study, which explores enhancing image SEO through advanced algorithms.

Generative AI is a transformative force that is redefining the field of image processing. Generative AI, powered by DL, offers novel methodologies for extracting and interpreting visual data semantically. The generation of descriptive metadata automatically is a key aspect of search engine algorithms, signaling significant efficiencies in image SEO. However, its practical applications remain nascent and largely unexplored [1]. As the digital age unfolds, image content has emerged as a key player in SEO. It establishes a vital connection between how we discover visuals online and engage with them. Early research laid the groundwork for leveraging visual features to boost search functionalities, but merging DL with image SEO is still relatively new. The contributions of [6], followed by advances from [7] in DL, have set the stage for a more profound exploration of how these technologies can enhance metadata creation (see Table I).

Study	Method	Results
[6]	VGG16	Improved metadata creation accuracy
[7]	CNN	Enhanced alt-text generation precision
[8]	Generative models	Increased image visibility
[9]	ML	Improved overall SEO performance

In this realm, generative AI promises to reshape image SEO, offering automation and refinement of metadata with a level of precision never seen before.

DL's influence on SEO extends to visual content, turning images into more than mere pictures. They become searchable elements, imbued with context. While metadata have always been a staple in SEO, the advent of Machine Learning (ML) and models like Generative Adversarial Networks (GANs) has revolutionized the way we describe images, making them more visible and relatable to users [8]. These AI-crafted descriptions do more than improve visibility; they enhance the search experience with their precision and detail [9]. The disruptive nature of generative AI holds promise for a radical transformation in image SEO. By exploring extensive datasets, AI uncovers the intricate interplay between images and keywords. This allows for the creation of alt-text that goes beyond simple descriptions to truly encapsulate the visual content's essence [10]. Authors in [11] delve into the synergy between generative AI and the complex demands of image SEO. They showcase how cutting-edge ML models can be customized to comprehend and produce the sorts of metadata favored by search engines and how these models perform in actual SEO scenarios.

The SEO journey has come a long way since the introduction of the term in 1991 with the launch of the first website [12]. Originally seen as Search Engine Marketing [13], SEO has evolved into an intricate practice, with the aim of earning top search engine rankings for select keywords [14]. Today's SEO specialists employ sophisticated tools to streamline their work, often automating routine tasks like data collection. The internet's role in promoting businesses has made SEO a fundamental digital marketing strategy, yet the research in this area remains limited [15]. As the web grows, more and more users are finding pages via search engines, making SEO a crucial element of internet marketing strategies that enhance a business's online profile [12]. Enter ChatGPT, an AI phenomenon by OpenAI, garnering attention for its advanced language capabilities [16, 17]. This AI's prowess in natural language processing suggests it may soon play a significant role in SEO, reshaping how websites rank and attract traffic from search engines [18]. Moreover, Large Language Models (LLMs) are proving their worth in e-commerce SEO, and the emergence of generative AI is rapidly altering the digital interactions [19]. To effectively bridge the current divide in SEO practices, this research introduces a generative AI framework designed to revolutionize the optimization of image content. The main concepts of the proposed framework are:

- Sophisticated image analysis and keyword extraction: Utilizing AWS Image Recognition [20], the proposed method performs deep analysis of images. This step allows for the accurate identification and extraction of keywords, which are essential for generating contextually relevant alt text.

- Dynamic alt text generation: Utilizing ChatGPT, we dynamically generate alt text that is finely tuned to meet SEO standards while being richly descriptive and contextually aligned with the content of the images. This process not only improves the accessibility of images but also enhances their relevance and visibility in search results.

- Automated SEO enhancement: The proposed system automates the update of alt attributes across web pages, seamlessly integrating the newly generated alt text into image tags. This automation extends beyond mere text generation to include a strategic enhancement of the webpage's overall SEO fabric, making each image more accessible and effectively indexed by search engines.

