

Insect Inside

Garnet Hertz will never want or need to debug his mobile robot, because it's controlled by a live cockroach. Fastened into the three-wheeled vehicle via velcro cemented to its back, the bug drives by moving a ping-pong ball under its feet. The ball fits into the workings of a Kensington trackball, turned 45 degrees so that its two axes correspond to angled-left and angled-right, rather than horizontal and vertical. The movements are then decoded and amplified by transistors to drive left and right rear wheels, which turn in slightly to reflect the roach's steering direction.

Power comes from twin 24-volt DC motors and a 24-volt battery. Meanwhile, four infrared proximity sensors surround the front of the vehicle and switch on a row of LEDs that shine in the roach's eyes when the vehicle approaches an object. Because cockroaches avoid light, this is intended to discourage the robot from bumping into things. But if the

insect evaluates the distance it travels based on the length of its unenhanced stride, it's possible that when its steps are greatly amplified — as they are when it is placed in the robot — its ability to navigate will be impaired.

The bug buggy's CPU is a Giant Madagascan Hissing Cockroach (*Gromphadorhina portentosa*). Hertz has worked with the species before, and it's well suited to such applications. Their size and strength let them move relatively large objects, and their native forest-floor habitat makes them well suited to being literally pressed into service. Working with insects requires no animal ethics procedures or approvals, unlike with mammals, and anyway, if you mistreat *G. portentosa*, it will hiss loudly. Cockroaches in general, meanwhile, carry a pile of personal and cultural associations. Everyone has had their own vivid experiences with the Kafkaesque insects, and this just adds to the fun.

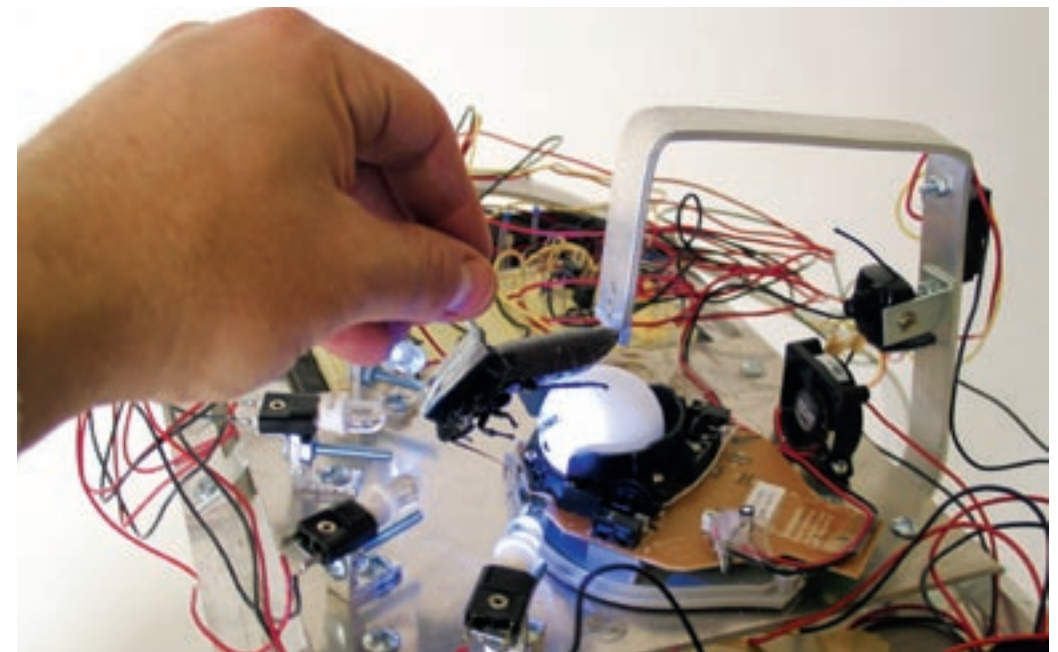
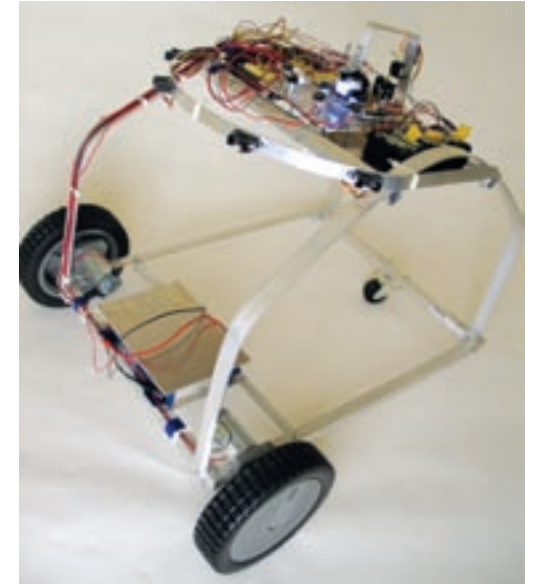
Photography by Garnet Hertz

