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Enhancing Reality for the Future

Steve Mann: 40 Years of Inventing Wearable HDR and Augmented Reality

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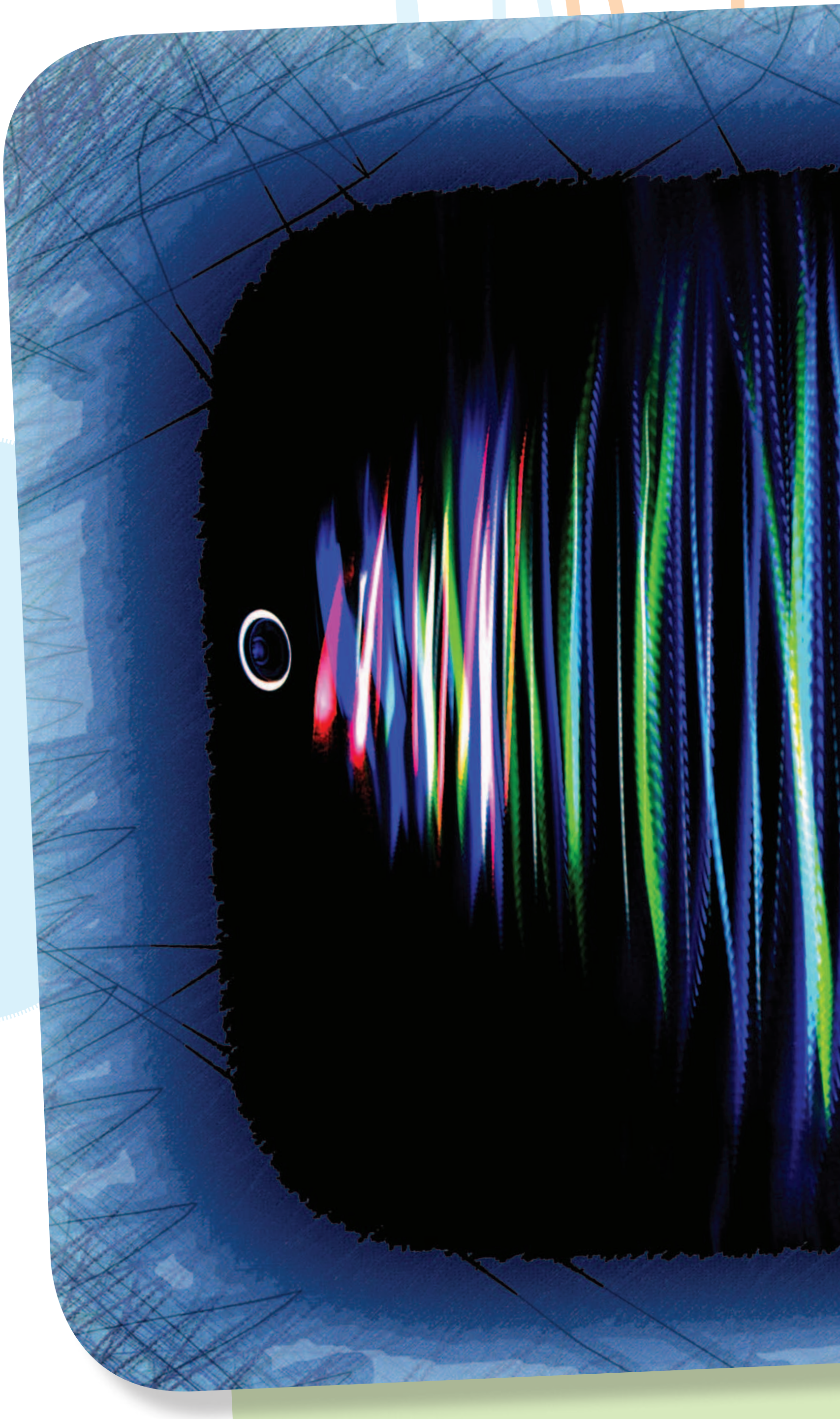
Phenomenal Augmented Reality

Advancing technology for the future of humanity.

