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# UserLens - Web Accessibility Tool for Autism, Dyslexia & Cognitive Disorders

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***Abstract:*** ***Web usability continues to pose major challenges for individuals with disabilities, sensory sensitivities, or cognitive differences, as most modern websites are not designed to accommodate their varied accessibility needs. Navigating complex, dynamic, and visually dense interfaces can often be overwhelming or impractical, reducing independence and limiting participation in the digital world. The lack of adaptable design options leaves many users struggling to engage comfortably and effectively with online content.***
***To address this, we propose a universal, user-controlled tool that enables individuals to reshape any webpage in real time according to their unique preferences. The tool allows users to adjust layouts, alter colour schemes, simplify interactions, and personalize content presentation—helping to remove distractions, improve readability, and enhance comfort. Through its modular and intuitive interface, it supports customizable profiles for different accessibility needs, such as Autism, Dyslexia, low vision, or ADHD. Designed for seamless integration with modern browsers and web platforms, it empowers users to transform online spaces into more inclusive, functional, and personally adaptive environments, demonstrating the potential of user-driven accessibility to advance digital equity.***

## I. INTRODUCTION

The internet has become the primary platform for accessing information, education, healthcare services, and professional resources. However, despite decades of research in accessibility, many websites still remain difficult to use for individuals with disabilities. The World Health Organization estimates that more than one billion people worldwide live with some form of disability, highlighting the importance of inclusive digital environments. Research consistently shows that accessibility challenges are particularly significant for users with cognitive and neurological conditions such as dyslexia, Attention Deficit Hyperactivity Disorder (ADHD), and Autism Spectrum Disorder (ASD).

Large-scale studies confirm the extent of this problem. The WebAIM Million report analyzed one million home pages using the WAVE accessibility evaluation engine and detected 49,991,225 accessibility errors, averaging 50 errors per page. These errors represent barriers that are highly likely to violate WCAG accessibility standards and directly impact end-user experience. In addition, modern websites are becoming increasingly complex. The average home page now contains more than 1050 elements, reflecting a 10% increase in complexity within a single year. Increased complexity often introduces more distractions, animations, and visual clutter, which can negatively affect users with cognitive disabilities.

To address accessibility barriers, many assistive technologies and browser extensions have been developed. Tools such as MindFlow, Helperbird, and other productivity or reading aids provide features such as dyslexia-friendly fonts, text-to-speech, distraction blocking, and reading rulers. These tools demonstrate the potential of browser extensions to support accessibility by allowing users to customize how they interact with web content. However, existing tools are typically designed to address a single aspect of accessibility, forcing users to rely on multiple separate solutions. For example, one extension may adjust fonts, another may provide summarization, and a different tool may offer text-to-speech capabilities. As a result, users often experience fragmented workflows that require switching between tools, manually copying text, or configuring several extensions simultaneously. This project introduces UserLens, a unified browser-based accessibility system designed to address these limitations. UserLens integrates visual customization, cognitive reading aids, and AI-powered contextual assistance into a single platform. Instead of requiring multiple independent tools, the system adapts web content dynamically according to a user's accessibility profile. By combining adaptive interface design with AI-assisted comprehension support, UserLens aims to improve readability, reduce cognitive load, and provide a more inclusive browsing experience.

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## II. RELATED PREVIOUSLY DONE WORK

Research on digital accessibility spans several areas, including adaptive user interfaces, assistive technologies, browser extensions, and AI-based accessibility solutions. These studies provide valuable insights into how technology can improve access to digital content for users with disabilities, but they also reveal several limitations that motivate the development of integrated systems such as UserLens.

*1)* Adaptive Interfaces for Disability-Adaptive interface research has explored how systems can dynamically adjust to users' abilities and preferences. Alekseev proposed an integrated approach for adaptive web accessibility systems that combine interface adaptation, accessibility modules, and monitoring components to improve usability for individuals with disabilities. UserLens extends this concept by combining interface adaptation with AI-based reading assistance, enabling both visual accessibility and improved understanding of complex content.

*2)* Browser Extensions for Accessibility-Research on browser extensions for students with disabilities identified a wide range of tools that support reading, writing, dictation, screen reading, and productivity tasks. Examples include extensions such as Grammarly, Speechify, and Helperbird, which provide text-to-speech, summarization, and visual customization features. UserLens addresses this limitation by integrating multiple accessibility features—including visual adjustments, reading assistance, and AI support—into a single extension.

