City of Bits

Space, Place, and the Infobahn

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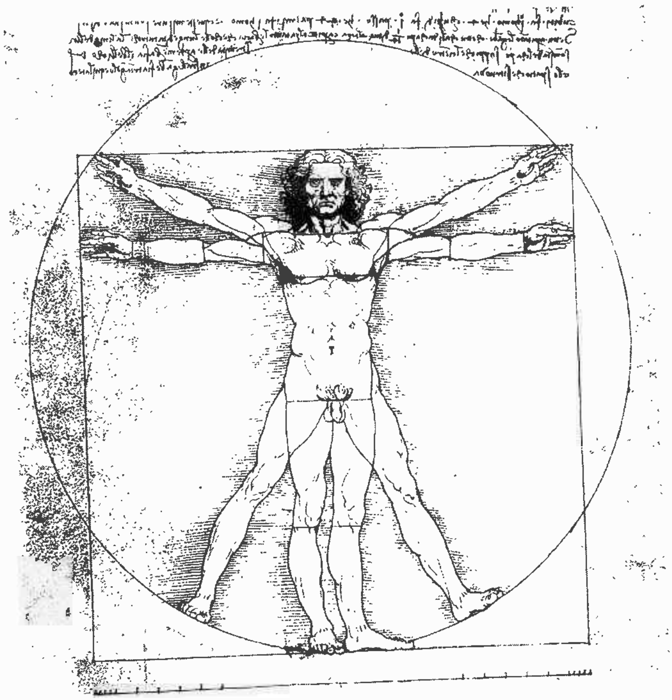

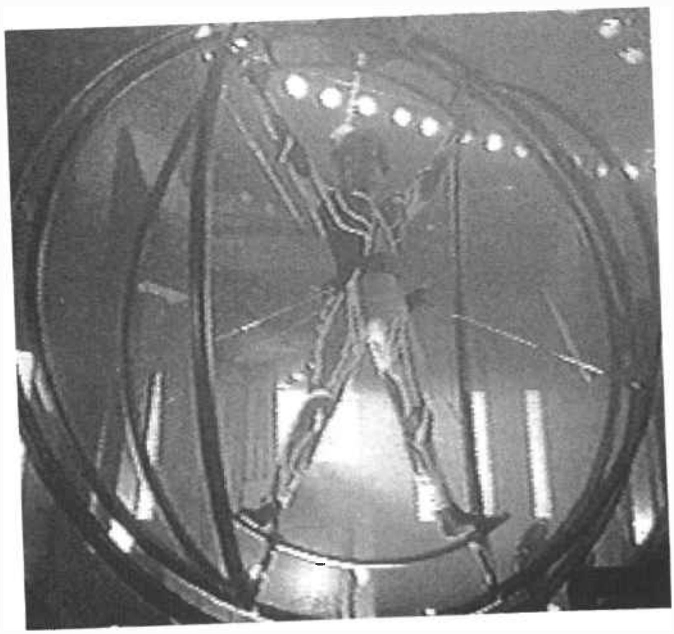

Bodies in space: Virtruvian Man and Lawnmower Man.

The sci-fi thriller *The Lawnmower Man* climaxes with a scene in which the fleshy body of the protagonist, Jobe Smith, is spread-eagled like Leonardo's *Vitruvian Man* in a whirling sphere, while his electronic avatar courses through the network. The camera cuts back and forth between the two conditions. As an ideally proportioned body inscribed in a circle evokes the humanist subject for which Renaissance cities and the buildings of Alberti and Bramante were made, so the fragmented figure of Jobe neatly suggests the incipient role of cities in the digital, electronic era — to house and delight subjects who have become sites of intersection between physical space and cyberspace.

CYBORG CITIZENS

VITRUVIAN MAN / LAWNMOWER MAN

Look around. The old body release — Monkeys 2.0 — no longer delivers what's needed; the users have been getting upgrade kits.[1]

I gaze from my window at the Nike-shod cyborgs on Memorial Drive. Their meat feet slap the surface of the solid world; their Walkman-augmented ears suck in signals from the virtual. Part-human, part-electronic jogging Januses, they have it two ways at once. Their bouncing bodies span different domains of existence.

