Design and Implementation of Real-Time Multi-Sensor Vision Systems

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Preface

The Microelectronic Systems Laboratory (LSM) of EPFL first started working on multi-camera vision systems back in 2009, when the concept of omnidirectional imaging using multiple sensors was still in its infancy. At that time, our research group took up the problem of building multi-sensor real-time imaging systems mainly as a challenge that required innovative solutions combining algorithms, system architectures, and hardware implementations. Conventional graphics processing hardware architectures prove remarkably inadequate for a number of tasks required for multi-sensor imaging. This called for a wide range of custom solutions that sought to optimize pixel-level processing, memory access, and parallelization. When we started our research activities in this domain, there were not even any user applications, nor any system specifications anticipated for multi-sensor vision systems.

Fast-forward to 2017, we see a very active field and a proliferation of exciting applications of multi-camera systems in virtual reality (VR), augmented reality (AR), security, surveillance, and many other areas. The research carried out by members of LSM during the past 7 years allows us to address a multitude of problems associated with multi-sensor imaging, including omnidirectional panorama construction, image blending, networks of cameras, disparity estimation—among others. Throughout the years, our research group has been fortunate to be at the forefront of this very exciting and fast-developing domain.

This book covers a number of topics that have been explored in the context of multi-camera vision systems, discussing aspects related to specialized algorithms as well as the associated hardware design and implementation. As such, the book offers a comprehensive theoretical basis for the understanding of multi-camera systems. We cover the basics of image formation, algorithms for stitching a panoramic image from multiple cameras, and multiple real-time hardware system architectures, in order to obtain panoramic videos. The topics covered in this book would be beneficial to graduate students specializing in omnidirectional multi-sensor systems, as well as HW/SW engineering professionals designing future systems for a wide range of VR/AR applications.

The authors are truly indebted to many individuals who have contributed to this work over the years. The early phases of this research were initiated by the very fruitful collaboration with Professor Pierre Vandergheynst and his group, who first brought the systems design challenge to the attention of the LSM team. Dr. Alexandre Schmid and Dr. Hossein Afshari of LSM have been instrumental in establishing the theoretical basis for the first multi-camera systems explored in this work, and in designing the first prototypes. Over the years, Mr. Sylvain Hauser and Mr. Peter Brühlmeier have provided their excellent skills for building some of the most unique and most complicated hardware platforms that enabled the experimental work presented here. The strong support and valuable advice offered by our colleagues at Armasuisse, Dr. Peter Wellig and Dr. Beat Ott, are highly appreciated. We thank our graduate project students, in particular, Mr. Jonathan Narinx, Mr. Selman Ergunay, Mr. Bilal Demir, Mr. Luis Gaemperle, Ms. Elieva Pignat, Ms. Ipek Baz, Mr. Andrea Richaud, and Mr. Raffaele Cappocia, for their contributions. We acknowledge the very valuable and consistent support of Mr. Bentley Woudstra and Mr. Karl Osen, who have successfully motivated the effort since the very early days. Finally, a very special note of thanks goes to Mr. François Stieger for his extraordinary support and encouragement. This work would not have been possible without their contributions.

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