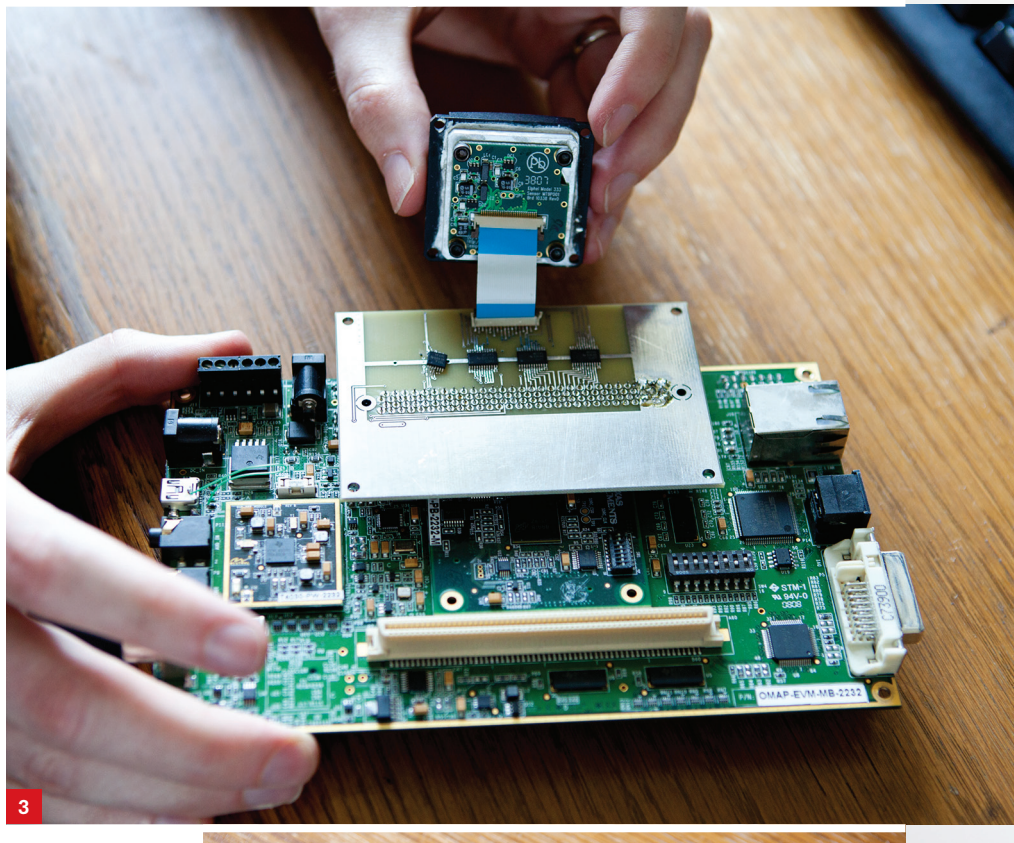
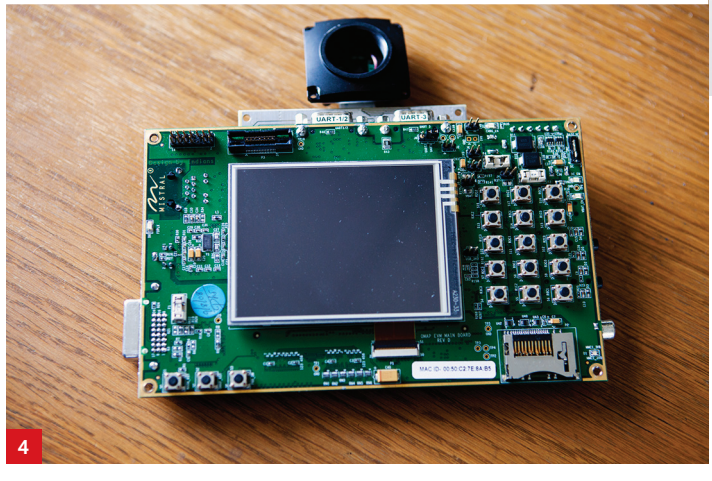
# Photographic Manipulation

A hackable camera opens new possibilities for digital photos.

