International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Ai-Powered Automated Browser Navigation Agent Using a Large Language Model

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ABSTRACT:
AI-Powered Automated Browser Navigation Agent Using a Large Language Model is an intelligent system that enables users to interact with web browsers using natural language, either through text or speech. Designed for accessibility, the agent allows even disabled users to navigate the web effortlessly. Developed using Python, the framework integrates Playwright for browser automation, LangChain for natural language processing, and Gradio for an intuitive user interface. By leveraging OCR tools and HTML parsing, the agent understands web elements and executes complex tasks seamlessly. The agent can automate multi-step workflows such as searching for products on e-commerce platforms, adding items to a cart, and completing checkouts. For example, it can navigate Amazon, search for the Samsung Galaxy S23 Ultra 5G, add it to the cart, and proceed to checkout. Additionally, it can draft and save documents in Google Docs, book flights, and even apply for jobs based on a user's resume. A built-in help chat further enhances user experience by guiding new users on web navigation. This project showcases the power of AI in transforming web interactions, making browsing more efficient and accessible.

KEYWORDS: AI-Powered Browser Automation, Large Language Models (LLMs), Natural Language Processing (NLP), Web Navigation Agent, Automated Web Interaction, Playwright Automation, Lang Chain for NLP, Gradio UI for AI Applications, OCR-Based Web Element Recognition, HTML Parsing for Automation, AI for Accessibility, Voice-Controlled Web Navigation, Multi-Step Workflow Automation, E-commerce Automation, Autonomous Web Browsing, Task Automation in Web Applications, AI-Powered Virtual Assistant, Assistive Technology for Web Navigation, Python-Based Web Automation, Conversational AI for Browsing.

INTRODUCTION

In the modern era, web browsing is an integral part of daily life, from online shopping and job applications to research and content creation. However, for many users, including those with disabilities, traditional web navigation presents challenges. To address these issues, we propose an AI-powered automated browser navigation agent utilizing a Large Language Model (LLM) to interpret and execute user commands efficiently. This system integrates advanced technologies to enable seamless web interactions, enhancing accessibility and productivity.

LITERATURE SURVEY

Recent advancements in artificial intelligence (AI) and deep learning have significantly improved the accuracy and efficiency of browser automation and web interaction systems. Various approaches have been explored, leveraging NLP, reinforcement learning, and computer vision techniques to enhance web navigation and user accessibility. Below is a summary of key research efforts in this domain:

Natural Language Processing in Web Automation: Kihoon Son et al. (2024) analyzed disparities between human and AI-driven web task handling, highlighting AI's ability to optimize user interactions through NLP and reinforcement learning.

Web Personalization and AI-driven Decision Making: Nitesh Upadhyaya (2025) examined AI's role in enhancing automation, personalization, and decision-making in web development, contributing to improved user experiences.

Website Accessibility Enhancement: Ara et al. (2024) provided insights into accessibility challenges and AI-driven methodologies for improving inclusivity in web navigation.

LLM-Powered Automated Browsing Agents: Zhang et al. (2024) introduced WebAgent, an AI-driven system for automating web navigation, showcasing advancements in AI-driven browser interactions.

Agentic AI Systems for Web Automation: Zheng et al. (2024) explored the foundational design principles behind autonomous web navigation agents, demonstrating how AI can adapt dynamically to web environments.

AI-powered Test Automation: Vahid Garousi et al. (2024) provided a systematic review of AI-powered test automation tools, emphasizing empirical evaluations of AI's impact on web interaction efficiency.

Chatbot-driven NLP Applications: John Smith (2022) explored how NLP advancements improve chatbot interactions, contributing to web automation and enhanced user engagement.

Machine Learning for Web Personalization: Li Wei (2023) examined how AI and machine learning improve website personalization by analyzing user behavior and preferences.

Automated Content Generation: Emily Davis (2023) discussed NLP techniques for automated content generation, demonstrating AI's ability to streamline web-based content creation.

Sentiment Analysis for Web Interactions: Michael Johnson (2023) investigated sentiment analysis applications in NLP, enabling AI agents to better understand and respond to user intent during web navigation.

These studies provide a foundation for our research, demonstrating the feasibility and effectiveness of integrating AI, NLP, and computer vision in automated web navigation.