Hertz is most interested in how the cockroach does *not* act like a computer chip, how its behavior defies easy logic. Watching the roachbot cruise along at slow walking speed, stumbling and bumping into things, it's impossible not to wonder about the underlying neural processes, which propagate through a distributed set of ganglia rather than a central brain. On another level, the robot system is meant to be funny, but some also see it as a dark reduction of human-machine interaction. Following this theme, Hertz's paper describing the project, "Control and Communication in the Animal and the Machine," takes its name from the subtitle of Norbert Wiener's seminal 1948 book, *Cybernetics*.

Hertz first demonstrated his roachmobile at last year's SIGGRAPH, where it milled around the audience during the conference's popular wearable-computing fashion show. At this year's SIGGRAPH, however, Hertz feels that his state-of-the-art roach couture may be ready for the runway.

—Paul Spinrad

✦ **Control and Communication in the Animal and the Machine:** conceptlab.com/control



MOUSEY THE JUNKBOT

By Gareth Branwyn

With a few spare parts, you can turn an old computer mouse into an amusing little robot. >>

Set up: p.99 **Make it:** p.100 **Use it:** p.109

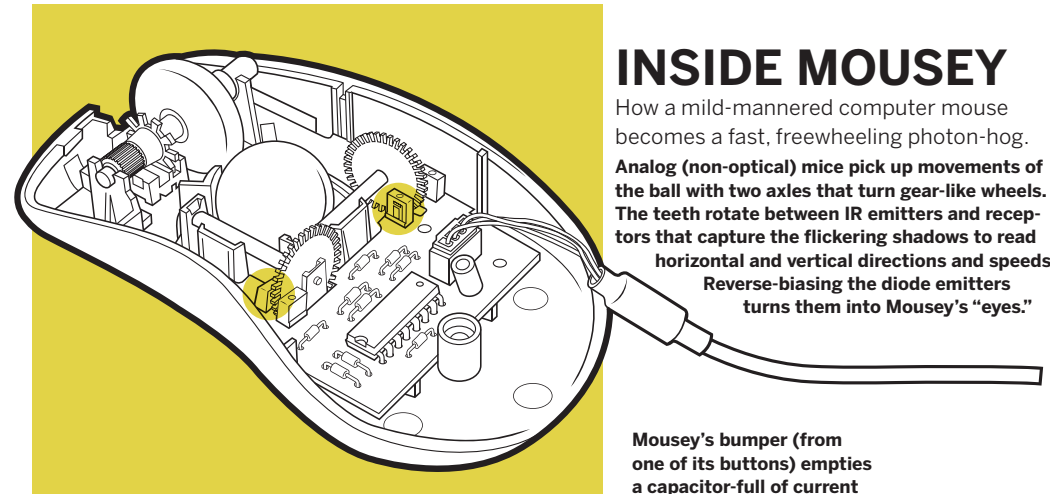
Photography by Kirk von Rohr

THE FINE ART OF MAKING “FRANKENMICE”

This project turns an analog computer mouse into a robot that'll delight friends and wow workmates down on the cube farm. Mousey's behavior is fittingly mouse-like. It scoots quickly across the floor, thanks to lively little motors. And when the critter crashes into anything, it speeds off in the opposite direction.

The robot's "brains" are an ingenious hack based on an audio operational amplifier (op-amp), an 8-pin chip that's normally used to drive answering machine speakers and other lo-fi equipment. Following Randy Sargent's pioneering design (see page 102), Mousey repurposes this chip to boost light-sensor input to motor-powerable levels. The result is simple, fast-reacting analog circuitry that fits inside a mouse case.

