

A Real-Time Camera-Based Eye-Tracking System for Nystagmus Identification and Motion Correction

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Project Overview



Six extraocular muscles control eye movement. American Academy of Ophthalmology, 2016.

Nystagmus Slow Phase Velocity Waveforms			
Pendular	Linear Jerk	Decreasing Jerk	Increasing Jerk



Demonstration of different types of nystagmus.

- Acquired nystagmus causes repetitive, involuntary eye movements that impairs visual stability and quality of life
- Nystagmus affects **1 in 1000** people; acquired nystagmus accounts for **17%** of pediatric and **40%** of adult cases^{1,2}
- Current treatments such as medications and surgery are ineffective, non-specific, and unable to adapt to progressive symptom changes³
- We propose a real-time eye-tracking system that detects and classifies nystagmus and computes a corrective motion vector
- The system distinguishes pathological oscillations from voluntary gaze shifts
- A computational model predicts necessary corrective movements to extraocular muscles to stabilize gaze

Need Statement

Patients suffering from **acquired nystagmus** need a **long-lasting treatment** that **adapts to worsening symptoms** over time in order to **reduce progressive visual instability**.

Solution Approach:

Camera-based eye tracker records eye position over time

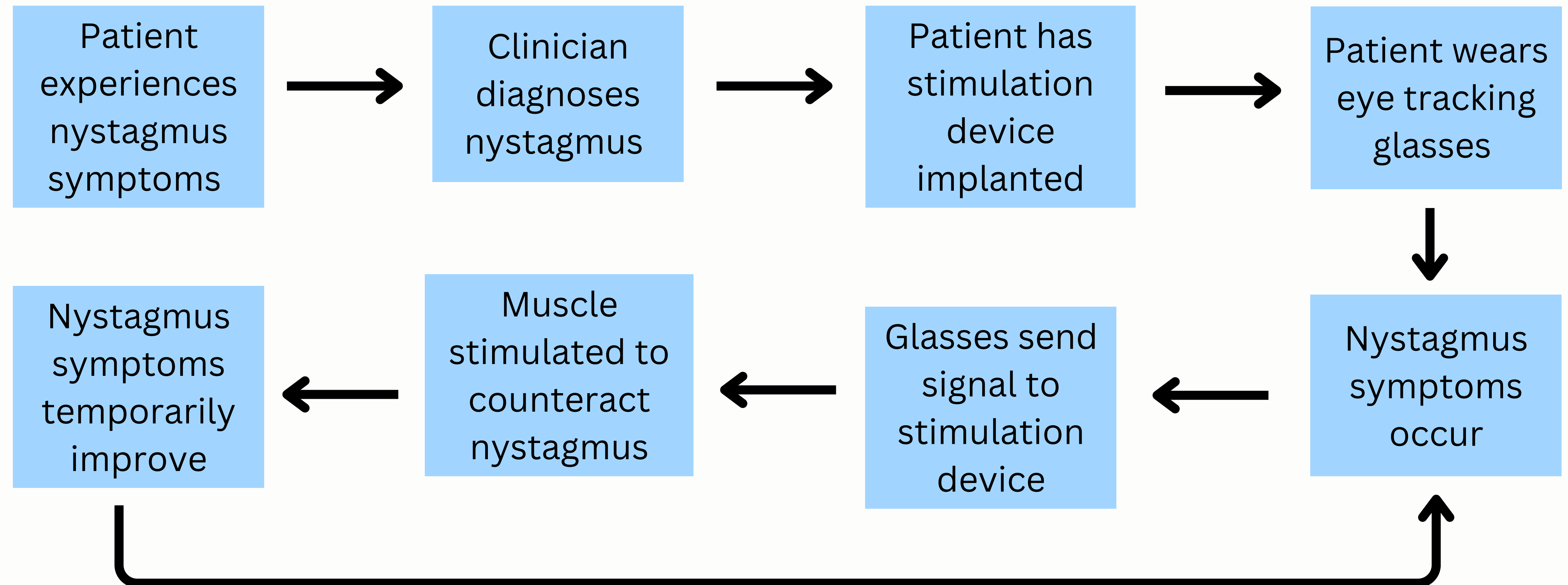


Calculation of counteracting velocity vector



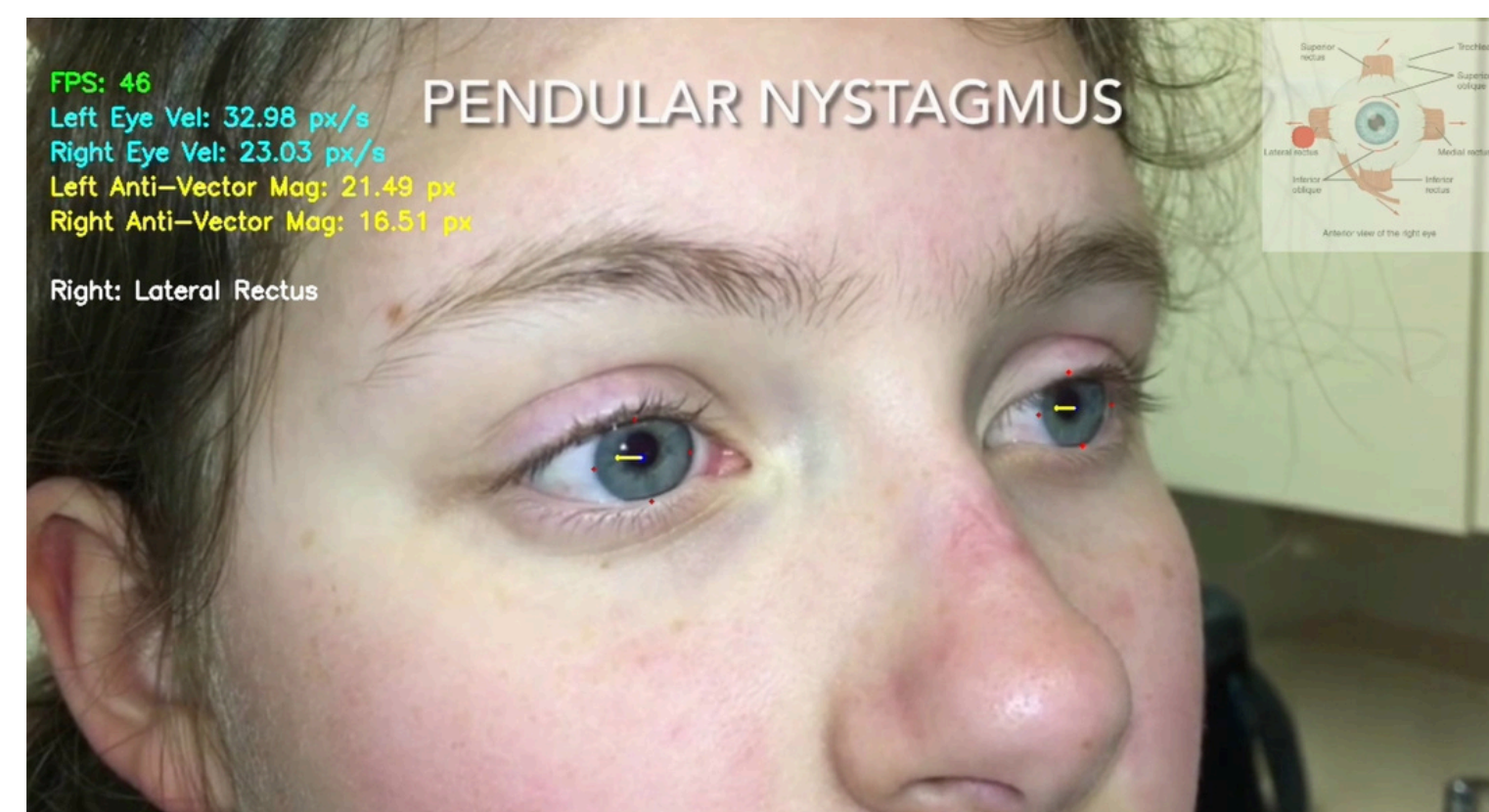
Stimulation of associated extraocular muscles

