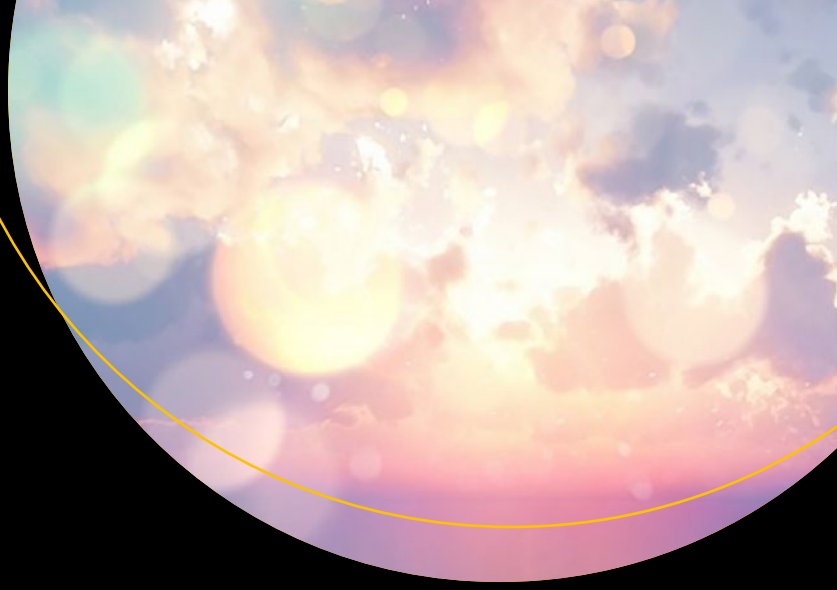

Mastering the Microsoft Kinect

Body Tracking, Object Detection, and the Azure Cloud Services

Vangos Pterneas

Apress®

Mastering the Microsoft Kinect

Body Tracking, Object Detection, and the Azure Cloud Services

Vangos Pterneas

Apress®

Mastering the Microsoft Kinect: Body Tracking, Object Detection, and the Azure Cloud Services

Vangos Pterneas
New York City, NY, USA

ISBN-13 (pbk): 978-1-4842-8069-0 ISBN-13 (electronic): 978-1-4842-8070-6
https://doi.org/10.1007/978-1-4842-8070-6

Copyright © 2022 by Vangos Pterneas

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

Trademarked names, logos, and images may appear in this book. Rather than use a trademark symbol with every occurrence of a trademarked name, logo, or image we use the names, logos, and images only in an editorial fashion and to the benefit of the trademark owner, with no intention of infringement of the trademark.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Managing Director, Apress Media LLC: Welmoed Spahr
Acquisitions Editor: Jonathan Gennick
Development Editor: Laura Berendson
Coordinating Editor: Jill Balzano

Cover image designed by Freepik (www.freepik.com)

Distributed to the book trade worldwide by Springer Science+Business Media LLC, 1 New York Plaza, Suite 4600, New York, NY 10004. Phone 1-800-SPRINGER, fax (201) 348-4505, e-mail orders-ny@springer-sbm.com, or visit www.springeronline.com. Apress Media, LLC is a California LLC and the sole member (owner) is Springer Science + Business Media Finance Inc (SSBM Finance Inc). SSBM Finance Inc is a **Delaware** corporation.

For information on translations, please e-mail booktranslations@springernature.com; for reprint, paperback, or audio rights, please e-mail bookpermissions@springernature.com.

Apress titles may be purchased in bulk for academic, corporate, or promotional use. eBook versions and licenses are also available for most titles. For more information, reference our Print and eBook Bulk Sales web page at http://www.apress.com/bulk-sales.

Any source code or other supplementary material referenced by the author in this book is available to readers on GitHub.

Printed on acid-free paper

In loving memory of my father.