Gareth Branwyn writes about the intersection of technology and culture for *Wired* and other publications, and is a member of MAKE's Advisory Board. He is also "Cyborg-in-Chief" of *Streetch.com*.

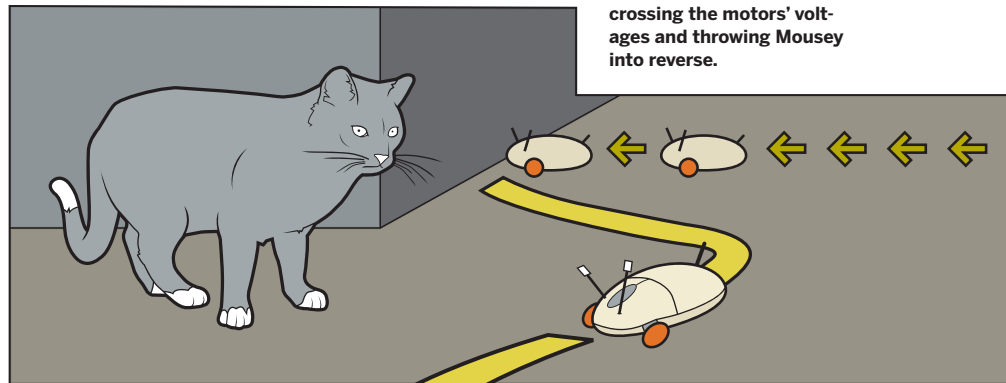


INSIDE MOUSEY

How a mild-mannered computer mouse becomes a fast, freewheeling photon-hog.

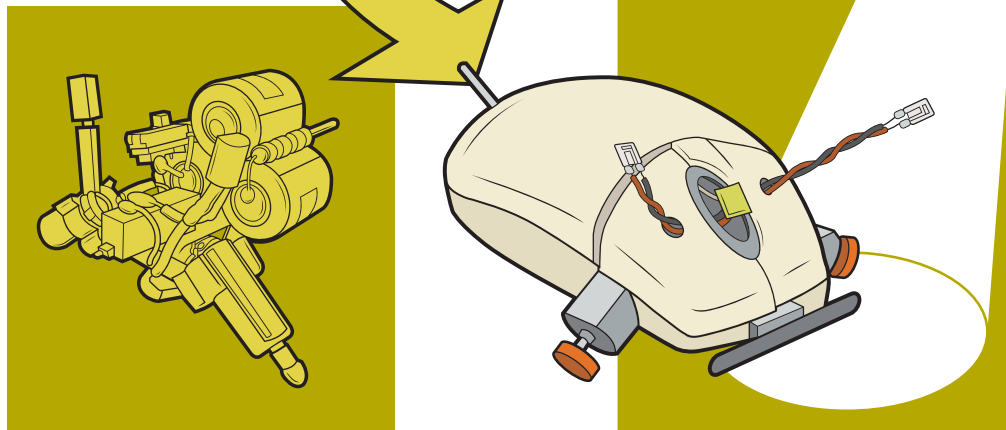
Analog (non-optical) mice pick up movements of the ball with two axles that turn gear-like wheels. The teeth rotate between IR emitters and receptors that capture the flickering shadows to read horizontal and vertical directions and speeds. Reverse-biasing the diode emitters turns them into Mousey's "eyes."

Mousey's bumper (from one of its buttons) empties a capacitor-full of current across a relay, temporarily crossing the motors' voltages and throwing Mousey into reverse.



