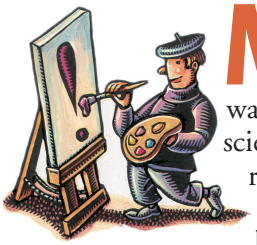
Web Science: A Provocative Invitation to Computer Science

Here's how it can awaken computer science to the interdisciplinary possibilities of the Web's socially embedded computing technology.



Much more than a provocative term, "Web science" signals a new way of thinking about computer science. Computer science researchers and professionals are familiar with the turbulence of technology innovation; Web science promoters challenge them to expand the scope of computer science. Indeed, declining enrollment and industry shifts have shaken computer science, so Web science promises to be an invigorating direction.

Writing in *Science* magazine last August, Sir Tim Berners-Lee and collaborators called for a new discipline [3] and detailed their case in an online 130-page monograph [2]. These esteemed revolutionaries offered a visionary manifesto that says that after 40 years of focusing on computer science, it is time for computer scientists to shift to Web science [9].

Their starting definition of the new discipline is the "science of decentralized information systems"; they followed with a rich research agenda of emerging technologies, including the Semantic Web, ontologies, Web services, and Web-scale computing (see the table here). This proposed shift to Web science raises the importance of such traditional computer science topics as graph theoretic models, network structure analyses, and search algorithms that are likely to be familiar to computer scientists. But Web science advocates make clear that understanding Google's technology and business success requires more than a discussion of Web crawling and distributed search algorithms. They insist something bigger and bolder is becoming important and will take an open mind for the traditional computer science community to absorb.

Socially Embedded

Although the research topics they describe have origins in computer science, "the Web as a technology," they say, "is socially embedded." The implications of this expanded view are profound, leading them to broaden their research agenda to address such social issues as trust, reputation, privacy, governance, copyright, and network communications standards. Since they recognize the essential social nature of Web technologies, they also embrace the idea that Web science must address user needs and requirements analysis through questions like: What do people and communities want from the Web?

The social perspective pushes Web science researchers toward a deep understanding of the information and services users want. The disruptive shift involves moving away from studying the technology toward studying what users can do with the technology [7]. While computer scientists have found Moore's Law to be a helpful measure of progress, Web scientists are more interested in counting page views and unique vis-

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itors. In short, the shift is from chips to clicks.

The social computing projects described in the Web science framework deal with massive multiplayer online role-playing games, online discussion groups, and photo-sharing Web sites that attract audiences in the tens of millions worldwide.

However, I wish the authors of the Web science framework would go even further to address such challenges as developing descriptive theories to explain the wide variations in adoption of social computing projects and prescriptive models to guide implementers. For example, they should be trying to understand whether moderated online communities generate greater participation when discussions are kept on topic and when harsh language is prohibited. They should ask: Does moderation inhibit spirited debate, thereby undermining interest? And how can successful discussion groups grow by, say, a factor of a hundred yet preserve the intense participation of their originators?

Computer Science	Web Science
Metrics	
Moore's Law	Page views
Order (n) algorithm analysis	Unique visitors/month
Gigabytes	Number of songs or videos
Topics	
Computer networks	Social networks
Packet switching	Voice over IP, music sharing
Information	Relationships
Programming languages	Wikis, blogs, tagging
Databases, operating systems, compilers	E-commerce, e-learning, e-government, medical informatics, financial analysis
3D graphics, rendering algorithms, computational geometry, object modeling	Creating and sharing video, animation, music, photos, maps
Focus	
Technology	Applications
Computers	Users
Supercomputers	Mobile devices
Proficient programmers	Universal usability

Computer science vs. Web science.

Web use is much more than access to decentralized information and discussion groups. The Web empowers individuals, invigorates collaboration, and unleashes social creativity. Innovative metrics are needed to capture the effect of children writing empathic email messages in foreign languages, blog entries that catalyze lively discussion, and scientific insight made possible by Web-based databases and visualization tools.

The social analysis of Web science must also deal with the negative aspects of Web-based social interaction (such as security breaches, identity theft, privacy violations, and the social disruptions of globalization). The Web produces such dangers because it provides opportunities for those who break laws, spread hate, or promote terrorism. These are troubling aspects of the Internet, so a responsible research agenda must include their study.

Richly Interdisciplinary

I urge a richly interdisciplinary path for Web science that also addresses the emerging applications for scientific collaboration, e-commerce, entertainment, social creativity, and social networking [6]. Explanatory theories are needed to understand why, say, eBay remains a huge success with few serious competitors. Predictive models are needed to understand why the video-sharing site YouTube and the photo-sharing site Flickr are so successful and why social networking sites like MySpace, FaceBook, and Friendster have hundreds of millions of users. Multiple scientific studies of Wikipedia would provide valuable understanding and guidance needed by implementers of public health information Web sites, community-response grids for emergency preparedness [8], and policy-oriented discussion groups. Most computer scientists are likely to dismiss these concerns as outside their territory, but Web scientists would eagerly take on these research challenges.

Another potentially strong distinction about Web science is its commitment to universal usability. While the framework document is brief on issues concerning the digital divide, Berners-Lee says, "The most important thing about the World Wide Web is that it is universal" [1]. The dimensions of that universality are more than the technologies of fast/slow networks or large/small displays. A universal usability research agenda must also address users who speak multiple languages, as well as users from diverse cultures, novices/experts, young/old, low-literacy users, and users with disabilities. Web science could take

on these research tasks, which promise profound payoffs in terms of increased participation in democratic processes and enhanced collective efficacy of communities. I hope Web science advocates will also dedicate themselves to addressing the economics of providing equitable access, the challenges of working in developing nations, and the strategies needed to train users with low literacy.

As part of their focus on universality, Web science advocates [2] assert that "Mobile access to the Web may become the dominant mode in many nations, particularly developing ones." The commitment to pervasive or ubiquitous access for users as they travel reflects more than just technological challenges; it generates opportunities for novel services with temporal and geospatial requirements. Cell phones, for example, are more than information-access devices, restructuring social expectations and offering life-altering opportunities, as well as life-saving resources. I hope these concerns will be a more substantial part of Web science.

Reform Movements

Calls for research and education in Web science are in harmony with many other reform movements that seek to redefine and reinvigorate computer science. Some are from within the traditional field of computer science (such as Georgia Tech's New Face of Computing initiative, www.cc.gatech.edu/symposium/), which offers a curriculum based on interdisciplinary threads. Nascent efforts from forward-looking computer science faculty deal with expanding the discipline to include new media, games, usability engineering, design, and the teaching of innovation [5]. Another approach to reviving computer science is to seek inspiration from such application areas as e-commerce, medical informatics, and computational biology.

Related developments include vigorous growth of alternative programs from the i-schools (information schools and colleges of information studies, www.ischools.org). These new curricula, which already generate high enrollment in the Universities of Maryland, Michigan, and North Carolina, focus on the use of information, exploratory search, text-analysis tools, human-computer interaction, social informatics, and digital libraries. These programs also cover applications in e-learning, public health information, and digital government, as well as social, ethical, policy, and economic issues.

Industry pressure also brings such healthy new cross-disciplinary ideas as IBM's promotion of "services science" as a new discipline aligned with requirements analysis and customer relationship management [4]. Services science also covers a wide range of Web-based transactions that are central to business-to-business relationships, workflow analysis, and business process modeling.

Conclusion

The Web science framework is a provocative research agenda that deserves serious review but that already needs expansion to adequately address such important issues as social computing, universal usability, and interdisciplinary strategies. Visionaries say it is time for a change, but will the traditional computer science community accept the invitation? I hope it will. C

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