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Scheimpflug with Computational Imaging to Extend the Depth of Field of Iris Recognition Systems

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Despite the enormous success of iris recognition in close-range and well-regulated spaces for biometric authentication, it has hitherto failed to gain wide-scale adoption in less controlled, public environments. The problem arises from a limitation in imaging called the depth of field (DOF): the limited range of distances beyond which subjects appear blurry in the image. The loss of spatial details in the iris image outside the small DOF limits the iris image capture to a small volume--the capture volume. Existing techniques to extend the capture volume are usually expensive, computationally intensive, or afflicted by noise. Is there a way to combine the classical Scheimpflug principle with the modern computational imaging techniques to extend the capture volume? The solution we found is, surprisingly, simple; yet, it provides several key advantages over existing approaches.

Our method, called Angular Focus Stacking (AFS), consists of capturing a set of images while rotating the lens, followed by registration, and blending of the in-focus regions from the images in the stack. The theoretical underpinnings of AFS arose from a pair of new and general imaging models we developed for Scheimpflug imaging that directly incorporates the pupil

parameters. The model revealed that we could register the images in the stack analytically if we pivot the lens at the center of its entrance pupil, rendering the registration process exact. Additionally, we found that a specific lens design further reduces the complexity of image registration making AFS suitable for real-time performance. We have demonstrated up to an order of magnitude improvement in the axial capture volume over conventional image capture without sacrificing optical resolution and signal-to-noise ratio. The total time required for capturing the set of images for AFS is less than the time needed for a single-exposure, conventional image for the same DOF and brightness level. The net reduction in capture time can significantly relax the constraints on subject movement during iris acquisition, making it less restrictive.

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To Vibha.