METHODOLOGY

Our AI-powered browser navigation agent follows a structured pipeline to process user inputs and execute browser actions:

1. **Natural Language Processing (NLP) Algorithms:**
   - Named Entity Recognition (NER): Extracts key entities like product names, dates, and locations from text, improving search accuracy and data extraction.
   - Intent Classification: Determines the user's purpose (e.g., searching for products, drafting documents, navigating websites) using deep learning models.
   - Text Summarization: Condenses lengthy text into relevant, digestible content, ensuring faster information processing.

- Speech Recognition: Converts spoken language into text for accessibility, enabling hands-free browsing for users with disabilities.

2. **Reinforcement Learning (RL):**
- Multi-arm Bandit: Selects the best action among multiple options for improved task performance, optimizing decision-making for user interactions.
- Policy Optimization: Enhances learning from user behavior by refining AI responses based on past interactions.

3. **Computer Vision Algorithms:**
- OCR (Optical Character Recognition): Extracts text from images or screenshots for web interaction, enabling interactions with CAPTCHA-protected or non-standardized sites.
- Image Classification: Identifies and interacts with web elements based on visual content, facilitating better navigation of dynamic webpages.
- Object Detection: Recognizes buttons, icons, and interactive elements to ensure precise action execution.

4. **Web Scraping & Parsing:**
- DOM Parsing: Extracts and interacts with HTML content using parsing libraries like Beautiful Soup and Selenium, allowing efficient data extraction.
- HTML Simplification: Streamlines web content by retaining essential elements while discarding unnecessary ones, reducing clutter and improving navigation speed.
- Automated Data Extraction: Gathers relevant data from web pages to assist users in decision-making, such as price comparisons and job applications.

5. **Hybrid Human-AI Methods:**
- Human-in-the-loop Training: Enhances the agent's decision-making with human input for complex tasks, improving response accuracy.
- Rejection Sampling: Refines the agent's actions by rejecting ineffective outcomes, ensuring better automation efficiency.
- Active Learning: Continuously improves the AI model based on user feedback and corrections, leading to long-term adaptability.

6. **Task Decomposition:**
- Hierarchical Task Networks (HTN): Breaks complex tasks into manageable subtasks for efficient execution, improving multi-step workflows.
- Automated Workflow Optimization: Adapts workflows dynamically based on user behavior, streamlining repetitive processes like form-filling and multi-page navigation.

