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Evaluating the efficiency of using ChatGPT and Google Services for scientific search

This research is devoted to comparison of ChatGPT and Google Search Engine in information retrieval efficiency, accuracy, and user experience. Through experiments and user studies, the study assesses their performance in various tasks, including question answering and dialogue interactions. Key metrics like response time, result relevance, query comprehension, and user satisfaction are compared, highlighting the strengths and weaknesses of each system. ChatGPT stands out in natural language understanding and personalized interactions, whereas Google Search Engine excels in quickly retrieving vast web information accurately. The findings offer insights into AI-driven conversational agents and traditional search engines, guiding the development of better information retrieval systems and enhancing online user experiences.

Key words: *large language model, metacognitive self-regulated learning, search engine, ChatGPT, Google services, response time, query comprehension.*

Introduction

Nowadays, amidst the ongoing prioritization of processing large volumes of real-time data, ChatGPT and Google.com stand out as key players in information retrieval and dissemination. ChatGPT, being recognized as a large language model (LLM) for research application, is widely applied in various domains [1–7]. The quantitative analysis of the impact of ChatGPT on human skills was proposed in work [1], which aimed to assess the extent to which ChatGPT influences various aspects of human cognitive abilities and communication proficiency. It was noted that scientists should consider ChatGPT as an additional tool to facilitate the production of higher quality scientific articles more expeditiously [2], thereby potentially augmenting the efficiency of scholarly discourse and re-

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search dissemination. Works [3, 4] also state that projecting the future applicability of ChatGPT in the cementitious composites sector. Thereby ChatGPT was used for mixed-method study explores the acceptance of ChatGPT as a tool for metacognitive self-regulated learning (MCSRL) among academics, and in work [5, 6] it was used to structure the reports, task resolution with ChatGPT. On the other hand Google search engine is known for its widespread accessibility and ability to swiftly retrieve diverse data from various sources. Its role in the production of scientific articles lies in providing access to up-to-date and verified information for research and literature review purposes. Many researchers employ Google Search Engine to search for scholarly articles, gather information for literature reviews, and seek validation for their assertions. Thereby, ChatGPT excels in natural language understanding and personalized interactions, while Google Search Engine retrieves vast amounts of web information quickly and accurately. The findings provide insights into AI-driven conversational agents and traditional search engines, informing the development of more effective information retrieval systems and improving user experiences online.