*3)* AI-Based Accessibility Support-Artificial intelligence has recently been applied to accessibility challenges, particularly in text simplification and content summarization. AI systems can transform complex documents into simpler language, improving comprehension for individuals with cognitive disabilities. UserLens improves on this approach by embedding AI assistance directly within the browser environment, allowing users to ask questions about the content of the page they are currently viewing.

Although previous research has made significant progress in improving accessibility technologies, several limitations remain:

*a)* Many adaptive systems focus only on interface design, without addressing content comprehension.
*b)* Existing browser extensions typically provide isolated features rather than integrated solutions.
*c)* AI tools are often separate from the browsing environment, requiring manual interaction.
*d)* Privacy and security concerns limit user adoption of third-party extensions.

UserLens addresses these limitations by combining adaptive interface customization, contextual AI assistance, and privacy-preserving architecture within a single unified browser extension.

## III. MATERIALS AND METHODS

The development of the UserLens system follows a design methodology combining web accessibility principles, adaptive interface design, and artificial intelligence integration. The project focuses on creating a browser-based accessibility solution capable of dynamically adapting web content according to individual user needs.The methodology consists of the following stages:

*1)* Literature Analysis: Existing research on accessibility tools, adaptive interfaces, AI-based accessibility systems, and browser extensions was analyzed to identify design principles and limitations in current technologies.

*2)* System Architecture Design: A modular architecture was designed to separate browser extension components from backend AI services. This approach improves security, scalability, and maintainability.

*3)* Extension Development: The browser extension was implemented using Google Chrome's Manifest V3 architecture, which separates background processes, content scripts, and user interface components.

*4)* Backend AI Integration: AI processing is handled through a FastAPI backend that performs tasks such as text summarization, simplification, and Retrieval-Augmented Generation.

*5)* Testing and Evaluation: The system is evaluated using usability metrics such as the System Usability Scale (SUS) and NASA-TLX workload index, along with automated accessibility metrics.

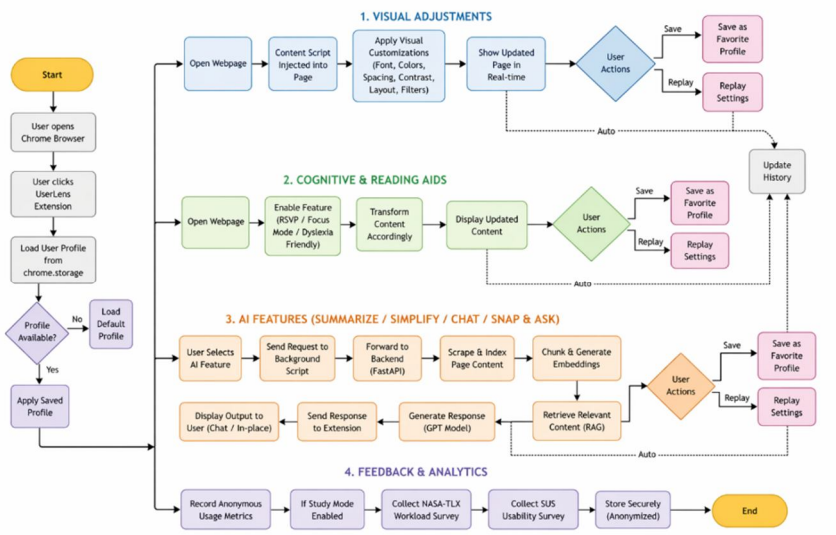
## IV. IMPLEMENTATION

UserLens is implemented as a Google Chrome browser extension that integrates accessibility features directly into the user's browsing environment. The system follows a client-server architecture, where the browser extension acts as the client interface while AI processing is performed by a backend server.

The extension is composed of several core components:

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Flowchart




*1)* Background Service Worker: The background script acts as the central controller for the extension. It manages message communication between different extension components and handles API requests to the backend server.

*2)* Popup Interface: The popup interface provides quick access to accessibility settings such as font selection, contrast modes, and AI assistance features.

