



CITIES

CYBERNETIC CITIES

REACTIVE INFRASTRUCTURE IS BUILT INTO CITIES

Twentieth-century science fiction brimmed with visions of robotic infrastructures constructed on a planetary scale. From Asimov's robot cities to the global robotic civilization of *The Matrix*, predictions of the reconstruction of the 20th century's static, dumb infrastructure into active, robotically enhanced systems have loomed large in the technological imagination. Over the next decade, we will see an acceleration of the pace of cybernetic upgrades to the planet's industrial-era infrastructure, as automation, locomotion, and intelligence are embedded in urban networks and structures for transportation, energy, and service delivery.

UNDERSTANDING HUMANS: The Anthropology of Cities

Cities are growing to unprecedented size and scale—now more than 20 megacities boast populations exceeding 10 million. To manage this complexity, sensory infrastructures and abundant computation are being used to measure and model cities in high resolution in real time. Understanding the feedback loops in these large, complex, and networked robotic/sensory systems will require an ever-greater anthropological understanding of our cities—how they function in real time and evolve over longer periods.



Parking lot surveillance

Prototype robotic surveillance systems have been developed to automatically flag and track humans involved in activities deemed suspicious—for example, someone moving from car to car in a parking garage.

Source: http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1334530



3D mapping for urban service robots

3D mapping systems are being developed capable of allowing service robots to navigate urban pedestrian areas.

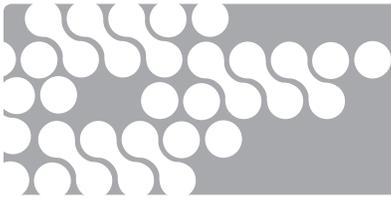
Source: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5354277&usertype=inst>



THE FUTURE OF
HUMAN-MACHINE
INTERACTION



INSTITUTE FOR THE FUTURE



AUGMENTING HUMANS: Urban Services to Streamline Daily Life

Robotic extensions of our 20th century urban infrastructure and networks will provide dramatic new capabilities to humans and human organizations. Buildings incorporating digital technology and robotics will work with humans to streamline many aspects of daily life. In areas that lack existing infrastructure, or areas where infrastructure is destroyed in disaster or warfare, robots will work with humans to quickly deploy urban services.



Source: http://www.compositemfg.com/qi_mobile_factory.htm

Onsite factories

Rapidly deployable shipping containers that house robotic factories and service plants can help bring production to new areas—for example, by building wind farm components onsite.



Source: <http://www.engadget.com/2009/02/06/robotic-smart-buildings-under-development-in-japan-j-g-ballard/>

Smart buildings

Robotic smart buildings are being developed in Japan that offer automated support for reception, deliveries, cleaning, and other routine functions.



INFRASTRUCTURE THAT REACTS TO HUMAN ACTIVITY IS BUILT INTO CITIES

AUTOMATING TASKS: Dull, Dirty, and Dangerous Civic Jobs

The provision of urban services is rife with dull, dirty, and dangerous jobs, and robots will be extensively deployed in these occupations. Fleets of autonomous vehicles can be quickly dispatched or dispatch themselves to respond to emergencies or react to subtle changes in urban activities. Small, inexpensive manufacturing robots will become an everyday part of maintaining and repairing cities—keeping roads and bridges in repair, or inspecting structures that are difficult or time-consuming to reach. New dull-and-dirty jobs, such as tending to urban farms, will emerge as well.



Source: <http://www.youtube.com/watch?v=ynhpqZdhHFI>

Automated subways

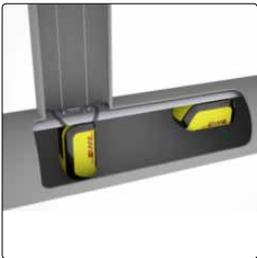
Over the past decade, fully automated subway lines have been deployed in a number of major cities, and transportation engineers expect this trend to spread.



Source: <http://news.bbc.co.uk/2/hi/8072619.stm>

Street cleaning

Dustbot is designed to coordinate trash collection from individual homes on demand.



Source: <http://www.wired.com/autopia/2009/07/robot-delivers-packages-through-sewers/>

Traversing sewers

There are many uses for robots that can traverse sewer networks—laying fiber cables, replacing aging conduits, and delivering packages.



Source: <http://spectrum.ieee.org/automaton/robotics/robotics-software/hibot-expliner-power-line-inspection-robot>

Power line inspection

The Expliner is a robot capable of maneuvering on a high-voltage line, inspecting for damage.

FORECAST

The last 150 years have seen important engineering innovations and civic infrastructure development. Existing networks and plants won't disappear in the 21st century. Today, infrastructure is becoming smart through embedded sensing, but in the future it will literally come alive through the infusion of robotic technologies. Beginning slowly over the next decade and accelerating thereafter, this infusion of technologies will utterly transform the way we build and operate these systems.

(1) Fluid network edges

Autonomous vehicles will allow fixed systems to be enhanced with mobile components. For instance, a water pipeline may not connect to a remote village, but an autonomous tanker could bridge the gap in a cost-effective way.

(2) Self-healing networks

Infrastructure plagued by the need for costly ongoing maintenance will be able to repair itself. For example,

water pipe robots are under development to help cities maintain their aging water infrastructure systems.

(3) Swarming for scale

Robots that normally provide urban services in a more distributed network could converge to achieve scale for special purposes at a specific time and place. Expect future robotic systems to improve communications not only with humans but also with each other.



WHY IS THIS IMPORTANT?



The developed world's civic infrastructure is aging rapidly and in some cases is on the verge of collapse. At the same time, megacity infrastructure is unlikely to scale in response to demand unless it can become more efficient, and urban activity patterns (traffic, energy demand, etc.) are becoming more dynamic. Robotic systems are a promising means for infrastructures to gain the additional flexibility needed to address these challenges.

RESOURCES

- “Design Requirements and Framework for a Robotic Infrastructure System” by Joshua D. Jackson, Dale W. Callahan, Donald S. Appleby, and Lea B. Callahan (in *Proceedings of the 5th WSEAS International Conference on Circuits, Systems, Electronics, Control & Signal Processing*, World Scientific and Engineering Academy and Society, 2006) describes the integration of large-scale robotics and the Internet. <http://portal.acm.org/citation.cfm?id=1376156>
- *Automated Construction Technologies: Analyses and Future Development Strategies* by Han Hoang (MIT Department of Architecture, 2005) is a master's thesis exploring the future of construction robotics. <http://hdl.handle.net/1721.1/33016>
- Isaac Asimov's “robot city” series describes a science-fiction vision of planetary-scale robotics. http://en.wikipedia.org/wiki/Isaac_Asimov's_Robot_City
- “Utopian Sea Cities of the Future: Assembled by Robots?” outlines a vision of how robots will be used to construct “cities” that are not feasible using contemporary methods. <http://www.archtopia.com/2010/01/06/utopian-sea-cities-of-the-future-assembled-by-robots/>



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