By Steve Mann



Steve Mann...brought with him an idea...and when he arrived here, a lot of people sort of said "wow this is very interesting...." I think it's probably one of the best examples we have of where somebody brought with them an extraordinarily interesting seed and then...it grew, and there are many people now, so-called cyborgs in the Media Lab and people working on wearable computers all over the place.

—Nicholas Negroponte,
founder, director, and chair,
Massachusetts Institute of Technology (MIT)
Media Lab

In my childhood, I started my own business repairing radios and televisions, and I also volunteered at a local radio and television repair shop where I had access to a wide range of consumer electronics (CE) devices like television receivers and television cameras. Like many others in the 1960s and 1970s, I was fascinated by video feedback: pointing a

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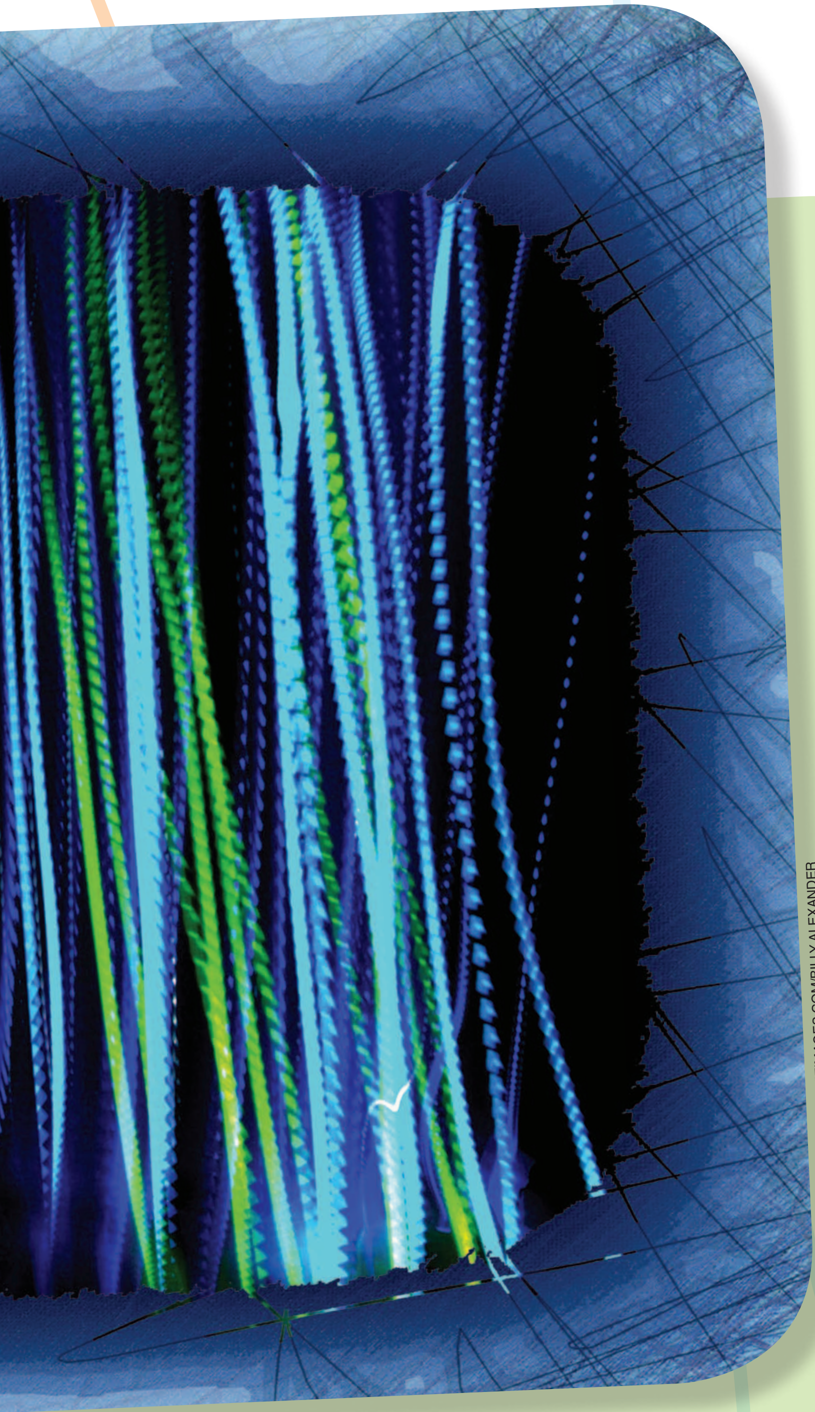
> Much of my own work has been directed at wearable computing and wearable AR. I brought many of my childhood inventions to MIT and founded the MIT wearable computing project as its first member.



