Machine Vision

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Automated Visual Inspection: Theory, Practice and Applications

Springer

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Dedicated to Professor Dr.-Ing. Franz Mesch

Preface

Machine vision and automated visual inspection are domains of automation technology with a steadily increasing economical relevance. Although the related industry is notably expanding since the past two decades, only a part of today's visual inspection tasks have been automated. This is why there is a great potential for economization in high income countries which may lead to both reduced costs and increased quality of the produced goods.

As visual perception is the main human sensation, the automation of visual inspection is somehow fascinating—at least for the authors of this book. When talking about the automation of visual inspection one might easily think that it cannot be that hard to teach a technical visual inspection system to perceive what a human can easily see with only a glimpse. Actually, users often state: 'As humans can see that instantly, it can't be that hard to achieve the same using a machine'. The answer is not easy at all but it depends on the individual case: for humans, some things represent easy tasks which however are difficult to automate—on the contrary, many other things can be done more precisely and particularly more reliably by machines, if an automation is possible.

Automated visual inspection is a complex and multi-disciplinary topic involving optics, mechanical and electrical engineering, mathematics and computer science. Systems for automated visual inspection are usually more or less complex mechatronic systems, which can only achieve the requested performance in an economical way, if all the necessary disciplines collaborate.

Everything starts with a visual inspection task that is to be carried out using an automated approach. In this context, image acquisition plays an important role: loss of information during that step can hardly be compensated during later image processing steps. The success of a visual inspection solution depends heavily on the quality of this first step.

Fortunately, when designing an automated visual inspection system, one usually has the benefit of several degrees of freedom, in order to obtain image data with sufficient quality and significance. This is why the suitability of the image acquisition for a given problem at least partly depends on the engineer. In order to exploit those degrees of freedom at the best, this book draws particular attention to image acquisition and the acquisition constellation, consisting of the test object, the illumination and the acquisition system.

This book has the ambition to thoroughly introduce the reader into the terms of automated visual inspection. For this purpose, the Chapters 2 to 6 of the book's first part deal with the physics of image formation and the required optical principles and techniques in an adequately extensive way. Based on that foundations, image acquisition for automated visual inspection will be treated in Chapter 7. In this key chapter, a multitude of different techniques for image acquisition will be explained in a systematic way, as well as important hints and tricks will be shown which are indispensable for a good visual inspection system.

In order to enable automated analysis of images in a computer, the analog image signals have to be transformed into digital signals. The underlying theory of signal processing and the effects of local sampling and quantization will be extensively discussed, especially in terms of system theory. Among others, Chapter 8 is devoted to the basics of digital processing of analog signals and prepares the reader for the second part of the book, which focuses on image analysis. Chapters 9 to 15 cover methods, which form the individual steps leading to a final inspection result based on the acquired image data.

The depth of the explanations of all covered subjects is chosen to provide the reader with insight into the respective motivation and backgrounds. No facts are supposed 'to appear from nowhere'; the underlying concepts should be thoroughly understood. Some theorems however will not be proven in a strict mathematical way. In fact, there will be sketches of the proofs, which will present their essential idea and help to understand important concepts. For an application-oriented reader who is nevertheless interested in what happens behind the scenes, consciously omitting technically flawlessly led proofs increases the book's readability and leads to a handy amount of pages.

The book on hand is partially based on lectures held by the author J. Beyerer at the Karlsruhe Institute of Technology (KIT, formerly University of Karlsruhe) since 1994 and by the author F. Puente León, initially at Technische Universität München (TUM) since 2003 and at KIT since 2008. It addresses itself to students studying in the fields of engineering science, computer science, physics and mathematics. As all needed concepts and methods are introduced in a sufficiently exhaustive way, it should be possible for advanced bachelor students to clearly understand the presented content. Furthermore, scientists, PhD students and especially master students dealing with automated visual inspection can profit from reading the book as its topics are appropriately elaborated.

Besides theory, practice is not missed out. The authors' industrial experience, which is incorporated into many topics of the book, brings benefits even to practically oriented readers who seek for robust and economic solutions for concrete visual inspection tasks. Nonetheless, the book does not loose itself into superficial recipes but yields enough substance for a deep understanding of the presented content.

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