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Design and Implementation of Autostereoscopic Displays

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Tutorial Texts in Optical Engineering
Volume TT99

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Introduction to the Series

Since its inception in 1989, the Tutorial Texts (TT) series has grown to cover many diverse fields of science and engineering. The initial idea for the series was to make material presented in SPIE short courses available to those who could not attend and to provide a reference text for those who could. Thus, many of the texts in this series are generated by augmenting course notes with descriptive text that further illuminates the subject. In this way, the TT becomes an excellent stand-alone reference that finds a much wider audience than only short course attendees.

Tutorial Texts have grown in popularity and in the scope of material covered since 1989. They no longer necessarily stem from short courses; rather, they are often generated independently by experts in the field. They are popular because they provide a ready reference to those wishing to learn about emerging technologies or the latest information within their field. The topics within the series have grown from the initial areas of geometrical optics, optical detectors, and image processing to include the emerging fields of nanotechnology, biomedical optics, fiber optics, and laser technologies. Authors contributing to the TT series are instructed to provide introductory material so that those new to the field may use the book as a starting point to get a basic grasp of the material. It is hoped that some readers may develop sufficient interest to take a short course by the author or pursue further research in more advanced books to delve deeper into the subject.

The books in this series are distinguished from other technical monographs and textbooks in the way in which the material is presented. In keeping with the tutorial nature of the series, there is an emphasis on the use of graphical and illustrative material to better elucidate basic and advanced concepts. There is also heavy use of tabular reference data and numerous examples to further explain the concepts presented. The publishing time for the books is kept to a minimum so that the books will be as timely and up-to-date as possible. Furthermore, these introductory books are competitively priced compared to more traditional books on the same subject.

When a proposal for a text is received, each proposal is evaluated to determine the relevance of the proposed topic. This initial reviewing process has been very helpful to authors in identifying, early in the writing process, the need for additional material or other changes in approach that would serve to strengthen the text. Once a manuscript is completed, it is peer reviewed to ensure that chapters communicate accurately the essential ingredients of the science and technologies under discussion.

It is my goal to maintain the style and quality of books in the series and to further expand the topic areas to include new emerging fields as they become of interest to our reading audience.

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Rutgers University
# Table of Contents

**Preface** xi

1 **Fundamentals of Autostereoscopic 3D Displays** 1
   1.1 Basic Geometric Optics 1
      1.1.1 Thin lens model 1
      1.1.2 Depth of field 3
   1.2 Human Visual System 4
      1.2.1 The human eye 4
      1.2.2 Spatial resolution and pixel density 5
      1.2.3 Spatial frequency 6
      1.2.4 Brightness and contrast 8
      1.2.5 Temporal frequency 8
   1.3 Display Basics 8
      1.3.1 Flat panel displays 8
      1.3.2 Projection displays 9
      1.3.3 Display size 10
      1.3.4 Display resolution and aspect ratio 11
      1.3.5 Photometry 12
      1.3.6 Frame rate 13
      1.3.7 Contrast ratio 13
      1.3.8 LCD structure 14
   1.4 Light Field Representation 15
   References 18

2 **3D Display Systems** 19
   2.1 History of 3D Display Technology 19
      2.1.1 Classification of 3D displays 22
   2.2 Depth Perception 23
   2.3 Autostereoscopic Displays 26
   2.4 Comparison between Multi-view and Integral Imaging Displays 29
   2.5 Other 3D Display Techniques 32
   References 38
3 Design and Implementation of Autostereoscopic Displays 41