Stephen Hawking, cyborg, speaks. Speaks? Stricken limbs and the Voltrax allophone generator built into his wheelchair team up to produce electronically mediated utterances. Immobilized flesh remains mute; fingers almost imperceptibly shift a joystick to select words from a displayed menu, then software and silicon retrieve stored sounds, assemble them into paragraphs, and emit them from speakers. Not the traditionally constituted body, but a new sort of electrosomatic construction now becomes the site of practice and project.

August 1991. Yo-Yo Ma, hypercellist, plays on the stage at Tanglewood.[2] His wrist, bow, and cello are all wired with special sensors. A computer translates the signals from these sensors into synthetic sound that a large audience hears through multiple speakers. Performer, instrument, computer, and speaker system become one cybernetic organism. Where are his/its boundaries?

Without leaving my office at MIT, I teach a class in Singapore. Like the cruelly immobilized physicist and the venturesome musician, I extend the limited affordances of my fleshy sensors and effectors through some ingenious electronic jiggery-pokery; a window opens on my computer screen and a distant video camera temporarily becomes my eyes and ears. I can control it from where I sit, as I would a camera in my own hands. At the same time, the students can see and hear me. I display and use my body at a distance. In an almost unconscious gesture, I adjust my tie in the video monitor — then realize with a start that I am not seeing a mirror but a picture of the picture that my audience views on the other side of the world. I am telepresent.

We are all cyborgs now.[3] Architects and urban designers of the digital era must begin by retheorizing the body in space.[4]

Nervous System / Bodynet

Imagine that your wristwatch communicates continuously with your pocket computer; the computer's electronic clock provides the time information, so the watch reduces to a simple, conveniently located display with no internal time-keeping mechanism or adjustment buttons to push. Similarly, by connecting to the computer, your camera can get the information that it needs to time-stamp and date-stamp images. One central electronic clock takes the place of the three that would otherwise be needed, and all three devices are kept perfectly synchronized. The computer itself might grab information from the NIST atomic clock radio broadcast so that it never needs to be set.

Now extend the idea. Anticipate the moment at which all your personal electronic devices — headphone audio player, cellular telephone, pager, dictaphone, camcorder, personal digital assistant (PDA), electronic stylus, radiomodem, calculator, Loran positioning system, smart spectacles, VCR remote, data glove, electronic jogging shoes that count your steps and flash warning signals at oncoming cars, medical monitoring system, pacemaker (if you are so unfortunate), and anything else that you might habitually wear or occasionally carry — can seamlessly be linked in a wireless bodynet that allows them to function as an integrated system and connects them to the worldwide digital network. You will be able to use your PDA to program your VCR, listen to pager messages through your Walkman, display coordinates from the Loran on your smart spectacles, download physiological data from an electronic exercise machine into your PDA, and transmit the output from your camcorder to remote locations via your wireless modem. As you jog in a strange city, you might record your route on your PDA, then have your Walkman give you directions back to your hotel. You get the idea.

By this point in the evolution of miniature electronic products, you will have acquired a collection of interchangeable, snap-in organs connected by exonerves.[5] Where these electronic organs interface to your sensory receptors and your muscles, there will be continuous bit-spits across the carbon/silicon gap. And where they bridge to the external digital world, your nervous system will plug into the worldwide digital net. You will have become a modular, reconfigurable, infinitely extensible cyborg.

Expect that electronic organs, as they become ever smaller and more intimately connected to you, will lose their traditional hard plastic carapaces.[6] They will become more like items of clothing — soft wearables that conform to the contours of your body; you will have them fitted like shoes, gloves, contact lenses, or hearing aids. Circuits may be woven into cloth. Microdevices may even be implanted surgically; electronic pacemakers and cochlear implants are now commonplace, neuromuscular simulation systems seem a promising way to repair spinal cord damage, there is intensive research into the possibility of implanted silicon retinas for the blind, and it is certainly not hard to imagine electronic ear studs, nose rings, or tattoos.[7] Some chips are tiny enough to be injectable and have already been used for tagging and tracking wildlife and identifying pets.[8]

Once you break the bounds of your bag of skin in this way, you will also begin to blend into the architecture. In other words, some of your electronic organs may be built into your surroundings. There is no great difference, after all, between a laptop computer and a desktop model, between a wristwatch and a clock on the wall, or between a hearing aid fitted into your ear and a special public telephone for the hard-of-hearing in its little booth. It is just a matter of what the organ is physically attached to, and that is of little importance in a wireless world where every electronic device has some built-in computation and telecommunications capacity. So "inhabitation" will take on a new meaning — one that has less to do with parking your bones in architecturally defined space and more with connecting your nervous system to nearby electronic organs. Your room and your home will become part of you, and you will become part of them.

