Eye Tracking Attachment for Early Alzheimer's Diagnosis

saccade

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Research

Over 200 peer-reviewed studies have established that saccadic eye movement abnormalities emerge in preclinical Alzheimer's, up to 15 years before symptoms appear.

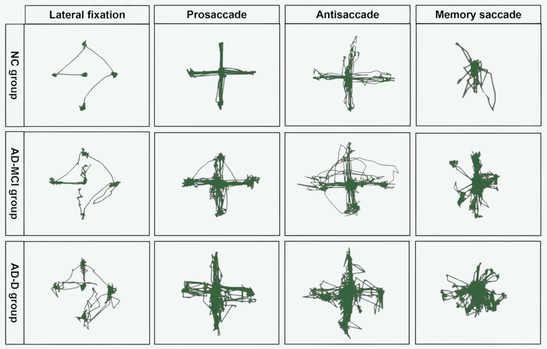


Figure 1: Gaze trajectories across four oculomotor tasks.

Healthy controls (NC, top row) show smooth, predictable patterns.

Eye movements grow progressively disordered across the Alzheimer's continuum - mild in early disease (AD-MCI) and severely erratic by the dementia stage

(AD-D). Adapted from Qi et al., 2024 (CC-BY 4.0).

Hardware Design

A magnetic light shield replacement for the Apple Vision Pro that houses two NIR cameras and on-board PCBs to capture eye movements at 200 fps within the original comfort and safety limits.

Figure 2. The stock Apple Vision Pro Light Seal. A knit-and-foam component that blocks light and conforms to the face during use. Houses magnets towards the user's face to connect cushion.

Figure 3. The Saccade hardware attachment. All camera, PCB, and illumination subsystems integrated into a single 3D printed chassis. Compatible with Apple's original cushion.

Figure 4. AVP Light Seal (Up) next to Saccade Chassis (Down)

Early Detection

Drugs like Lecanemab (FDA 2023) and Donanemab (FDA 2024) are the first disease-modifying Alzheimer's therapies shown to slow cognitive decline in Phase 3 clinical trials but only when administered before significant cognitive symptoms appear.

"A change in diet, exercise, sleep patterns, and new drugs slows Alzheimer's progression, and in some cases avoids symptoms entirely." Dr. Philip DeLeo, MD, Neurologist

Despite this treatment window, no current screening tool meets the criteria for routine pre-symptomatic Alzheimer's detection. Saccade closes this gap with a 10-minute, non-invasive, point-of-care test.

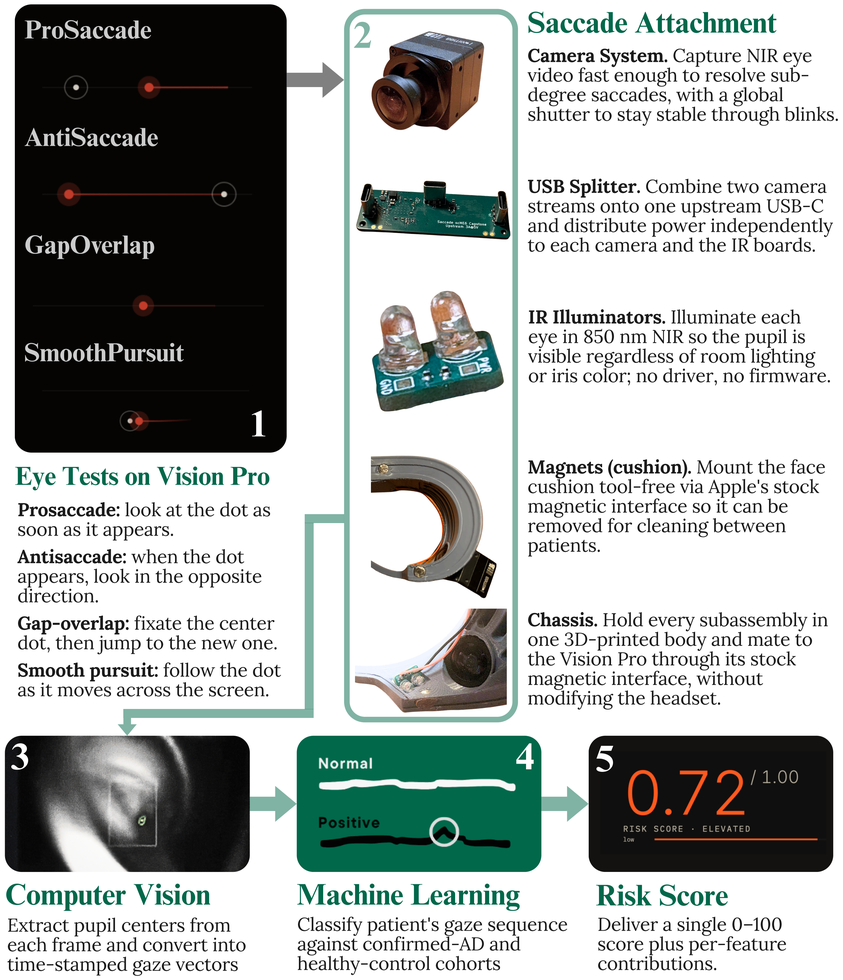
Final Design

Figure 5: Saccade Prototype

The fully assembled Saccade prototype, mated to a stock Apple Vision Pro.

