TECHNOLOGY IN ACTION™

Meet the Kinect

An Introduction to Programming Natural User Interfaces

CREATE SOFTWARE CAPABLE OF READING AND REACTING TO BODY MOVEMENT USING THE MICROSOFT KINECT

Sean Kean, Jonathan Hall, and Phoenix Perry

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Meet the Kinect: Programming and Scripting Natural User Interfaces

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Dedicated to Christa Erickson, artist, educator,
flaneuse, and esteemed mentor.

—Sean Kean

Contents at a Glance

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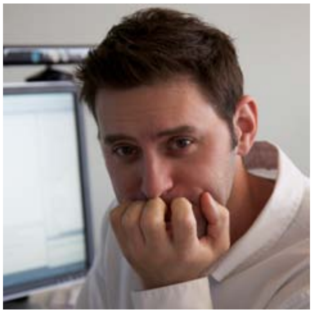
About the Authors

Sean Kean is an artist and entrepreneur living in Brooklyn, New York. With a background spanning engineering, art, education, and travel, he is passionate about simplifying complex technology in order to make tools more accessible to others. Insatiable in his curiosity, the author has filled his passport as a flight attendant, rediscovered learning through play as an early childhood educator, studied the streets and buildings of New York City in order to earn both a taxi driver license and real estate sales license, and has been programming well enough to be dangerous for more than 20 years. Sean is currently working to bridge the gap between the physical and digital worlds at HERE, Inc. (`http://here.st`), to bring volumetric 3D TVs mainstream with the VoxieBox (`www.voxiebox.com`), and to help professionals working with volumetric depth cameras, software, and displays to connect to each other through the Volumetric Society (`www.volumetric.org`) via a publication, conference, and local chapter meetups you can help set up in your city.

Jonathan C. Hall is one of the creators of Sensecast, an application that makes it easy to build motion-controlled interfaces for content using a Kinect. He has been an independent designer/developer for digital projects for the last decade. Hall has also done stints as a beat reporter, a researcher for the smartest person in the world, a technology consultant to the likes of Rob Jarvik and King Abdullah II of Jordan, and a student of the sciences and humanities. Jonathan holds a BA from Harvard University, where he studied languages and religion, and about half a PhD (Communications) from Columbia University.

Phoenix Perry was born in Denver, CO, in 1975. From digital arts curator to Creative Director, she has gained extensive experience in new media, design, and user interfaces. Perry's work spans a large range of disciplines, including drawing, generative art, video, games, and sound. Her projects have been seen worldwide at venues and festivals, including Come out and Play, the Maker Faire at the New York Hall of Science, the Lincoln Center, Transmediale, the Yerba Buena Center for the Arts, the LAMCA, Harvest Works, Babycastles, the European Media Arts Festival, GenArt, the Seoul Film Festival, and Harvestworks. She is adjunct faculty at NYU-Poly in Integrated Digital Media and owns Devotion Gallery in Brooklyn, NY.

About the Technical Reviewer



■ **Jarrett Webb** creates imaginative, dynamic, interactive, immersive experiences using multi-touch technology and the Kinect. He lives in Austin, TX.

Acknowledgments

With deep gratitude to my parents and to my wife, Kate, who have supported even my most ill-advised endeavors.

Jonathan C. Hall

My thanks to Amir Hirsch, Alona Lerman, the OpenKinect community, and the amazing team at Apress for helping make this book possible.

Phoenix Perry

CHAPTER 1

Getting Started

In this chapter you'll unbox a new Kinect—or if you have one already, you'll disconnect it from your Xbox. Then you'll install some software, plug the Kinect into a computer, and take a look at what all of the fuss is about with this unique device. You'll learn what the different components of the Kinect are and be able to play with some simple controls to get a feel for how all the parts work together to make the magic happen.

The Kinect is marketed, packaged, and designed for use with Microsoft's Xbox gaming console. The Xbox is a remarkable living room entertainment system, and if you haven't tried Dance Central or Kinect Sports, I recommend that you do—playing those two games at the 24-hour Best Buy in Union Square here in NYC is what got me so excited about the Kinect in the first place. I dragged as many friends as I could down to the store so they could see this amazing technology in action.

