"These structures can bend and twist, but no element in the structure bends and twists," says Robert Skelton of the Structural Systems and Control Laboratory at the University of California in San Diego. "It's the architecture of life."

While Dr Skelton is working on solving the engineering equations associated with tensegrity systems, Tristan d'Estrée Sterk at the Office for Robotic Architectural Media & the Bureau for Responsive Architecture, an architectural practice based in Vancouver, Canada, has begun to construct prototypes of shape-changing "building envelopes" based on tensegrity structures. Lightweight skeletal frameworks, composed of rods and wires and controlled by pneumatic "muscles", serve as the walls of a building; adjusting their configuration changes the building's shape. Mr Sterk is also developing the "brain" needed to control such a building based on information from internal and external sensors.

Anders Nereim, chairman of the department of architecture and designed objects at the School of the Art Institute of Chicago, is not convinced that a central brain is the best way to control a responsive building, however. He suggests that the building should instead resemble a decentralised ecological system and should be made up of many independent sensors and actuators. Some of his prototypes include shadow-seeking lights that move around, and curtains made of flexible solar panels that use the energy they collect to open and close themselves. "Distributed systems can recover from damage," says Mr Nereim.

Cars are already capable of monitoring their own performance and acting with a certain degree of autonomy, from cruise-control systems to airbag sensors. Such responsive behaviour is considered normal for a car; architects argue that the same sort of ideas should be incorporated into buildings, too. And just as the performance of a car can be simulated in advance to choose the best design for a range of driving conditions, the same should be done for buildings, argues Gian Carlo Magnoli, an architect and the co-director of the Kinetic Design Group at the Massachusetts Institute of Technology. He is devising blueprints for responsive houses. "We need to evolve designs for the best performing responsive-building models," he says.

So will we end up with cities of skyscrapers that wave in the breeze? It sounds crazy. But, says Mr Sterk, many ideas that were once considered crazy are now commonplace. "Electricity was a batty idea, but now it's universal," he says. The same was true of suspension bridges and elevators. Dynamic, intelligent, adaptable buildings are "the logical next step", he claims. ■

It all depends on your point of view

Computing: New techniques analyse two-dimensional pictures to produce detailed three-dimensional models of the world

COMPUTERS can look, but they cannot see. Cheap digital sensors can act as their eyes, but programming machines to make sense of what they see is extremely difficult. Even when they can identify faces and vehicles, computers' inability to understand context results in ludicrous mistakes, such as finding faces in clouds or cars halfway up trees. Humans, by contrast, are able to construct a mental model of a scene from a photograph by taking into account the relative sizes of recognised objects, the laws of physics and some basic common sense. Now several research groups are building new computer-vision systems to enable computers to do the same thing.

Researchers at Carnegie Mellon University believe they have achieved a breakthrough in the reconstruction of three-dimensional models from two-dimensional images (pictured). Their system analyses photographs of outdoor scenes, identifies "sky" and "ground" regions, and looks for visual cues that distinguish horizontal surfaces from vertical ones. It then reconstructs the scene by cutting and folding the original image, taking into account the constraints that apply in the real world: skies are blue, horizons are horizontal and most objects sit on the ground. "In our world things don't just float," says Martial Hebert, who co-developed the software with his colleagues Alexei Efros and Derek Hoiem.

Using multiple images of a particular object or scene reduces ambiguity and makes possible more accurate three-dimensional reconstructions. That is the approach taken by Photosynth, a system being developed by researchers at Microsoft's Live Labs, a joint venture between the software giant's research arm and its MSN portal. Photosynth trawls the internet for digital photos of a place or object. Each photo is analysed to extract hundreds of distinctive features, and images that share particular features are linked together. The software then works out the relationship between the features to generate a three-dimensional model through which users can navigate.

What might such systems be used for? Pascal Fua of the Ecole Polytechnique Fédérale de Lausanne, in Switzerland, has built a system that analyses video footage

No special glasses required

from a single camera to reconstruct how an object moves in three dimensions. He and his team are using the technology with the yacht *Alinghi*, the present holder of the America's Cup. The idea is to improve the design of the yacht's sails by analysing how they behave under actual sailing conditions, thus dispensing with the need for expensive wind-tunnel tests that might not have been able to reproduce racing conditions accurately.

Dr Fua's technology is also being developed for surveillance applications. The aim is to combine video and still images from a network of video cameras, on the ground and in the air, to generate a constantly updated three-dimensional representation of an area under surveillance, tracking and analysing individuals and groups and triggering alarms if appropriate. This project, called Dynamic Visual Networks, involves a consortium of European firms and universities.

