

# Home Surveillance with Internet Remote Access

*You don't put kids under surveillance: it might frighten you.*

~Garrison Keillor, "Easter," *Leaving Home*

**F**riends of ours built a retirement home some years ago and became concerned about theft and vandalism while they waited in another city to sell their old house and move in. Being the sort to use technology to solve problems, they installed a Black Box VueMate Hub ([catalog.blackbox.com](http://catalog.blackbox.com)), to which they connected closed circuit television cameras. A long-distance call from their PC to the hub gave them access to the cameras, letting them monitor the site whenever they chose.

The unfortunate part of this story is that the VueMate Hub goes for close to \$700, plus the cost of cameras. The long-distance phone bills to actually *use* the system seem like chump change in comparison, and despite spending all that money, they could only access the cameras from a PC with the necessary software loaded.

## Never Be Out of Reach

As with seemingly everything else, the Internet has revolutionized what you can build for remote surveillance and security. Low-cost video cameras, driven by the market for desktop video conferencing and webcams, have improved to where they generate reasonably high-quality video and provide embedded video compression. Broadband Internet access offers both speed advantages and a permanent connection to the net, making it suitable for remote monitoring. The global reach of the Internet means that you can monitor your home from Abu Dhabi, if you happen to be there.

# chapter 6

## in this chapter

- Sensors and alerts
- TrackerPod and TrackerCam
- Setting up surveillance
- Extending your system

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One of the things that tends to raise the initial cost of the Black Box unit is its ability to multiplex four separate cameras. This is an important feature, because it's impossible to monitor your entire home from just one camera unless that camera is quite a way above the house. You can also increase the coverage you get from each camera with a motion sensor and tracking camera base. You'll see how to set up these features in this project, along with how to integrate your surveillance system with the Internet and access it from any computer with a Web browser.

### Sensors and Alerts

Figure 6-1 shows the organization of the overall surveillance system. We used video cameras because they are inexpensive and widely available, and because video cameras are easier to interface to a PC than a still camera. Most video cameras can take still images, too. The system looks simple, consisting of only the camera(s), PC, and broadband modem, but is difficult to implement because of the mismatch between the data rate from the video camera and the uplink rate through the broadband connection. You could see as much as 4 MBps (32 Mbps) from each camera, yet a typical uplink rate is only 128 Kbps. That's roughly a 30:1 differential, which means you're not going to be pumping broadcast quality video out to the Internet.

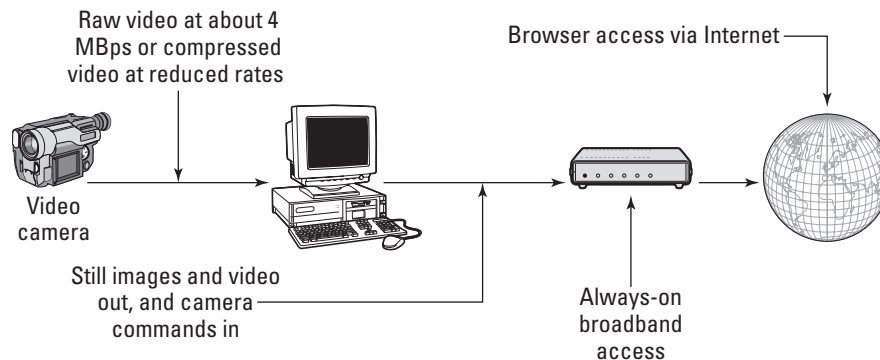


FIGURE 6-1: Surveillance system block diagram

You have many options for using the available Internet bandwidth. For example, if you're working with still photos, you can:

- Transmit on command
- Transmit at set intervals
- Transmit at set intervals whenever there's motion

The still photos can be large or small, and can be compressed with lossless or lossy compression — such as JPEG — if you really need to make them small.

Video is much like a rapid succession of still images, so choosing your resolution still matters. The video *frame rate* is similar to the interval between still photos, with *slow scan* video referring to video at only a few frames per second. If you get the frame rate high enough so that *motion compensation* can compactly encode object motion differences between successive frames, video compression technologies — such as MPEG-1, MPEG-2, or MPEG-4 — are usable.