That said, this book is the unofficial manual for how to take a Kinect and use it outside the living room—no Xbox required. Now, let's make sure you have everything you need to unplug your Kinect from the game system—or purchase one by itself, plug it into your computer, and get tinkering.

Buying the Correct Kinect

When I wanted to get my own Kinect, I spent a lot of time trying to figure out the right product to buy out of all of the Xbox Kinect–branded merchandise. I really wanted to play the Xbox games *and* have a Kinect that could work on my computer. Unfortunately, the Xbox Kinect system bundle isn't packaged with this goal in mind.

I ended up deciding to purchase the standalone Kinect sensor (Figure 1-1) and saved some money by getting a used Xbox system on which to play the games. The standalone Kinect sensor package includes an adapter cable that lets your Kinect draw power directly from a wall outlet instead of from the Xbox console.

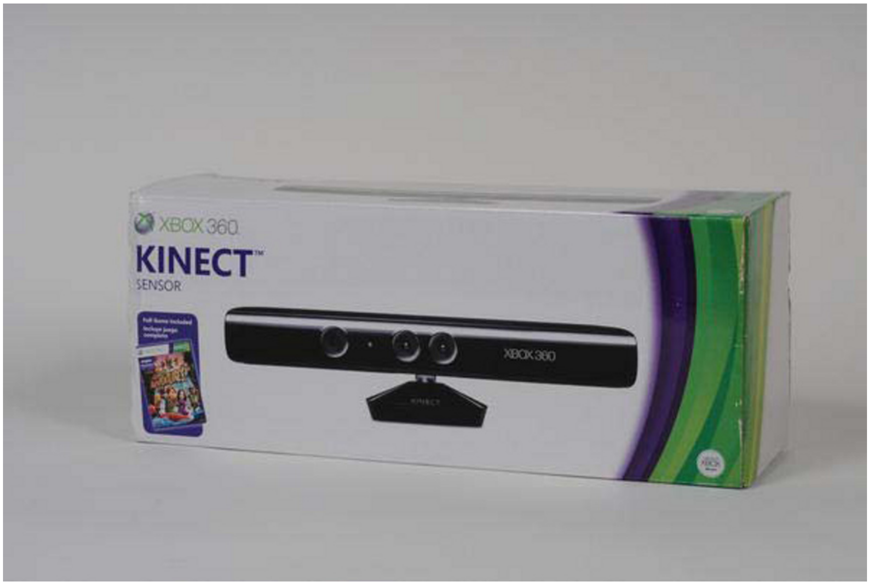
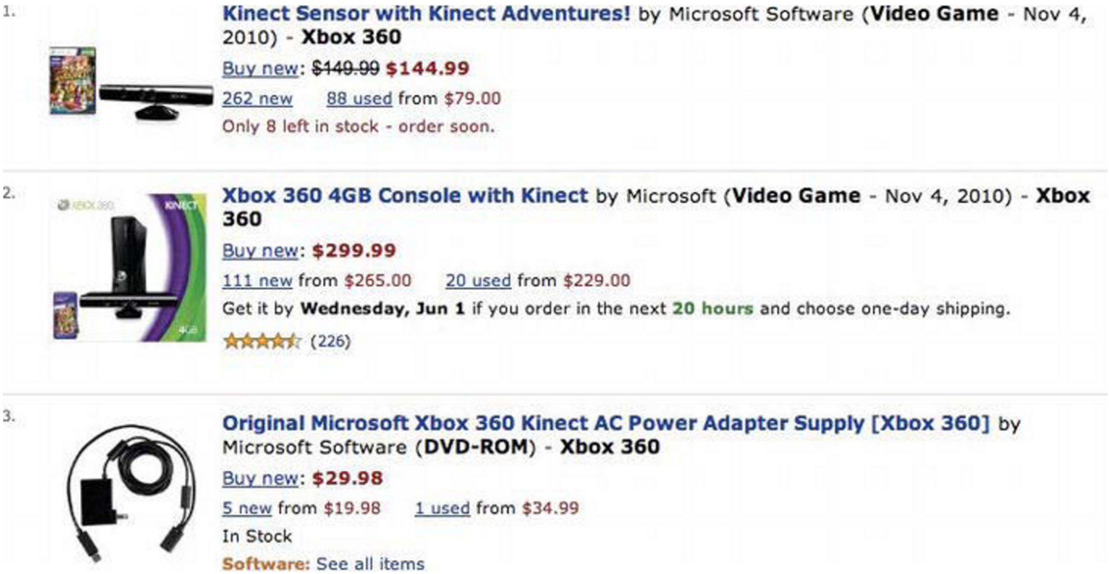