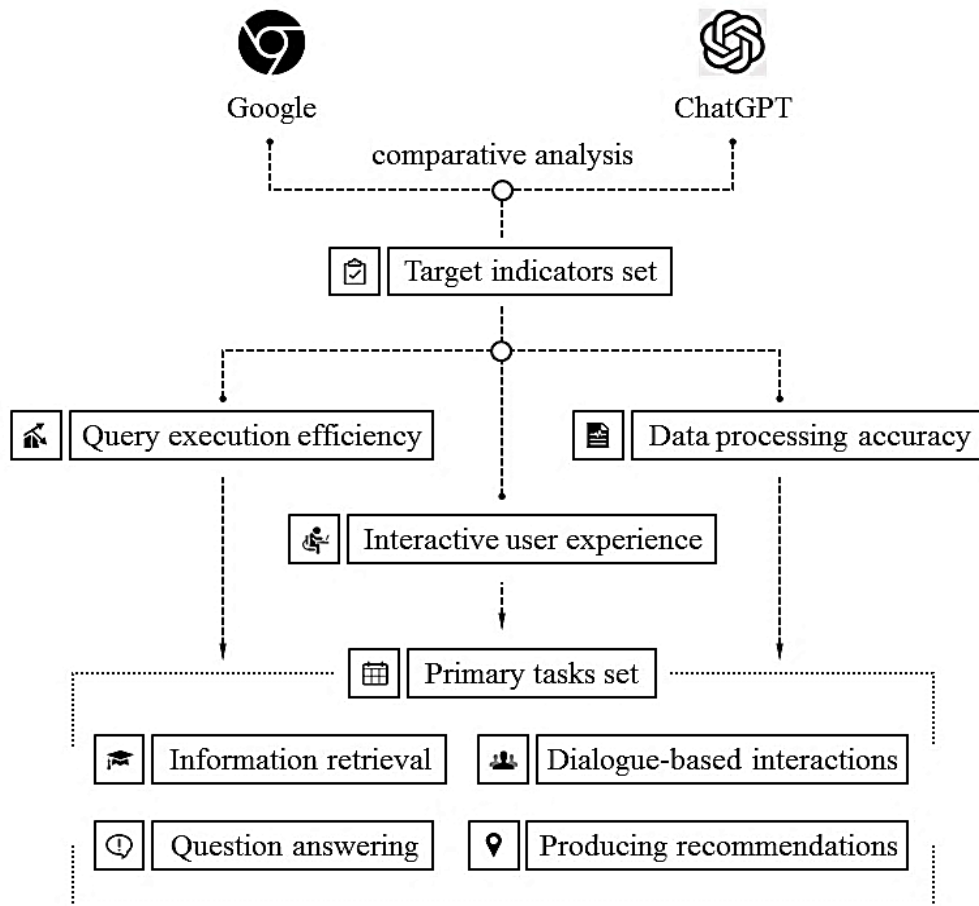


Fig. 1. Diagram of conducting comparative analysis between ChatGPT and Google Search Engine based on target indicators set

Therefore, **the aim of the study** is to conduct a comparative analysis of ChatGPT and Google Search Engine, focusing on efficiency, accuracy, and user experience

(Fig. 1). Through experiments and user studies, the study evaluates their performance in information retrieval, question answering, producing recommendations, and dialogue-based interactions. Key metrics such as response time, result relevance, query comprehension, and user satisfaction are compared, revealing strengths and weaknesses of each system [8].

1. Comparative Analysis: ChatGPT and Google Search Engine for Information Retrieval

In this study, we will compare ChatGPT system and Google Search Engine, aiming to ascertain their effectiveness in analyzing the Asian LED market. The findings of this comparative analysis will assist businesses in making informed decisions regarding the utilization of tools to ensure access to the most relevant and reliable information. The preliminary analysis conducted using the Google Search Engine allowed us to identify the key players in the Asian LED market, including:

1. Vietnam LED lighting market [8]. The Vietnam LED lighting market size reached US\$ 647,6 Million in 2022. Looking forward, IMARC Group expects the market to reach US\$ 982,8 Million by 2028, exhibiting a growth rate (CAGR) of 7 % during 2023–2028.

2. The Philippines LED lighting market [9]. The Philippines LED lighting market reached a market size of almost USD 425 million in the year 2020. The Philippines LED lighting industry is further expected to grow at a CAGR of 13 % between 2021 and 2026 to reach a value of almost USD 884,8 million by 2026.

3. India LED lighting market [10]. The Indian LED lighting market reached a value of US\$ 2.8 Billion in 2021. Looking forward, IMARC Group expects the market to reach US\$ 9.7 Billion by 2027, exhibiting a CAGR of 23.31 % during 2022–2027.

In the context of Google Search Engine, valuable information is often found in reports, which typically require a substantial monetary investment ranging from \$2000 to \$5000 per report. However, it's worth noting that certain segments of these reports are publicly accessible, offering essential insights into market trends and conditions without the need for full purchase. These excerpts provide sufficient information to grasp common trends and market situations. Conversely, ChatGPT offers a distinct approach (Tables 1 and 2). It swiftly provides welcome insights into specific markets of various countries, offering a comprehensive view of market conditions across regions such as Asia, America, and Europe. However, ChatGPT limitations become apparent when seeking in-depth information or comprehensive analyses. It lacks the capability to furnish extensive numerical data, graphical representations, or trend analyses. Nonetheless, its ability to rapidly retrieve essential information remains highly valuable.