## Building and Using Your Surveillance System from Kits

Our baseline design for the surveillance system solves the bandwidth problem by using compressed still images triggered by motion in the camera field of view, and minimizes the number of cameras needed by following moving objects with the camera. A tracking camera detects movement at a distance, then keeps the moving object in the field of view as it gets closer; the result is that you need fewer cameras to cover the surveillance area.

### Parts List

We expected this to be a difficult project when we started to design it, largely because when we had last looked at webcams they did nothing but capture a small video image — no zoom, no tracking base, and no triggering when there's motion. However, our Google search for *pan/tilt camera mount* turned up nearly 18,000 hits. SmartHome was the first hit ([www.smarthome.com/7742.html](http://www.smarthome.com/7742.html)), but at \$399.99 for just the camera mount, their equipment was impractical for this project. More refined searching (*pan/tilt camera mount motion tracking*) turned up the TrackerPod robotic camera base and TrackerCam software from Eagletron which, together with a webcam like the Logitech QuickCam Pro 4000, gave us a low-cost system with strong capabilities. The parts we used are shown in Table 6-1.

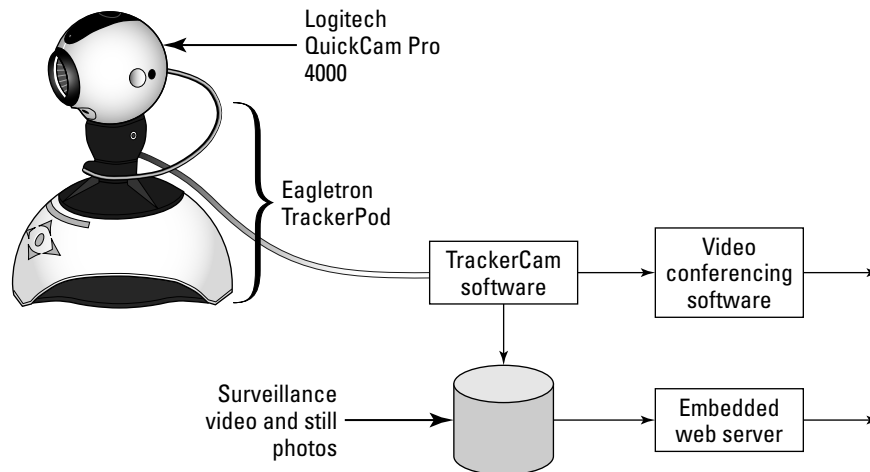
**Table 6-1 Home Surveillance Parts List**

<i>Part</i>	<i>Manufacturer and Model Number</i>
Motion Base and Software	Eagletron TrackerPod and TrackerCam Software (\$174.99) <a href="http://www.pantiltcam.com/TCamWeb/productdes.htm">www.pantiltcam.com/TCamWeb/productdes.htm</a>
Camera	Logitech QuickCam Pro 4000 (\$70 and up; see <a href="http://www.shopper.com">www.shopper.com</a> ) <a href="http://www.logitech.com/index.cfm?page=products/details&amp;CONTENTID=5042">www.logitech.com/index.cfm?page=products/details&amp;CONTENTID=5042</a>

Figure 6-2 is an overview of how the TrackerPod and a camera combine into a surveillance system. The camera and TrackerPod both have USB connections. The camera interface carries audio and video to the computer, and zoom, resolution, and image adjustment commands to the camera. The TrackerPod interface carries position information to the camera and pan, tilt,

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and LED commands to the servo base. Under control of the TrackerCam software, you can point the camera, record video and stills, upload to Web sites, and monitor or control the camera remotely.



**FIGURE 6-2: TrackerPod, camera, and software integration**

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The Logitech QuickCam Pro 4000 (Figure 6-3) provides surveillance images and sound, offering video resolution up to 640×480 pixels at up to 30 frames per second and still photos at resolutions up to 1280×960 pixels.



