Preface

An emerging trend in the automobile industry is its convergence with information technology (IT). Indeed, it has been estimated that almost 90 % of new automobile technologies involve IT in some form. *Smart* driving technologies that improve safety as well as *green* fuel technologies are quite representative of the convergence between IT and automobiles. The former technologies, in particular, include three key elements: sensing of driving environments, detection of objects and potential hazards (pedestrians, lanes on the road, other vehicles, traffic signals, stationary objects, etc.), and the generation of driving control signals including warning signals. The first two elements are usually implemented using machine vision, radar, and sonar together with vehicle-to-vehicle and vehicle-to-infrastructure communication. These are the most commonly used technologies to realize novel systems such as a smart parking assistance, lane keeping assistance, smart cruise control, collision avoidance, and ultimately fully autonomous self-driving vehicles.

This book is organized into 10 chapters to cover system-on-a-chip (SoC) design—including both algorithms and hardware—related with image sensing and object detection by using the camera for smart driving systems, as shown in Fig. 1. First, lens correction techniques for distorted images captured by cameras installed on vehicles are presented. Second, novel super-resolution algorithm suited to a low-cost vehicle camera is presented. Next, image enhancement techniques to improve object detection from the captured images are discussed. Then, two chapters present algorithms and techniques for accurate detection of several different types of objects (pedestrians, road lanes other vehicles, traffic signals, stationary objects, etc.). This is followed by a discussion of the SoC architecture and hardware design necessary to implement these algorithms in real time. Finally, the software environment and reliability issues for automotive SoC platforms are discussed.

Chapter 1 introduces the needs and requirements of an image vision system for smart and safe driving in a novel IT-converged automobile. Next, we present and discuss the platform architecture for addressing the components of the automotive vision system. This platform is implemented as a System-on-a-Chip (SoC) platform, and its hardware architecture along with its software environment are introduced.

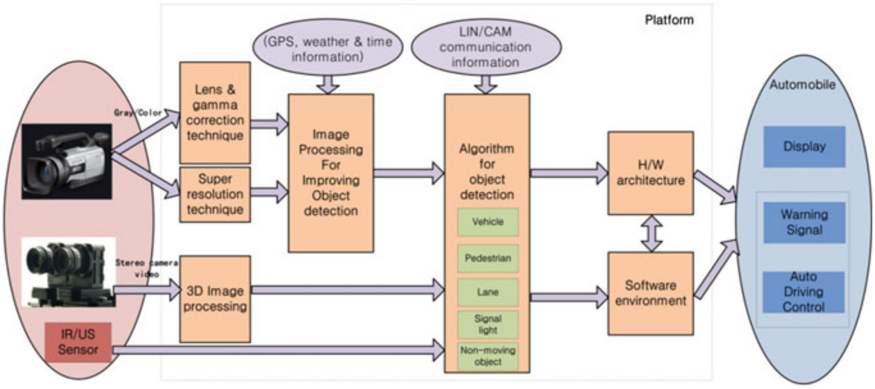

Fig. 1 SoC platform architecture for automobile vision system

Chapter 2 presents a lens distortion correction algorithm based on a geometric invariant suitable to a vehicle camera. This method adopts cross-ratio invariability for a perspective projection and minimized distortion. In addition, we describe a new gamma correction approach to deal with rapid variation in luminous intensity. To reduce the computation complexity, we introduce an objective numerical descriptor for luminance and contrast as well as gamma correction based on a tone-mapping approach.

Chapter 3 presents a novel super-resolution algorithm suited to a low-cost vehicle camera. We introduce a smart and robust registration algorithm that takes into account rotation and shift estimation. To reduce the registration error, this algorithm determines the optimal reference image where even other super-resolution algorithms discard this registration error. The algorithm follows the warp–blur observation model because the blur parameter is considerably larger than the warp parameter for camera rotation and/or vibration.

Chapter 4 introduces image processing algorithms for improving object detection. These algorithms can be used to improve the object recognition rate for poor images that have been captured under inadequate conditions such as low illumination, rainfall, or snowfall. Furthermore, a high-dynamic-range tone-mapping technique that improves image quality is described.

Chapter 5 explains coarse-to-fine vehicle and pedestrian detection techniques. In the case of vehicle detection, we describe mono-camera-based vehicle detection systems in which low-level edges and high-level bag-of-features are incorporated. Specifically, once initial candidates are obtained using edge information, these candidates are further verified using a bag-of-features. On the other hand, in the case of pedestrian detection, we explain certain popular Histogram of Oriented Gradient (HOG) detectors and part-based detectors. The use of edge-based coarse detection in the base detectors greatly reduces the detection time.

Chapter 6 discusses various driver monitoring systems as well as some methods for predicting unsafe driving behaviors. We describe the design considerations that led us to develop the driver monitoring system architecture, discuss the software responsible for control and data acquisition, and present some of the data screening and feature extraction algorithms that predict unsafe driving behaviors.

Chapter 7 covers various aspects of SoC architectures for automobile vision system. After a brief introduction, it surveys existing SoC architectures as well as architecture design issues and methodologies, ranging from single- to multi-core SoC architectures. The chapter further discusses on-chip communications among cores, hardware blocks, and memories. It also covers the issue of mapping applications to SoC architectures.

Chapter 8 introduces a hardware accelerator that performs interest point detection and matching for image-based recognition applications in real time. Interest point detection and matching are basic and one of the most computation-intensive operations, in general, vision tasks such as object recognition/tracking, image matching/stitching, and simultaneous localization and mapping. This chapter describes a pattern matching-based image recognition processor that unifies architectures for features from accelerated segment tests and binary robust independent elementary features with low power dissipation and a high frame rate.

Chapter 9 introduces a software development environment for automotive SoC. AUTOSAR, a standardized automotive software architecture, is a partnership of automotive manufacturers and suppliers working in collaboration to establish an open industry standard for automotive E/E architectures. This chapter describes this software architecture in detail, covering the consideration of safety requirements, scalability of different vehicle and platform variants, and implementation and standardization of the basic functions based on the cooperation of standards. In addition, this chapter covers maintainability throughout the entire product life cycle, software updates, and upgrades over vehicle lifetime.

Chapter 10 covers reliability issues of automobile electronic system. Current vehicles are built with complex electronic systems embedded with more than a hundred microprocessors through complicated automotive networks. In the de facto ISO 26262 standard in the automotive industry, Automotive Safety Integrity Level (ASIL) is classified into four different levels. In this chapter, the ISO 26262 hardware ASIL is described in detail. Finally, we introduce fault diagnosis architectures that use various designs for testability techniques such as scan design, built-in self-test, and IEEE boundary scan design for increasing hardware reliability.

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