Figure 1-1. *Kinect Sensor with Kinect Adventures!—The* **only** *Xbox Kinect product that comes with all the parts ready to hook up to your computer.*

Another option is to buy the Kinect bundle that includes an Xbox console and the Kinect sensor. You see that bundle as the second item in Figure 1-2. The danger is that people often purchase the Kinect bundle thinking that it will immediately work for them…until they bring it home and find that they are missing a cable and now have to buy one online and wait for it to arrive.

What the Kinect bundle lacks is the power adapter that you need in order to use your Kinect with a personal computer via USB. While I fully endorse getting the full Xbox Kinect system bundle, you'll need to purchase this additional accessory, a US $30 power adapter, to be able to connect the Kinect to your computer via normal USB. Figure 1-2 shows that power adapter, which is the third item listed in the figure.



1. **Kinect Sensor with Kinect Adventures!** by Microsoft Software (**Video Game** - Nov 4, 2010) - **Xbox 360**
   Buy new: ~~$149.99~~ **$144.99**
   262 new 88 used from $79.00
   Only 8 left in stock - order soon.

2. **Xbox 360 4GB Console with Kinect** by Microsoft (**Video Game** - Nov 4, 2010) - **Xbox 360**
   Buy new: **$299.99**
   111 new from $265.00 20 used from $229.00
   Get it by **Wednesday, Jun 1** if you order in the next **20 hours** and choose one-day shipping.
   ★★★★½ (226)

3. **Original Microsoft Xbox 360 Kinect AC Power Adapter Supply [Xbox 360]** by Microsoft Software (**DVD-ROM**) - **Xbox 360**
   Buy new: **$29.98**
   5 new from $19.98 1 used from $34.99
   In Stock
   Software: See all items

Figure 1-2. *Online product listings on Amazon.com for Kinect-related products—The first listing is the Kinect you should probably get; otherwise, you will also need to purchase the third listing.*

You might choose to go both routes at the same time: buy the standalone sensor for your computer and buy the bundle for playing games. That's an expensive path, but it lets you keep a Kinect plugged into your computer for tinkering and always have another Kinect to use with your Xbox without having to move cords and cameras around. Newer drivers and software are becoming available to support the use of multiple Kinects simultaneously, so you might find value in having more than one at your disposal.

Separating a Kinect from an Xbox

So, you already have an Xbox? Awesome. Okay, now you need to borrow the Kinect from your Xbox and bring it over to a computer. You'll probably want to ask permission from whomever's Kinect you are using before you proceed. I'm sure they'll miss it! Tell them you'll give it back after you show them all the cool stuff you can do with a Kinect on a computer once you get through Chapter 3. They'll thank you!

Disconnecting the Kinect from a late model Xbox is very straightforward. Simply locate the Kinect, follow the cord to the back of your Xbox, and pull it out. Done. Now, you'll just need the Kinect AC adapter and you'll be ready to move on to downloading and installing software.

If you've got a Kinect successfully hooked up to an early model Xbox, that's great news—it means you've got all the parts necessary to take the sensor and plug it into your computer. To disconnect your Kinect from an older model Xbox, you'll be removing two components—the Kinect sensor itself, and the attached cable that leads to the Xbox and AC wall outlet (Figure 1-3). Once you've disconnected those two things, you are all set.