**FIGURE 6-3: Logitech QuickCam Pro 4000**

*Logitech® and QuickCam® are registered trademarks of Logitech.*

### Powering the TrackerPod

The TrackerPod requires power from the USB port to drive the motors in the base. The Dell 4550 computer we used couldn't supply as much power to the USB port as our model of the TrackerPod wanted, causing the TrackerPod to constantly reset and the TrackerCam software to lose control. Eagletron has auxiliary power supplies for the early TrackerPods to work around this problem, and added current limiters to the motor base circuits in a revised version to reduce the peak draw. The TrackerCam software detects when there's a power problem, giving you this dialog box:



You'll need an auxiliary power supply if your computer can't supply enough power at the USB port. Click on the first button to bring up a Web page from which you can order the necessary power supply.

Dismount the camera from the base, then use a screw-in mount supplied with the TrackerPod to attach the camera to the motion base and form the assembly shown in Figure 6-3. Be sure to install the software before connecting the camera and base to the computer, because the software installation supplies the necessary USB drives.

### Working with the TrackerCam Software

Once you install and start the TrackerCam software (you'll have to work through several configuration dialog boxes; the one to go online/offline can be canceled for now), and connect the camera and TrackerPod, you'll see the display on the right of Figure 6-4, labeled Initial TrackerCam Window.

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FIGURE 6-4: Initial TrackerCam window and controls window

Click the button in the lower left to open the options window and use the button next to the right edge of the display pane to make the display window larger (see Figure 6-5).



FIGURE 6-5: Expanded TrackerCam window

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The window that opens when you click on Tuner in the TrackerCam window (lower left of Figure 6-5) is the interface you use to set up the enormous number of settings for TrackerCam. The defaults are reasonable, for the most part, with the exception of left/right directions. If TrackerCam is set up correctly, clicking on a point in the video window should slew the camera to make that point the center of the image. If the base goes the wrong way, reverse the control direction. Do that by bringing up the tuner (not to be confused with the Configuration Wizard, which is what TrackerCam opens as the tuner when it first starts up and asks if you want the tuner), then in the Display and Camera section select Specify Field of View. On that page, make the existing value for Horizontal FOV negative and the controls will reverse direction. Click on Enter FOV Values, then test your work in the video window.

### Live Internet Surveillance

The easiest way to set up surveillance with TrackerCam is to enable the embedded Web server and access live video with a Web browser. Figure 6-6 shows what TrackerCam video looks like in a browser. The video display updates at the rate shown in the lower left; you can use the tuner to adjust the update rate. Using TrackerCam across a LAN permits the full 30 frames per second (fps), while you'll have to throttle down the rate across the Internet. The requirement to run at slow frame rates across the Internet rules out video compression like MPEG-1 or MPEG-2, so TrackerCam uses JPEG compression on individual frames.



FIGURE 6-6: See what's going on from anywhere with slow scan video.

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JPEG compression outputs variable image sizes depending on the image resolution, scene complexity, and compression quality setting. A typical 320×240 image shrinks to 3KB after JPEG compression (24 Kb), so you'd need 24 Kbps for 1 fps. The bandwidth requirement scales with frame rate, so you need 48 Kbps for 2 fps, 72 Kbps for 3 fps, and so on. You might get 2 fps through a 56K modem if you get a good connection; the 128 Kbps uplink common to ISDN, DSL, and some wireless systems may support 5 fps. You're using 720 Kbps for 30 fps at 320×240 resolution.

The Communication pane in Figure 6-4 lets you access the controls to turn on the embedded server for live video. Click on the rightmost icon in the pane to get the dialog box in Figure 6-7 and turn on Put Me Online and, optionally, Guests Allowed. After you make sure the IP address in the lower right is correct, the URLs at the bottom can be copied and pasted into Web browsers for remote access. Disable guests and create user accounts unless you want the camera images open to everyone or unless you've taken other access security measures.

