ACKNOWLEDGEMENTS

I am greatly indebted to Dr. Marc P. Christensen, my advisor, for his unyielding support and astute guidance during my Ph.D. I sincerely admire his inexhaustible patience, and his ability to deconstruct complex problems and illuminate the essence in simple terms. I have tried my best to learn these valuable skills by observing him. I thank him for masterfully shaping my thoughts through critical questioning, helpful discussions, insightful suggestions, and at the same time giving me the freedom to define and pursue the research in my own way.

I am very grateful to my friend and colleague Dr. Prasanna Rangarajan. I have spent several years collaborating with him on a multitude of Optics and Imaging research. I have grown as a researcher seeing and admiring his tenacious work ethics, math wizardry, and problem-solving methods. I thank him for the endless stimulating whiteboard discussions, for sharing his knowledge and ideas, and for helping me refine the mathematical model in this thesis.

I express my sincere gratitude to Dr. Panos Papamichalis, Dr. Dinesh Rajan and Dr. Predrag Milojkovic for shaping my research through hard questioning, vocational guidance, perceptive comments, encouragement and help without question whenever I required.

I thank Dr. Delores M. Etter and Dr. Yunkai Zhou for serving on my dissertation committee and giving meaningful feedback on the research work despite their busy schedule. They have always been most sympathetic and accommodating to all my needs.

I am very grateful to Dr. Duncan MacFarlane for providing critical feedback on my work and giving valuable suggestions on improving as a researcher.

I will forever be grateful to my Master’s thesis advisor Dr. Scott Douglas for initiating me to research. Without that opportunity, my life would have inevitably carved out a different path.

I have been very fortunate to be part of a highly motivated and talented group of researchers during my time at SMU: Dr. Manjunath Somayaji, Dr. Vikrant Bhakta, Dr. Esmaeil Faramarzi, Ting Li, Nick Saulnier, Jack Ho, Muralidhar Balaji, Aparna Viswanath and Ashwini Subramanian. I have learned a lot from each of them, and I will always cherish their friendship. I will always be indebted to Dr. Manjunath Somayaji for thoughtfully guiding me both on technical and non-technical matters whenever I needed. I am thankful to Dr. Vikrant Bhakta for being a supportive friend and collaborator. It was Dr. Bhakta and Dr. Somayaji who had initiated the groundwork for examining various techniques for solving the limited capture volume problem in iris recognition.

I would like to thank Jack Strobel of Harwin Camera, Inc. for going out of his way to help with issues related to the view camera we bought from Sinar. I also thank Senior Lecturer Charles DeBus for being kind enough to teach me the basics of view camera photography and allowing me to use his film development lab for my experimentation with a view camera.

Life could have been difficult during my time at SMU without all the help, support and care I received from Susan Bailey, Jay Kirk, Mitzi Hennessey, Julie Bednar, Misti Compton, Kristine R. Reiley, Elizabeth Van Dyken, Lorna Runge and Jim Dees. Susan is very thoughtful and compassionate. I will always be grateful for the generosity Susan, Mitzi, Julie, Misti, and Kristine have shown towards me. Jim's attention to details has ensured the quality of the dissertation. He has also been very kind and helpful with issues related to admission when I needed.

I would like to thank my friends outside the sphere of my research who have motivated me to achieve whatever little I have till now—Sid Choraria, Kiran Tatiparthi, Ruan Chimata, Srinivas Bandi, Arun Hegde, Dipto Mukherjee, Zahid Najam and Nithin Mohandas. I will always be grateful for their generosity and encouragement.

I have been blessed to have a beautiful family. I thank my parents for the immense personal sacrifices they have made for providing me the best education, incommensurable love and care, and constant inspiration. I am grateful for the gift of a wonderful brother and sweet sister. I highly cherish their boundless love and warmest affection. I am very fortunate to have kindhearted and understanding parents-in-law. I can’t thank them enough for their immense love, tiresome patience, and unceasing words of encouragement.

Last but not the least, I thank my wife and best friend, Vibha, for her steadfast support, unfathomable patience, and unconditional love for me through the vicissitudes of our life. Time just seems to fly in her presence.

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Scheimpflug with Computational Imaging to Extend the Depth of

Field of Iris Recognition Systems

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Doctor of Philosophy December 17, 2016

Dissertation completed November 28, 2016

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.