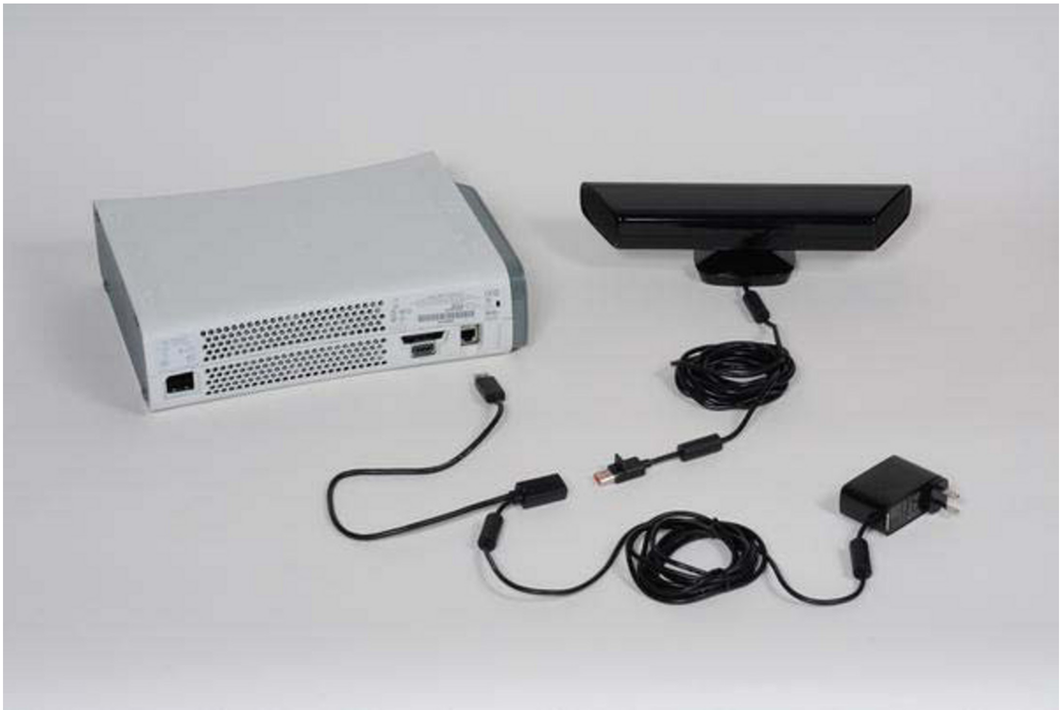


Figure 1-3. *Unplugging the Kinect and AC adapter from an early model Xbox game console (Photo courtesy Microsoft)*

Making Sure You Have the AC Adapter

If you have a new model Xbox with a Kinect, it's possible that they were purchased as a bundle. If that's the case, then you probably don't yet own the adapter cable necessary to make the Kinect work on a computer. Unfortunately, now you'll have to purchase the AC adapter cable before you can continue. The third item in Figure 1-2 shows the product information for the adapter as it should appear on Amazon.com. Figure 1-4 shows a better image of the cable itself.