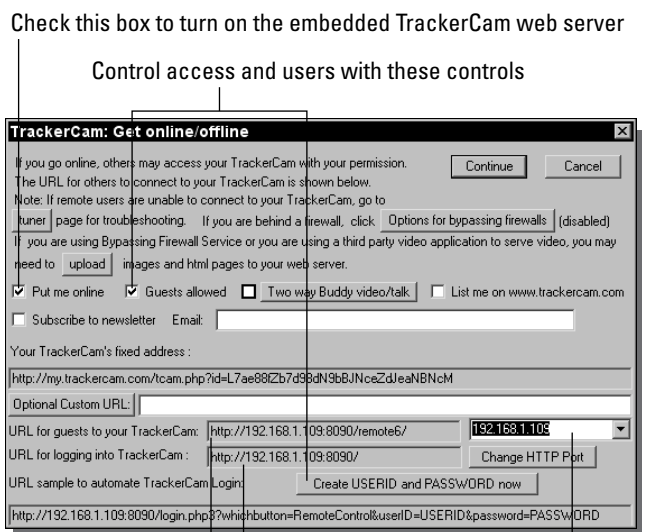


FIGURE 6-7: The Online/Offline dialog box gives you controls for remote access to TrackerCam.

## Recorded Internet Surveillance

The problem with live surveillance is that if something happens when you're not looking, you miss it. TrackerCam lets you record surveillance images on disk and access those images either locally from a computer with local or shared network disk access, or across the Internet using a

## Cable/DSL Router Security and TrackerCam

You already know that you're vulnerable to attack any time your computers are connected to the Internet. One of the best ways to protect your computers from attack is to use an external hardware router providing Network Address Translation (NAT), because most of those routers can be set up to allow no unsolicited access to your computers from outside your LAN. That's the approach we use (which is why our IP addresses you see in this chapter are sequences like 192.168.1.109), and the logs we get from our router make it evident we're being probed constantly. The problem with routers like the Linksys we use, though, is that it takes some work to permit outside access when you want it.

This screen shot from the browser interface to our router shows how we set it up for remote access to both TrackerCam and HomeSeer (see Chapter 3). The idea is that anytime an external network request to access one of the indicated ports or port ranges arrives at our router, it's diverted to the internal address shown. We turned on both TCP and UDP access rather than have to research whether UDP is needed in addition to TCP, but if you're even more paranoid than we are, you'll try the software with only TCP enabled and see what happens.

LINKSYS®

Filters Forwarding Dynamic Routing Static Routing DMZ Host MAC Addr. Clone Wireless Setup

Port forwarding can be used to set up public services on your network. When users from the Internet make certain requests on your router, they will be redirected to the specified IP.

Customized Applications	Ext.Port	Protocol TCP	Protocol UDP	IP Address	Enable
TrackerCam	8090 To 8090	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	192.168.1.109	<input checked="" type="checkbox"/>
TCam Chat	8095 To 809	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	192.168.1.109	<input checked="" type="checkbox"/>
HomeSeer	80 To 80	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	192.168.1.109	<input checked="" type="checkbox"/>
	0 To 0	<input type="checkbox"/>	<input type="checkbox"/>	192.168.1.0	<input type="checkbox"/>
	0 To 0	<input type="checkbox"/>	<input type="checkbox"/>	192.168.1.0	<input type="checkbox"/>
	0 To 0	<input type="checkbox"/>	<input type="checkbox"/>	192.168.1.0	<input type="checkbox"/>
	0 To 0	<input type="checkbox"/>	<input type="checkbox"/>	192.168.1.0	<input type="checkbox"/>
	0 To 0	<input type="checkbox"/>	<input type="checkbox"/>	192.168.1.0	<input type="checkbox"/>
	0 To 0	<input type="checkbox"/>	<input type="checkbox"/>	192.168.1.0	<input type="checkbox"/>
	0 To 0	<input type="checkbox"/>	<input type="checkbox"/>	192.168.1.0	<input type="checkbox"/>

Done Internet

Use port forwarding on your router to direct incoming requests to a specific computer.