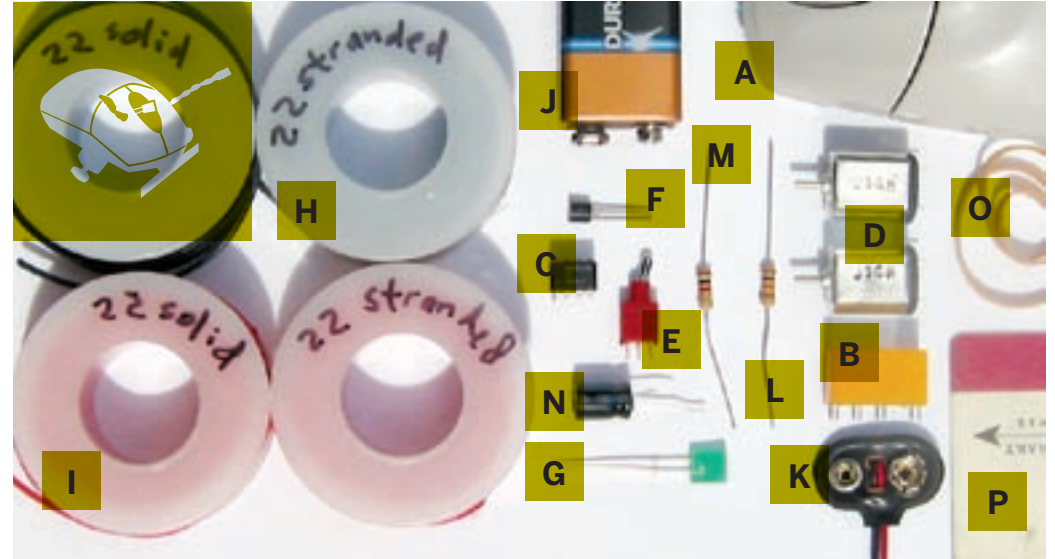
Randy Sargent's Herbie (below) was the first LM386-based bot. It finished last in the 1996 Robothon's line-following race, but went on to spawn many descendent designs.

The eyes' light difference is amplified and tapped into the circuit between the two motors, wired in series. As one motor draws less power, the other uses more, steering the bot.



SET UP.

Visit makezine.com/02/mousebot for source list.



First, you'll need an analog (non-optical) mouse to cannibalize for its case and several parts inside. If you don't have an old mouse or two gathering dust, ask friends and colleagues. Otherwise, you can buy a new, super-cheap model such as the Kensington ValueMouse, which costs \$10 and has enough space to fit all of your components inside. The bigger and more symmetrical the mouse, the easier the build will be. "Handed" mice with asymmetrical, curved bodies present problems.

The other components can be scavenged, or purchased from an electronics retailer. For the motors and other specialty parts, we recommend Dave Hrynkiw's Solarbotics (solarbotics.com) as an excellent source. Where available, we've listed Solarbotics parts numbers for components, and they now offer a complete mousey kit for about \$20 (without the mouse).

For an electronic symbols key, see page 113.

MATERIALS:

Mouse case [A]

2 Light sensors
From mouse

SPST touch switch
From mouse

Double-pole, double-throw (DPDT) 5-volt relay [B]
From analog modem, or Solarbotics #RE1

LM386 audio operational amplifier (op-amp) [C]
From answering machine, speakerphone, intercom, etc., or Solarbotics #LM386

2 Small 4.5 VDC motors [D]
From motorized toys, or Solarbotics #RM1A / Mabu-chi FF-030-PN

SPST toggle switch [E]
Solarbotics #SWT2

2N3904 or PN2222 NPN-type transistor [F]
Solarbotics #TR3904/TR2222

Light-emitting diode (LED) [G]

2 Spools of 22 to 24-gauge stranded hook-up wire [H]
Ideally, 1 black and 1 red

4 Pieces of 22-gauge, solid-core hook-up wire [I]
Ideally, 2 red and 2 black, 6½" long

9V battery [J]

9V battery snap [K]

1kΩ to 20kΩ resistor [L]

1kΩ resistor [M]

10μF to 100μF electrolytic capacitor [N]

Rubber band or other tire-making material [O]

Small piece of plastic [P]
At least ¼" x 2½" of hard, springy, thin plastic, like .030" Plasticard stock, or an old credit card

Piece of Velcro or two-way tape (optional)

TOOLS:

Phillips screwdriver
For disassembling mouse

Dremel tool

With bits and cutting discs

Needlenose pliers

Digital multimeter (DMM)

