The well-known Moore’s law says that the transistor density on integrated circuits approximately doubles every two years. Another law that has been studied in recent years involves the amount of digital information created and transmitted worldwide. In 2006, this amount was slightly less than 200 Exabytes (1 EB is equal to $10^{18}$ bytes), about 300 EB in 2007, 500 EB in 2008, and more than 700 EB in 2009. It is estimated that in 2011 the amount will reach 1800 EB. Based on this historical trend, the amount of digital information globally created and transmitted has become an exponential function of time. Furthermore, the discrepancy between the information that is produced and the information that is stored is diverging exponentially.

This phenomenon, often called the data deluge, is obviously caused by the advent of modern technologies. For example, more than 1.8 billion people now access the Internet, and, apparently, at least 4.5 billion users utilize cell phones. Other examples of the data deluge include geographically distributed sensor and actuator networks, electrical smart grids, traffic-management algorithms, and cyberphysical systems. It is estimated that only 5% of the data contains words or numbers; the remaining consists of diverse data, generated by digital cameras, VoIP (voice over IP), satellite images, video conferencing, digital TV, and security systems. Most of this data is completely irrelevant, and there is a need to filter the redundant, corrupt, and irrelevant information. In control-theoretic terms, it is arguable that such filtering would certainly enhance the performance of the relevant feedback loops.

This growth phenomenon is drawing increasing attention in many areas other than control, such as business, finance, and management. For example, a recent issue of *The Economist* was titled “The Data Deluge,” with the subtitle “Businesses, governments, and society are only starting to tap its vast potential.” With the background above serving as motivation, the remainder of this column considers the following questions: Is the data deluge relevant for systems and control? Might there be a new line of research on how control system performance can be improved in the presence of the data deluge? For the control community, perhaps a simple starting point for new work is the desire to visualize and aggregate information so that its main features can be quickly processed without being overwhelmed by the data deluge. An interesting approach to visualization, certainly of interest to us, is the construction of specific graphs depicting nodes and links. Beautiful examples are the Leydesdorff citation maps showing interactions between scientific journals in a specific technical area. To illustrate, in Figure 1 some of the main control journals are represented by nodes (the size of each node is proportional to the impact factor) connected by undirected links (the color of each link is proportional to the number of cross citations). It is immediately clear where the flow of information is so that the journals can be aggregated in various clusters showing specific categories within control.

![Figure 1 Leydesdorff citation map for control journals based on the 2007 Journal Citation Report. The size of each node is proportional to the impact factor, and the color of each link is proportional to the number of cross-citations (black is very weak, green is weak, cyan is medium, and blue is strong). The map was prepared using data provided by Elsevier Ltd.](image-url)
An important notion, relevant to control theorists, that can be used to analyze the data deluge phenomenon is the concept of obliquity, which was coined by Sir James W. Black, a Scottish doctor and pharmacologist who was awarded the Nobel Prize for Medicine in 1988. This concept was later generalized and extended to economics by John Kay, who recently published the book *Obliquity: Why Our Goals Are Best Achieved Indirectly*. Connections between obliquity and the theory of chaos have already been investigated by physicists. Obliquity is a term meaning the act of reaching a goal through indirect, rather than direct, means. The theory of obliquity is based on the observation that in a complex uncertain environment, no future event, or the effect of some action, can be predicted accurately enough by means of a direct brute force approach; such a calculation would require an exorbitant level of computation. Therefore, an indirect approach is often deemed more suitable.

In the control area perhaps the best example of a methodology for obliquity is discrete-time dynamic programming, as a multistage recursion for computing the optimal value of a function. While in principle we can enumerate all possible paths through the state space, in many cases, a Bellman-style backward recursion reduces a nearly impossible computational task to one that is reasonable. It can also be argued that various instances of obliquity already exist in the control area, such as model predictive control, receding horizon control, adaptive control, and sequential online optimization algorithms, to name a few. These approaches have been developed as a response to not having enough data, so the objective might be looking at the problem from a different angle with the attempt to develop a general methodology. I believe that *obliquity for control* is a challenging subject for future research, which could lead to the development of successful and practically useful control techniques for coping with the data deluge.

**SOCIETY NEWS**

A student-led event titled “Symposium on Emerging Topics in Control & Modeling: Biomedical Systems” was held at the University of Illinois at Urbana-Champaign at the end of April. This successful event was partially sponsored by the IEEE Control Systems Society (CSS). The goal of this two-day, single-track symposium was to expose academic researchers, including students, in dynamic systems, control, and modeling to key problems in biomedical systems with the objective of initiating collaborations across diverse areas and communities. The symposium engaged the full spectrum of biomedical researchers through the following sessions: invited presentations by industry and academic researchers, a graduate student poster session, and a panel session that also included physicians who provided their views on the exciting area of biomedical systems.

The spring meeting of the CSS Executive Committee was held in my hometown at Politecnico di Torino, Italy, in early May. Society officers and journal editors met for two days discussing various topics of interest to CSS and its members. The main objective of the meeting was to initiate discussions regarding conferences, journals, and current activities of the Society. These discussions continued during the meeting of the Board of Governors that took place in Baltimore at the end of June. The picture in Figure 2 was taken in front of the Castello del Valentino, where the School of Architecture at Politecnico di Torino is located. After the meeting, some officers extended their stay and gave lectures dealing with hybrid systems, large-scale systems, and dynamic vision. The Society officers also interacted with faculty at the research institute IEIIT, Politecnico di Torino.

(continued on page 21)

As I read your editorial “Plagiarize This!” (in the May 2010 issue), I was struck by two thoughts. First, as an electrical engineer, I wonder if it is plagiarism to copy an active filter out of an article. I personally consider those circuit constructs to be basic building blocks similar to words in the vocabulary. How I interconnect those words to make complete sentences is my intellectual property. Likewise, how many related lines of software constitutes plagiarism? Viva la Open Source!

In a like manner, how many selected written words constitute plagiarism? Is a concept just a basic building block, like the active filter? Must we cite well known phrases such as, “Who you gonna call?” (Ray Parker, Jr; “Ghostbusters” theme song; 1984). This leads to my second thought; while citations are important, it is seldom that I look up the source. I don’t have the time or resources when reading a magazine. (I make a distinction between magazine and journal.) The magazine is to me a source of ideas, not proofs or arguments. I read the magazine to determine what to research and read next. It stimulates my thinking.

So for me, formal quotes and citations can get in the way. This is especially true if an equation or graph is given with a citation but without further explanation. I would rather have the author provide an explanation verbatim from the source throughout the work and have it cited generally in a bibliography rather than have numerous citations with Id. and Ibid. references in the endnotes.

I fully agree that the copying of entire paragraphs without citation is theft. But the use of a catch phrase may be considered flattery. While most Americans know the phrase “Who you gonna call?” and its origin, how many know of Ray Parker, Jr.? To me, the right approach depends on the context and intent. Let’s be fair and diligent but not petty in our application of plagiarism criteria.

Jeffrey Rockel

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