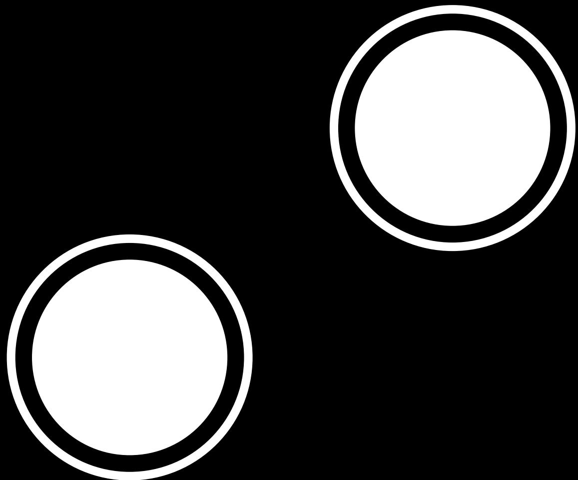


Surface Capacitance: The most basic capacitive touchscreen consists of a glass substrate coated with conductive material, charged at each of the four corners to generate a uniform electrostatic field. The screen detects when fingertip disrupts the field (imagine the classic two-dimensional representation of Einstein's Theory of Relativity), but it cannot register more than one contact point.

Resistive Touchscreens: In resistive touchscreens, a flexible surface actually responds to the physical press, in which the two infinitesimally separated layers come into contact, detecting a kind of 'dead spot'. Commonly seen in ATMs, credit card scanners, and older in-flight entertainment systems, these screens offer the advantage of reading non-capacitive stimuli (gloved fingers, styluses, etc.) but cannot detect multiple points and are generally being phased out due to improvements in capacitive screens.

Frustrated Total Internal Reflection: It is also possible to detect touch through machine vision. As in fiber-optic cables, a sheet of glass or acrylic will also 'totally' refract infrared light projected onto the material, such that those wavelengths will only escape the medium at points of contact. In Frustrated Total Internal Reflection, the IR camera underneath detects one or more fingertips on the back- or edge-lit screen. This technique is granular enough to read fingerprints, but the optical process demands greater overall volume. As in rear-projection televisions, the camera distance is proportional to the size of the screen.

Capacitive Fingerprinting: Even as HCI expands toward haptic and speech-based interfaces, the touchscreen still has untapped potential. A team of computer scientists from Disney Research, CMU, and the University of Tokyo are developing a capacitive screen that can detect touches from multiple different users. Dubbed 'capacitive fingerprinting', their work explores 'how the electrical properties of users' bodies' – bone densities, muscle mass, etc. – can be used to identify and differentiate multiple users touching a screen.

Touchy or Feely?

On the Mundane Magic of Multi-touch

By Ray Hu

On the surface, the space-age glass of the touchscreen and the human epidermis are tactile opposites, each everything the other is not. The former is hard, cold, clear, absolutely smooth, and yet brittle for its crystalline structure; the latter is soft, warm, opaque, and visibly lined with the wrinkles and pores of personal topography. More and more the twain shall meet as multi-touch technology marks the paragon of digital prestidigitation. As the fingertip and touchscreen inexorably become codependent, it makes just as much sense to measure the sensitivity of a screen as it does to refer to the capacitance, or electric potential, of a fingertip.