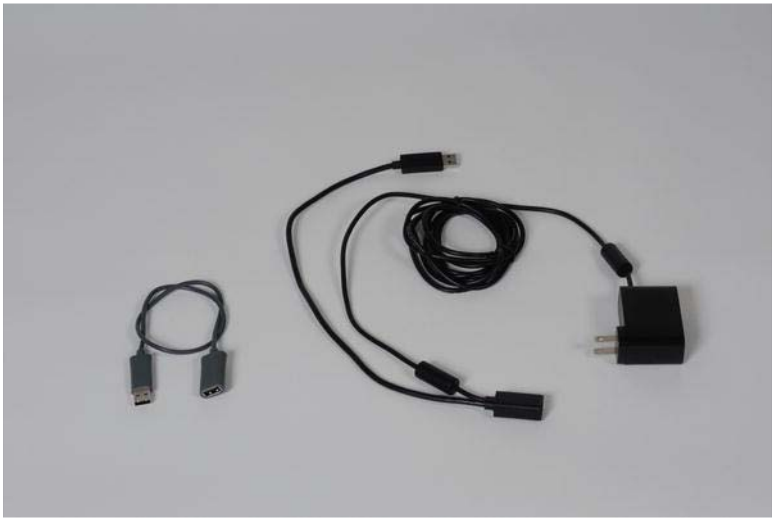


Figure 1-4. *Kinect USB extender on the left for newer XBox syststems, and the Kinect power adapter on the right.*

The power adapter cable is required for two reasons. First, the Kinect requires more power than a standard USB port can deliver, probably because of all of the components it has inside, such as a motor, a number of sensors, and a fan to push air through the device for cooling. The special USB port on the late model Xbox can deliver this extra power, but because your computer can't, you have to compensate for that by plugging the Kinect into an electrical outlet with the AC adapter provided on the cable. This need for an adapter cable is frustrating if you want to go mobile with the Kinect and a laptop—you'll need a 12-volt battery and some careful modification to get past that problem.

The second reason you need the adapter cable is that the cord on the Kinect uses a proprietary, Xbox-only USB connector. This is frustrating, I know. The AC adapter cable has a port that accepts this special USB shape on one end and turns it into a standard USB connector on the other. The older Xbox systems have a standard USB port, which is why they also require an adapter cable to be compatible with the Kinect. When Microsoft launches a version of Windows with Kinect support built-in, they may introduce a lower-power version of the Kinect for use with computers that doesn't require this pesky AC adapter attachment.

Inspecting the Kinect, Part by Part

Now that you've acquired a Kinect, let's take a closer look at all the parts. Figure 1-5 shows all the items in the box from a standalone, Kinect Sensor purchase. The only ones you need to follow along with this book are the AC Adapter and the Kinect itself. You can keep the USB extender, manuals, and Kinect Adventures game disc in the box, as you may need them if you have or plan to get an Xbox.

Before you throw away that box, you should know that it functions as a handy way to store and transport the bulky and oddly shaped Kinect. The device is pretty rugged; very few are returned defective or broken, and they can take a beating. However, the original box is a popular way for people to bring the sensor to and from meetups and hackathons in NYC. The foam inside is shaped perfectly to hold the Kinect, making the box a simple, portable container, so you might want to hang on to it just in case.