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television camera at a television receiver that was picking up the signal from the camera. However, rather than move the camera around a stationary TV set like everyone else did, I let the camera remain stationary, and moved the TV receiver around the room.

I was amazed by what I discovered. The way the TV glowed brilliantly when the camera could "see" it, and less brilliantly when the camera could not see it, allowed me to "sweep" the TV back and forth to "display" the camera's capacity to "see." In this way, I was less interested in the fractal or self-similar recursive patterns on the screen that other artists were interested in creating [1] and more interested in thinking of the camera's sight field as the subject matter of the art (Figure 1).

The glow from the TV allowed me to see an otherwise invisible thing—the camera's capacity to see. This was an early form of augmented reality (AR) in which the glow from the TV was overlaid on top of the physical space around the camera, thus making additional information around the camera visable. I call this *phenomenaugmented reality*, i.e., augmenting reality with physical phenomena and phenomenology.

AR FROM A LIGHT BULB

I soon realized that I did not need to haul around an entire TV set, and that I could connect television receiving circuits to an amplifier feeding into a light bulb. Back in those days, many CE devices had wiring diagrams, schematic diagrams, and parts lists printed on their back panels (unlike today where manufacturers keep processes secret while they collect all kinds of information about us). So I simply tapped into the video amplifier output of a television receiver and connected that to a power amplifier that had enough power to

The real power of wearable computing is to bring AR into everyday life, resulting in 3-D gesture-based wearable computing in 1997, the smartwatch in 1998, and, more importantly, Digital Eye Glass.

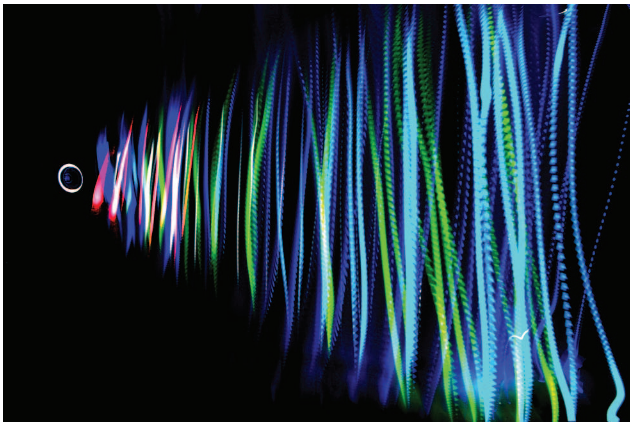


FIGURE 1. A long-exposure photograph of a television receiver swept back and forth in front of a television camera to which the receiver is tuned. Colored filters were used to capture a range of signal sensitivities.

directly drive an incandescent light bulb. Waving the bulb around the vicinity of a camera, it would glow more brilliantly wherever the camera could "see" it, thus creating a three-dimensional (3-D) AR display into the physical world. This led me to inventing, designing, and building a variety of "phenomenamplifiers"—devices that receive signals and overlay them onto the real world, to make visible the otherwise invisible world of radio and television (Figure 2).

SWIM

When I was 12 years old, I built an AR wand with 35 incandescent light bulbs mounted to a wooden stick, driven by a wearable computer, based on my simple observation that real-world phenomena can be made visible by light bulbs connected to an amplifier. I called it the sequential wave imprinting machine (SWIM) [2] (Figure 3).