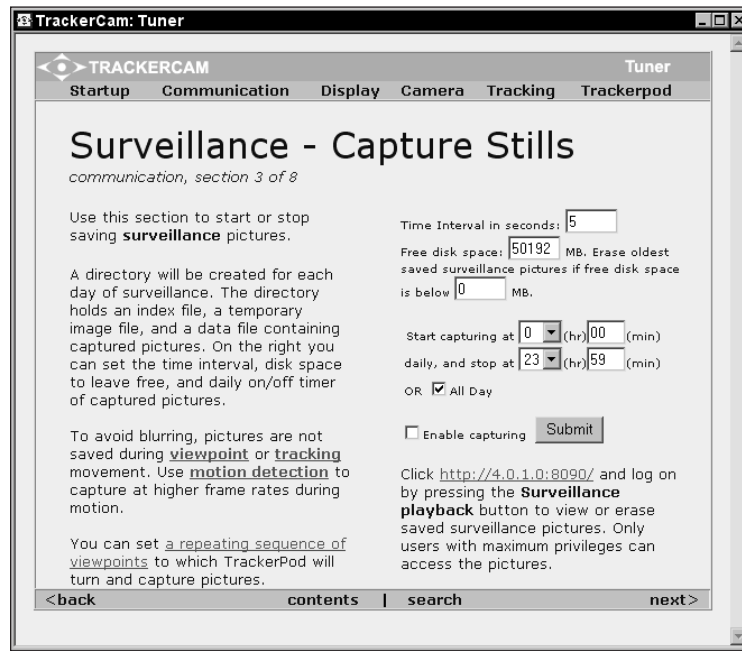
*Continued*

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*Continued*

In practice, though, we don't leave any of those ports open on a regular basis—we open them when external access is required and close them again when the need goes away. We get from tens to hundreds of probes of our network every hour, so it's just prudent to keep the ports closed if they don't need to be used.

Web browser. Set up surveillance through the tuner (click on the Tuner button in the main TrackerPod window, Figure 6-5, then pick Surveillance—Capture Stills, found under Communications. The configuration page (see Figure 6-8) lets you choose how often you save an image, how much disk space surveillance may use, and when surveillance is active.



**FIGURE 6-8:** Use the Surveillance—Capture Stills page to enable still photo surveillance, define how often to capture an image, control disk use, and set times.

You can do more than simply position the camera and have it snap images. For example, from the tuner contents section choose Viewpoint Order in the Tracking section. Define a sequence of viewpoints (places at which the camera points) on this page (see Figure 6-9), and let surveillance visit the viewpoints in sequence. The grid you see is a plane in front of the camera, so by choosing a box you specify both pan and tilt. Define viewpoints by clicking in the box where the camera should point; if you clear all existing points you can simply click all the viewpoint

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positions in sequence to create the path. If you name them using the pane on the right, those names will show up in the remote browser window and can be selected to point the camera. You can define the times at which viewpoints are active, too.

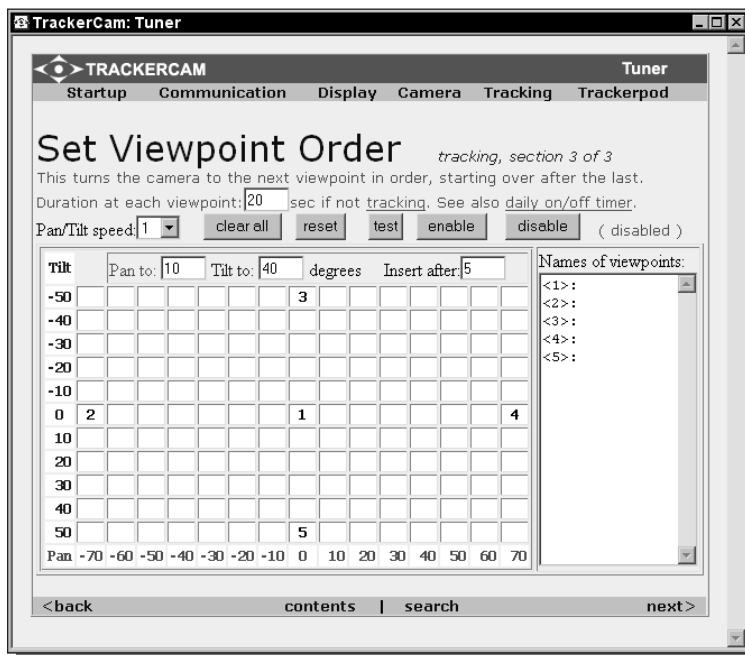


FIGURE 6-9: Set up viewpoints to have the camera scan an area under surveillance.