*3)* Side Panel Interface: A persistent side panel provides advanced features including reading tools, accessibility profile configuration, AI chat functionality, and research instruments.

*4)* Content Script: The content script is injected into web pages and performs real-time transformations of the Document Object Model (DOM). It extracts page text, modifies visual elements, and applies accessibility settings.

*5)* AI Backend: The backend server processes AI requests such as summarization, simplification, and contextual question answering. All AI processing occurs server-side to protect API credentials and maintain security.

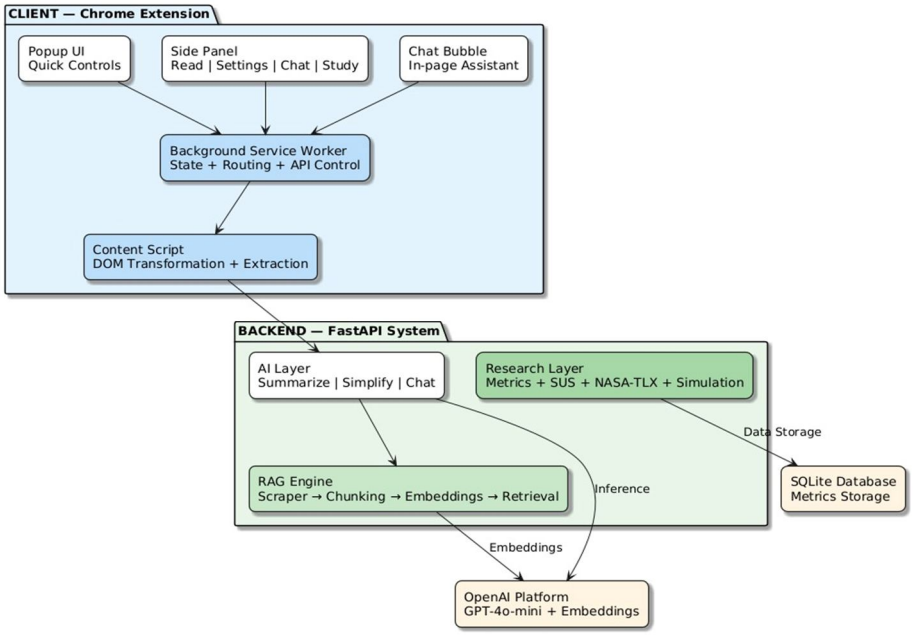
The system also includes privacy safeguards that detect sensitive pages such as login forms or payment pages. When such pages are detected, AI processing is automatically disabled to protect user privacy.

| Implementation Phase | Description | Benefits | Main Issues / Disabilities |
|---|---|---|---|
| System Design | Development of the conceptual architecture of UserLens, including a Chrome extension frontend (popup, side panel, and content scripts) and a FastAPI backend server that communicates with the OpenAI API. The system architecture defines components such as the background service worker, RAG service, scraper service, metrics API, and SQLite metrics database. | Modular architecture improves maintainability and scalability. The separation between extension UI, backend services, and AI modules ensures secure handling of API keys and prevents exposure of sensitive data in the browser environment. | Designing an architecture that simultaneously supports accessibility, AI integration, and privacy constraints requires careful requirement analysis and strict adherence to accessibility standards such as WCAG 2.2. |
| Prototype Implementation | Development of the main system modules including accessibility profile management, DOM transformation through content scripts, AI content transformation endpoints, RAG-based chat functionality, and adaptive UI components implemented with React and TypeScript. | Early implementation allows testing of features such as AI summarization, simplification, accessibility profiles, and real-time DOM transformations. It also enables iterative development and debugging before deployment. | Integrating multiple modules such as RAG retrieval, AI APIs, and browser extension scripts may introduce compatibility and synchronization challenges between frontend and backend components. |