II. INTEGRATING GENERATIVE AI AND DL FOR DYNAMIC ALT TEXT GENERATION

The proposed approach introduces an innovative methodology for image SEO enhancement that utilizes the synergy between Natural Language Processing (NLP) and image recognition technologies. By harnessing this synergy, we dynamically generate alt attributes for images that are not only SEO-friendly but also tailored to enhance discoverability in search engine results. Figure 1 presents a systematic DL-driven process to improve the SEO of images by generating precise and impactful alt attributes that heighten search engine visibility and user accessibility.
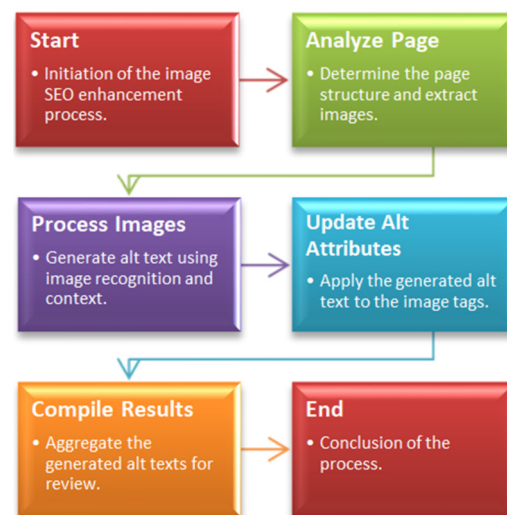

Fig. 1.   Flowchart of the DL-driven process for enhancing image SEO.

Figure 1 offers a concise representation of the AI-infused strategy to elevate image SEO. The process begins with the initial web page analysis, proceeds to image processing utilizing sophisticated AI algorithms, updates alt attributes for SEO enhancement, then compiles the results for comprehensive analysis, and ultimately wraps up the enhancement process.

The proposed methodology effectively integrates DL technologies to optimize image SEO. Specifically, DL is utilized through AWS Image Recognition, which employs sophisticated neural network models to accurately identify and extract keywords from images. This step is crucial as it feeds into the generation of contextually relevant alt text for each image. Additionally, ChatGPT is used to dynamically generate the alt text itself. ChatGPT operates on the principles of DL, utilizing a vast network of trained neural pathways to produce natural language outputs that are not only relevant but also finely tuned to enhance SEO. This use of generative DL models ensures that the alt text is not only descriptive and relevant but also optimized for search engines. This integration of advanced DL technologies with the generative AI approach culminates in the process illustrated in Figure 2. The Figure provides a detailed view of how each component contributes to the generation of SEO-enhanced alt text. From the initial image analysis to the dynamic alt text generation, each step is clearly illustrated. This visual representation underscores the seamless interaction of each stage, ensuring a coherent understanding of how the methodology enhances image discoverability in search engine results.
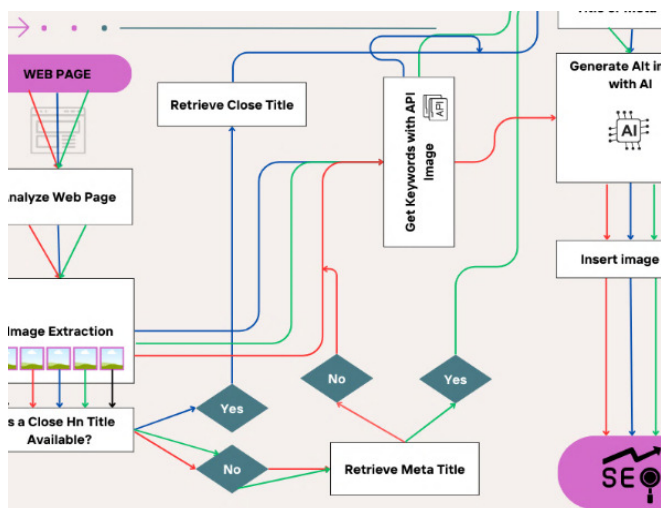
Fig. 2.   Detailed process diagram of AI-generated alt text creation.

The process outlined in Figure 2 begins with a thorough analysis of the web page's structure to identify all images. This crucial step determines whether the page features a coherent layout with headings that provide contextual information, directly influencing the subsequent generation of alt text or lacks such structure. A "structured" page features distinct headings close to images, providing clear contextual clues. An "unstructured" page, on the other hand, lacks these headings, necessitating alternative methods for context derivation. This assessment directly impacts the approach for generating alt text. Depending on the page structure, each image is processed using a tailored method:

- Structured Page: For pages with clear headings near images, the algorithm detects the closest heading to ensure contextual relevance. The image is then analyzed by AWS Recognition. It identifies objects, scenes, and activities

within the image and generates a list of relevant keywords, complete with confidence percentages (see Figure 3). These keywords are then seamlessly combined with the contextual heading to create descriptive, context-rich alt text that is optimized for search engines.