But you will not even have to own the electronic organs to which you connect, and they will not have to be close by. Consider plain old telephone service; you rent channels and access to remote devices as you require them. This principle will be extended as digital networks grow in density of connection points, bandwidth, and geographic coverage and as different types of electronic organs are connected into them. We will all become mighty morphing cyborgs capable of reconfiguring ourselves by the minute — of renting extended nervous tissue and organ capacity and of redeploying our extensions in space as our needs change and as our resources allow. Think of yourself on some evening in the not-so-distant future, when wearable, fitted, and implanted electronic organs connected by bodynets are as commonplace as cotton; your intimate infrastructure connects you seamlessly to a planetful of bits, and you have software in your underwear. It's eleven o'clock, Smarty Pants; do you know where your network extensions are tonight?

For cyborgs, then, the border between interiority and exteriority is destabilized. Distinctions between self and other are open to reconstruction. Difference becomes provisional.

And perhaps, as the boundaries of the body and the limits of the nervous system become less definite, metaphysicians will be tempted to reformulate the mind/body problem as the mind/network problem. Some may want to argue that the seat of the cyborg soul — the postmodern pineal gland — is no longer to be sought just on the wet side of the carbon/silicon divide.

Eyes / Television

In the historic haunts of unaugmented humankind, space and time were continuous; a window divided inside from outside, but the very same place was always there on the other side, and there was no time difference across the glass. In the world that we cyborgs inhabit, though, the electronic retinas of our video cameras produce shifts and fragments. Rooms and buildings now have new kinds of apertures; the scenes that we see through the glass are rescaled and distant, the place on the other side may change from moment to moment, and the action may be a replay.

Punch anticipated this in 1879: a cartoon showed the imagined "Edison's Telephonoscope (transmits light as well as sound)" opening up a video window above the bedroom mantelpiece of a comfortable Victorian villa. Paterfamilias and materfamilias in Wilton Place were seen teleconferencing with their children in antipodean Ceylon. The electric camera obscura was soon, in fact, a reality: in 1884 Paul Nipkow patented the Nipkow disk system for electromechanically converting pictures into electrical signals and then decoding them at a reception point; in 1926 John Logie Baird produced a television system that really worked, and from 1929 to 1937 the BBC used the Baird system to provide broadcast television service; in 1939 at the New York World's Fair RCA unveiled its electronic, CRT-based television system; in 1975 cable television operators begin to receive programming from communications satellites.[9] A century after the prescient *Punch* cartoon appeared, C-Span and CNN went on the air.

Late afternoon, Cambridge, England. I sit at the desk of a Xerox PARC researcher. Outside, through the grimy window to the street, I can glimpse the sun setting over stone spires. Simultaneously, through the electronic window before me, I see an empty office at Xerox PARC headquarters in Palo Alto, California. And, through the window of that distant office, that same sun is visible rising over the ochre Palo Alto hills. I am in the media space that has been constructed to weld two distant office buildings together by adding continuously open, two-way, electronic windows at both ends.[10]

Fancy hotel room, Riyadh. A one-way electronic window opens onto the CNN newsroom in Atlanta. An arrow on the bedside table points the prayerful to Mecca, but the satellite dish on the roof turns news junkies and insomniacs toward Georgia. An amplified muezzin, calling from somewhere outside, marks the moment for morning devotions; beyond the electronic window, the news anchor greets the top of the hour with a fast-paced rundown of the day's top stories. Right now, the same window is open in thousands and thousands of similar hotel rooms spread around the world. Ted Turner has succeeded in electronically organizing them all into a gigantic, inverted panopticon. But the antipanoptic center — the place that draws gazes from all the scattered cyborg cells — can be switched instantaneously; as we watch, it moves to London, then to Sydney, to Beijing, then back to Atlanta. And it can slide back in time as signals generated from video recordings (which have become visually indistinguishable from live camera output) are switched into the transmission.