| Implementation Phase | Description | Benefits | Main Issues / Disabilities |
|---|---|---|---|
| Integration into Real Environment | Deployment of the FastAPI backend locally (localhost:8787) and integration with the Chrome extension using HTTP API calls. The extension communicates with the backend for AI operations while applying accessibility transformations directly within web pages. | Enables real-world testing on actual web pages and ensures that accessibility features such as font adjustments, color filters, layout modifications, and AI assistance operate within real browsing environments. | Integration challenges include handling sensitive page detection, ensuring secure API communication, and managing browser permissions required by Manifest V3 architecture. |
| Testing and Performance Evaluation | Evaluation of the system through unit testing, integration testing, accessibility testing, and performance testing. Metrics such as readability improvement (Flesch-Kincaid and SMOG scores), WCAG compliance improvements, SUS usability scores, and NASA-TLX workload measurements are used to assess system effectiveness. | Provides objective measurements of usability, accessibility improvement, and cognitive workload reduction. These metrics allow developers to refine accessibility profiles and AI transformations. | Testing with diverse disability groups is difficult due to participant availability and variability in accessibility needs. Simulated datasets are therefore used alongside real user testing to establish baseline performance metrics. |

## V. SYSTEM DESIGN/ARCHITECTURE

The UserLens system follows a modular client-server architecture. The browser extension acts as the client side and handles the user interface, page interaction, and accessibility transformations, while the backend server manages AI-based processing and contextual question answering. The extension is composed of a background service worker, popup interface, side panel, and content script. The background service worker manages communication between components and coordinates backend requests. The popup provides quick access to accessibility settings such as font changes, contrast modes, and AI options. The side panel offers advanced tools including profile management, reading support, and chat-based assistance. The content script is injected into webpages and performs real-time DOM transformations, applying the selected accessibility preferences directly to the page. On the backend, a FastAPI server handles summarization, simplification, and retrieval-augmented generation based question answering. This server communicates with the browser extension through HTTP requests and processes webpage content in a secure manner. The architecture also includes privacy safeguards that disable AI processing on sensitive pages such as login or payment forms




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## VI. EVALUATION METRICS

The effectiveness of UserLens can be evaluated using both usability and accessibility metrics. The System Usability Scale (SUS) is used to measure how easy and acceptable the system is for users. A higher SUS score indicates better perceived usability and a more intuitive user experience.NASA-TLX is used to assess cognitive workload across dimensions such as mental demand, effort, frustration, and performance. This is especially important for an accessibility tool, since one of the project goals is to reduce the mental effort required to browse and understand content. In addition, readability-based metrics such as Flesch-Kincaid and SMOG can be used to measure how simplification features improve the clarity of text. WCAG-related checks can also be applied to assess whether the transformed content better supports accessibility standards

*1)* Usability (40%)
- *System Usability Scale (SUS)*: Measures ease of use and acceptance.
- Target: ≥ 80 SUS score → strong usability.

*2)* Cognitive Workload (30%)
- *NASA-TLX*: Evaluates mental demand, effort, frustration, and performance.
- Goal: ≥ 25% reduction in workload compared to baseline browsing.

*3)* Readability (20%)
- *Flesch-Kincaid & SMOG*: Assess clarity of simplified text.
- Aim: ≥ 30% improvement in readability scores.

*4)* Accessibility Standards (10%)
- *WCAG checks*: Ensure transformed content meets compliance.
- Target: ≥ 90% WCAG success rate.

## VII. RESULTS AND DISCUSSION

The UserLens prototype demonstrates that accessibility features can be integrated directly into the browsing environment through a browser extension-based approach. The modular design allows users to modify webpage appearance, reduce distractions, and receive AI-assisted explanations without leaving the page. This creates a more seamless interaction than using multiple disconnected tools.From a design perspective, the system addresses several major issues found in existing accessibility solutions. It reduces fragmentation by combining multiple accessibility features in one platform, supports personalization through user profiles, and preserves workflow continuity by keeping AI assistance within the browser. The privacy-aware backend further improves trust by limiting processing on sensitive pages. Since the project is currently in the stage of design and prototype development, the main outcome is the architectural and functional feasibility of the system rather than numerical experiment results. The planned evaluation framework with SUS, NASA-TLX, and readability metrics provides a strong basis for future testing with real users. Overall, the project indicates that browser-integrated accessibility systems can offer a practical and flexible way to support users with cognitive and mild visual impairments.