Fig. 3.   An example of AWS Recognition output.

- Unstructured Page: In the absence of a structured layout, the algorithm utilizes the page's meta title as a contextual anchor. If a meta title is unavailable, it defaults to a generic context. This analysis leverages AWS Recognition's capability to detect visual elements and activities, ensuring that the alt text generated is relevant even in less structured environments. This approach ensures that each image is accompanied by alt text that enhances its discoverability and relevance in the search results. The keywords are then extracted from the image using the same image recognition API, and the alt text is generated based on these keywords, ensuring relevance even in less structured environments.

Central to the proposed approach is the automated updating of the alt attribute for each image. By integrating the generated alt text into the image tags, this step ensures that images are not only accessible but also optimally indexed by search engines.

Leveraging the SEO best, we construct commands for the ChatGPT API. ChatGPT's capabilities in NLP are employed to synthesize the extracted keywords and contextual titles into effective alt text. The API integrates its extensive pre-trained knowledge base with current SEO rules to recommend optimal

keyword combinations and generate content that adheres to the highest SEO standards. To generate SEO-optimized alternative texts, we followed these steps:

1. SEO Reference: We used the principles from an article from Semrush as the main guideline for optimizing alternative texts [21].

2. Title Retrieval: We extract the title from each paragraph containing an image. If no paragraph title is available, we used the page title.

3. Command Creation: We use the best SEO practices from the Semrush article to create the command (see Figure 4). ChatGPT API can analyze articles from websites like Semrush by integrating knowledge acquired during its training. It uses this information to recommend best practices for keyword combination and content generation, adhering to established SEO rules.


```
$title = "Nature and Landscape";
$keywords = [
    "Nature (100%)",
    "Outdoors (100%)",
    "Scenery (100%)",
    "Mountain (100%)",
    "Mountain Range (100%)",
    "Peak (99.95%)",
    "Landscape (99.9%)",
    "Panoramic (92.27%)"
];
$instructions = "Generate an alt text by combining these keywords and the title for a natural landscape image, following the best SEO practices from the Semrush article.";
$articleUrl = "https://www.semrush.com/blog/image-seo";
```

Fig. 4.   Alternate text prompt.

Algorithm 1 delineates the precise mechanics of our AI-driven methodology for generating SEO-friendly alt text.

```
Algorithm 1: Optimize Image Alt Texts
using AI Technologies
Input: Webpage URL containing images
Output: Webpage with updated alt
attributes for images
1: Extract Images(I) from Webpage(URL)
2: FOR each image i ∈ I DO
3:    context C ← FindContext(i)
4:    keywords K ←AWS_Image_Recognition(i)
5:    dscription D ← ChatGPT(C, K)
6:    UpdateAltAttribute(i, D)
7: END FOR
8: Return Updated Webpage
```

Algorithm 1 utilizes both AWS Image Recognition for keyword extraction and ChatGPT for NLP, demonstrating the integration of these advanced technologies in the proposed approach. The steps taken from the initial webpage analysis through to the final application of the optimized alt attributes are outlined.

III.   EXPERIMENTAL RESULTS AND VALIDATION

To validate the effectiveness of the DL-driven methodology for enhancing image SEO, we selected a specific website to serve as a test environment. All images used for testing were created using AI to ensure consistency and control in the experimental setup. The test webpage, which includes these AI-generated images, is available for review at [https://project.acad-heni.com/]. This setup provides a clear demonstration of how the proposed methodology improves the alt text generation and overall SEO performance of digital content. The ContentForest Image Alt Text Checker offered a

detailed examination of the webpage's image attributes, flagging images that were missing alt text. The tool's findings, depicted in Figure 5, revealed that none of the webpage's images had alt text assigned. This presented a prime opportunity to demonstrate the efficacy of the DL approach in enhancing image SEO and improving web accessibility.