House of Microsoft mogul Bill Gates, Seattle. The interior wall panels are not what they seem. They turn out to be huge, flat video screens. In repose they simulate the surfaces of standard architectural materials, but activated they become electronic windows opening onto anything at all. Architectural solids and voids become fluidly interchangeable, and the usual relationship of interior to exterior space is twisted into jaw-dropping paradox. That old *Punch* cartoon flashes again into my mind.

Kresge Auditorium, MIT. A conference is assembled in honor of artificial intelligence pioneer Marvin Minsky. On stage is a hole in space — a video window into a book-lined study in Sri Lanka (the former British colony of Ceylon). Without leaving his tropical home, Arthur C. Clarke steps into view, delivers the keynote, and fields questions from the audience. In 1993 this is still fairly unusual — a tour-de-force of jury-rigged electronics — but the business pages tell us, and the audience is abuzz with talk, of the feverish rush to wire American communities for two-way, interactive video. Soon we will be able casually to create holes in space wherever and whenever we want them.[11] Every place with a network connection will potentially have every other such place just outside the window.

Once, places were bounded by walls and horizons. Days were defined by sunrises and sunsets. But we video cyborgs see things differently. The Net has become a worldwide, time-zone-spanning optic nerve with electronic eyeballs at its endpoints.

Ears / Telephony

Café Peón Contreras, Mérida. A trio sings and plays as I drink Montejo beer. It's a familiar, traditional arrangement. The musicians and the audience are within easy sight and earshot of each other in a public place, and the music holds us all in a face-to-face, synchronized relationship for as long as the performance lasts.

Around the same time, Frank Sinatra's fading voice croaks duets with a clutch of mostly unlikely partners.[12] But his ol' blue eyes don't see them, and the audience doesn't assemble in his bodily presence. It's One More for My Baby and One More for the Information Superhighway. Sinatra remains concealed in a Capitol Records studio in Hollywood, while strangers on the Net, far more than just a glance away, telecroon in their tracks over distortion-free fiber-optic lines — Tony Bennett doing "New York, New York" from Manhattan, Liza Minelli from Brazil, Aretha Franklin from Detroit, and so on across the globe.[13] (The time delay, unlike the delay with a satellite link, is imperceptible.) Producer Phil Ramone digitally assembles these disembodied vocals, and I finally hear the result on my rental car stereo — along with thousands of other commuters tuned to the same station — as I sit in morning traffic on the Bay Bridge to Oakland. A *New York Times* critic harrumphs: "No matter how gratifying the results, however, can they be called duets? A duet implies spontaneous interaction and mutual responsiveness between two performers in each other's presence, a condition obviously not met by a recording of performers widely separated in time and space. To call the disk 'Duets' seems a misnomer."[14]

The Mérida trio performance takes *place* at a certain spot and has its particular evening hour. And I am *there* in the old-fashioned way: in person, unplugged. The problematic Sinatra duets, though, are constructed in cyberspace by cyborgs of a species that began to emerge on March 10, 1876, when Alexander Graham Bell, Professor of Vocal Physiology in the School of Oratory of Boston University, first successfully connected an electromechanical ear to an electromechanical voice box by an electric wire. And I can listen in *only* with the aid of my own artificial audio organs; if I tried to get within actual earshot of the performance, I would most certainly find that there's no there there. Not only have the configurations of our bodies changed — with their now endlessly multiplied, displaced, and time-shifted speech and hearing organs — but also their relationships to the city's spaces and temporal rhythms.

Telephony did not replace face-to-face human contact; indeed, Bell's very first telephone message was "Mr. Watson — come here — I want to see you." Rather, it created a new form of contact; it extended and redefined the sphere of interaction and inhabitation. Now familiar, this acoustic hyperextension once seemed spooky; Avital Ronell reminds us that the circus showman Phineas T. Barnum "was loath to display the telephone, because he didn't wish to freak out his audience with this voiced partial limb, no doubt, whereas limbless figures were still held to be digestible."[15]

Barnum's suckers would have been even more stupefied by the Convolvotron — a clever, recently invented digital device that places electronically synthesized or recreated sounds in particular locations.[16] It can surround us with virtual cocktail parties of voices that seem to come from empty points in space.

But we're different now. We telephonic cyborgs are comfortably at home in a world of disembodied sounds — of speech displaced in space and time from its origins, of performances that do not require stages or places to assemble audiences, and of conversations without the confrontation of bodies. And we meet in places that cannot be found on city maps.