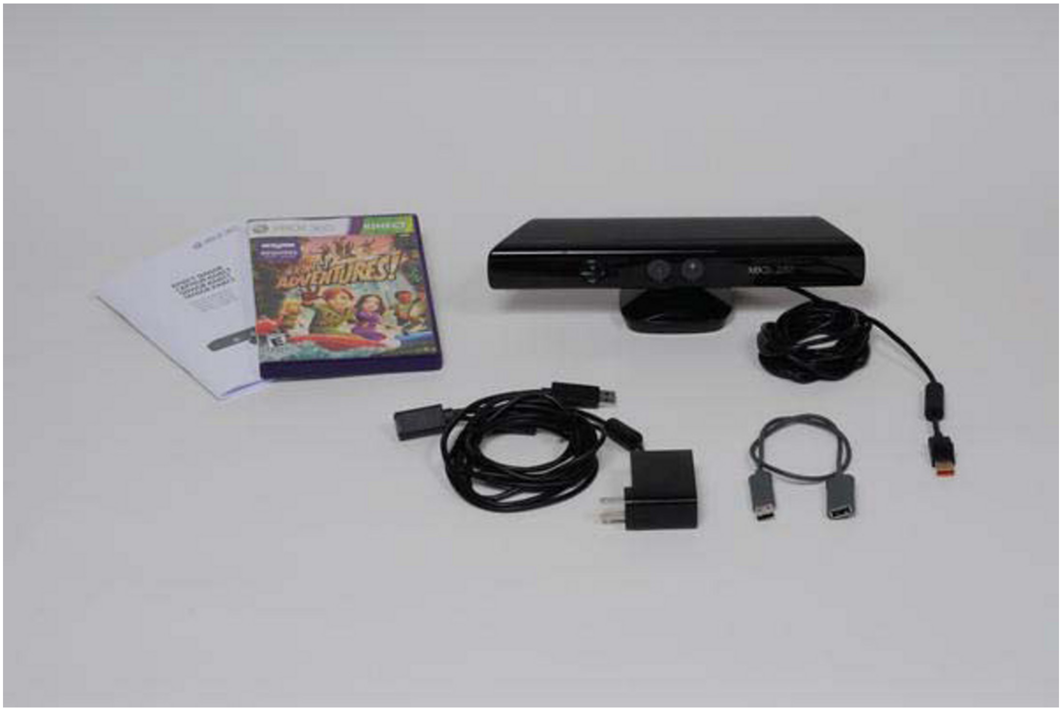


Figure 1-5. *Contents of standalone Kinect sensor box: Manual, Kinect Adventures! game disc, the Kinect itself, AC adapter, and special USB extender.*

Now, let's take a look at the inputs and outputs you'll be able to take advantage of in applications and when building your own projects or products. Being able to identify all the components on the outside of the device (Figure 1-6) will be very helpful going forward. There's a lot going on, and many people aren't quite sure which part does what. After reading through this section, you'll know the function of every part and be able to apply that knowledge to your advantage.

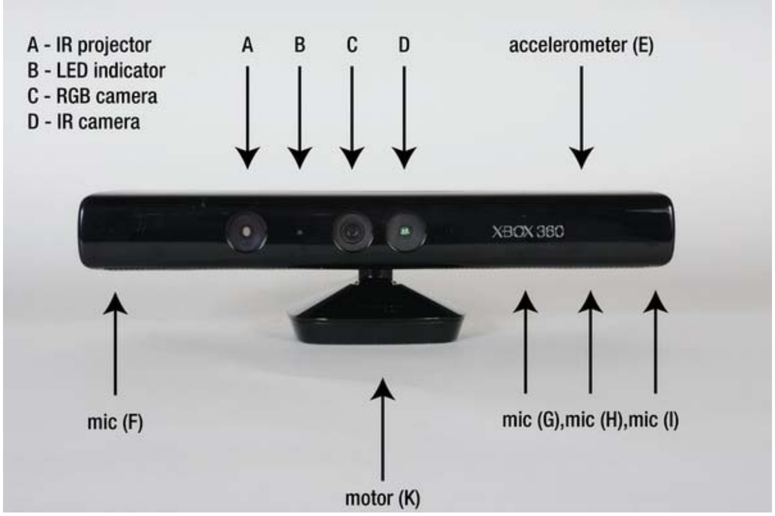


Figure 1-6. *Kinect external component identification— Output: A) IR (infrared) structured-light laser projector, B) LED indicator, and K) motor to control tilt-in base. Input: F-I) Four microphones, C-D) two cameras (RGB and IR), and E) one accelerometer*

There are two basic ideas when working with hardware, and with technology in general, that are really important: input and output. Input is information that comes into a system from an external source, and output is information that goes out from a system. I learned about inputs and outputs by hooking up stereos, TVs, and VCRs as a kid. An input to a stereo might be through a microphone or an iPod, whereas an output could be to a speaker or amplifier. Many devices, such as an amplifier, can both receive input and send output. The Kinect has sensors that act as inputs, reading (or sampling) information in space about the physical environment in front of it. The Kinect also has actuators (outputs) that allow it to write or act upon the physical space by changing it in different ways.

There are four microphones on the Kinect—that’s right, four! That’s not just stereo; it’s actually quadraphonic sound. Combined with advanced digital signal processing in software, these four mics can be used to do remarkable things. In combination, these four audio inputs can work to filter out background noise and detect the relative position of anyone speaking within a room. Looking at the Kinect head on, there are three adjacent mics on the right side, just below the “XBOX 360” label (Figure 1-6, G-I). A fourth microphone is on the left side (Figure 1-6, F). Microsoft’s official Kinect SDK (Software Development Kit) is the first to reveal how to access the microphones, although other drivers are expected to provide access to this hardware in the future.