The wearable computer I built to drive the SWIM was housed in a wooden cabinet with a shoulder strap and a control surfacing for setting parameters like forward/reverse (direction in which the lights were sequenced), rate, sensitivity, gain (amplification), and bias (background idle level of the lamps when no signals were being received). Input was from a rabbit ears-style antenna connected to screw terminals, and output was through 12 wires (every fifth lamp was connected to a group of seven wires, through each of the five groups of seven, i.e., $7 \times 5 = 35$ lamps connected by $7 + 5 = 12$ wires) (Figure 4).

This allowed me to see radio waves as well as to sense sensing (to visualize vision) itself. A metaconversation is a conversation about conversations. Metadata is data about data. So, I called this metasensing: sensing sensors and sensing their capacity to sense, e.g., to see what a camera can see (Figures 5 and 6).

The phenomenamplifier had two modes of operation: 1) a battery-powered mode at low wattages for use in a darkened room at around 245 W, and 2) a tethered mode of operation at up to 2,500 W, which required a long extension cord trailing back to an external power source. Originally, it was a 3-D AR system that required no eyewear to see. In the original version, all you needed was a darkened room and to let your eyes adjust to the dark and you could see the trails of light from 3-D shapes overlaid onto reality.

By the late 1970s and early 1980s, I'd added various forms of head-mounted display devices to the phenomenaugmented

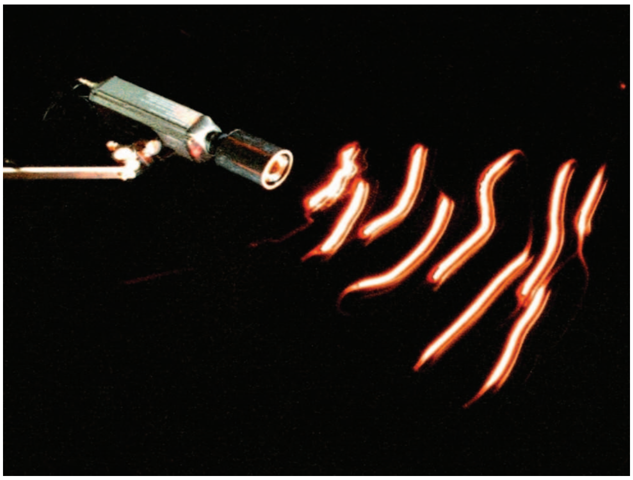


FIGURE 2. A long-exposure photograph of a television receiver connected to an incandescent light bulb swept back and forth.

FIGURE 3. A sequential wave imprinting machine developed by Steve Mann in 1974, on display at the National Gallery in Ottawa, Canada, April 2015.

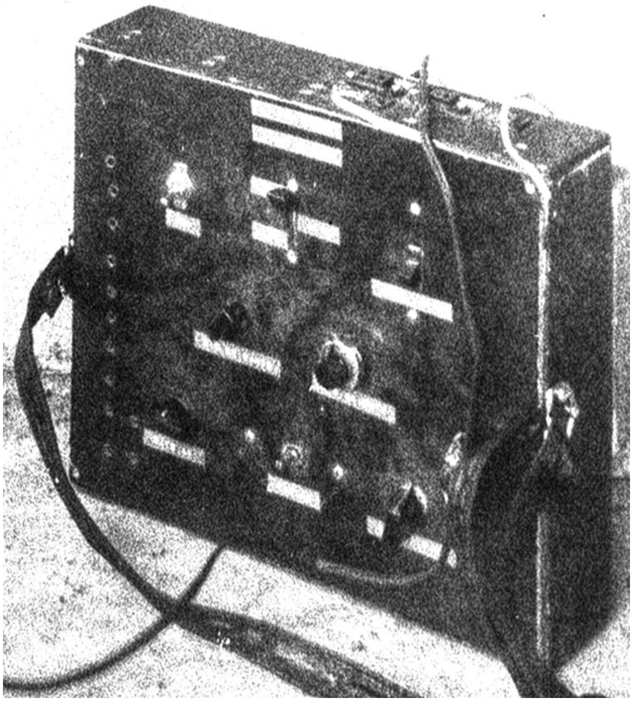


FIGURE 4. The phenomenamplifier developed by Steve Mann in 1974.

