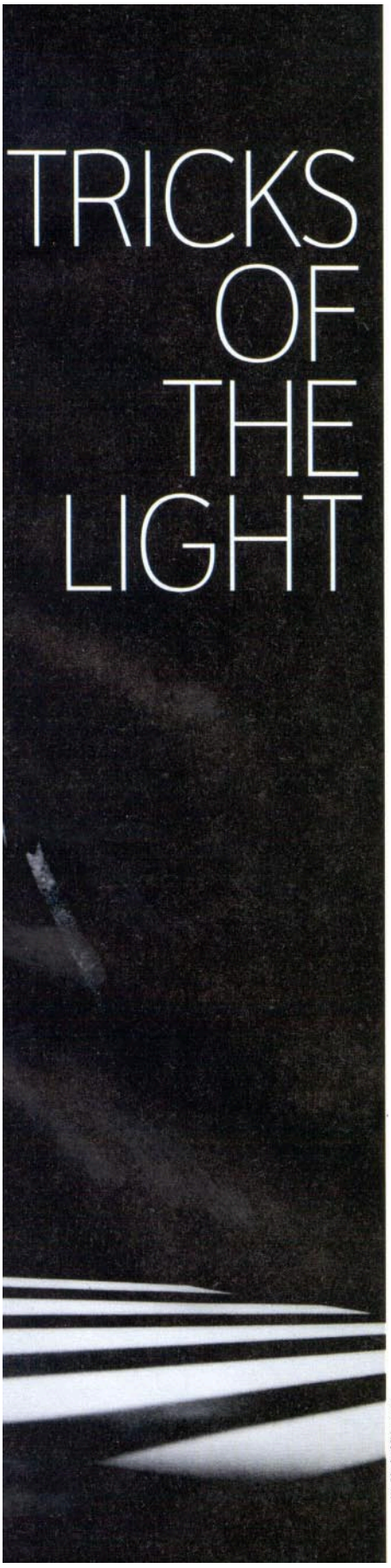
A 21st-century conjuror is revealing secrets that have lain hidden for 5000 years. Michael Brooks marvels at the magic

TRICKS OF THE LIGHT



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TOM MALZBENDER is a master of illusion. Using a strange black dome, he can alter the appearance of any object he chooses. He can instantly coat it with shiny liquid metal. He can even illuminate it from angles that are physically impossible.

Malzbender works at the visual computing department of Hewlett-Packard Laboratories in Palo Alto, California. His job is to map the texture of rough surfaces using digital photographs and reproduce those surfaces perfectly as computer graphics in a virtual world. Because of his weird powers, there is something of a queue forming outside his door—a line of researchers who see his abilities as a potential money-spinner.

So far, however, Malzbender has eschewed the promise of a profitable future in favour of illuminating the past. He is helping archaeologists revisit the dawn of the written word—by using his powers to reveal long-lost details of ancient civilisations hidden on badly eroded clay tablets.

Malzbender first got the idea of applying his skills to archaeology in 1999, when he attended a lecture given by Bruce Zuckerman, director of the University of Southern California's West Semitic Research Project in Los Angeles. Zuckerman has spent twenty years developing high-resolution photographic techniques for reading cuneiform inscriptions—the earliest known form of writing, dating back as far as 3000 BC—written on clay tablets.

Babylonian scribes used sharpened reeds to write on wet clay, but the surface of the tablets that Zuckerman is studying have worn away over the millennia and the inscriptions have faded. Even with his new techniques Zuckerman was finding it almost impossible to discover what the scribes had written.

During Zuckerman's talk, Malzbender realised that the technology he and his colleague Dan Gelb had been developing at Hewlett-Packard might help to reveal the hidden details of Zuckerman's cuneiform inscriptions. So after the talk, Zuckerman arranged to give Malzbender a tablet from the university's collection to test the technique. Malzbender quickly set to work.

His tools are simple: a computer and a specially designed, lightproof plastic dome about a metre across, with a digital camera mounted in the top. Inside the dome are 50 computer-controlled flash bulbs arranged to provide illumination from a variety of angles. But this simple set-up allows Malzbender to create a computer model of the surface of the tablet that's exact in every detail.

It works like this. Malzbender places the dome over the tablet and flicks a switch. The camera then takes 50 colour digital photographs of the object, each one lit with white light by a different bulb. Small marks in the surface of the tablet reflect and scatter different wavelengths of light in different directions. So by controlling which flash bulbs fire on each shot, every image will show the tablet illuminated with different patterns of light and colour.