X-ACTO/hobby knife

Soldering iron

Solder sucker or desoldering bulb

Wire cutters/wire snips

Breadboard, hook-up wire

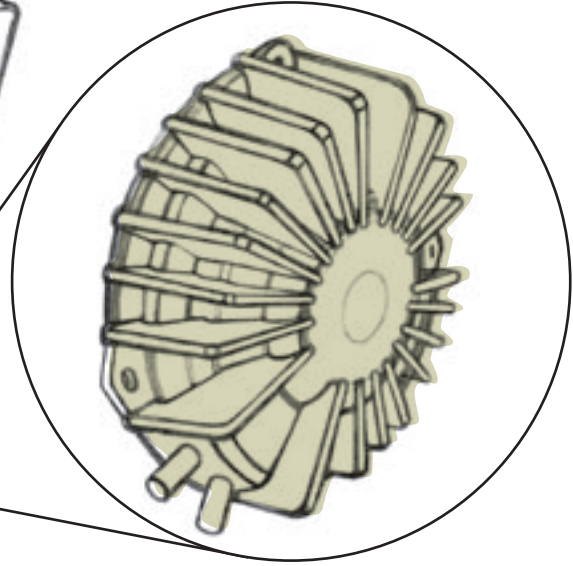
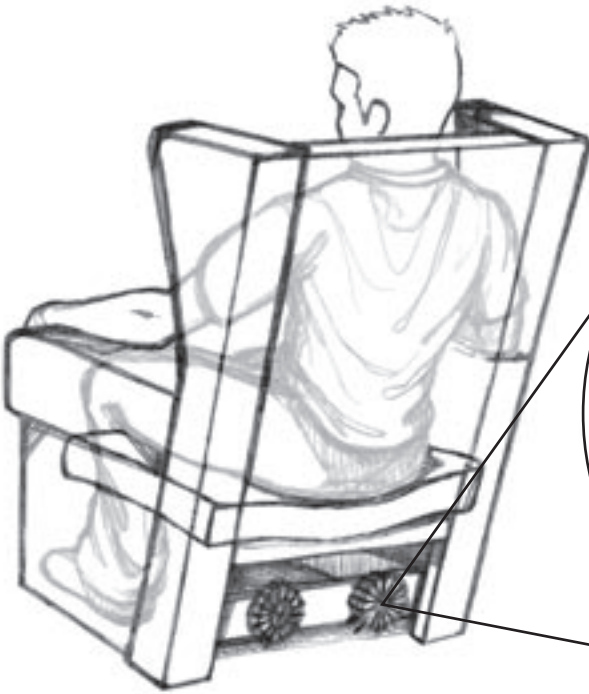
Superglue, epoxy, or other contact cement

Poster putty, electrical tape, cellophane tape

Ruler

Protective goggles, mask

Illustration by Timmy Kuocynda



LET'S RUMBLE

Hack your couch to give you a kick in the pants.

By Craig Engler

Bass shakers are like the rumble packs in a Playstation or Xbox game controller. They make whatever they're attached to rumble when they get a signal from the LFE (low frequency effects) channel of your audio system. That means when the T-Rex puts its foot down in *Jurassic Park*, you don't just hear it ... you feel it.

You can buy an \$800 shaker system from a commercial outfit like Buttkicker or Clark, or you can put the components together yourself for as little as \$30. I've done it both ways, and I like the \$30 results better. That cost assumes you have some speaker wire and an old receiver or amp around. If you don't, plan on spending another \$50-\$100 for a used amp or receiver, plus \$10 on speaker wire at RadioShack.

You can get the shakers at partsexpress.com or on eBay. When I bought mine, a pair of Aura Bass Shakers was going for \$30, and the pro model was about twice that. People who've used both report little difference, so don't worry about buying the cheap pair. (I happen to have bought the pros before I found this out, so the ones shown here are the pros.)

For the receiver, make sure it puts out the necessary watts per channel (25 for the Aura, 50 for the pro) and you're set. Any speaker wire should do. You'll also need an RCA "Y" splitter and cable, which together run about \$6.

Prepare to have many moving experiences with your bass shakers.



On my home theater chairs, I decided the best place to mount the shakers was on the back of the frame, underneath this flap.

Eyeballing it, I can tell the shaker will fit, but I'll only be able to fasten it with two screws. Ideally, you want to use four screws.



Use the RCA splitter on the subwoofer out line of your primary receiver. This way, you can send the signal both to your subwoofer and to the receiver you'll be using to power the shakers.

Once you've got your parts in hand, start by installing the shakers in your seating. One per chair is a good rule of thumb. If you have a couch, you may want more, but I'd start with one and see how much shaking you get. I didn't notice much difference in my three-seater couch whether I had one or four installed. I settled on two because a) I had extra shakers and b) I thought it might

even out the shaking effect more.

You can attach the shakers to any surface you can get four screws into, but you'll get the best shaking if you can fit them onto the longest part of your seating that's suspended between two points. On my couch, that was the piece of wood that ran the length of the seating, between the legs on either side. I had to pull off the underlining of the couch to do it, and then I used a staple gun to put the underlining back on after running my wiring.