Fig. 5.   Pre-optimization alt text analysis using the content forest.

Following the initial analysis, we developed and utilized a tool that automatically identifies the most closely related title to each image, ensuring that the generated alt text is not only descriptive but contextually relevant. The tool scans the webpage and analyzes the proximity of textual content to images. It detects the nearest heading tags (such as h1, h2, h3) relative to each image, providing a clear indication of the associated context. This approach is rooted in the understanding that images often relate to adjacent content, which is crucial for formulating accurate and effective alt text. Figure 6 exemplifies the initial stage of the AI-driven methodology, where our custom-developed tool scans the test webpage to analyze the proximity of textual content to images. The alt fields are blank to underscore that this step focuses solely on linking images with their relevant textual contexts, setting the stage for the next phase where alt texts are dynamically generated based on this foundational data.

Fig. 6.   Alignment between images and web page content.

Building on the precise context detection, the proposed methodology integrates AWS Image Recognition to further refine the alt text generation process. This DL-powered service examines each image, identifying key elements and assigning confidence scores that reflect the accuracy of these identifications.

Figure 7 depicts the AWS Image Recognition tool at work, where it evaluates an image to detect and assign relevance scores to various keywords. For instance, it discerns elements such as "Nature" and "Mountain" with a high degree of certainty. This functionality is instrumental in the proposed methodology. It lays the groundwork for generating alt attributes that not only accurately describe the image content but also enhance the SEO framework of the webpage by leveraging precise keyword integration.

Fig. 7.   AWS image recognition: System's confidence levels in classifying landscape features.

Building on the analytical strengths of AWS Image Recognition, we incorporated an image keyword recognition feature that significantly enhances the precision of the SEO optimization process. This feature thoroughly examines each image and lists relevant keywords that are most likely to be associated with the image content. The proposed methodology, as exemplified in Figure 8, illustrates how this tool not only identifies but also quantifies the relevance of each keyword, contributing to a more robust and targeted alt text generation.

Following the image recognition step, we utilized the innovative AI capabilities of ChatGPT to generate descriptive alt texts. Based on the keywords identified by AWS Image Recognition, ChatGPT crafted coherent and SEO-optimized alt texts that encapsulate the essence of each image. The newly added alt texts, now integrated into the web page's image tags, serve to enhance the accessibility for visually impaired users

and improve the overall SEO performance of the site. Figure 9 displays the images accompanied by their generated alt descriptions, demonstrating the practical application and effectiveness of the proposed approach. The final step in the proposed methodology is the application of the generated alt text to the images on the webpage. As shown in Figure 10, the previously identified keywords and context are synthesized into descriptive alt text by the AI-driven process. This alt text is now embedded within the image tags, effectively updating the webpage's HTML to enhance search engine indexing and improve web accessibility.


Fig. 8.   Enhancement of SEO optimization through keyword recognition.

Fig. 9.   Alt texts generated by integrating AWS image recognition and ChatGPT.

After applying the AI-driven methodology to generate and integrate alt attributes into the webpage, we conducted a post-implementation audit using the ContentForest image alt text checker. This tool re-evaluated the webpage to ensure that each image now possessed an AI-generated alt text that adhered to SEO best practices. The checker, as shown in Figure 11, confirmed the presence of alt attributes for all images, validating the successful application of the proposed approach and demonstrating its practical utility in enhancing web accessibility and SEO. The synthesized report from the ContentForest confirmed the AI-generated alt texts to be both descriptive and aligned with SEO best practices. For instance, an image previously lacking an alt attribute was assigned "Panoramic view of a scenic mountain range," reflecting the AI's capacity to contextualize and describe image content effectively. The bar chart in Figure 12 visually represents the transformation in the alt tag status of images on the target website. Following the outlined process, each image was successfully equipped with a descriptive alt tag, underscoring the effectiveness of the proposed approach in enriching web content for better SEO performance.

Fig. 10.   Integration of AI-generated alt text into webpage image tags.

