PanOculus: A Novel, Multifaceted Diagnostic Tool for Ocular Disease Powered by a Variable Focus Liquid Lens, Deep Learning, and Telemedicine Technology

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Retinal diseases such as glaucoma and diabetic retinopathy (DR) currently devastate the developing world, causing permanent visual impairment when left undiagnosed and untreated. Glaucoma is the leading cause of irreversible vision loss worldwide, affecting nearly 80 million people, while DR is the leading cause of blindness among working-age adults, affecting a third of the world's 285 million diabetics [CDC]. Diagnosis for these maladies is often conducted using optical coherence tomography or fundoscopy with a trained ophthalmologist—an extremely inaccessible process preventing the diagnosis of millions in developing nations. The goal of PanOculus was to formulate an inexpensive and accessible solution to the impediment of diagnosing and treating diabetic retinopathy, glaucoma, and other retinal diseases in developing countries. PanOculus uses a diagnostic pipeline integrating both hardware and software. The hardware consists of a mobile phone attachment with a variable-focus liquid lens to capture a photo of the retina. The liquid lens, consisting of water and polydimethylsiloxane, permits adjustable focal length through manipulation of voltage, allowing it to be controlled by an Arduino board to alter the magnification and focus of the image. The software includes an iOS application enabled with a machine learning algorithm, trained on over 20,000 images sourced from medical facilities, to instantly identify eye diseases from images through visual segmentation of exudates, microaneurysms, and cup/disk ratio abnormalities. The app is enabled with cloud compatibility to remotely share results with physicians. The algorithm achieved an accuracy of 92.3%—a statistically significant result compared to the global mean of 79.2% for retinal disease diagnosis [BMC].