Comprehensive analysis includes data pertaining to Google Search and ChatGPT in the LED Asian market. For Google Search, a selective presentation of data is provided, omitting the extensive and costly reports that encompass approximately 100 pages each. While the initial ten pages are accessible without charge, they offer a profound and comprehensive analysis featuring abundant numerical data. Moreover, these reports can be continuously updated in real-time and span across multiple years, enabling comparisons between past forecasts and present circumstances. This functionality facilitates a deeper understanding of market trends over time, a feature that ChatGPT lacks. Conversely, ChatGPT swiftly furnishes a wealth of essential information, although its output is

condensed and primarily presented in tabular form for comparison purposes. This enables rapid assessments across different countries within the LED market.

Table 1. Comprehensive analysis of the Asian LED market (A-N countries) using ChatGPT 3.5 and 4.0

Country	Annual grow rate, %	Size, billions USD	Notes
Afghanistan	N/A	0,002	Data obtained based on ChatGPT
Bangladesh	N/A	1	Data obtained based on ChatGPT
Bhutan	5,3	0,08	Data obtained based on ChatGPT
Brunei	8	0,7681	Data obtained based on ChatGPT
Cambodia	N/A	0,03	Data obtained based on ChatGPT
China (Mainland)	10,9	20	Data obtained based on ChatGPT
India	10,4	14,5	Data obtained based on ChatGPT
Indonesia	8	2,2	Data obtained based on ChatGPT
Indonesia	20	0,389	Data obtained based on ChatGPT
Iran	10,3	0,1	Data obtained based on ChatGPT
Iraq	N/A	N/A	Data obtained based on ChatGPT
Israel	7,2	0,122	Data obtained based on ChatGPT
Japan	3,7	6,8	Data obtained based on ChatGPT
Jordan	N/A	0,5	Data obtained based on ChatGPT
Kazakhstan	16,7	0,02	Data obtained based on ChatGPT
Kuwait	N/A	0,014	Data obtained based on ChatGPT
Kyrgyzstan	N/A	0,08	Data obtained based on ChatGPT
Laos	N/A	N/A	LEDs are 0.2% from light market
Malaysia	7,9	0,5993	Data obtained based on ChatGPT
Mongolia	N/A	N/A	No statistics in the Internet
Myanmar	N/A	0,006	Data obtained based on ChatGPT
North Korea	N/A	N/A	No statistics in the Internet
Nepal	7	0,015	Data obtained based on ChatGPT

This enables rapid assessments across different countries within the LED market. However, there are limitations regarding data availability for certain countries, notably North Korea. Despite these disparities, ChatGPT excels in providing immediate insights, albeit with a focus on essential information rather than in-depth analysis or historical

comparisons. It is important to acknowledge that while data obtained from Google correlates with that acquired through ChatGPT, there are discrepancies in the exact numerical values. Although trends remain consistent across both sources, the specific numerical data may vary. This indicates that while ChatGPT can accurately identify overarching trends and general market conditions, it lacks precision when it comes to specific numerical figures. Consequently, any numerical data provided by ChatGPT should be cross-checked for accuracy. Nonetheless, researchers can rely on the trends identified by ChatGPT, bearing in mind its limitations in accessing real-time online information. ChatGPT operates primarily based on its internal databases and algorithms, which may not always yield precise or accurate numerical data. However, its strengths lie in providing valuable insights and trends rather than exact numerical figures.

Table 2. Comprehensive analysis of the Asian LED market (O-Z countries) using ChatGPT 3.5 and 4.0

Country	Annual grow rate, %	Size, billions USD	Notes
Oman	N/A	0,013	Data obtained based on ChatGPT
Pakistan	21,77	0,118	Data obtained based on ChatGPT
Qatar	12,2	0,22	Data obtained based on ChatGPT
South Korea	11,7	11,06	Data obtained based on ChatGPT
Saudi Arabia	13,2	2,01	Data obtained based on ChatGPT
Singapore	6,4	0,8153	Data obtained based on ChatGPT
Sri Lanka	6,2	0,09	Data obtained based on ChatGPT
Syria	9,7	0,003	Data obtained based on ChatGPT
Tajikistan	N/A	0,08	Data obtained based on ChatGPT
Thailand	13,3	8,8	Data obtained based on ChatGPT
The Philippines	10,5	0,89	Data obtained based on ChatGPT
Turkey	N/A	2,2	Data obtained based on ChatGPT
Turkmenistan	N/A	0,1	Data obtained based on ChatGPT
UAE	10	4	Data obtained based on ChatGPT
Uzbekistan	N/A	N/A	<i>No statistics in the Internet</i>
Vietnam	5,5	0,6	Data obtained based on ChatGPT
Yemen	N/A	0,02	Data obtained based on ChatGPT