The Kinect kind of looks like a huge, clunky old webcam, which is fitting because there’s actually a standard webcam built right into the middle of it (Figure 1-6, C). Next to it is an infrared camera, which is a bit more exotic than a standard webcam. Equally interesting, if not downright mysterious, is the 3-axis accelerometer inside the device, behind the “XBOX 360” label. Most people didn’t expect the Kinect to contain such a sensor, which is more common in devices designed to be held in your hand, such as a mobile phone or the Nintendo Wii controller.

Now, for the outputs. You may have heard that the Kinect has a laser in it—it’s true. You can see it glowing red (Figure 1-6, A) when the Kinect is plugged in, even though the light the projector emits is in the infrared spectrum and mostly invisible. It works in combination with the infrared camera on the unit (Figure 1-6, D) to derive the exact position in space of everything in the room it occupies. The other light-based output is the LED indicator (Figure 1-6, B). It's not easily accessible from frameworks such as OpenNI; however, if you have a project that would benefit from feedback through the hardware, this may be of interest to you. It could be an ideal way for the application to alert a user that something is happening without requiring a screen. For example, in the 3D capture tool MatterPort, the user picks up the Kinect and walks around the room—away from the computer—to photograph objects. An audible beep from the computer lets the user know once a particular view has been adequately analyzed. This beep could be accompanied by a flicker of the LED light on the unit as an additional cue, so the user doesn't have to be looking at the screen to register it.

Finally, the Kinect has the functional opposite of a sensor, called an actuator, in the form of a small motor driving gears that pitch the tilt of the camera 30 degrees up or down. This could be put to novel use in the applications you build. For example, by sweeping the device and its sensor elements up and down through space, the Kinect can be used to capture high-resolution scans of the environment around it. If you want to mount a Kinect to a robot, the motor could provide the mechanical up-and-down motion of the camera. Additionally, if you employ face or body tracking, you can adjust the position of the camera to adapt when a person moves out of the field of view.

Now that we have identified all of the Kinect hardware, let's put it to use with software. You'll have a chance to see the imagery that comes from the RGB camera, as well as the depth image computed from the infrared projector and camera combination.

KINECT TEARDOWN!

Interested in an insider view of the Kinect? The website iFixit has put together a writeup and a video that take you through a tear-down of the Kinect device.

Read the teardown article at: http://www.ifixit.com/Teardown/Microsoft-Kinect-Teardown/4066/

Watch the teardown video at: http://www.ifixit.com/blog/blog/2010/11/05/kinect-teardown-video/

Please don't try it at home! Don't risk your own device. If you're curious about what's inside, visit iFixit.com.

Downloading and Installing Software

The first time I plugged my Kinect into a computer to see how it worked, I used the software you'll install in this section. That software is RGBDemo, and I still reach for it whenever I want to demonstrate what the Kinect is capable of and how it is different from a standard webcam. RGB stands for red, green and blue—the colors the webcam in the middle of the Kinect can see. The D in Demo also stands for depth, which the IR projector and IR camera generate with the help of a structured-light chip from a company called PrimeSense. Who is PrimeSense?

PrimeSense is the Israeli company whose hardware reference design and structured-light decoding chip are at the heart of the Kinect's volumetric 3D camera system. This was a surprise to many who had tracked the evolution of the Kinect (originally code-named Project Natal), as many thought Microsoft would use the intellectual property of the two time-of-flight 3D sensor companies they had recently acquired—3DV Systems and Canesta. Following the lead of the OpenKinect project, PrimeSense went on to help found OpenNI in an effort to put the best tools in the hands of developers. OpenNI has launched the first major store offering PC applications that make use of volumetric cameras such as those in the Kinect with the debut of Arena, which will be covered in more detail in Chapter 3.