Muscles / Actuators

Suddenly I feel the shock of a major earthquake, but it doesn't bother me a bit; I'm playing around on a hydraulically actuated, computer-controlled shaking table — a device that is more normally used to test structural prototypes for seismic safety — and I'm experiencing a simulation generated from seismograph data. Mechanical muscles move my body.

Luxor hotel-casino, Las Vegas. Along with other paying customers, I strap myself into an even more advanced kind of motion simulator.[17] A wide-angle screen before us presents a pilot's-eye view of a high-speed, twisting, turning, diving flight through a fantastic three-dimensional environment, and the accelerations of our seats are precisely synchronized with the projected images to produce the corresponding g-forces and jolts. It is a scary, stomach-churning roller coaster ride through a vast virtual landscape, but we never actually move more than a few feet, and from beginning to end we don't leave the same small, darkened room. The phenomenal motion is far greater than the actual motion; it's all in the cunning programming.

Anaheim Convention Center. I line up with the computer graphics geeks and off-duty demo-dollies to check out the Sega R360. Doug Trumbull's Luxor ride milks all of its thrills out of sliding motions along just two axes, but this one does 360-degree rotations. And I strap on a head-mounted display instead of watching a projection screen. The illusion of flying like Superman is complete. Killer vestibulars!

Physical movement and phenomenal motion can now be disconnected; we teleporting cyborgs have found loopholes in Newton's laws.

Hands / Telemanipulators

An operating table; a surgeon's scalpel moves precisely across the surface of an eyeball to make a delicate incision. But the scalpel is teleoperated, and the surgeon is hundreds of miles away, grasping a force-feedback device and watching the output from a medical imaging system on a video monitor.

Actually, this scene is a simulation, and the scalpel is merely cutting into a grape. But by the early 1990s robotic surgery and telesurgery had been active research topics for some time, and there had been many such experiments. Tissue removal had been practiced on chicken breasts, brain surgery on watermelons.[18] And there had been some successful practical applications of robotic devices to surgical tasks requiring positional certainty and rapid performance: in March 1991, at Shaftesbury Hospital in London, the world's first active surgical robot was used to perform prostate surgery on a live patient,[19] and in November 1992 Robodoc — a specialized robotic arm — helped replace the arthritic hip of a sixty-four-year-old Sacramento man.[20] Specialized telemanipulators were becoming an increasingly important part of the cyborg organ repertoire.

There are endless reasons for robotically extending your reach. If you are a skilled surgeon, you might want to make your capabilities more widely available through use of remote manipulation techniques, or you might just want to stay well away from dangerous places like battlefields or the South Side of Chicago. If you are an astronomer, you might wish to use a telescope without actually having to go to some distant, isolated site. If you are a vulcanologist, you might not want to climb down into an active crater to take a look.[21] If you are a construction machinery operator, you might rather work from the comfort and safety of an air-conditioned site office than from a vertiginous, noisy, dusty cab.[22] If you are a cop or a bomb disposal specialist, you might very understandably want to get a dangerous job done without having to put your flesh on the line.[23] If you are a planetary geologist, you may simply have no way of getting your own body to the terrain that you want to explore.[24] And if you are in your right mind, you will not want to get too cozy with infectious samples in a medical laboratory or with a nuclear power plant or hazardous chemical plant in an emergency situation. Just equip yourself with the right sorts of video eyes and electromechanical hands.

Just as boxers with long arms stand less chance of getting belted in the jaw than opponents with shorter reaches, so cyborg soldiers equipped with teleoperated weapons can stay safely in the rear echelon and avoid the dangers of front-line combat. In the Gulf War, for the first time, teleoperated weapons actually played a significant battlefield role.[25] The sky was abuzz with Pioneer RPVs (remotely piloted vehicles) — teleoperated, pilotless planes that were used to track Iraqi forces, spot missile sites, search for mines, and survey bomb damage. The 82nd Airborne used Pointer RPVs to patrol base perimeters, and German mine sweepers deployed teleoperated patrol boats. In the future, the hand that holds the weapon may grow even longer: a 1987 *Military Review* article speculated, "In a physiological sense, when needed, soldiers may actually appear to be three miles tall and twenty miles wide . . . we might hope to create future warriors that we could send forward surrounded by protecting robots or remote control aircraft."[26] Goliath is being reinvented.