Two USB-C 3.0 cables carry uncompressed dual-eye video to a host MacBook in real time.

System Architecture



Eye Tests on Vision Pro

Prosaccade: look at the dot as soon as it appears.

Antisaccade: when the dot appears, look in the opposite direction.

Gap-overlap: fixate the center dot, then jump to the new one.

Smooth pursuit: follow the dot as it moves across the screen.

Saccade Attachment

Camera System. Capture NIR eye video fast enough to resolve sub-degree saccades, with a global shutter to stay stable through blinks.

USB Splitter. Combine two camera streams onto one upstream USB-C and distribute power independently to each camera and the IR boards.

IR Illuminators. Illuminate each eye in 850 nm NIR so the pupil is visible regardless of room lighting or iris color; no driver, no firmware.

Magnets (cushion). Mount the face cushion tool-free via Apple's stock magnetic interface so it can be removed for cleaning between patients.

Chassis. Hold every subassembly in one 3D-printed body and mate to the Vision Pro through its stock magnetic interface, without modifying the headset.

Computer Vision

Extract pupil centers from each frame and convert into time-stamped gaze vectors

Machine Learning

Classify patient's gaze sequence against confirmed-AD and healthy-control cohorts

Risk Score

Deliver a single 0–100 score plus per-feature contributions.

Thermal Testing

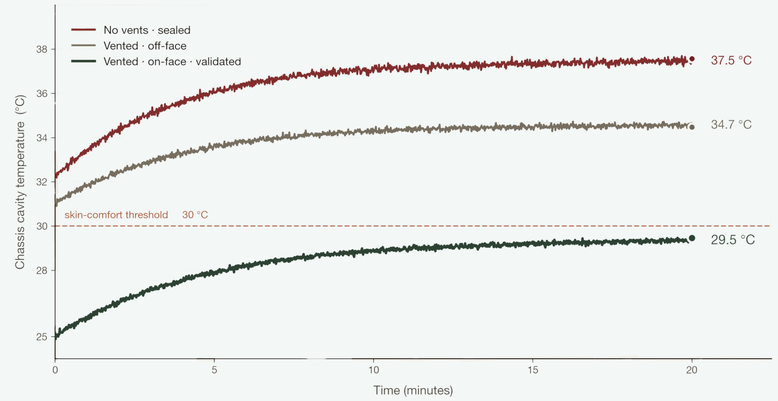


Figure 6: Chassis cavity temperature across a 20-minute session under three setups

The dashed line marks the 30 °C skin-comfort threshold; the shaded region above indicates the unsafe range. A sealed chassis plateaued at 37.5 °C, above the threshold.

After adding passive vents, the off-face plateau dropped to 34.7 °C, and the on-face vented configuration stabilized at 29.5 °C, within the comfort envelope for the full session.

Material Testing

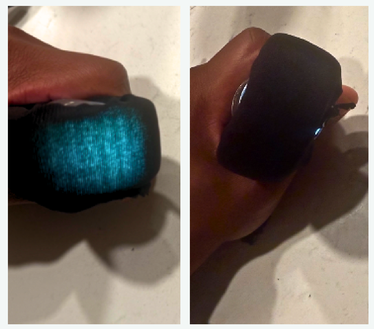


Figure 7. Vent fabric blend selection.

Four polyester-based fabrics were screened against the two functional criteria for a worn medical device vent:

moisture absorption during use, and light blockage at the 55° vent angle (the geometric fail-safe preventing ambient light from leaking onto the Vision Pro screen).

The 90/10 polyester-cotton blend met both criteria and was selected as the production vent inlay, seated in a 1 mm recess behind each vent slat.

Computer Vision Testing

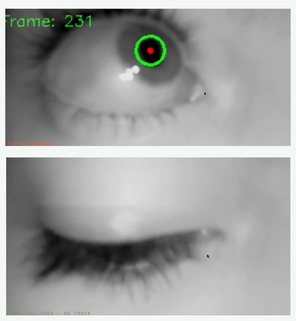


Figure 8. Initial top-mount placement test against a baseline pupil-detection CV model.

Top: eye open, pupil resolves cleanly, frame counter advances (green circle marks the detected pupil).

Bottom: on every blink and downward gaze, the eyelid drops into the camera's line of sight and occludes the pupil, freezing tracking.

Because the four oculomotor paradigms require continuous capture through blinks and downward saccades, this failure drove the final design choice to mount the cameras at the lower chassis corners, where the optical path angles upward and the eyelid no longer crosses it.

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