Physics and media

by N. Gershenfeld

Bits are bits has been the very successful mantra of the MIT Media Laboratory for its first decade. “Media” has historically meant film vs television vs radio vs newspapers vs books, each of these an entirely separate business, even in a company that does all. In retrospect it is now obvious how artificial it is to categorize information by the package that delivers it. These barriers are now being blown to bits, correctly focusing the interest where it should be: on how to gather, filter, transform, and deliver information to people in a form that is appropriate to the context. Ideas rather than pixels can and should be the primitive unit.

An unspoken corollary to “bits are bits” is that “atoms are just atoms,” implying that the atoms that have traditionally been used to deliver bits (ink, silver halide, celluloid, etc.) are now just archaic artifacts. Bits can be copied and changed; atoms cannot. Bits can freely come and go at the speed of light; atoms consume scarce resources to create, deliver, and destroy them. This distinction between bits and atoms is mirrored in the relatively clear boundary between hardware and software, the components of which are usually developed by separate people in separate companies with limited contact.

The world, of course, is much more complex and interesting than a simple division between bits and atoms. Many of the most significant opportunities and greatest challenges for information systems lie at this boundary, and for many of the most successful mature technologies this distinction can not be made at all. Think of a nicely printed and bound book. It is considered technophobic to prefer a book to a laptop, but in many ways that preference is very rational. The book boots instantly, has a high-contrast high-resolution display viewable from any angle in bright or dim light, permits rapid searches with instant visual and tactile feedback on the state, is shockproof, and operates indefinitely without batteries or maintenance. No laptop comes close to these specs. Now consider a Stradivarius. It measures roughly ten input degrees of freedom with about a 16-bit effective resolution on millisecond time scales and does a gigaflop-scale computation to map measured gestures to sounds. Its very successful user interface uses tactile, auditory, and visual feedback to enable players to perform subtle and complex control tasks. Once again, no current workstation can match this performance. In both of these examples, the underlying technology works better than most available “high”-technology alternatives, and it is not possible to separate the user interface from the rest of the system.

Bits and atoms

The only problem with a book or a cello is that it can only be one book or one cello. Although that is not all bad, it would be even better if these objects could gain digital virtues such as the ability to be copied, distributed, shared, and changed, without sacrificing their many other charms. For these reasons, the Physics and Media Group of the MIT Media Lab is working on projects that include digital musical instruments and electronic books that can emulate and generalize the performance of their great predecessors. The overall mission of the group is to explore the boundary between the content of information and its physical representation.

The papers in this section of the issue survey our work in a number of these important areas. In the first, I look at a very basic connection between bits and physics: the thermodynamic implications of the design of algorithms. The simple fact that a bit exists, and has a value that can be distinguished, has significant consequences for the dissipation of energy associated with manipulating it. Computation is of no use unless it can be controlled; the next paper

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by Smith shows that underlying the very old idea of capacitance sensing are a number of interesting current transport pathways, and that an inverse theory can be used to unobtrusively and remotely find a person in a weak electric field (for example, in order to use a hand as a three-dimensional mouse). Zimmerman then explains how the small nanoamp currents induced by such a field can be modulated to send messages through a body, thereby creating a Personal Area Network. Such personal devices will not be usable if they require frequent battery changes, and so in the subsequent paper Starner considers the properties of the human body itself as a power source. Successfully recovering this power will require improved materials and mechanisms to convert force into electrical energy; Fletcher looks at the general problem of force transduction for both input and output. Finally, Verplaetse closes by examining the prospects and motivations for autonomous objects (such as pens and cameras) to use inertial devices to determine their motion. These papers range from results with immediate applications to speculation about long-term trends, but all touch on the excitement and value that come from jointly considering meaning and mechanism.

Just as the work of the first decade of the Media Lab can be viewed as abstracting the content of bits from the particular atoms that represent them, as the Media Lab enters its second decade the work of the Physics and Media Group and the larger Things That Think industrial research consortium can be viewed as bringing much more capable bits and atoms back together. We share a belief that this is the pathway to developing systems that can unobtrusively and responsively meet people's desires and needs.

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