Conversely, if robotic devices are constructed at insect size, they can also be used to get closer than we otherwise could and thus to manipulate things that are too small to be grasped by the fingertips. Rodney Brooks contrived a cockroach-sized robot at MIT in 1988, then set to work on piezoelectric motor-powered ant robots about a millimeter across. These might, he suggested, be used to crawl into arteries and unclog them, reconnect severed neurons, or skate across eyeballs to perform retinal surgery.[27] Tiny telemanipulators and robots seem particularly well suited to laparoscopic surgery, in which instruments and cameras are inserted through very small incisions in the body while the surgeon watches a video monitor, perhaps from a remote location. Johannes Smits of Boston University, inventor of a micromotor device, has suggested that minute electromechanical bugs could also act as miniature spies: "Imagine what you could do with an ant if you could control it. You could make it walk into CIA headquarters."[28]

By using a microscope instead of an ordinary video camera and a micromanipulator in place of a human-scaled telerobot, you can go right down to the atomic scale and act in the world you find there. The UNC/UCLA nanomanipulator, for example, employs a head-mounted stereo display to view data from a scanning-tunneling microscope in real time and makes use of the microscope probe tip as a manipulator. A force-feedback arm provides the effect of running a nanoscaled hand across the displayed surfaces and pushing things around.[29] Ultra-Lilliputian nanorobots — which have at least been the subject of serious speculation — could submarine through veins and arteries and perform molecular-level surgery.[30]

All this is the outcome of an evolutionary process that began in the second half of the eighteenth century, when scientists began to play with the idea of accomplishing action at a distance by sending electricity through wires.[31] Early experiments produced sparks or moved pith balls. By the early nineteenth century there was much scientific speculation about the possibility of telegraphy — writing at a distance. By 1843 Samuel Morse had successfully constructed a long-distance telegraph line between Washington and Baltimore, and opened it with the Morse-coded message "What hath God wrought." By the 1890s William Crookes was imagining the "new and astonishing" possibility of wireless telegraphy, and as the twentieth century dawned Guglielmo Marconi transmitted a wireless signal across the Atlantic. (Marconi's first transatlantic message was one of modernist minimalism — a single pulse, just one bit of information.) Now, any device connected to the worldwide telecommunications network is potentially a site for action by anyone anywhere on that net. So virtual reality researcher Warren Robinett has extrapolated from the telegraph to bodily telepresence: "In a few years visual telepresence may be widely available, so that a person can move by virtual travel instantly to distant locations, just as it is now possible with the telephone for hearing only. If, at that time, most controllable devices are linked to the communications network, then it will be possible for a person to project by virtual travel to a distant location and initiate actions there through the actuators available at that site."[32]

Unlike Leonardo's Vitruvian Man, we telemanipulating cyborgs cannot be encircled by neat arcs swept through our outstretched limbs. Our grasp has no limits — upper or lower. We have no fixed scale.

Brains / Artificial Intelligence

An anonymous street in Tokyo. As usual in this huge and confusing metropolis, I have absolutely no idea where I am. So my companion casually punches a button on the dashboard of his car, and the latest Japanese consumer electronics wonder beeps into action. It instantly grabs our coordinates from the global positioning satellite system, displays a detailed street map on a dashboard screen, and indicates our position and direction with an arrow.[33] As we navigate the intricate route from Shinjuku to Asakusa, the system continuously updates the display to reflect our current location — automatically rotating and recentering the map to keep the arrow just below the middle of the map and pointing straight ahead. The real city that surrounds us and the video city that guides us are held in perfect coincidence.

But this is just the beginning. A vehicle that knows where it is, and can pull information relevant to its location out of a database of geographically coded information, can do a lot more than display maps.[34] For example, it might look up interesting facts in online guidebooks and read you a commentary on the passing scene. With slightly more sophisticated programming, it could learn what you particularly cared about — the highlights of local history, perhaps, or census information, or the agricultural products of the area — and, like a knowledgeable and attentive companion, it could offer only observations likely to interest you. If you were driving a delivery truck, looking at real estate, canvassing for a political cause, or performing some other specialized task requiring information about passing buildings and their occupants, the system could supply it. For travelers it could deal with some immediately practical concerns — directing you to the nearest gas station or to the closest inexpensive Chinese restaurant, or finding you a bed for the night. And it could tell you what's on and what's open in your immediate neighborhood.