Clinical Workflow for iCrutch

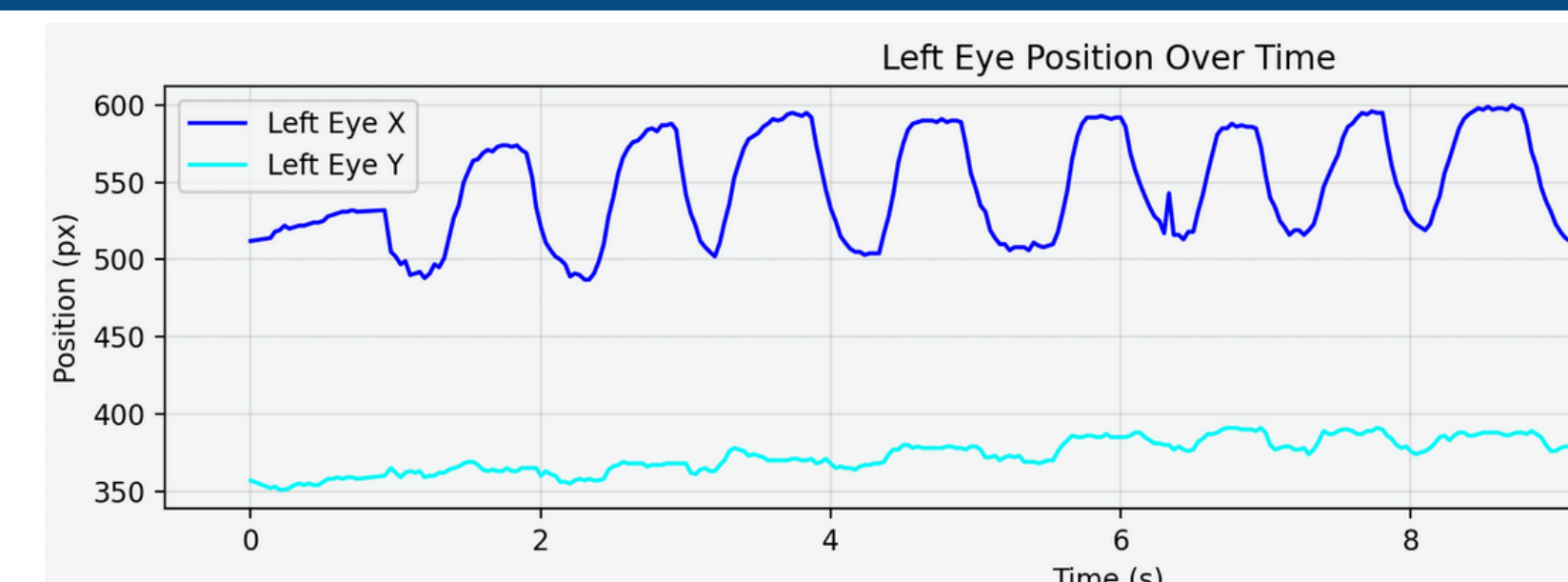


Solution Output

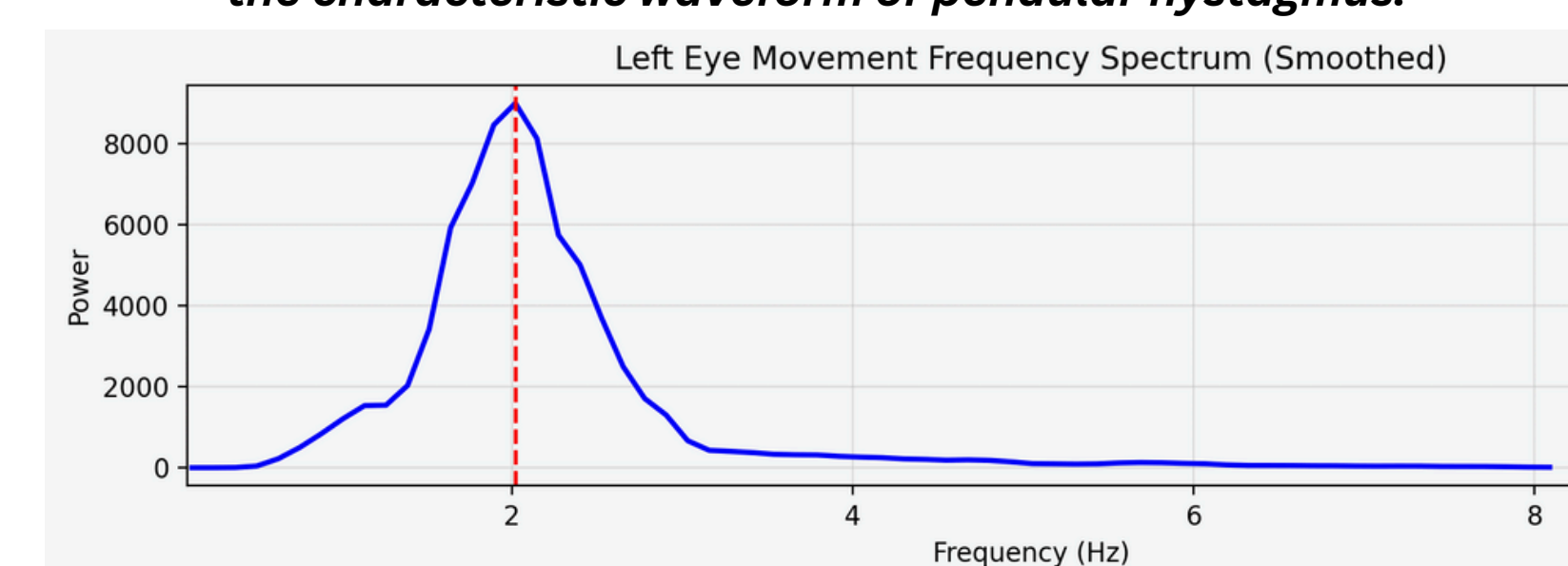
Live Feed



Velocities of anti-vectors for right and left eye movement are calculated and displayed. Anti-vectors are shown with yellow arrows. The associated counteracting extraocular muscles are highlighted in red.



Horizontal (X) and vertical (Y) left eye position over time, showing the characteristic waveform of pendular nystagmus.



Frequency spectrum of left eye movement showing a dominant peak at 2 Hz, indicating presence of nystagmus oscillatory patterns.



Demonstration of the solution on real patient videos.

User Needs

1

Must identify the presence of nystagmus and the extraocular muscles involved in real-time with minimal latency

2

Must continuously track eye movement velocity for slow phase motion correction

3

Must adapt to patient-to-patient differences and various lighting conditions

References: [1] Nystagmus Network. (n.d.). What is nystagmus? [2] Dumitrescu, A. V., Scruggs, B. A., & Drack, A. V. (2020). Clinical guidelines: Childhood nystagmus workup. American Academy of Ophthalmology. [3] Ospina LH. Dealing with Nystagmus. J Binocul Vis Ocul Motil. (2018). [4] All About Vision. (n.d.). Types of nystagmus American Academy of Ophthalmology. (n.d.). Eye muscles. Retrieved April 22, 2025, from <https://www.aaof.org/eye-health/anatomy/eye-muscles>