It is imperative to acknowledge that the ChatGPT managed to access information pertaining to countries such as Yemen, Tajikistan and Turkmenistan, which were not readily obtainable through conventional Google Search methods.

2. Comparative analysis: ChatGPT and Google Search Engine for information retrieval

The next task involves conducting a Comparative Analysis of ChatGPT and the Google Search Engine for information retrieval in the domain of signal processing in near-infrared (NIRs) technology. At the initial stage, results were obtained for the ChatGPT 3.5 service, resulting in three text blocks (Table 3). In turn, the application of the ChatGPT 4.0 service enabled the retrieval of four blocks of structured data, each accompanied by a title (Table 4).

Table 3. Signal processing in NIRs technology information retrieval results (ChatGPT 3.5)

№	Text blocks
1	Near-infrared spectroscopy (NIRS) is a non-invasive optical technique used to measure the oxygen saturation (SpO ₂) levels in human tissue. This technology relies on the principle that different molecules absorb light at specific wavelengths. In the case of NIRS, near-infrared light is directed into the tissue, and the amount of light that is absorbed and scattered is measured.
2	Hemoglobin, the protein responsible for carrying oxygen in the blood, has different absorption characteristics depending on its oxygenation state. By measuring the absorption of near-infrared light, NIRS can determine the levels of oxygenated and deoxygenated hemoglobin in the tissue, allowing for the calculation of SpO ₂ .
3	NIRS technology has various applications in medicine, including monitoring oxygen levels in brain tissue during surgery, assessing tissue perfusion in critical care settings, and monitoring muscle oxygenation during exercise. Its non-invasive nature and ability to provide real-time data make it a valuable tool in clinical practice.

Finally, the utilization of the Google Search Engine provided a list of references to scientific research in the specified field:

1. Monitoring tissue oxygenation by near infrared spectroscopy (NIRS): background and current applications [11].
2. Measuring human tissue oxygenation with near infrared spectroscopy [12].
3. Noninvasive Tissue Blood Oxygenation Measurement Based on Near Infrared Spectroscopy [13].
4. Detection of hypoxia by near-infrared spectroscopy and pulse oximetry: a comparative study [14].
5. Near-infrared spectroscopy as an index of brain and tissue oxygenation [15].
6. Near Infrared Spectroscopy: Introduction. Theory [16].

A noticeable distinction arises when comparing the outcomes presented above with those generated by ChatGPT. Notably, Google predominantly yields results encompassing technical details derived from published scientific papers, medical studies, and empirical investigations. Conversely, ChatGPT's outcomes diverge by primarily furnishing generic information on NIRS technology, omitting crucial findings accessible through Google links. Such findings include insights into biological windows within the optical spectrum facilitated by NIRS technology, signal processing methodologies utilizing locking amplification technology, and various other pertinent details. Consequently, ChatGPT's outcomes serve to offer researchers a cursory understanding of the topic,

eschewing in-depth analyses, case studies, and specific medical instances. However, ChatGPT excels in swiftly addressing key thematic concerns, furnishing rudimentary yet essential insights into the technology under scrutiny.