Silicon-smart vehicles can also calculate efficient routes from their current locations to specified destinations. Finding the shortest path through a street network is a straightforward software task (though doing so efficiently can get a bit tricky when the network is large), and whatever information is available about current traffic conditions can be factored in. The chosen route might simply be displayed on a dashboard screen, but it can almost as easily be output as a sequence of instructions from a robotic back-seat driver — "Next left," "You just made a wrong turn," and so on. Integration of some simple speech-recognition capabilities can even allow the driver to ask "What now?"

Not only may vehicles sense where they are in the road system, but the road system may also be equipped with electronic sensors enabling it to detect where the vehicles are. So the old ideas of the tollbooth and the on-ramp meter can be updated; charges for the use of a road can, in principle, be adjusted instantaneously according to the level of road congestion.[35] The task of the smart vehicle then becomes not just one of calculating the shortest or quickest path to a specified destination, but of computing the cheapest path or of finding a reasonably quick route that does not cost too much. In the future, travel through cities will involve continuous information exchange between smart vehicles and smart roadway systems.[36]

As I contemplate all this, I recall Roy Rogers and Trigger — an all-terrain vehicle with abundant onboard intelligence. Trigger always knew where he was, could find his way home if necessary, and understood moment-by-moment what his master needed; horse and cowboy functioned as one. But when the horse vanished from everyday life, leaving behind the horseless carriage, the onboard intelligence went too; there was a technological gap to be filled. (Roy obviously didn't have quite the same relationship to his jeep.) Increasingly, now, electronics are doing the job. Soon, our automobiles will be at least as smart as Trigger, and the car-and-driver relationship will return to the cowpoke-and-horseflesh mode. And when they get smarter still, the horseless carriage may evolve into the driverless automobile.

As a result, we are beginning to know and use cities in new ways. Long ago the urban theorist Kevin Lynch pointed out the fundamental relationship between human cognition and urban form — the importance of the learned mental maps that knowledgeable locals carry about inside their skulls. These mental maps, together with the landmarks and edges that provide orientation within the urban fabric, are what make a city seem familiar and comprehensible. But for us artificially intelligent cyborgs, the ability to navigate through the streets and gain access to a city's resources isn't all in our heads. Increasingly, we rely on our electronic extensions — smart vehicles and hand-held devices, together with the invisible landmarks provided by electronic positioning systems — to orient us in the urban fabric, to capture and process knowledge of our surroundings, and to get us to where we want to go.

Being There

For millennia architects have been concerned with the skin-bounded body and its immediate sensory environment — with providing shelter, warmth, and safety, with casting light on the surfaces that surround it, with creating conditions for conversation and music, with orchestrating the touch of hard and soft and rough and smooth materials, and with breezes and scents. Now they must contemplate electronically augmented, reconfigurable, virtual bodies that can sense and act at a distance but that also remain partially anchored in their immediate surroundings. (The *Neuromancer* fantasy of cyberspace that totally masks physical space — and so produces completely disembodied electronic existence — represents a theoretical limit, not a practical condition.)

When you wear your Walkman on the bus, your feet are on the floor and your eyes see the physical enclosure, but an electronic audio environment masks the immediately surrounding one and your ears are in another place. When you don a head-mounted stereo display to play *Dactyl Nightmare* in a virtual reality arcade, the immediate visual environment is supplanted by virtual space, but your sense of touch reminds you that you still remain surrounded by now-invisible solid objects. When you juxtapose a videoconference window to a distant time zone with a glazed opening to the immediate surroundings, you can contrast night with day and winter with summer. Increasingly the architectures of physical space and cyberspace — of the specifically situated body and of its fluid electronic extensions — are superimposed, intertwined, and hybridized in complex ways. The classical unities of architectural space and experience have shattered — as the dramatic unities long ago fragmented on the stage — and architects now need to design for this new condition.

As we look back to previous eras, we multiply augmented cyborgs can recognize that we have much to be thankful for. But we should not forget our roots — the cultures of those long, pre-silicon centuries in which our ancestors had to do it all with protoplasm. They had little opportunity to extend their nervous systems or upgrade their bodies, so they made places for inhabitation — buildings and cities — that were carefully fitted to the scale and limitations of the original equipment and structured to promote constant face-to-face, eye-to-eye, within earshot and within arm's length contact.

Life in pre-cyborg places was a very different experience. You really had to be there.

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