Richard Radke of the Rensselaer Polytechnic Institute in New York is working in a similar vein. He is developing software to allow hundreds of cameras, working together in small groups, to analyse their surroundings. Wireless camera "nodes" could be randomly sprinkled in large numbers over the area of interest, which might be a battlefield or the scene of a natural disaster. Each one would compose a list of distinctive features it could see and then quiz its neighbours to see if they could see any of the same features from their vantage points. By combining the results gathered, it would then be possible to reconstruct the scene. In future, some of the cameras might even be able to crawl or fly to fill in further detail.

Constructing detailed, real-time three-dimensional models of places from swarms of tiny cameras—a virtual model of a real scene—would have mind-boggling applications. Relief workers could fly through a model of a disaster area to look for survivors and guide rescue helicopters. Soldiers could look around corners or inside buildings before launching an attack. And security guards could patrol a wide area by whizzing around it in virtual rather than real space. What of the implications for privacy and civil liberties? Like the technology itself, it all depends on your point of view. ■

Always greener

Materials: The technology of synthetic grass has moved on since the days of AstroTurf. A new form of fake grass has taken root

PLAYING football in the driving rain, with the mud flying, is a rite of passage for teenagers the world over. But for how much longer? Mud-free synthetic grass is slowly taking over playing fields, especially in America. More than half of the country's National Football League (NFL) teams have it, at least on their practice facilities. Thousands of high schools and colleges have also installed fake grass, and the number is rising fast. The leading synthetic supplier is FieldTurf, a Canadian firm that started out in the late 1980s selling tennis and golf surfaces, and then moved into soccer, football and lacrosse. Even FIFA, the international soccer federation, has approved it in recent years.

The idea of fake grass is hardly new. For decades managers have looked for alternatives to natural grass, which is costly and difficult to maintain. The 1970s and 1980s were boom times for AstroTurf, made from heated nylon. It was first used in 1966 in Houston's Astrodome (recently famed for hosting evacuees from Hurricane Katrina). Some likened it to a rug, others to concrete, and players complained that it caused knee injuries.

But a new generation of fake grass has revived the industry. Strands of artificial grass made from polyethylene fibres are sewn into a base and are then surrounded and supported by a granular mixture that simulates soil. In the case of FieldTurf, this mixture contains sand, the ground-up soles of training shoes and rubber granules made from old tyres, which are cryogenically frozen, shattered and then ground up. All this is carefully laid down atop a bed of gravel, with drainage pipes to let water run off. It resembles grass, but with a plastic sheen and black sandy granules at its roots.

Lots of teams are installing it, largely because maintenance is so easy. In damp climates, real turf gets torn up by constant use. In dry ones, it demands constant watering. Synthetic turf suffers from neither problem, and also suits indoor stadiums. Rainfall helps keep it clean: water seeps through the rubber and drains into pipes just below the surface. FieldTurf also makes machines for annual deep-cleaning. The drawback is the cost. Fake grass costs nearly twice as much as sod to install, though it costs less to maintain.

As with AstroTurf, some players dislike the new surface. There are worries that it heats up unnaturally in the hot weather; Troy Squires of FieldTurf says the increase in temperature is minimal. Baseball, which likes grass, and women's field hockey, which prefers old AstroTurf for faster play, are still resisting FieldTurf, says Andrew McNitt, a turf specialist at Pennsylvania State University.

The product will no doubt continue to improve. FieldTurf is looking at new materials: instead of gravel underneath the surface, it might start using recycled plastic tiles, which would be faster and cheaper to install. And it is seeking out new markets, too—perhaps, says Mr McNitt, in home putting greens, or in lawns in the hot, dry south-west. It might not be as pleasant as grass between the toes, but it is very convenient. ■

FieldTurf has moved onto AstroTurf's lawn

The joy of physics

Video games: Software that encapsulates the laws of physics is a key ingredient in making games more realistic

IF YOU found studying physics at school difficult or tedious, you may well have wished for a pill that could impart instant knowledge of the subject. Alas, no such pill exists—but the designers of video games routinely use something very similar as they strive to make their games more lifelike. By dropping in a "physics model"—in essence, a lump of software that encapsulates how objects behave in the real world—they can teach their games to understand physics. What is the use of photo-realistic graphics and surround sound, after all, if in-game items do not behave realistically?

Gamers really began to take notice of physics models with the release in 2004 of "Half-Life 2". Objects in the game roll down slopes and bounce realistically off each other; wooden items splinter when shot at and can be set on fire; metal items create sparks when scraped against walls. This is not just eye candy: many of the puzzles in "Half-Life 2" exploit the realism of the physics model. A seesaw can be turned into a ramp by placing blocks on one end, for example.

"The Elder Scrolls IV: Oblivion", a role-playing game released in March, also includes strikingly lifelike physics. One internet video-clip features a vast room in which thousands of books have been lined up like dominoes in intricate patterns. The first volume is tipped over and hits the second book, starting a chain reaction of toppling books, swords, vegetables and other objects arranged in increasingly elaborate configurations.

As well as enhancing the realism of