By TOM SIMONITE

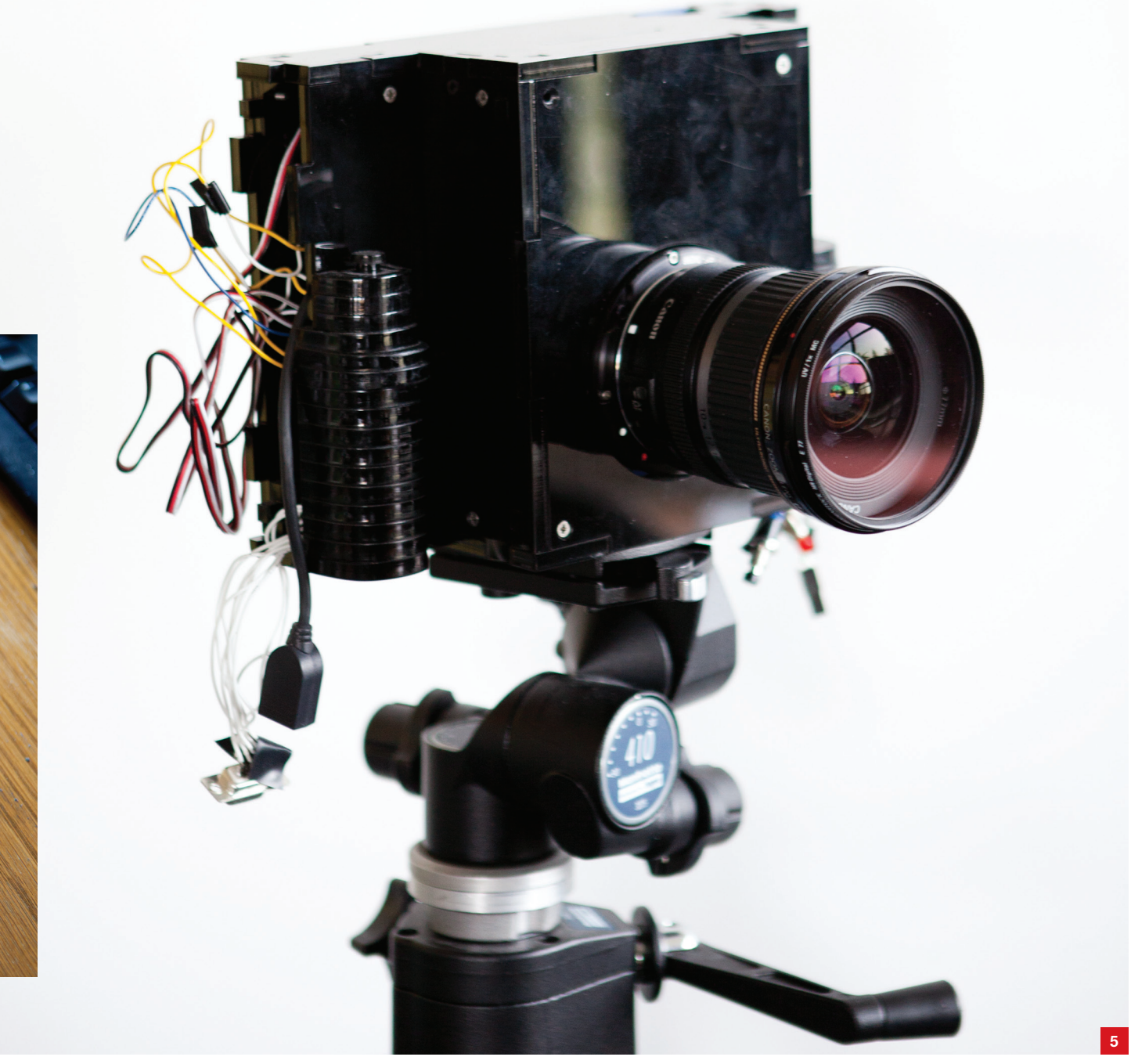




David Jacobs, a graduate student at Stanford University, kneels on the floor and tosses playing cards into the air. A clunky black box with two flashes on top illuminates the cards midflight with strobing light and creates a digital photo that traces their progress through the air. Meet the Frankencamera, a hackable device made at Stanford to prove that the locked-down technology of commercial cameras is holding photography back.

Today's cameras are essentially computers with optical components, but much of that computational power is inaccessible to consumers. Manufacturers block changes to the software and much of the hardware. The Frankencamera, however, can be reprogrammed or modified with extra sensors or controls.

Marc Levoy, a professor of computer science and electrical engineering, built the device to accelerate a field called computational photography, which uses software to push the limits of today's cameras. A version is being developed to sell to a waiting list of researchers. But Levoy says he is developing the techniques to pressure camera firms to open up. "I don't want to get into the camera business," he says. "The goal is to spur industry to do this themselves."

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**1.** The Frankencamera's case is carved from sheets of acrylic plastic using a laser cutter, following a design stored on a computer. Large sections are cut out to make the case's main panels; smaller pieces are glued into stacks to make some parts, such as the camera's grip.

