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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 regulated spaces for biometric authentication, it has hitherto failed to gain wide-scale adoption in large, unrestricted environments. The problem arises from a fundamental limitation of optical imaging called the depth of field—the limited range of distances within which subjects appear sharp in the image. The loss of details in the iris image outside a small finite volume—the capture volume—dramatically deteriorates the performance of iris recognition beyond a small range of distances. Existing techniques are usually expensive, computationally complex, or exhibit low signal-to-noise ratio. Is there a way to combine the classical Scheimpflug technique with modern computational imaging to find a reliable method that can significantly extend the depth of field of iris recognition? Unexpectedly, the technique we found in this thesis is simple. Additionally, provides several key advantages over existing approaches.

We developed a pair of equations that describe imaging in systems in which the lens and the sensor can rotate about independent pivots. The primary advantage of our models over existing models is that they directly incorporate the pupil parameters, allowing us to predict the nature of

the image in such systems efficiently. Furthermore, analysis of geometric properties using our model led to the discovery of the set of conditions required for synthesizing an extended depth of field image from a sequence of images captured while continually rotating the lens. We call this new computational technique angular focus stacking. One of the key advantages of our method is that the improvement is the depth of field is constrained only by magnification. Additionally, we found that rotation of the lens about the center of the entrance pupil allows us to analytically register the images in the stack instead of relying on computationally intensive algorithms.

The angular focus stacking method is tailor-made for significantly extending the capture volume of iris acquisition systems, yet it is simple, easily scalable, cost-effective and computationally efficient for real-time performance. Moreover, we obtain huge gains in depth of field without sacrificing optical resolution and signal-to-noise ratio. Additionally, we have demonstrated that we can capture images for angular focus stacking within a fraction of the time required by traditional imaging for the same depth of field and exposure level. Therefore, the constraint on subject movement within the large capture volume can be significantly relaxed using the proposed method.

TABLE OF CONTENTS

LIST OF FIGURES

Figure

LIST OF TABLES

Tables

To Vibha.