An infrared detector allows electricity to flow into a visible light in the presence of infrared light from a surveillance camera.

reality system, and created a general purpose tetherless wearable computer system capable of transmitting and receiving voice, video, data, multimedia graphics, etc. This also evolved into a visual art form, e.g., AR that is affected by phenomena around it, and also AR that can affect the environment around it, or both (Figure 7).

WEARABLE AR

AR has a long history from precursors like McCollum's Stereoscopic Television Apparatus of 1943. By 1959, portable battery-operated television was possible in the world of CE, e.g., by way of the Philco Safari. In 1961, Philco produced a head-mounted display for remote viewing of surveillance cameras [3], and Ivan Sutherland produced a system for viewing computer graphics by way of similar head-mounted displays in 1968 [4].

The work of Sutherland and many others involved large-scale projects tethered to buildings, not portable or wearable devices. Much of my own work has been directed at wearable computing and wearable AR. I brought many of my childhood inventions to MIT and founded the MIT wearable computing project as its first member.

Indeed, the SWIM formed the basis of the portfolio that I submitted to MIT for acceptance into the MIT Media Lab in the early 1990s. I must also give credit to many of my contemporaries, such as Thad Starner, who worked with me at MIT in the early days of the MIT Wearable Computing Project and introduced many important concepts like the "Tin Lizzy" and the "remembrance agent" [6].

The real power of wearable computing is to bring AR into everyday life, resulting in 3-D gesture-based wearable computing in 1997 [7], the smartwatch in 1998 [8], and more importantly, the Digital Eye Glass [7].

INSPIRING FUTURE GENERATIONS

Much of my work came from a childhood fascination with CE technologies, and it is important that we teach future generations the fundamentals of technology in a way that is

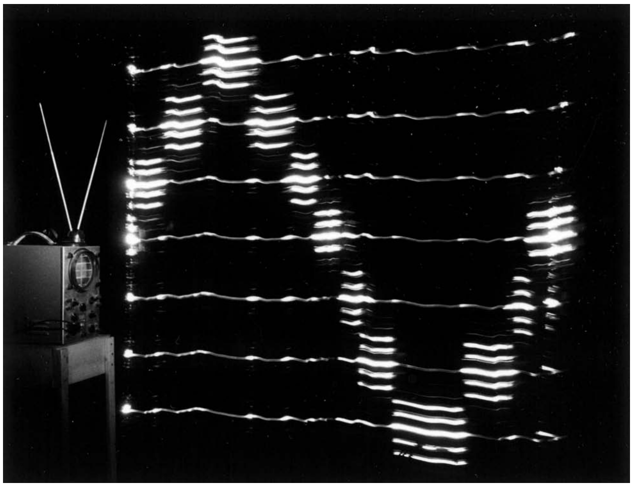


FIGURE 5. The visualization of a channel 7 video transmitter's radio frequency carrier as a standing wave: AR overlay using the SWIM AR wand.