## VIII. CONCLUSION

UserLens proposes an integrated approach to web accessibility by combining adaptive interface customization, cognitive reading support, and AI-based contextual assistance within a single browser extension. The system is designed to address common barriers faced by users with dyslexia, ADHD, autism spectrum disorder, and low vision, especially when browsing complex and visually dense websites. By shifting accessibility support directly into the browsing environment, the project reduces dependence on separate tools and improves the continuity of user interaction. The modular architecture, privacy safeguards, and evaluation framework make the system practical for future development and research. UserLens therefore represents a step toward more inclusive, flexible, and user-centered web access.

## IX. ACKNOWLEDGMENT

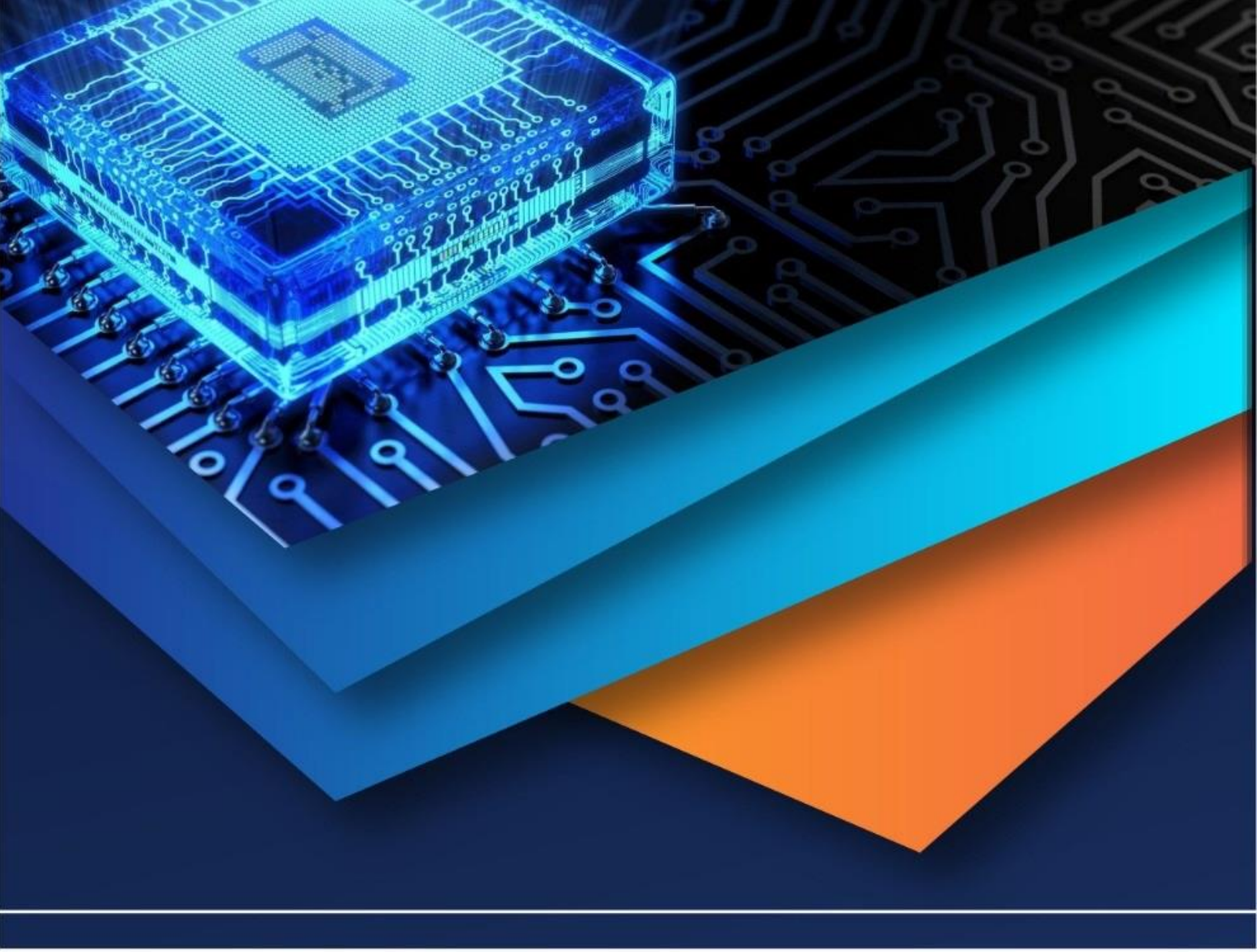
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