Table 4. Signal processing in NIRs technology information retrieval results (ChatGPT 3.5)

№	Text blocks
1	<p>Introduction. Near-infrared spectroscopy (NIRS) technology is an innovative method widely used in the medical field to measure the oxygen saturation (SpO₂) in human tissues. It is a non-invasive, painless procedure that uses light to monitor the oxygenation and hemodynamics in the body's tissues, including muscle and brain tissue. This technique is particularly beneficial for its ability to continuously and dynamically assess the oxygen status in various clinical settings, offering insights for patient care.</p>
2	<p>How NIRS Works. NIRS technology relies on the principle that oxygenated and deoxygenated hemoglobin in the blood absorb near-infrared light differently. By directing near-infrared light (usually wavelengths between 700 to 900 nanometers) into the tissue and detecting the amount of light absorbed or scattered, NIRS devices can calculate the concentration of oxygenated hemoglobin (HbO₂) and deoxygenated hemoglobin (HHb) in the blood. The ratio or difference between these concentrations is then used to estimate tissue oxygen saturation (StO₂), which is somewhat analogous to peripheral oxygen saturation (SpO₂) measured by conventional pulse oximetry, but with a focus on tissue rather than arterial blood oxygenation.</p>
3	<p style="text-align: center;">Applications of NIRS</p> <p>Neonatology: NIRS is extensively used in neonatal care to monitor the cerebral oxygenation of premature infants. It helps in detecting and managing potential risks of brain injuries due to inadequate oxygenation.</p> <p>Cardiac Surgery: During cardiac surgeries and other procedures requiring cardiopulmonary bypass, NIRS monitors the cerebral oxygen saturation, providing critical information about the patient's brain oxygenation status, which can guide interventions to prevent neurological damage.</p> <p>Intensive Care Units (ICUs). NIRS is useful in critically ill patients for monitoring tissue oxygenation and guiding therapeutic decisions, especially in cases where traditional pulse oximetry might not be reflective of the peripheral tissues' oxygenation.</p> <p>Sports Medicine and Physical Therapy: NIRS is also applied in the field of sports medicine to assess muscle oxygenation and hemodynamics during exercise, aiding in the optimization of training programs and recovery strategies.</p>
4	<p style="text-align: center;">Advantages and Limitations</p> <p>The main advantage of NIRS technology is its non-invasiveness and the ability to provide real-time monitoring of tissue oxygenation. However, it does have limitations, including sensitivity to motion artifacts and potential inaccuracies when there is a significant presence of nonoxygenated hemoglobin or in conditions with abnormal tissue perfusion. The interpretation of NIRS data can also be complicated by individual variations in anatomy and physiological conditions.</p> <p>In summary, NIRS technology represents a powerful tool in measuring tissue oxygenation (SpO₂) and offers a wealth of opportunities for enhancing patient care across a spectrum of medical disciplines. Its non-invasive nature and ability to provide real-time data make it invaluable for monitoring and managing various health conditions.</p>

3. ChatGPT and Google Search Engine comparative analysis results

When comparing ChatGPT with Google.com (specifically in the context of information retrieval and engagement), both platforms offer unique advantages and face certain shortcomings.