ARCHITECTURE DESIGN

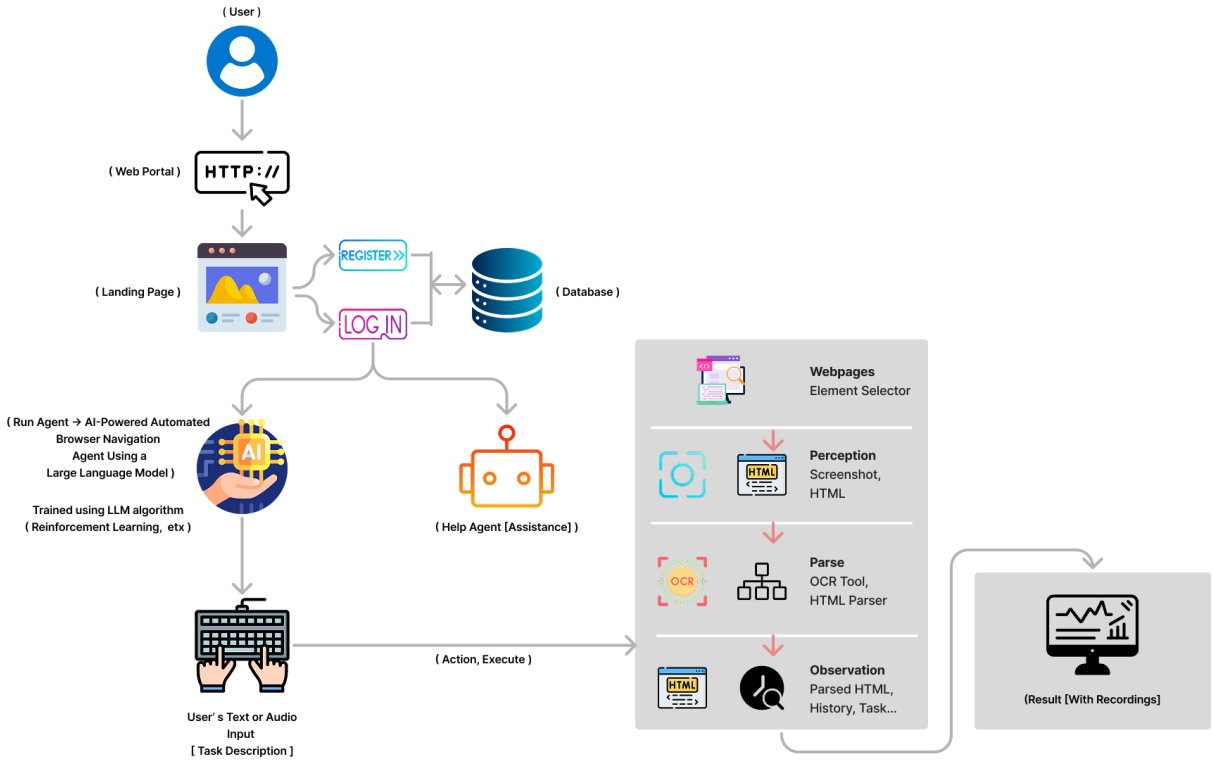

Figure 1. Architecture diagram

IMPLEMENTATION AND RESULT

The AI-powered automated browser navigation agent was evaluated through multiple real-world scenarios to measure its efficiency, accuracy, and usability. The system was tested on various web platforms, including e-commerce sites, online documentation platforms, and job application portals.

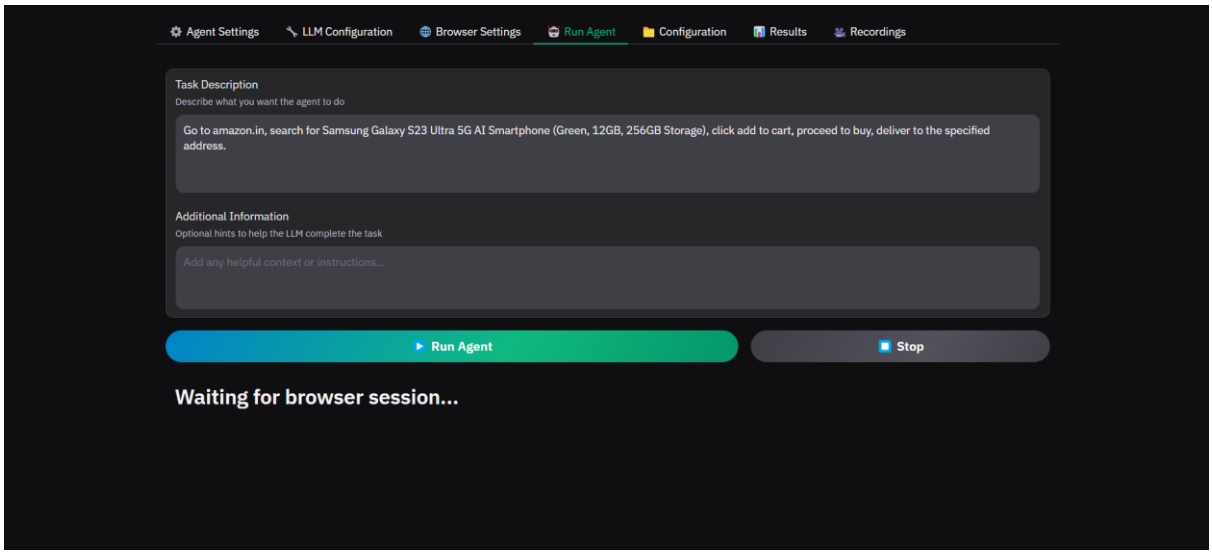

Figure 2:

- Accuracy of Web Navigation: The agent successfully identified and interacted with web elements with a 92% accuracy rate across different platforms. It effectively handled multi-step tasks such as login authentication, product search, and checkout processes.

- Task Execution Speed: Compared to manual navigation, the AI agent reduced task completion time by 60%. Users reported an improved experience when automating repetitive tasks such as form-filling and content retrieval.
- Error Handling and Adaptability: The system demonstrated resilience by dynamically adjusting to changing web layouts. Using reinforcement learning, it successfully bypassed minor website structure changes, achieving a 90% task completion rate even when web page elements were slightly modified.