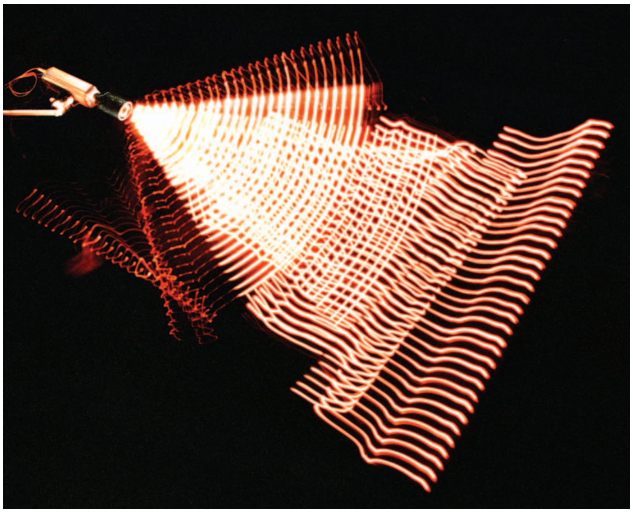
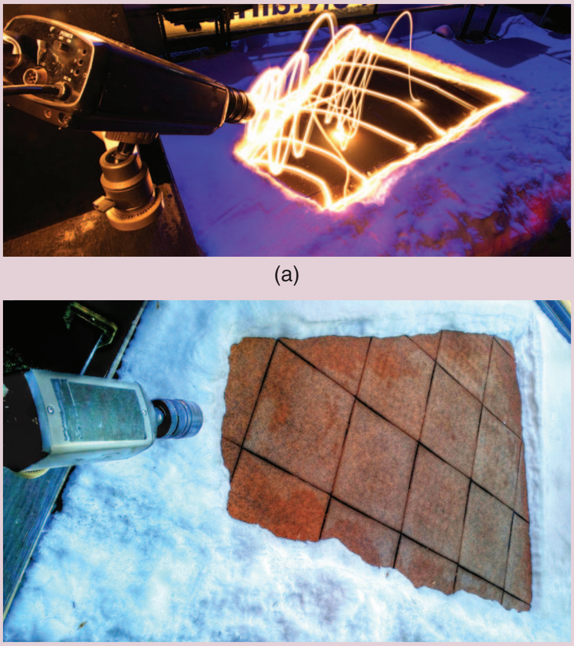


FIGURE 6. An example of seeing sight and visualizing vision of a camera, which Mann called metasensing.

Waving the bulb around the vicinity of a camera, it would glow more brilliantly wherever the camera could "see" it, thus creating a three-dimensional AR display into the physical world.



(a)

(b)

FIGURE 7. (a) "TV snow: Television camera watching the snow melt," S. Mann, 2013, was a surveillance-based snow sculpture in which the phenomenamplifier was powerful enough to affect the world. (b) The lightpainting with a 1,500-W light bulb was powerful enough to actually melt the snow in areas where the camera was "watching." In this way, the snow becomes a canvas similar to the photographic medium. Other examples included the use of steel as the canvas, using a 12,000-W phenomenamplifier to pick up television signals of cameras watching the steel melt, e.g., with the camera's gaze "burning" a hole through the steel.

simple and compelling. In this sense, I've taught my children how to build simple AR devices and how to present this work at their schools (Figure 8). Here, the basic principle is simplified: an infrared detector allows electricity to flow into a visible light emitter (light-emitting diode) in the presence of infrared light from a surveillance camera (many surveillance cameras have infrared illuminators built into them) (Figure 9). Likewise, my students and I seek to advance the state of AR and metasensing as a solid scientific basis for CE devices and ongoing research [11].

CONCLUSION

What have we learned from all this? Metasensing is the sensing of sensing, and, in many ways, it involves feedback, such as video feedback or other sensory feedback. It is an example of a larger overarching philosophy called humanistic intelligence (HI) [9], which is sensory intelligence that arises by having the human being in the feedback loop of a computational process.

HI is not about replacing humans with computers, as is a goal of artificial intelligence (AI). Instead of singularity and AI, we should think about the sensularity [10] and HI as the basis upon which to base our design of CE devices. In my work, I try to live by the IEEE's slogan "Advancing technology for humanity," and that is why I formulated the concept of HI.

ABOUT THE AUTHOR

Steve Mann (mann@eyetap.org) earned his Ph.D. degree from the Massachusetts Institute of Technology. He is chief scientist, Rotman School of Management CDLab, the University of Toronto, and chief scientist, Meta (www.getameta.com). He is widely known as "the father of the wearable computer" and the inventor of HDR imaging (first at digitally combining multiple pictures of the same scene to improve dynamic range).