### Motion Detection and Tracking

You can also set up your system to recognize motion and start collecting images when motion is present. The TrackerCam software has algorithms built in to detect and follow motion in the frames received from the camera. Figure 6-10 shows the motion detection algorithm in operation. The white bounding box in the figure shows the area of the image in which it has identified motion, in this case because the dog had just turned around. You can set the threshold for motion detection to be more or less sensitive, depending on the size and speed of the motion you want to see or exclude.

Once TrackerCam detects motion and establishes a bounding box, it can use that detection to trigger snapping a still image or motion clip. Basing your surveillance on motion detection helps eliminate recording useless images. TrackerCam can also slew the TrackerPod to follow the bounding box, keeping in the field of view as the object in the box moves. Test the motion tracking not only for sensitivity, but to check the speed at which the TrackerPod slews — too slow, and it can't keep up.

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**FIGURE 6-10:** A bounding box in the camera view shows the area TrackerCam identified as containing motion.

Detailed settings for tracking and motion capture are in the Capture Motion page under Communication, shown in Figure 6-11. The top part of the right column lets you enable or disable motion tracking (which is the same as the Track button in the main window), and set the detection threshold. The rest of the right column sets the parameters for motion-based video capture.

### Video Conferencing

One of the problems with desktop video conferencing is that the camera is so close that if you move to one side to do something you're out of the picture. The TrackerPod solves the basic problem by being able to track your movements, but because there are so many video conferencing applications (including CUseeMe and Microsoft NetMeeting), it's impractical for the TrackerCam software to include the equivalent of all those programs. Instead, TrackerCam implements a "pseudo camera," interposing itself between the actual camera and any application wanting access to video from a camera. This feature makes the motion tracking functions available invisibly to the other application, which simply thinks it's getting a video stream from a fixed camera.

The left-hand icon in the Communication pane in the options window starts your video conferencing application. The first time you click on the icon you'll get a dialog box used to identify the application; after that, the application simply starts. Figure 6-12 shows how this works. TrackerCam is running behind NetMeeting, while the identical image in both the NetMeeting and TrackerCam windows shows you that they're getting the same video feed.

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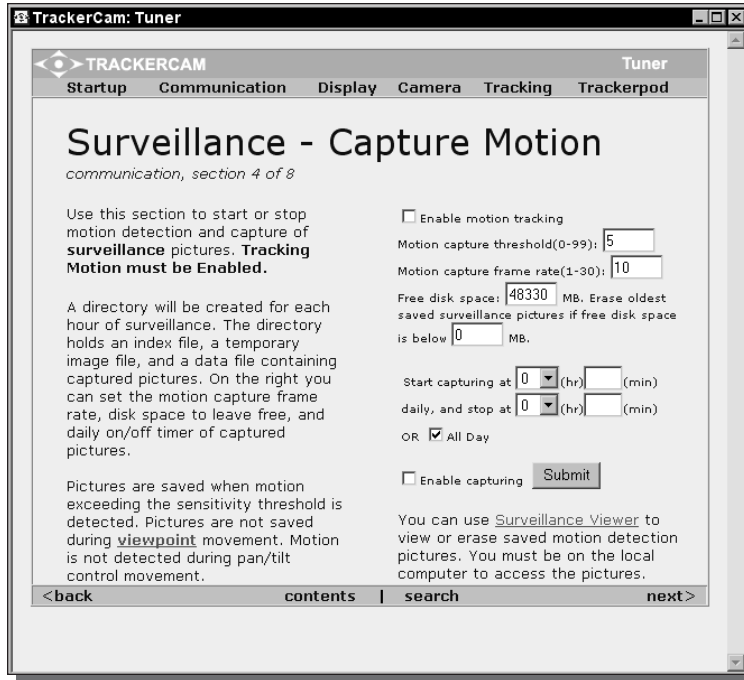


FIGURE 6-11: The Capture Motion settings page in the TrackerCam Tuner



FIGURE 6-12: Configure NetMeeting to use the TrackerCam Capture camera and you'll have motion tracking from within NetMeeting.