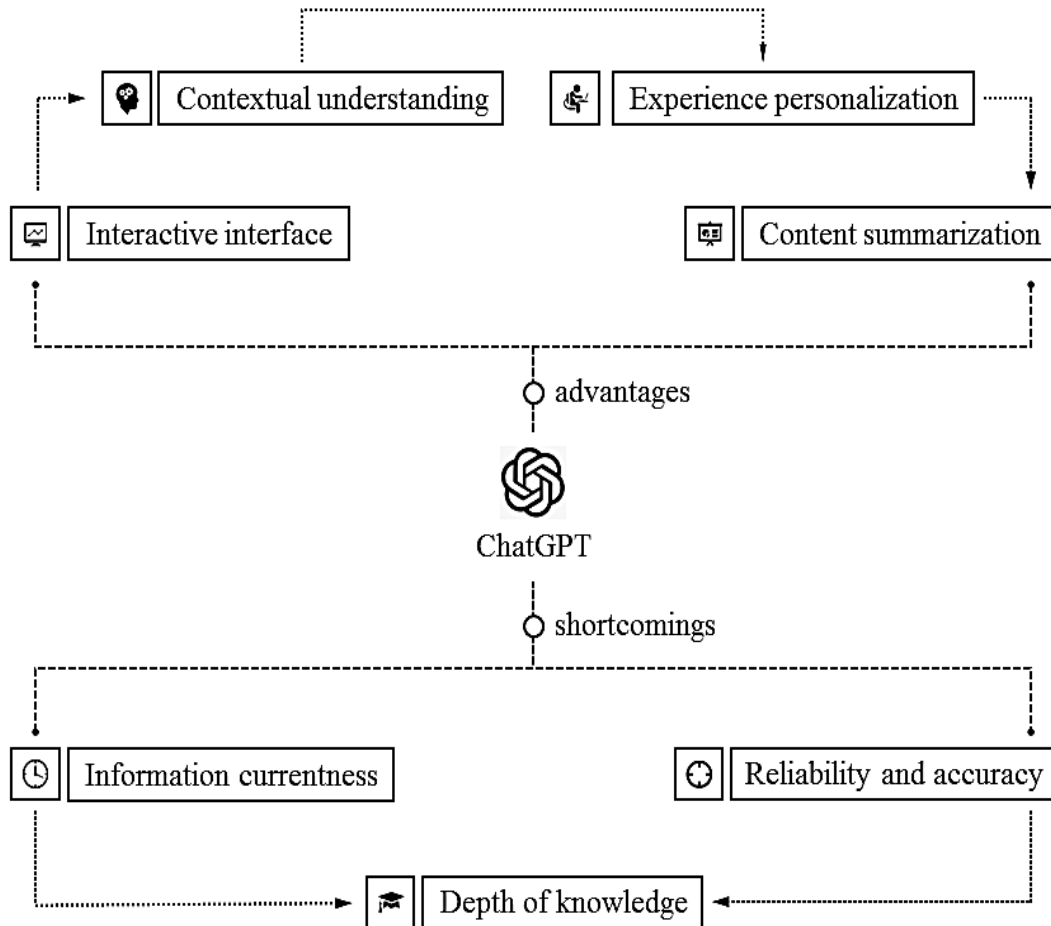


Fig. 2. Diagram of the effectiveness assessment of ChatGPT services application in scientific research

In particular, the following ChatGPT advantages can be highlighted (Fig. 2):

- interactive interface: ChatGPT provides a conversational interface, enabling users to ask follow-up questions or clarify previous answers in a seamless manner;
- contextual understanding: it can maintain context over the course of a conversation, which can lead to more accurate and relevant responses as the conversation progresses;
- experience personalization: though constrained by privacy and ethical guidelines, ChatGPT can tailor responses based on the immediate context of the conversation, offering a more personalized interaction;
- content creation and summarization: beyond just finding information, ChatGPT is adept at generating content, summarizing complex topics, and even creating text based on specific requirements or styles.