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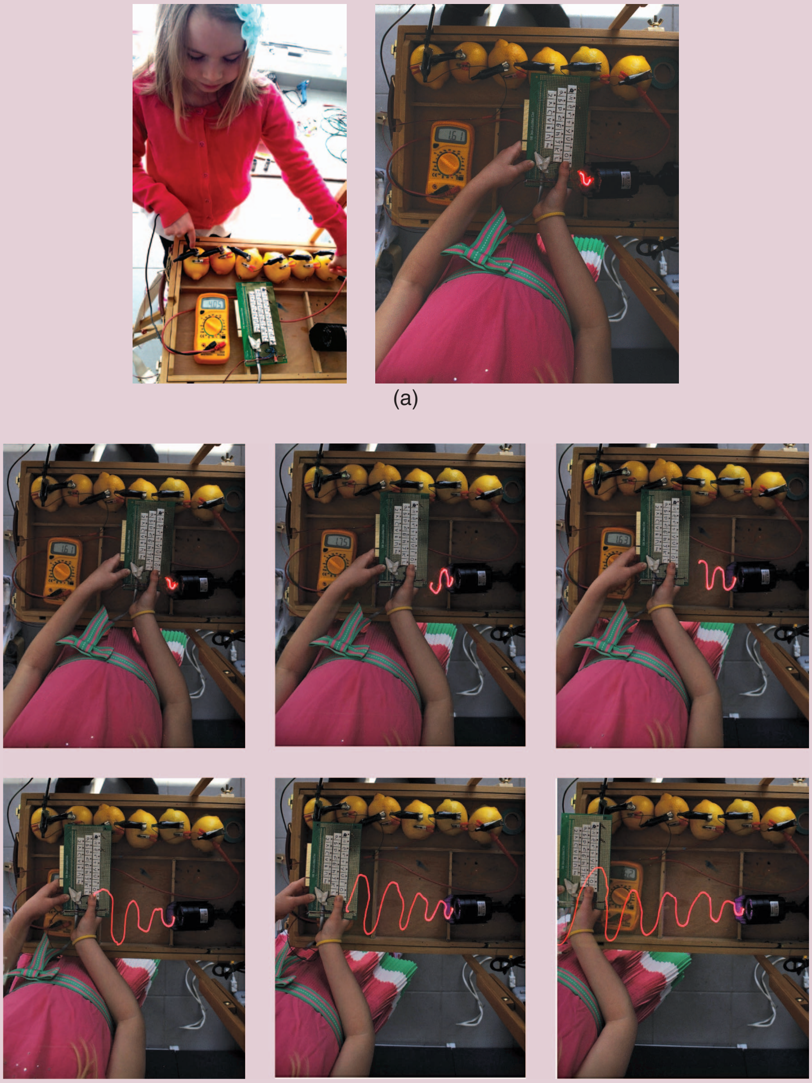

(a)

(b)

FIGURE 8. (a) A six-penny AR system. Stephanie, age 8, has built a phenomenaugmented reality system powered by six pennies, six zinc screws, and six lemons. (b) Six frames of video from a video sequence showing a demonstration of the six-penny AR system. The red LED glows more brightly wherever the camera can "see" it more clearly.

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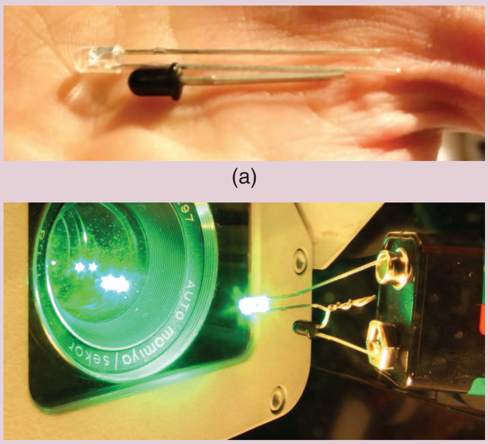

(a)

(b)

FIGURE 9. (a) and (b) The infrared detector allows electricity to flow into a visible-light emitter from a 9-V battery, when in the field of view/illumination of a surveillance camera that has an infrared illumination source built in.