Experiencing Cactus - Browsing The Web Using Your Eyes

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Abstract

Cactus is a novel, gaze-driven web browser developed specifically as an assistive technology for individuals with severe motor impairments, including those living in a locked-in state. Funded by Xjenza Malta under the FUSION R&I Research Excellence Programme, the project aims to deliver a more intuitive and efficient assistive technology (user agent) that provides access to websites, irrespective of their conformance with the Web Content Accessibility Guidelines (WCAG). Recursive spatial decomposition is carried out on all webpage elements in real-time, while quadtrees are used to hold a spatial index of all interactive elements currently visible on the screen. Unlike the state-of-the-art, which largely relies on click-emulation mode switching and continuous zooming to disambiguate clickable elements, Cactus introduces an interaction sidebar containing potentially actionable elements closest to the user's current gaze location. These elements, which are loaded from the Quadtree structure, are then rendered using appropriate affordances for eye-tracker users. Cactus also supports a second input modality that can be used to bypass dwelling when activating elements. This speeds up interaction while also reducing fatigue in continuous use. This demo showcases Cactus, where attendees will be able to experience unbounded web browsing using an eye tracker and an optional adaptive switch.

CCS Concepts

• **Human-centered computing**; • **Empirical studies in interaction design; Accessibility technologies; Pointing; Web-based interaction**;

Keywords

Eye tracking, Web accessibility, Assistive technology, Multimodal input, Human-computer interaction, Gaze-native Interaction patterns

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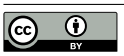

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1 Introduction

Accessing the web is essential, but traditional browsers are often unusable for individuals with limited motor function. Eye-tracking offers a hands-free alternative, yet despite recent advances, gaze interaction presents unique challenges: it lacks the pixel-level precision of a mouse, making it difficult to interact with small targets such as links, fly-out menus, or tightly packed buttons. Cactus was designed to overcome this barrier through its multi-modal interface and novel quadtree-powered interaction sidebar, making gaze-based interaction quicker, more practical and accessible. It is built with Electron [1], an open-source framework for building cross-platform desktop apps using web technologies, powered by Node.js and the Chromium rendering engine.

2 System Overview

Cactus, as described in [2], continuously analyses a webpage's Document Object Model (DOM) and uses a quadtree data structure to spatially organise visible and active interactive elements as painted on the screen. This allows it to quickly identify elements near the user's current gaze point and generate an eye-tracker-friendly version of these elements (e.g. links, buttons, dropdowns) for easy interaction on what is referred to as the interaction sidebar. As shown in Figure 1, the system works with low-cost eye trackers (e.g. Tobii Eye Tracker 4C) and is also designed to run across three platforms (Windows, macOS, and Linux). Users can dwell on a target in the interaction sidebar to trigger an action or, where possible, use an external adaptive switch for selection. Cactus natively supports mapping multiple switches to different functionalities, allowing actions like scrolling, tabbing, or switching tabs to be carried out with minimal effort.

Cactus is a fully-featured browser that is designed to work seamlessly on websites that do not fully adhere to accessibility standards, ensuring reliable interaction across the vast majority of websites. It features a multilingual keyboard that adapts dynamically to different input types, making data entry fast and efficient in multiple languages. The system also supports complex interaction scenarios, such as controlling embedded media, selecting small or densely packed links (Figure 2 and Figure 3) or expanding hierarchical flyout menus — tasks that are typically challenging with the state-of-the-art purpose-built browsers. To enhance precision, Cactus applies real-time gaze smoothing, averaging saccadic movement to reduce jitter and keep the eye-controlled cursor stable and responsive. By transforming cluttered web pages into structured, gaze-friendly environments, Cactus preserves both the visual layout and functionality of the original website while making it significantly more accessible.

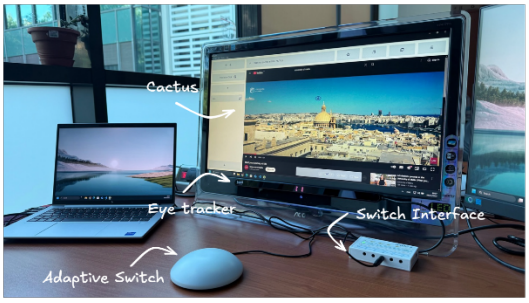

Figure 1: Cactus setup with an eye-tracker and an adaptive switch.

Figure 2: Cactus interacting with dense links

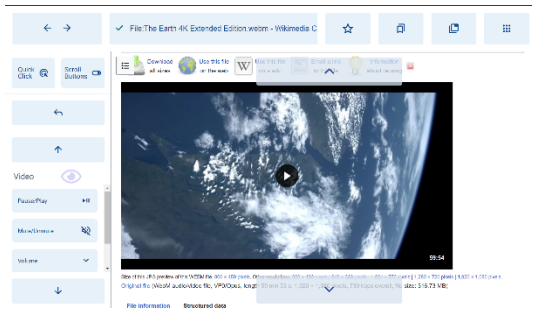

Figure 3: Cactus interacting with embedded media

3 Significance

Cactus demonstrates how research in HCI, accessibility, and web engineering can be combined to produce real-world tools that empower people with severe motor impairments. By making it open-source, Cactus invites collaboration from developers, researchers, and clinicians aiming to advance gaze-based interaction and expand the landscape of assistive web technologies. This approach supports innovation and promotes digital accessibility through shared tools and knowledge.

4 EXPERIENCE REQUIREMENTS

Attendees will experience efficient eye-driven web browsing. Starting with a calibration process, participants will then be able to browse real-world webpages. Tasks will include selecting links, inputting text, and also exploring different browser features. Participants will be able to appreciate how Cactus avoids common challenges in gaze browsing, such as incorrect link activations, difficulties navigating complex menu structures, as well as inefficiencies caused by dwelling delays. The setup will include a laptop connected to a 24" LED monitor and an adaptive switch, with access to a stable Wi-Fi connection.

References

[1] Electron – build cross-platform desktop apps with Javascript, HTML and CSS. Retrieved June 24, 2025 from https://www.electronjs.org/

[2] Vella, D. and Porter, C., 2024. Remapping the Document Object Model using Geometric and Hierarchical Data Structures for Efficient Eye Control [Online]. Proceedings of the ACM on Human-Computer Interaction, 8(ETRA), pp.1–16. Available from: https://doi.org/10.1145/3655608 [Accessed 24 June 2025]