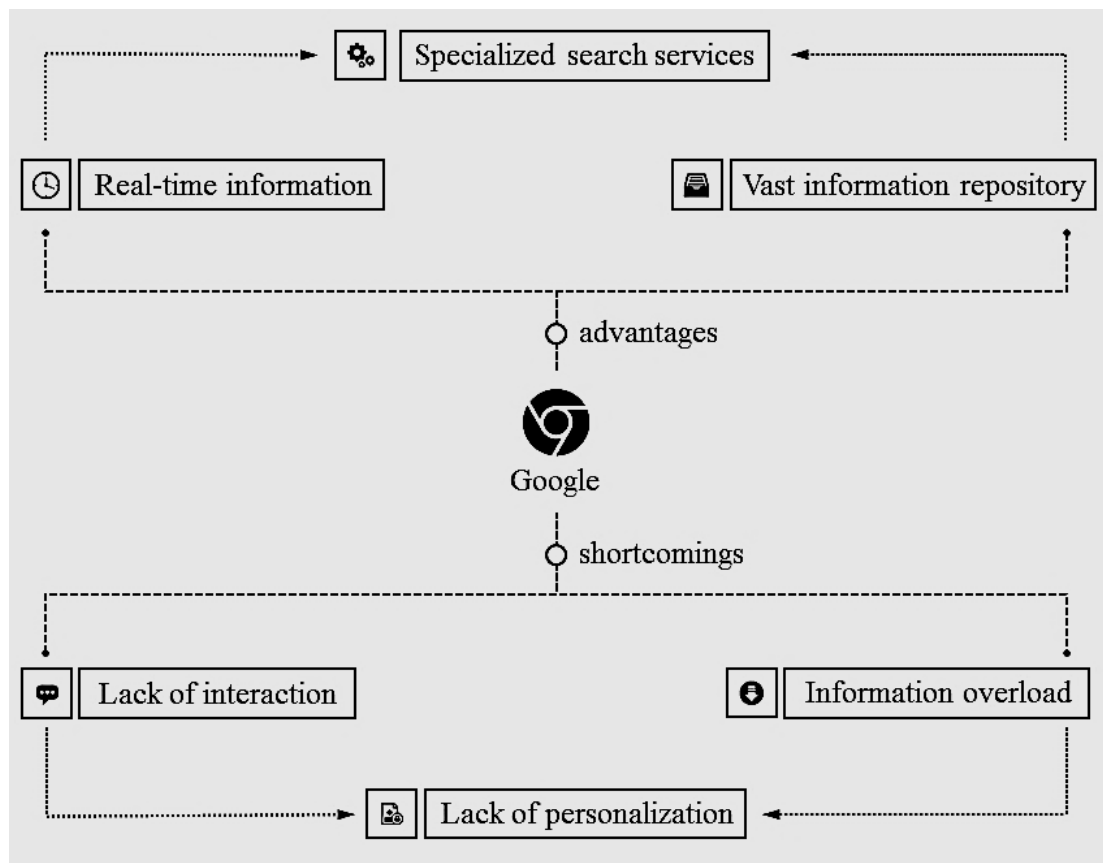


Fig. 3. Diagram of the effectiveness assessment of Google Search Engine services application in scientific research

However, it is also necessary to mention some shortcomings which are typical for ChatGPT services (Fig. 2):

- currentness of information: as of its latest update, ChatGPT might not have access to real-time information or the latest developments in various fields;
- reliability and accuracy: While generally reliable, ChatGPT's responses can occasionally contain inaccuracies or «hallucinations» (fabricated information), since its knowledge is based on pre-existing data up to its last training cut-off;
- depth of knowledge: in highly specialized or niche areas, ChatGPT might not provide as detailed or accurate information as a dedicated expert or source might.

Similarly, services based on the Google Search Engine are characterized by the following advantages (Fig. 3):

- access to real-time information: Google Search Engine service can provide the latest news, research, and developments across various fields, something that is inherently limited in models like ChatGPT by their training cut-off dates;
- vast information repository: leveraging the entire web, Google Search Engine service offers unparalleled depth and breadth of information, covering nearly every conceivable subject;
- specialized searches: Google provides tools for specific types of information, such as scholarly articles (Google Scholar), precise locations (Google Maps), and visual searches (Google Images).

According to the conducted analysis, typical drawbacks of the Google Search Engine can also be identified (Fig. 3):

— lack of interaction: although Google has made strides with conversational AI through Google Assistant, the core search engine lacks the conversational context understanding that ChatGPT offers.

— information overload: the sheer volume of search results can sometimes be overwhelming, making it to find concise, synthesized answers or requiring significant effort to distill the essence from multiple sources;

— lack of personalization in certain contexts: while Google Search Engine service customizes search results based on past searches, it might not always provide the immediate contextual personalization in answers that an interactive AI conversation can.

Conclusions

The analysis conducted has shown that ChatGPT offers a more interactive and conversational experience with capabilities in content creation and summaries, but it may lag behind the latest developments and detailed expertise. Google excels in providing the most current and comprehensive information across a wide array of topics but lacks the personalized interactivity and contextual understanding of a conversational AI. The choice between ChatGPT and Google may depend on the user's specific needs: whether they value up-to-the-minute information and breadth of knowledge, or a conversational, context-aware experience with a more human-like interaction.

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