Malzbender and Gelb's image-processing software then divides each photograph into six million pixels, each pixel corresponding to a single point on the surface of the tablet. The software records the relative brightness and the spectrum of light scattered from each point, and then combines data from all 50 photographs to produce a detailed map of the tablet's response to light.

Reveal the invisible

By correlating the colour and brightness of each pixel with the lighting angle, the software can work out the exact orientation of the tablet's surface at that point. Malzbender then uses software to build a computer model of the tablet from this information. Since this model can tell him exactly how the real tablet responds to light, he can manipulate and study it under virtual lighting conditions to extract extra details from the faded inscriptions.

To get the most from his virtual tablet, the first thing he does is alter its appearance, transforming its crumbly, dull clay surface into a highly polished reflective one—as if he had coated it with an ultra-thin layer of molten metal. To do this he simply makes every point on the virtual tablet reflect light more strongly. The human eye can tell a lot more about subtle surface shape if a material is highly reflective. Scratches in metal, for instance, are much more obvious than the same scratches on dull plastic.

Then he waves a virtual spotlight across the tablet and looks for markings. Malzbender and Gelb have discovered that they can get even more information from a faded tablet if the pixels only create reflections when the spotlight is aimed directly at them. Now a tiny change in lighting angle dramatically alters the amount of visible detail—if you move the light source slightly to one side, the pixel will go dark.

Knowing the orientation of each point on the clay also enables the software to defy the laws of physics. Sometimes, by accentuating shadows, an oblique lighting angle gives the best view of the marks and lines on the tablet, for example. But in the real world there's only so far you can go: once the light source is below the edge of the tablet, nothing will reach its surface.

With his virtual tablet, though, Malzbender is not bound by natural laws. "We can put the light source in physically implausible locations," he says. They can move it round the tablet to illuminate it from behind, for example. The team can even simulate the effect of a light suspended between the walls of a millimetre-wide scratch.

The results are stunning. Writing that was almost invisible to the naked eye now practically jumps off the clay at them. "We were even able to note the fingerprints of the scribe who held the clay while it was still wet," Zuckerman recalls.

He was so impressed that last August he persuaded Malzbender to perform his tricks for Walter Bodine, an expert in Babylonian writing at Yale University. The Yale Babylonian Collection comprises 40,000 clay tablets covered with cuneiform script. Because the work is so difficult and time-consuming, the majority of them have not been closely examined or transcribed.

Bodine had spent six years painstakingly deciphering and transcribing the faint, crumbling text inscribed on one particular tablet. However, there were some details that simply couldn't be discerned. Until, that is, Malzbender arrived to perform his magic. Bodine says they were able to recover new details almost immediately.

Those details are themselves illuminating. Bodine's tablet was a draft contract: around 3100 BC, a Sumerian trader named Ur Ningal was selling slaves. The contract stipulated that, if the goods proved faulty, the buyer could return them for a full refund. Who'd have thought the money-back guarantee had such ancient origins?

Bodine is very excited by the information Malzbender's device has revealed. "This has given me a whole new set of data," he says. "I have found quite a number of things I haven't been able to see before." Using the technology is child's play: Malzbender and his team have developed an archaeologist-friendly software interface for their prototype dome. Bodine is looking forward to ditching his anglepoise lamp and magnifying glass. "I sure hope we get one of these devices at Yale," he says. "This will cut the work of years down to months."

He could be out of luck, however. "We do plan to continue our collaboration with Bruce Zuckerman and the people at Yale," says Malzbender. But the market probably isn't sufficiently large to warrant Hewlett-Packard opening a production line for the hardware. The software, on the other hand, is certain to be exploited. The team is already looking into developing their image-manipulation techniques as plug-ins for commercial image-processing software packages. Managers at General Motors hope the techniques will help in the development of photo-realistic computer graphics for their car designers, allowing a computer to show, for instance, how spray-painted surfaces will look under different lighting conditions.

And Malzbender could soon be using his illusions to catch thieves. He is talking with police agencies about applications in forensic science. Would-be criminals beware: Malzbender has already exposed a set of fingerprints that no one had seen for 5000 years. Revealing modern prints—from feet or fingers—might prove as easy as switching on the light. □