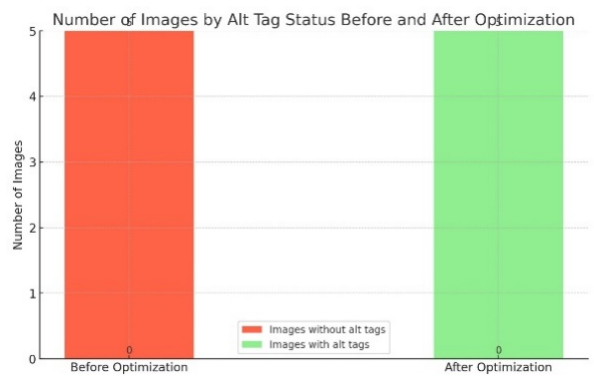Fig. 11.   Validation of the AI-generated alt text using the ContentForest.

Fig. 12.   Comparative analysis of image alt tag implementation pre and post AI-enhancement.

The transition from a complete absence of alt tags to their full-fledged implementation signifies not just a technical enhancement but also marks an advancement in making web content more accessible and SEO-compliant.

IV.   DISCUSSION

To assess the effectiveness of an SEO article, a comprehensive audit examining multiple aspects is usually necessary. However, in our specific case of alternative texts for images, we limited ourselves to using well-established references such as Semrush, the confidence values from AWS Recognition, and the analytical capabilities of GPT. These tools ensured the quality and relevance of the generated alt texts. To assess the effectiveness of SEO, it is crucial to consider the entire page or article, not just a few images. In our scenario, although the experiment involved only five images, it is important to note that AWS Recognition and GPT have the capability to process and optimize content on an image-by-image basis. Each image is individually analyzed and optimized for SEO based on robust references, ensuring a consistent and precise approach to improving the overall SEO of the page, regardless of the number of images.

V.   CONCLUSION

This paper has demonstrated an innovative AI-enhanced approach to improving image SEO through the integration of DL and NLP technologies. By utilizing AWS Image Recognition and ChatGPT, we have not only automated the creation of SEO-friendly alt text but have also aligned these processes with the dynamic algorithms of search engines, marking a significant step forward in SEO practices.

Results indicate a substantial increase in the visibility and accessibility of images on the tested website, showcasing the potential of the proposed methodology to transform digital marketing strategies. The automation of alt text generation is particularly promising, as it supports more scalable and effective SEO practices, ensuring that digital content is both accessible and optimized for search engine algorithms.

Future studies could extend the proposed approach to different types of digital content, such as videos and interactive media, to broaden the scope of AI applications in SEO. Additionally, the long-term effects of AI-driven SEO on user

engagement and search engine rankings warrant further investigation.

ACKNOWLEDGMENT

REFERENCES

[1] D. Lewandowski and S. Schultheiß, "Public awareness and attitudes towards search engine optimization," *Behaviour & Information Technology*, vol. 42, no. 8, pp. 1025–1044, Jun. 2023, https://doi.org/10.1080/0144929X.2022.2056507.

[2] A. S. Alkarim, A. S. A.-M. Al-Ghamdi, and M. Ragab, "Ensemble Learning-based Algorithms for Traffic Flow Prediction in Smart Traffic Systems," *Engineering, Technology & Applied Science Research*, vol. 14, no. 2, pp. 13090–13094, Apr. 2024, https://doi.org/10.48084/etasr.6767.

[3] C. Atheeq, R. Sultana, S. A. Sabahath, and M. A. K. Mohammed, "Advancing IoT Cybersecurity: Adaptive Threat Identification with Deep Learning in Cyber-Physical Systems," *Engineering, Technology & Applied Science Research*, vol. 14, no. 2, pp. 13559–13566, Apr. 2024, https://doi.org/10.48084/etasr.6969.

[4] W. Ismaiel, A. Alhalangy, A. O. Y. Mohamed, and A. I. A. Musa, "Deep Learning, Ensemble and Supervised Machine Learning for Arabic Speech Emotion Recognition," *Engineering, Technology & Applied Science Research*, vol. 14, no. 2, pp. 13757–13764, Apr. 2024, https://doi.org/10.48084/etasr.7134.