3.1 Design of Multi-view Displays 41

3.1.1 Concept of the view image 44

3.1.2 Number of views 45

3.1.3 View interval 46

3.2 Design of Integral Imaging Displays 46

3.2.1 Design of parameters 51

3.3 Implementation of a Lenticular 3D Display 56

3.4 Implementation of a Parallax-Barrier Display 60

3.4.1 Implementation 61

3.4.2 LCD monitor disassembly 62

3.4.3 Alignment 67

3.4.4 Calibration 68

References 69

4 Acquisition of 3D Information 71

4.1 Acquisition via Computer Graphic Objects 71

4.1.1 A simple program with OpenGL 72

4.1.2 Camera pickup using OpenGL 73

4.1.3 Generating an elemental or base image with OpenGL 77

4.1.4 3D model import 83

4.2 Acquisition of 3D Information from Real Objects 83

4.2.1 Elemental images for 3D reconstruction 89

4.3 Calibration of Acquired Information 92

4.4 Light Field Camera 93

References 96

5 Advanced 3D Display Issues 99

5.1 Moiré 99

5.2 Lens-Slanting Technique 101

5.2.1 Example system 1 107

5.2.2 Example system 2 108

5.3 Implementation of a Slanted Lenticular Display 111

5.4 Slanted Pixel Technique 113

5.5 Crosstalk 118

5.5.1 Crosstalk of a stereoscopic display 118

5.5.2 Crosstalk of a multi-view display 119

References 122

6 Multiplexing Techniques in Autostereoscopic Displays 125

6.1 Spatial Multiplexing Techniques 127

6.1.1 Multi-projection based on integral floating 127

6.1.2 Principles of projection geometry 127

6.1.3 Viewing characteristics 130
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1.4 Example systems</td>
<td>132</td>
</tr>
<tr>
<td>6.1.5 Multi-projection systems based on integral imaging</td>
<td>133</td>
</tr>
<tr>
<td>6.1.6 Principles of projection geometry</td>
<td>134</td>
</tr>
<tr>
<td>6.1.7 Example systems</td>
<td>139</td>
</tr>
<tr>
<td>6.2 Implementation of a Multi-projection System</td>
<td>142</td>
</tr>
<tr>
<td>6.2.1 Selection of a projector</td>
<td>142</td>
</tr>
<tr>
<td>6.2.2 Operational system</td>
<td>144</td>
</tr>
<tr>
<td>6.2.3 Preparing 3D content</td>
<td>144</td>
</tr>
<tr>
<td>6.3 Other Multiplexing Techniques</td>
<td>145</td>
</tr>
<tr>
<td>6.3.1 Compressive light field display (CLFD)</td>
<td>145</td>
</tr>
<tr>
<td>6.3.2 The DepthCube™ 3D volumetric display</td>
<td>146</td>
</tr>
<tr>
<td>6.4 Super Multi-view Displays</td>
<td>147</td>
</tr>
<tr>
<td>6.4.1 Measurement of accommodation response of SMV condition using an autorefractometer</td>
<td>147</td>
</tr>
<tr>
<td>6.4.2 Accommodation response of the SMV system</td>
<td>147</td>
</tr>
<tr>
<td>References</td>
<td>149</td>
</tr>
<tr>
<td>Appendix Raspberry Pi System for Driving a Multi-projection Display</td>
<td>151</td>
</tr>
<tr>
<td>Index</td>
<td>159</td>
</tr>
</tbody>
</table>
Since the early 2000s, flat-panel displays have advanced exponentially in both multi-user and personal applications. Color expression and the resolution of images provided by the state-of-the-art displays are beyond the perceptible range of human eyes and virtually indistinguishable from the real world. However, display technologies can go further to provide an immersive and realistic experience. In order to achieve those goals, a three-dimensional (3D) expression of a display is an essential factor because we live in a 3D world and perceive it as 3D information.

3D displays are beneficial compared to two-dimensional (2D) displays because the process of observing images is more similar to the natural experience than that of 2D displays. However, the technological limitation of 3D displays limits the popularity of 3D display applications. Current applications of 3D displays are mostly focused on the entertainment area such as movies and games due to the fixed viewing positions of observers or the use of viewing aids and the ease of generating 3D contents using computer-graphics technologies rather than picking up 3D images from real objects. If the viewing conditions of 3D images and acquisition techniques of 3D information are developed enough, we can expect many other 3D display applications in addition to entertainment applications. A 3D video call or 3D teleconference can be good examples. Virtual reality (VR) or augmented reality (AR) can also have more effects on real-life applications with 3D displays. Moreover, a 3D visualization of scientific results in medical, biological, or other technological fields will be beneficial to academic analysis and education. 3D displays will be also helpful for industrial development. The prototyping of a product will be accelerated, and the training of employees will be done much more effectively with 3D displays. Consequently, many applications that currently use 2D displays may potentially use 3D displays instead.

For those purposes, one of the barriers that current 3D displays must overcome is glasses. Glasses-free, or autostereoscopic, displays provide perspectives of images according to the position of an observer. For providing perspectives, various optical elements are used in autostereoscopic systems. Although autostereoscopic technologies encompass various display technologies, a multi-view-based method is the current mainstream of 3D displays.
because of its compatibility with flat-panel displays. This book introduces various autostereoscopic technologies from the fundamental principles of the parallax barrier method to the latest multi-projection super-multi-view displays.

The beginning chapters explain the process of the observation of 3D images from a light source to an observer. In the real world, light emitted from a source is reflected or scattered at an object, collected by eyes and, perceived as an object. The observation of 3D images through a 3D display includes more steps: capturing, processing, and display. Instead of directly observing a real object, the information is captured by an imaging device and processed, then it is reconstructed by a 3D display. For those new to display technology, the overall background of 3D display technologies is introduced in Chapter 1. Chapters 2 and 3 focus on directional-view-based 3D displays, including multi-view and integral imaging displays. The practical guide to fabrication of each display system is provided for understanding of the basic principle of each display method. Chapter 4 deals with the acquisition of 3D information from computer graphics and real objects using an optical method. Later chapters cover further details of multi-view technologies and introduce recently reported advanced 3D display technologies.

Possible readers of this book range from undergraduate students to display manufacturers in the industry. Display basics and fundamentals of 3D displays can be a practical guide to those who do not have any background knowledge of display technologies. Examples of multi-view systems will help readers understand the configuration of basic 3D display systems. For readers with some previous knowledge of 3D display technologies, detailed explanations are also provided for advanced display technologies, such as the slanted lens technique and multi-projection systems. The References will be helpful for further study.

We tried our best to cover a wide range of autostereoscopic displays from its conceptual beginning to recent research. Because the technological advancements of conventional 2D displays affect the development of 3D displays, we also tried to cover the basics of 2D displays, including flat panel displays as well as projection-type displays. We believe that this book will help readers improve their comprehension of autostereoscopic displays. We hope that our book contributes to more active research on autostereoscopic 3D displays to realize a world of 3D displays in the near future.

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