## Building a Surveillance System to Your Own Design

There's really no end to what you can do with a home surveillance system. You can start with the basic system we describe and enhance it to meet your specific requirements, or you can start with entirely different equipment and software. The driving factors are what you want to accomplish and how much you're willing to spend.

### Multiple Cameras

You will need more than one camera if your objective is to watch your entire house. You can easily tie multiple cameras to your PC if they're webcams with USB interfaces, but if you're using standard composite video you'll need a PC interface able to accept and digitize the analog video signal. One possibility is the Webcam Corporation Model WCSP100-4, a PCI board accepting four NTSC or PAL analog video signals. The board includes software to monitor the cameras and give you a combined quadrant display of all four (see Figure 6-13). You can watch the video remotely with a Web browser, and you can set up the software to initiate video recording when it detects motion and to send you an e-mail alert.



FIGURE 6-13: Simultaneous quadrant display from four cameras

## Long Cables and Wireless Cameras

For the same reason that it's hard to put full-motion video onto the Internet — it's hard to transmit lots of bits a long distance — the camera's data rate makes it difficult for you to set up your cameras a long way from your PC. You don't always have a choice, though, so you may need to design remote cameras into your surveillance system. The following sections discuss some of your options.

### Long Cables

Many webcams use a USB interface into the PC, which would normally limit you to keeping the computer in the same room as the PC. Eagletron, the maker of the TrackerPod we used in the baseline design, makes an adapter that will extend USB cables as far as 200 feet. At \$160 for the 150-foot version, those adapters ([secure.eagletron.com/TCam/purchase/cart.php?Item=H2002E150](http://secure.eagletron.com/TCam/purchase/cart.php?Item=H2002E150)) are expensive, so you'll want to be careful where you use them.

### Wireless

One possibility is a wireless pan/tilt camera, but these are expensive too. The X10 Vanguard is representative (\$799.99 list; \$499.99 special offer in early 2003; see [www.x10.com/products/vanguard\\_sg1.htm](http://www.x10.com/products/vanguard_sg1.htm)). Equivalent cameras we researched were even more expensive.

You also have the option of a stationary wireless camera, such as the X10 Xcam2 (\$79.99 at [www.x10.com/products/x10\\_vk45a.htm](http://www.x10.com/products/x10_vk45a.htm)). It's an order of magnitude cheaper, but you'll need more cameras to get full area coverage.

If you already have cameras that produce standard composite video, Radio Shack makes wireless audio/video senders (catalog number 15-2572 at [www.radioshack.com/](http://www.radioshack.com/)) for under \$100. These units transmit the composite video plus stereo to the paired receiver; if your requirements are within their range, which is affected by walls, metal, people, and other interference, they're small and simple.

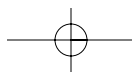
## Integrated Home Automation

You can combine video surveillance with home automation (see the coffee pot controller in Chapter 3 for an introduction to X10 equipment). The X10 Floodcam is an example ([www.x10.com/products/x10\\_vt38a.htm](http://www.x10.com/products/x10_vt38a.htm)); it combines a wireless camera, floodlights, and a motion sensor, and transmits the motion indication to your X10 system for further response. The camera can be turned on and off from the X10 system, too.

On a simpler level, the power supply for the stationary X10 Xcam2 will respond to your X10 controls, turning the camera on and off.

## Archiving to Removable Storage

Security installations in which permanent storage of what's recorded is necessary often record the video to videotape. You could do that, but it's difficult to do if you're using the motion tracking features of the TrackerPod. Instead, if you have a CD-RW or DVD writer, you could dump the captured files to optical disk. You could use one of the many available programs to



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make your optical drive work like a read-write drive, then either write a program to dump directories to disk or use something like the Unison file synchronizer ([www.cis.upenn.edu/~bcpierce/unison/](http://www.cis.upenn.edu/~bcpierce/unison/)). If you need control over the times at which the application runs, consider using a Windows scheduled task.

### Summary

The essence of surveillance is making images of interesting events available remotely. As you dig into building a surveillance system, you'll grapple not only with the camera issues of resolution, image quality, and field of view, but also system control and communications bandwidth. You'll need to strike a balance among those characteristics if you want to keep costs within reason.