If you're only using one shaker, make sure to center it, otherwise you might feel the shaking more on one side than the other (in other words, don't put them in the arms of your couch or chair). With multiple shakers, spread them out as evenly as possible. If you really can't find a place to screw them in, you can also use zip ties and attach them to the seating springs, but that won't transmit the shaking effect throughout the whole seat as efficiently. Still, in a pinch, it's a quick and easy solution.

Next, hook the shakers up. Start by splitting the RCA wire going to your subwoofer with the RCA "Y" splitter, and run the split signal into your

The best tools, software, gadgets, books, magazines, and websites.

TOOLBOX

HARDSHELL

Boblbee Megalopolis backpack
\$189, www.boblbee.com



Keep your stuff safe beneath a shiny, high-impact plastic, injection-molded shell.

(Megalopolis Executive Spark shown)

I'm hard on gear. I drag my PowerBook, iPod, and digital camera everywhere I go. So over the years I've gone through a lot of bags and packs for storing gear.

The one pack I've found that serves all my needs is the Boblbee Megalopolis. It has a lightweight ergonomic ABS plastic outer shell that keeps my tech safe not only from the elements, but from direct impact. It also has a padded inner pocket that holds a 17-inch laptop. Because the laptop sits directly against the padded inner area that goes against the wearer's back, it's about as safe as it can be.

It also has connections for a variety of additional modules and holders. With a pair of side pockets and a bedroll strapped on, I can carry everything I need for a weekend trip. At \$189, this may not be the cheapest option for lugging your gear, but it's certainly the most durable. And most of the parts are easily replaceable, including the outer shell. I've even modded mine so that I can plug all my gear into a power strip inside and simply plug in the pack itself at the end of my day.

—Josh Ellis

TIVO FOR RADIO

RadioSHARK
\$70, griffintechology.com



I've been trying to figure out how to listen to "This American Life" on my iPod, without having to buy the episodes on Audible.com (too expensive). I tried Radio Recorder (xrl.us/radiorecorder) and AudioHijack (rogueamoeba.com), both of which allow you to record RealAudio streams, but I have had bad luck with RealAudio — the stream hardly ever plays from start to finish, leaving me with an incomplete program.

Hopefully, I'll never have to open a RealAudio file again now that I've got a RadioSHARK. This is a real AM/FM radio that plugs into your computer's USB port.

(It gets its name from its shark-fin shape.) You tune the radio and schedule a recording by using the application that comes with the RadioSHARK. The application saves files as huge AIFFs or much smaller AACs — your choice.

Now I'm able to record "This American Life," "Science Friday," and "Fresh Air" and listen to them while I work out at the gym.

RadioSHARK is great to use live, as well. Like TiVo, you can pause live radio, rewind, and — if you've got enough of a program stored in the buffer — fast forward, too.

—Mark Frauenfelder

MAKE FAVORITE GADGET

iLife for Your TV

EyeHome
\$149 refurbished, elgato.com

Elgato's EyeHome is my favorite new toy. It's fundamentally an iLife-to-audio-and-video converter: plug an ethernet cable into the "input" side of it, and then connect the A/V outputs of your choice (RCA-jack analog or SPDIF audio; video is composite, component, or S-Video) to your home theater system (in my case, a crappy TV and an ancient stereo). The EyeHome communicates (HTTP over port 8000) with an EyeHome server installed on a Mac in the network, requests content, and plays it back. It works just fine over 802.11g. The unit is tiny: 8"x8"x1½" and weighs less than a pound. And, because it's fanless, it's utterly silent.

The content it plays can be EyeTV-recorded TV shows, music from your iTunes library, video files, or photos from iPhoto albums. There's also a web browser of limited utility. For the things I most wanted to do with it — listen to music and watch movies — it works marvelously. I can hear some compression artifacts in the audio (a tinny high end and some overall murkiness), but it's still quite listenable. The picture viewer is at least as good as my DVD player's JPG viewer.

Its inability to play purchased iTunes Music Store tracks or QuickTime movies is a bit distressing, but if you're willing to put up with some transcoding to get your video into MPEG or DivX format and your audio into something without DRM, it's not a big problem.

—Adam Thornton



Use EyeHome to send content from your Mac to your TV and stereo.

Photography by Noelle Gaberman and courtesy of individual manufacturers