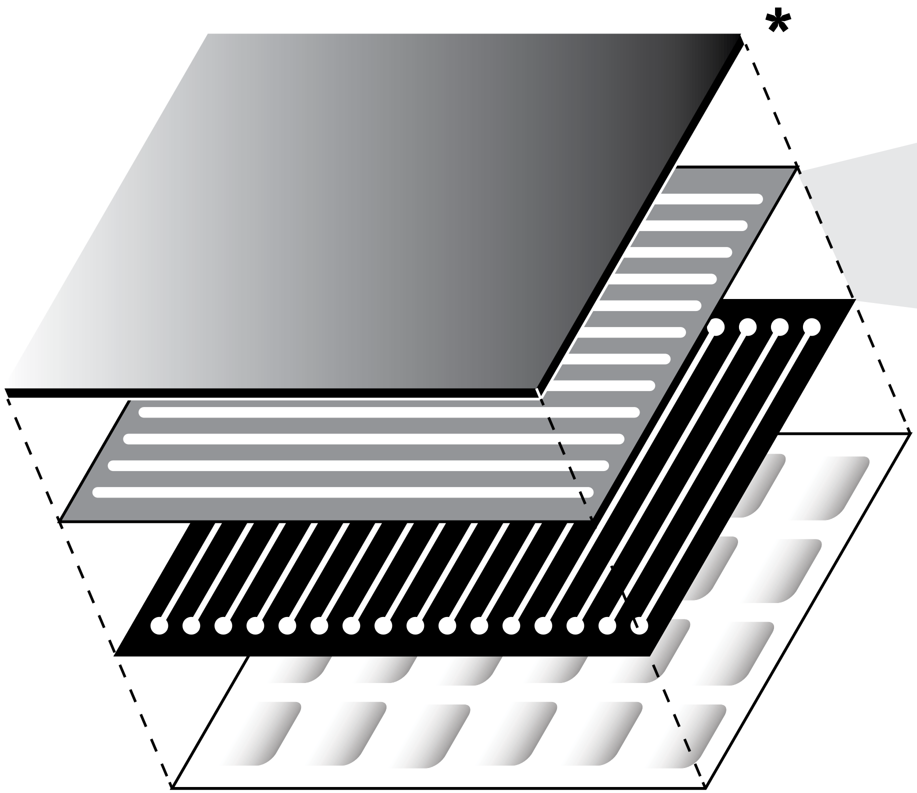
The latest capacitive screen consists of a high-tech sandwich: Between the pixel-packed LCD display and a sturdy pane of glass lies a pair of invisible substrates, conductively pinstriped and orthogonally oriented to form a dense X-Y grid. When one or more fingers disrupt this electrostatic field, the firmware identifies a touch, tap, swipe, or pinch with the high precision and near-instantaneous speed that we take for granted today; each gesture can be reduced to an algebraic formula on the Cartesian coordinate plane.

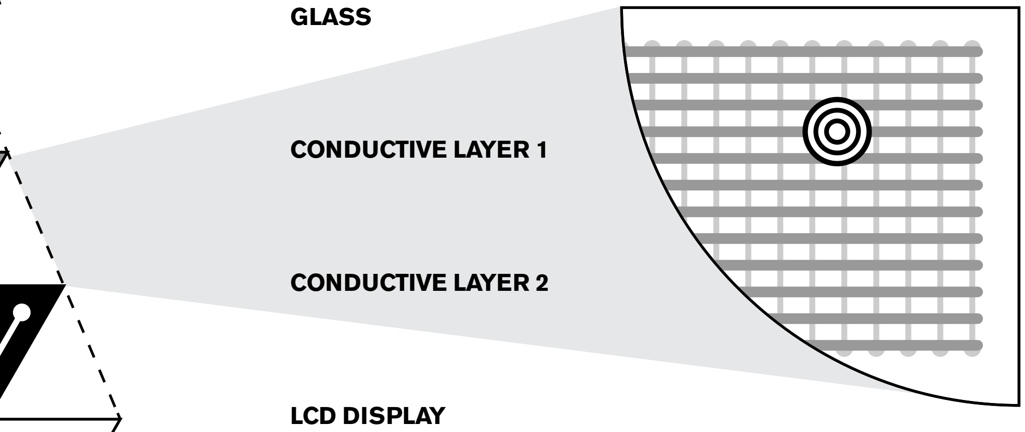
Nevertheless, this advanced technology is nothing compared to the sheer complexity of human skin. The outermost protective layers, or epidermis, are primarily composed of keratin – a protein that forms the continuous surface of the largest organ of one's body – under which lies immune cells, melanin (pigment), and of course the relevant receptors for pressure, temperature, vibration, and pain. With over 3,000 of these nerve endings, the fingertip is easily one of the most sensitive parts of the body – the other being the lips – while the rest of the body averages around 200 per square centimetre.

For comparison, the grid density of the iPhone has doubled from 25 points per centimetre to 50, in tandem with screen resolution, between 2008 and 2012. But these sensors are only part of the equation when it comes to the latency, or response time, of the capacitive screen or the nerve impulse, and here computers can compensate with superior processing power. Somatosensory signals may reach the thalamus in a matter of milliseconds, but it can take upwards of ten times as long for the brain to process them; the iPad 2 – the fastest touchscreen on the market today – clocks in at a blazing nine milliseconds, effectively instantaneous to both hand and eye.

Despite all this, we still hesitate to describe our fingertips as electronic, and to conceive of a screen as capable of feeling. The screen abides as the interface of the moment, yet the metaphysical distance between skin and glass remains the insurmountable barrier to consummating the bionic circuit of man and machine.

Finger bowl, Fingerbreadth, Finger food, Finger footsies, Finger hat





How a multi-touch capacitive screen works

* Schematic of a basic capacitive touchscreen