StabilEyes - New Assistive Technology for Nystagmus to Produce a Stabile Real-Time Video Image

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Introduction: Nystagmus is a visual condition in which the eyes make involuntary, repetitive motions that often result in blurred vision and reduced depth perception. The condition has an estimated prevalence of 0.24% in the general population (approximately 785,000 individuals in the United States)[1]. Current treatment options for nystagmus include corrective eyeglasses or contact lenses, medications, surgery, and rehabilitation therapy. Unfortunately, these methods often have imperfect success and/or are prohibitively expensive, especially for people with limited means. Our free, open-source application (app) will run on any smartphone or tablet, using the front-facing camera to detect eye motion and, subsequently, stabilizing a real-time image of the environment for the user, captured by the back-facing camera. We present here an initial method for detecting eye motion using the simple strategy of finding repetitive motion in the image with 1st order moment calculations, from which image translation will be informed.

Materials and Methods: Pupil-tracking is an established technology, generally requiring either higher quality cameras than the front-facing ones in cell phones or specialized hardware mounted around the eyes. We intend instead to use the existing smartphones or tablets already in the hands of most people. The premise of our system is that we need only detect the frequency and phase of eye movements, not actual pupil location, to stabilize the image for the user with nystagmus. Our present algorithm is implemented in C++ using the open-source computer vision library, OpenCV. We take advantage of OpenCV's face classifier to identify a rectangular region containing both eyes. We then use a sum-absolute-difference motion tracking algorithm to track this region of the face. As the eyes move back and forth within this region, the changing location of the iris against the sclera (whites of the eyes) is expected to produce a 1st order moment ("center of mass") that varies temporally in phase with eye motion. To test our algorithm, we created "pseudo-nystagmus" videos from individual facial images of normal volunteers captured by the internal camera of a laptop computer while the subjects focused on a dot at various known locations along the *x* axis of the computer display.

Results and Discussion: A pseudo-nystagmus sequence was created to simulate sinusoidal eye motion in the *x* direction with a period of 176 frames per cycle for a duration of 2 cycles. Figure 1 shows the *x* component of the 1st order moment (in units of inter-pixel distance) automatically computed by the algorithm described above. These preliminary results show reliable tracking of the eye motion with acceptable signal-to-noise ratio. The speed of the algorithm (running on a Macintosh laptop) was approximately 21 frames per second. Given that nystagmus typically exhibits a frequency in the range of 4 cycles per second, this is a realistic processing time.

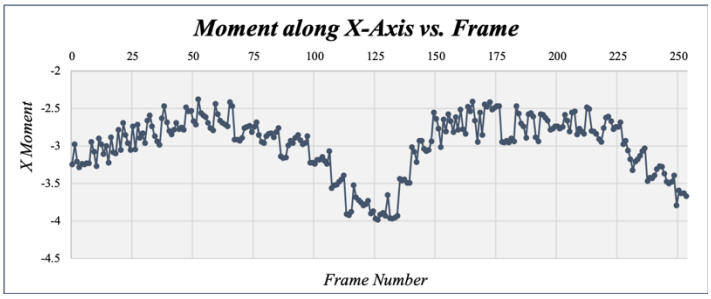

Figure 1. Computed 1st order moment of automatically identified region containing both

Conclusions: We are developing a new app for the smartphone/tablet, using this ubiquitous platform to provide a stabilized image of the environment in real time. Our initial results are encouraging in terms of reliability and speed. We will incorporate a phase-lock-loop algorithm to extract the frequency and phase information from the 1st order moment, to translate the image. The user will adjust the translation amplitude for optimum stability. We are expecting to combine the StabilEyes app with a new peripheral device called FingerSight, which we are also developing, in which a miniature camera and 4 vibrators are mounted on the finger via a ring. In this system, the view of the environment being stabilized would be acquired by moving the hand instead of the smartphone.

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References:

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