**2.** Chips are soldered onto the power circuit board, which converts the electrical signals from the camera's programmable components and its image sensor, allowing them to communicate. The board was designed in the Stanford lab and made by a contract supplier.

**3.** The completed power circuit board is connected to the back of the Frankencamera's image sensor (held at the top of the image) and its main circuit board (bottom of the image). The main circuit board is an off-the-shelf product more typically used as a test bed for mobile phones running Google's Android operating system. Its processor (the large chip at the board's center) is more powerful than that found in most digital cameras. The Frankencamera is equipped with a version of the Linux operating system that's been customized to control camera hardware and peripherals of all kinds, from flashguns to motorized camera mounts that can be programmed to swivel and pan.

**4.** This view shows the reverse side of the camera's main circuit board, bearing the touch-screen LCD panel (center) that is the camera's viewfinder. The researchers are developing new ways to use such screens to control cameras.

**5.** The electronics are fitted inside the case to complete the Frankencamera. The main circuit board connects to an electronic lens mount to control the focus and other settings of conventional lenses. Some of the wires seen here are loose cabling. The USB connector (left side of image) allows for the use of extra hardware.

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**6.** David Jacobs, one of the graduate students working on Marc Levoy's project, prepares for an experiment by attaching a top plate with two hot shoes, used to mount and control flashguns. Conventional cameras can control multiple flash units, but they can be triggered only once, simultaneously, during an exposure. The Frankencamera can be programmed to set off up to eight flashguns at different times during a shot.

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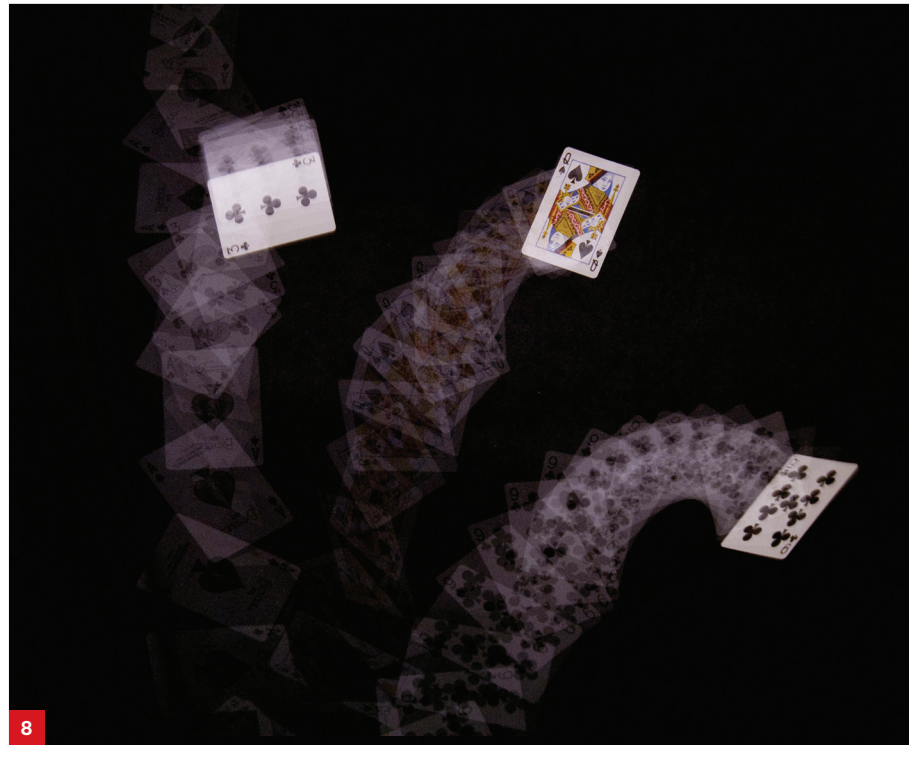
**7.** Jacobs throws cards into the air while a fellow graduate student presses the shutter release. He programmed the camera so that when the shutter opens, the first flashgun strobes on and off for one second. Just as the strobing ends, the second flashgun is triggered, firing once with a much brighter light than the strobe.



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**8.** The final image. The strobing flash unit lights up the cards again and again as they move through the air. Each time they are lit up, the camera's sensor adds to its image, recording their trajectories in a series of steps. The high-powered blast from the second flash allows the Frankencamera to capture a brighter image of the cards at the end of the strobe sequence.

www See the Frankencamera take shape: **technologyreview.com/demo**

JEN SISKA. BOTTOM: COURTESY OF STANFORD