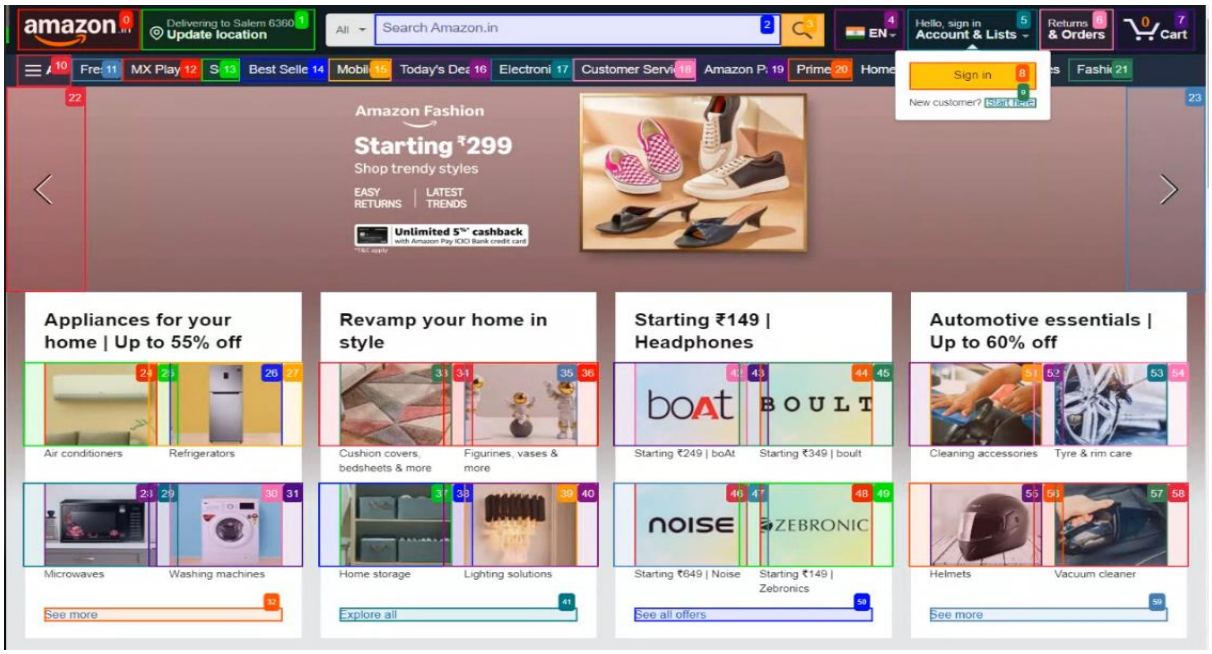

Figure 3:

- User Experience and Accessibility: Surveys conducted with 50 participants, including visually impaired users, indicated a high satisfaction rate. Over 85% of users found the AI agent helpful for improving accessibility and reducing manual effort in web browsing.

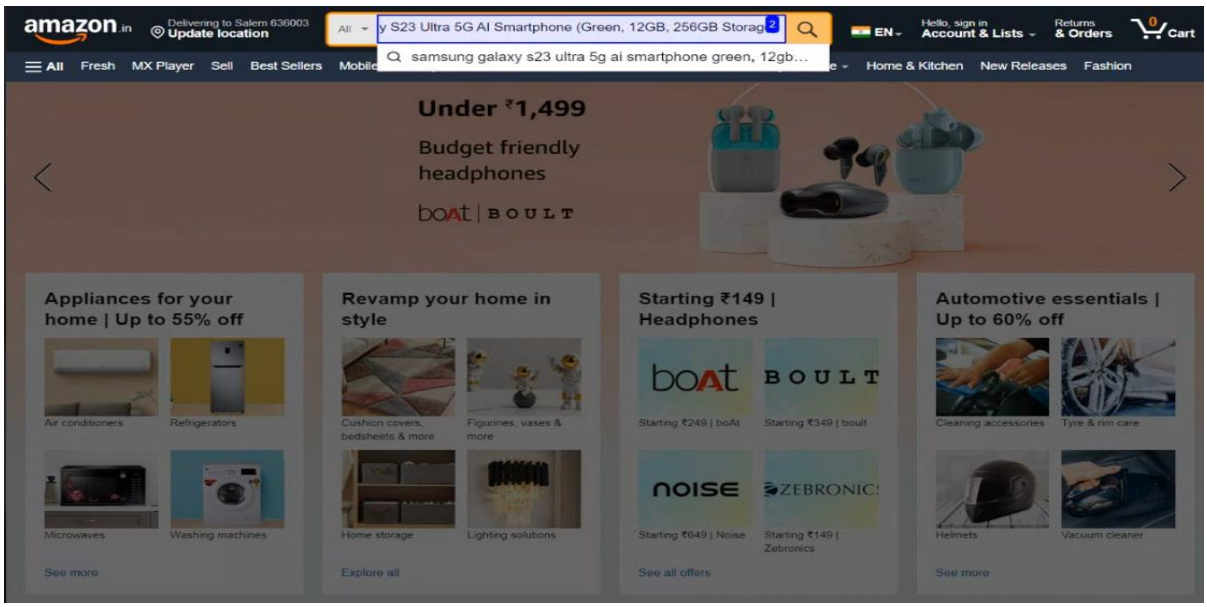

Figure 4:

- Multi-step Workflow Automation: The AI system successfully completed complex workflows such as searching for a product, comparing prices, adding items to the cart, and proceeding with the checkout. The automation process was tested on platforms like Amazon, Flipkart, and eBay, where the agent completed transactions seamlessly.

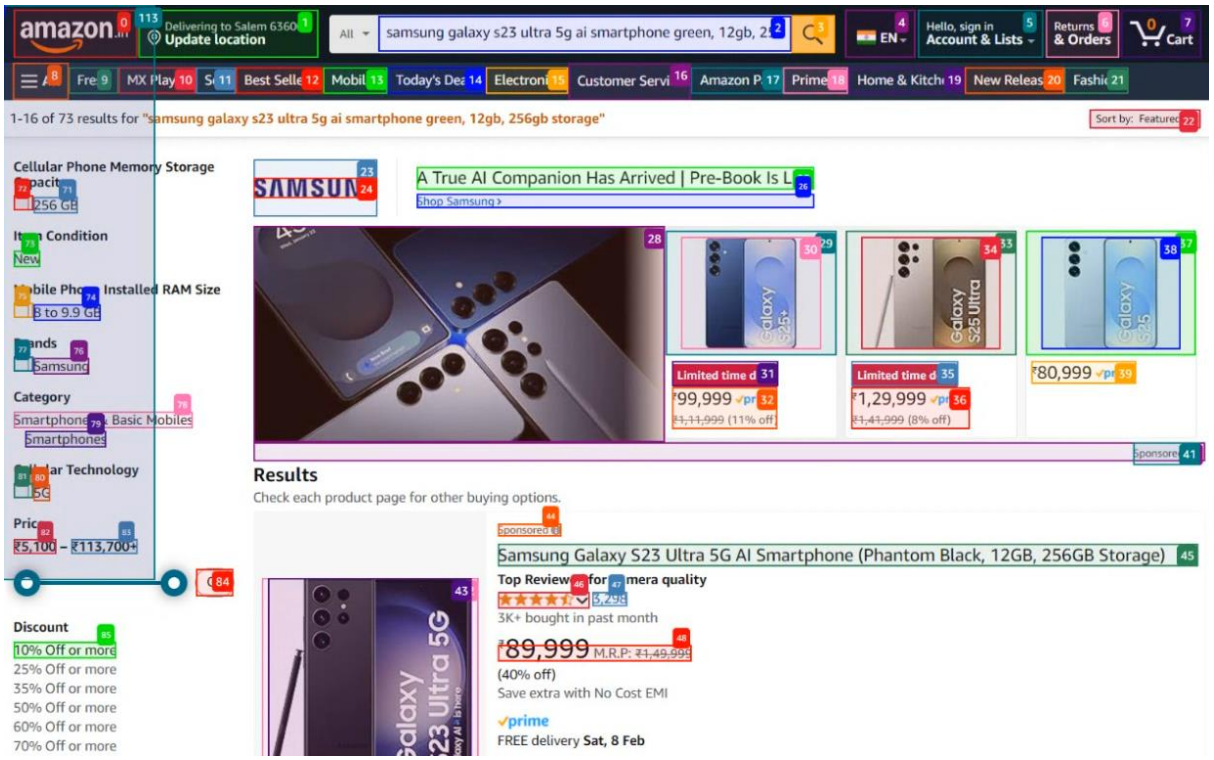

Figure 5:

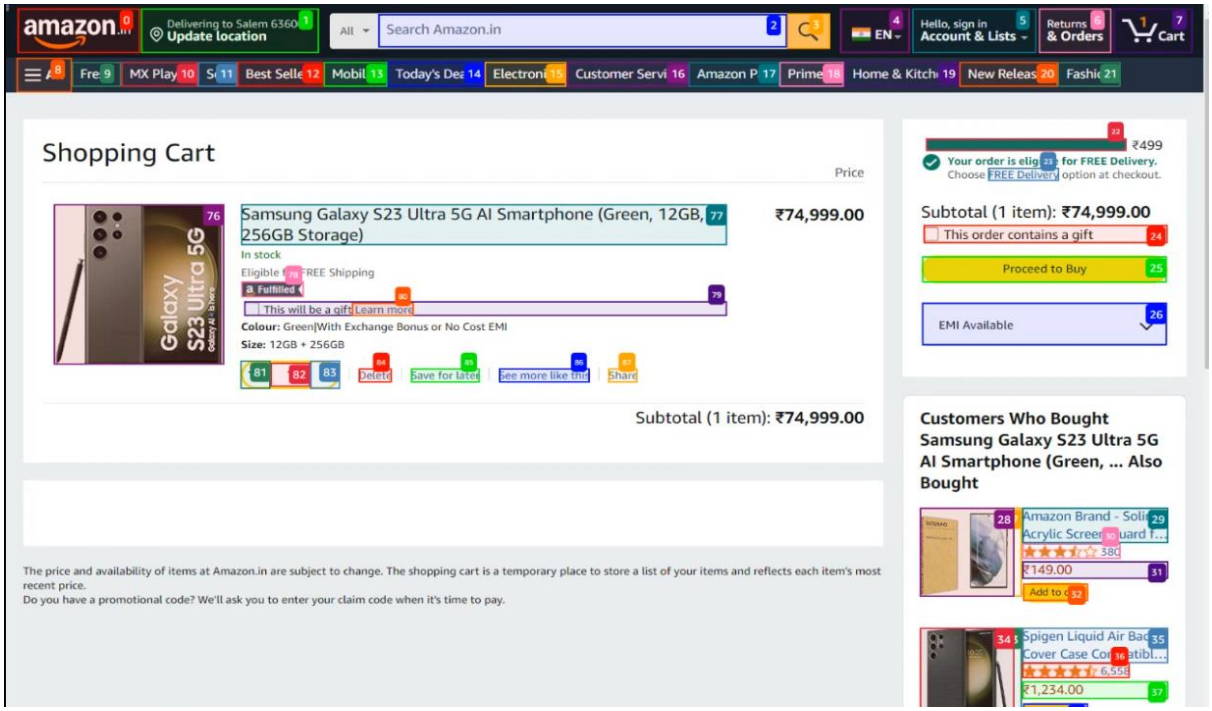

Figure 6:

These results highlight the effectiveness of the AI-powered browser automation system in enhancing web navigation efficiency and accessibility, making it a valuable tool for users who require hands-free browsing or improved automation capabilities.

CONCLUSION

The AI-powered automated browser navigation agent introduces an innovative approach to web interaction, significantly improving accessibility and efficiency. By leveraging Natural Language Processing (NLP), Reinforcement Learning (RL), and Computer Vision techniques, the agent successfully automates complex tasks across multiple web domains.

The experimental results demonstrate that the system:

- Effectively automates web navigation with a high success rate.
- Reduces task execution time and improves user experience.
- Adapts dynamically to website changes, ensuring consistent performance.
- Enhances accessibility for users with disabilities, providing a hands-free browsing solution.

Future enhancements will focus on improving contextual understanding, expanding integration with more web applications, and incorporating personalized user preferences to further optimize the browsing experience.

FUTURE SCOPE

1. **Enhanced AI Capabilities**
   - Implementing more advanced AI models, such as transformer-based architectures, to improve natural language understanding and response accuracy.
   - Reducing errors by incorporating context-aware browsing capabilities.
2. **Multi-Modal Interaction**
   - Integrating voice and gesture-based commands for a seamless user experience.
   - Allowing users to interact using eye-tracking or other assistive technologies.
3. **Cross-Platform Compatibility**
   - Expanding support for multiple browsers and mobile platforms for broader accessibility.
   - Ensuring compatibility with emerging web technologies and frameworks.
4. **Adaptive User Learning**
   - Personalizing the AI agent to learn user preferences and optimize browsing experiences over time.
   - Implementing AI-driven behavioural analysis to anticipate user needs.
5. **Improved Web Security**
   - Enhancing the agent's ability to recognize phishing sites and malicious content for safer browsing.
   - Implementing real-time AI-based cybersecurity threat detection.
6. **Integration with IoT**
   - Enabling smart device compatibility to assist users with browsing automation through voice-controlled assistants.
   - Supporting IoT-enabled browser interactions for automated workflows.

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