Table of Contents

About the Author xi

About the Technical Reviewer xiii

Acknowledgments xv

Introduction xvii

Part I: Meet the Kinect 1

Chapter 1: Mixed Reality and Kinect 3

A Brief History of Mixed Reality 3

Natural User Interfaces 5

Kinect Sensor Anatomy 10

The RGB Video Camera 12

The Depth Sensor 12

The Microphone Arrays 16

The IMU (Accelerometer and Gyroscope) 17

The External Sync Pins 17

Enhancing Kinect with Azure 18

Key Points 18

Chapter 2: The Developer Toolbox 21

Overview of the Microsoft Azure SDK 21

Azure Kinect Sensor SDK 22

Sensor SDK System Requirements 22

The Kinect Viewer 23

Azure Kinect Body Tracking SDK 32

Body Tracking SDK System Requirements 32

The Kinect Body Tracking Viewer 34

Setting Up the Development Environment 35
Unity3D and Visual Studio 36
Bringing It All Together 39
Key Points 39

Part II: The Basics 41

Chapter 3: Configuring the Device 43

Adding the Kinect SDKs in Unity3D 43
The Azure Kinect Binaries 44
Running in the Editor 51
Deploying Your Unity Application 52
Mastering Azure Kinect: Source Code 54
Starting and Stopping the Device 55
Basic Device Properties 57
Kinect Device Configuration 58
Handling Invalid Configurations 61
Receiving Captures 62
Reading Data 65
Key Points 66

Chapter 4: Color Data 69

Structure of a Color Frame 69
The BGRA32 Color Format 71
The MJPG Color Format 74
Displaying Color Data in Unity3D 75
Specifying the Color Configuration 76
Reading Kinect Color Data as BGRA32 78
Reading Kinect Color Data as MJPG 79
Key Points 80

Chapter 5: Depth Data 83

Structure of a Depth Frame 83

Narrow and Wide Fields of View 85

Displaying Depth Data in Unity3D 89

Depth Configuration and Data 91

Grayscale Depth Visualization 94

Jet Depth Visualization 94

Ambiguous Depth Cases 96

Too Close to the Camera or Too Far from the Camera 96

Object Edges 97

Moving Objects 98

Corners 99

Key Points 100

Chapter 6: Body Tracking 103

The Technology of Body Tracking 103

The New Azure Kinect Approach 105

Structure of a Human Body 107

Joint ID 107

Joint Confidence Level 110

Joint Position 110

Acquiring Body Data 111

Tracker Initialization 112

Tracker Update 115

Constructing Body Objects 116

Tracker Release 116

Displaying Body Data in Unity3D 117

Key Points 125

Part III: The Magic 127

Chapter 7: Streaming Data in the Background 129

Creating a Data Package 130

Creating the Streaming Class 131

Starting and Stopping the Device 132

Streaming Data in a Background Thread 134

Updating the Main Thread 137

Using the KinectSensor Class 138

Key Points 140

Chapter 8: Coordinate Mapping 143

Coordinate Systems 144

2D Coordinates 145

3D Coordinates 145

Coordinate Mapping 146

Coordinate Transformations 149

World to Color 151

World to Depth 153

Color to World 154

Depth to World 156

Color to Depth 157

Depth to Color 158

Using the Coordinate Mapper Class 159

The Complete Coordinate Mapper Class 161

Key Points 166

Chapter 9: Augmented Reality: Removing the Background of the Users 169

Mixing the Physical and the Digital Worlds 170

Background Removal 170

The Body Index Map 174

Mapping Color to Depth 178

A Background Removal Game in Unity3D 185
Key Points 189

Chapter 10: Motion Analysis 191

Motion Analysis 192
1) Skeleton Data 192
2) Measurements 193
3) Feedback 193
Measuring Physical Distances 194
Example: Evaluating a Squat 197
Measuring Angles 200
Example: Counting Bicep Curls 205
Measuring Speed 211
Example: How Fast Are You Walking? 212
Key Points 216

Part IV: The "Azure" in Kinect 217

Chapter 11: Azure Cognitive Services 219

There Is an API for That! 220
Azure Cognitive Services 221
Offline Approach 221
Online Approach 222
Understanding Azure in Kinect 224
Creating a Computer Vision API 224
Key Points 232
A Demo Service for You 232

Chapter 12: Computer Vision and Object Detection 233

Do You Need a Kinect After All? 235
The Azure Cognitive Services SDK 237
The Computer Vision NuGet Package 238
Importing the Packages in Unity3D 239

Creating a New Unity Scene 241
Referencing the Azure Computer Vision SDK 242
Computer Vision in Action 243
Input: Kinect Color Frames 244
Output: Object Rectangles 247
Coordinate Mapping 248
Visualizing the Results 250
Closing the Service 256
Key Points 257

Index 259