Preface

Advances in Embedded Computer Vision

This book offers a fresh look at the advances that the field of embedded computer vision has made in recent years. It is similar in structure to the similarly named book, *Embedded Computer Vision*, published in 2008 also by Springer, but the content is all new.

What Is Embedded Computer Vision?

If you are new to this field, think of *Embedded Computer Vision* as the art of doing *computer vision*, with its complex algorithms and high computational and data bandwidth requirements, on processing platforms with serious constraints in terms of power, size, and cost, what we typically call *embedded systems*. These constraints come from specific requirements in which such systems are used: mobile devices (such as smart phones and tablets), robots, cars, micro air vehicles, remote cameras, etc.

Can It Be Done?

Oh, yes, it can be done! It is not easy, and that is why our field is still dominated by, in the language of *The LEGO Movie,* master builders. In Part I we present a number of success stories, in Part II we have descriptions of recent developments in our field, and in Part III we take a look at what the future challenges might be.

Target Audience

This book is meant for researchers, both in academia and industry, practitioners, and innovation managers interested in embedded computer vision. It offers insights at a variety of different levels: historical perspective, markets, technologies, systems, algorithms, embedded implementation, tools, and future developments.

The book can be used in academic teaching and research in various ways. It could be used as reading material for specialized advanced courses, for example, to introduce students of a computer vision course into state-of-the-art problems and applications of embedded vision technologies. To help with that, the chapters in the book are self-contained and could be assigned to students as individual reading material in seminar courses. The book may also provide an inspiring source of information for students and supervisors who are looking for promising and industry-relevant topics for Master and Ph.D. theses in the field of embedded vision.

Organization of the Book

Each chapter is a self-contained unit describing a particular topic. The chapters are grouped into three parts:

Part I: Success Stories—with detailed descriptions of three major success stories in our field—the optical mouse, robotic vision, and vision for automotive safety.

Part II: State of the Art—with seven chapters on the recent work in embedded 3D vision, unmanned aerial vehicles, automotive vision, mobile vision, and augmented reality.

Part III: Future Challenges—with three chapters that provide a peek into some of the future research directions.

Overview of Chapters

Before we briefly describe each chapter in the book, we would like to emphasize two areas of research that experienced a significant growth in the last few years.

The embedded realization of 3D vision technologies is of high relevance for a variety of applications including robotics and automotive safety, and it is currently receiving increased attention with the growing availability of stereo cameras on mobile devices such as tablets and smart phones. Especially in outdoor scenarios, with bright sunlight and varying imaging distances, stereo cameras offer advantages compared to other 3D sensors such as Microsoft's Kinect or time-of-flight sensors. The importance of embedded stereo matching algorithms that enable the

computation of high-quality depth maps in real-time on resource-limited systems is well reflected by several contributions in the book.

A recent trend towards the development of small unmanned aerial vehicles (UAVs) increases the demand for light-weight and low-power sensors and processing units that can be used on-board the moving platform. The embedded implementation of image and video processing algorithms for fast and reliable self-localization, collision avoidance, and object recognition is a basic requirement for envisioned applications such as search and rescue tasks.

Part I: Success Stories

- In Chap. 1, "The Optical Mouse: Early Biomimetic Embedded Vision," Dick Lyon recalls his 1980 work on the development of the Xerox optical mouse integrated circuit. He emphasizes the mouse's bio-mimetic vision architecture and connections to other things going on in the vision and integrated circuit fields at the time.
- In Chap. 2, "Consumer Robotics: A Platform for Embedding Computer Vision in Everyday Life," authors Mario E. Munich, Phil Fong, Jason Meltzer, and Ethan Eade describe their work in robotic vision. They present a graph-based SLAM approach designed to operate on computationally constrained platforms using monocular vision and odometry.
- In Chap. 3, "Embedded Vision in Advanced Driver Assistance Systems," Zoran Nikolić tells us about applications of computer vision in advanced driver assistance systems—automotive vision.

Part II: State of the Art

- In Chap. 4, "Computer Vision for Micro Air Vehicles," authors Roland Brockers, Martin Humenberger, Yoshi Kuwata, Larry Matthies, and Stephan Weiss show us how their autonomous flight navigation framework for micro air vehicles addresses the challenges of low-power, small size solution for navigation in cluttered environments where these small unmanned aerial vehicles have to operate.
- In Chap. 5, "Stereo Vision Algorithms Suited to Constrained FPGA Cameras," Stefano Mattoccia reviews stereo vision algorithms suited for FPGA-based cameras. In particular, this chapter deals with the implementation of such algorithms on embedded camera systems with constrained hardware resources.
- In Chap. 6, "Plane Sweeping in Eye-gaze Corrected, Tele-immersive 3D Video Conferencing," authors Maarten Dumont, Patrik Goorts, and Gauthier Lafruit extend the stereo disparity estimation towards multiple cameras. Targeting high-quality image post-processing applications, they describe a view interpolation system, synthesizing new intermediate viewpoints for application in tele-immersive 3D video conferencing.
- In Chap. 7, "Challenges in Embedded Vision for Augmented Reality," authors Rajesh Narasimha, Norbert Stöffler, Darko Stanimirović, Peter Meier, and Markus Tremmel give us a broad overview of augmented reality applications.

- In Chap. 8, "Tic-Tac-Tandroid: A Tic-Tac-Toe Mobile Vision App," authors Milena Djordjević-Kisačanin, Vinjai Vale, and Branislav Kisačanin present an 8th grade science fair project in which an Android app was created for smart phones that can play the game of tic-tac-toe by "seeing" a hand-drawn board, and "thinking" of the next best move.
- In Chap. 9, "Vehicle Detection Onboard Small Unmanned Aircraft," authors Mathias Kölsch and Robert Zaborowski present their work on ground vehicle detection from a small flight platform.
- In Chap. 10, "Vision-based Lane Analysis: Exploration of Issues and Approaches for Embedded Realization," authors Ravi Kumar Satzoda and Mohan M. Trivedi give us insight into their latest algorithmic approaches for efficient automotive vision.

Part III: Future Challenges

- In Chap. 11, "Distributed Smart Cameras in the Age of Cloud Computing and the Internet-of-Things," Marilyn Wolf surveys development in embedded computer vision systems related to the Internet of Things. The chapter considers algorithms, software architectures, and hardware platforms.
- In Chap. 12, "Data-driven Stream Mining Systems for Computer Vision," authors Shuvra S. Bhattacharyya, Mihaela van der Schaar, Onur Atan, Cem Tekin, and Kishan Sudusinghe discuss their ideas about how the huge volumes of image data coming from networks with large numbers of cameras can be processed in a systematic and efficient framework.
- In Chap. 13, "Designing Vision Systems that See Better," authors Sek Chai, Sehoon Lim, and David Zhang present a summary of their work on computational sensing. This chapter introduces the reader to a branch of computer vision that deals with computationally improving captured imagery by fundamentally changing how light is sensed, captured, and processed.

How This Book Came About

As organizers of the ninth Embedded Vision Workshop in 2013 (these workshops have been held almost every year at IEEE CVPR conferences), we were in a unique position to help satisfy the need for a focused, comprehensive overview of recent developments in embedded computer vision. We invited a number of authors who contributed to recent Embedded Vision Workshops and the result of that collaboration is in front of you!

Plano, TX, USA, August 2014 — Branislav Kisačanin
Vienna, Austria — Margrit Gelautz

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