Emerging technologies are poised to reshape our urban environments.

By William J. Mitchell
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These days computers are mostly devices in drag. The gadgets that surround us wear the distinctive gear and play the varied roles of telephones, MP3 players, digital cameras, watches, and date books. Under the surface, microchips and software are what make these otherwise inert lumps of metal and plastic useful. The same goes for domestic appliances, automobiles, laboratory equipment, prostheses, and the electrical and mechanical systems of buildings. Our cities are fast transforming into artificial ecosystems of interconnected, interdependent intelligent digital organisms. This is the fundamentally new technological condition confronting architects and product designers in the twenty-first century. At the MIT Design Laboratory, my colleagues and I work with teams of students to explore the emerging opportunities this condition provides.

It’s obvious that embedding intelligence in objects creates new functionality (that’s the usual motivation for doing it), but less immediately evident is that it also alters the shapes and sizes of parts and the spatial relationships among them. Eventually this enables surprising new forms to develop. Look at digital cameras, for example. The early models replaced film with a sensor array and memory chip but remained otherwise unchanged. Camera designers soon realized, however, that sensor arrays are naturally smaller than 35mm film frames, which allows lenses and light paths to be miniaturized. And thin flat display screens present exactly what the sensors see, so there’s an opportunity to get rid of traditional viewfinders. As a result the digital camera has evolved an entirely new physiognomy—that of a slightly overweight credit card, with a minuscule lens on the front and a display screen occupying most of the back. This restructuring has also allowed digital “cameras” (if it still makes sense to call them that) to form unexpected alliances. On a desktop the encounter of a rotary-dial phone and a Leica would have seemed like that of a sewing machine and an umbrella. But the combination of a wireless telephone and digital-imaging device fits in your pocket has been a big hit.

A particularly powerful design strategy under these conditions is to look for the ways that embedded intelligence loosens traditional relationships and constraints, and seize these as opportunities for fundamentally reimagining a product or system’s organization, shape, and scale. In my Smart Cities research group, we recently did this in the design of a concept car for General Motors. The miniaturization of components combined with digital controls enabled us to stuff all of the essential mechanical systems—electric drive motor, suspension, steering, and braking—into the space of a wheel. In other words, the traditional arrangement of the drivetrain and suspension systems was eliminated and replaced by digitally controlled robotic wheels, with very simple mechanical connections to the car body. The design not only provided extraordinary maneuverability (the wheels can, for example, turn at 90 degrees for easy parallel parking), it also gave us an opportunity to rethink the body and interior. We took advantage of this to simplify and reduce the footprint, and create a vehicle that could fold and stack like a supermarket shopping cart.

Such a smart vehicle, in turn, opens up the possibility of restructuring urban transportation and energy distribution systems. Under one scenario it functions as a shared-use personal transportation device; you pick one from the front of the line, swipe your credit card, and drive away, and then return it to the back of another stack when you arrive at your destination. With enough of these cars in the city—particularly at transit stations and major destinations—it’s like having valet parking or a waiting taxi wherever you want it, with the added advantage that the vehicles recharge while parked in the stacks. This overcomes the problem of an electric car’s limited range, which will remain with us until battery technology radically improves. And since it puts a lot of battery capacity into the power grid, it enables effective use of clean but intermittent power sources such as solar panels and wind turbines.

Kent Larson’s House_n research group has pursued similar thinking at an architectural scale. House_n’s PlaceLab, in Cambridge, is an elegant though fairly
standard-looking apartment that has been blanketed unobtrusively with tiny sensors. These generate a stream of data about what's happening inside. Through use of pattern-recognition techniques (like the speech-recognition systems that take your airline reservations over the phone), the apartment recognizes inhabitant behaviors, such as making a cup of coffee, doing laundry, or brushing teeth. It is capable of unobtrusively monitoring patterns of activity and certain vital signs, and of knowing whether its inhabitants are eating right, getting enough exercise, or taking their medication—and then prompting them accordingly. As independence-preserving health-care systems for aging baby boomers, sensate apartments are promising alternatives to nursing homes.

At the urban scale, Carlo Ratti's SENSEable City Laboratory has investigated smart parking. Right now the parking-space market operates very inefficiently due to lack of information: there are sellers who offer parking spaces scattered around the city, and there are buyers who drive around more or less randomly until they see vacant spots. Imagine a system in which parking spaces have sensors that send out wireless signals indicating when spaces are unoccupied. Your cell phone and car's electronic navigation system show where the available ones are. Software automatically reserves a nearby space and guides you to it. Maybe the software is smart enough to choose a lot in the price range you've specified, or even to bid automatically in eBay-style real-time auctions for spaces currently on offer. This not only creates a more efficient market but opens up the possibility of managing demand and urban congestion through pricing policy.

In another Smart Cities project we've explored the uses of pixels that have been liberated from the imprisonment of rectangular screens and set free in urban space. Each of these emancipated autonomous pixels consists of a photovoltaic cell, a battery, an LED, and wireless networking in a small package that can be taped to a wall anywhere. Flocks of them—fixed to buildings, in motion on vehicles, or in some combination of the two—can be controlled wirelessly and programmed to behave in a coordinated fashion. (Think of them as robotic fireflies.) This breaks down the traditional distinction between computer displays and lighting systems, and provides a new and very inexpensive way of visually defining and unifying urban public spaces. Instead of applying cute little New Urbanist porches to every building or making all facades Georgian (as in the famous squares of Dublin), we can create a different but very powerful kind of architectural unity with low-cost programmable electronics. The treatment can vary with the time of day, with the seasons, and for celebrations and holidays.

We can even make robotic water droplets. In a Smart Cities project for Zaragoza, in Spain, we have proposed a programmable water curtain to activate public spaces. It consists essentially of an overhead pipe with computer-controlled solenoid valves. By programming these valves we can display patterns, images, and lines of text in the falling water. Through sensors linked to the control software, the form of the programmed water can be adjusted to light, wind, and temperature conditions. And it can respond to people—parting like the Red Sea when they approach, for example.

These projects intimate the emergence of a new stage in the evolution of cities. Preindustrial cities were mostly skeleton and skin—inert material arranged to provide shelter, security, and intensification of land use. In the industrial era, buildings and neighborhoods acquired more and more elaborate flow systems for water and energy supplies, sewage, ventilation, transportation, and trash removal. With their inputs, outputs, and artificial physiologies, they began to resemble living organisms. Today these organisms are developing artificial nervous systems that enable them to behave in intelligently coordinated ways. As the cities and their components become smarter, they begin to take new shapes and patterns. They become programmable. And the design of their software becomes as crucial—socially, economically, and culturally—as that of their hardware.

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