[5] M. Amara, N. Smairi, S. Mnasri, and A. Zidouri, "Revitalizing Arabic Character Classification: Unleashing the Power of Deep Learning with Transfer Learning and Data Augmentation Techniques," *Arabian Journal for Science and Engineering*, Mar. 2024, https://doi.org/10.1007/s13369-024-08818-9.

[6] M. N. A. Khan and A. Mahmood, "A distinctive approach to obtain higher page rank through search engine optimization," *Sādhanā*, vol. 43, no. 3, Mar. 2018, Art. No. 43, https://doi.org/10.1007/s12046-018-0812-3.

[7] R. Asrigo and E. R. Kaburuan, "Improving E-Commerce Website Rank Using Search Engine Optimization (SEO)," *International Journal of Intelligent Systems and Applications in Engineering*, vol. 12, no. 14s, pp. 430–440, Feb. 2024.

[8] M. Iqbal, M. Noman, Engr. Dr. A. Manzoor, and M. Muneeb Abid, "Search Engine Optimization (SEO): A Study of important key factors in achieving a better Search Engine Result Page (SERP) Position," *Sukkur IBA Journal of Computing and Mathematical Sciences*, vol. 6, pp. 1–15, Jul. 2022, https://doi.org/10.30537/sjcms.v6i1.

[9] M. Poturak, D. Keco, and E. Tutnic, "Influence of search engine optimization (SEO) on business performance: Case study of private university in Sarajevo," *International Journal of Research in Business and Social Science (2147-4478)*, vol. 11, no. 4, pp. 59–68, 2022.

[10] A. Erdmann, R. Arilla, and J. M. Ponzoa, "Search engine optimization: The long-term strategy of keyword choice," *Journal of Business Research*, vol. 144, pp. 650–662, May 2022, https://doi.org/10.1016/j.jbusres.2022.01.065.

[11] K. Kowalczyk and T. Szandala, "Enhancing SEO in Single-Page Web Applications in Contrast With Multi-Page Applications," *IEEE Access*, vol. 12, pp. 11597–11614, 2024, https://doi.org/10.1109/ACCESS.2024.3355740.

[12] E. Fubel, N. M. Groll, P. Gundlach, Q. Han, and M. Kaiser, "Beyond Rankings: Exploring the Impact of SERP Features on Organic Click-through Rates." arXiv, May 31, 2023, https://doi.org/10.48550/arXiv.2306.01785.

[13] P. S. Grover and L. Ahuja, "An overview of search engine optimization," presented at the 2021 9th International Conference on Reliability, Infocom Technologies, 2021.

[14] S. Sharma, S. P. Panda, and S. Verma, "Role and analysis of various SEO strategies to improve website ranking," presented at the 2022 International Conference on Machine Learning, Big Data, Cloud and Parallel Computing (COM-IT-CON), Vol. 1, IEEE, 2022.

[15] J.-C. Chen, "State-of-the-art in the search engine optimisation world," in EuroMed Journal of Management, vol. 5, no. 2, pp. 151-167, 2023.

[16] T. Wu et al., "A brief overview of ChatGPT: The history, status quo and potential future development," IEEE/CAA Journal of Automatica Sinica, vol. 10, no. 5, pp. 1122-1136, 2023.

[17] K. Cutler, "ChatGPT and search engine optimisation: The future is here," Applied Marketing Analytics, vol. 9, no. 1, pp. 8-22, 2023.

[18] G. Chodak and K. Błażyczek, "Large Language Models for Search Engine Optimization in E-commerce," in *Advanced Computing (IACC 2023)*, 2024, pp. 333–344, https://doi.org/10.1007/978-3-031-56700-1_27.

[19] S. Feuerriegel, J. Hartmann, C. Janiesch, and P. Zschech, "Generative AI," *Business & Information Systems Engineering*, vol. 66, no. 1, pp. 111–126, Feb. 2024, https://doi.org/10.1007/s12599-023-00834-7.

[20] A. Wittig and M. Wittig, *Amazon Web Services in Action, Third Edition: An in-depth guide to AWS*, Shelter Island, NY, USA: Manning, 2023.

[21] R. Handley, S. Go, and Z. Paruch, "Image SEO: How to Optimize Images for Search Engines & Users," *Semrush Blog* (updated regularly), https://www.semrush.com/blog/image-seo.