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THE IMPACT OF THE INTERNET ON RESEARCHERS' TRAINING

The paper explores the reasons that have made the Internet even more important for the training of researchers, both for pure statisticians and scientists who use statistics for analysing experimental data. The author discusses various aspects of the role of the Internet and focuses on those contributions that populate the network with valuable tools and services (electronic journals, electronic books, virtual labs, data archives and examples of data analysis, etc.). An extensive bibliography has been provided to guide new users, through the millions of sites of the chaotic World Wide Web, towards the most interesting places for people involved in statistics.

1. INTRODUCTION

Most people have discovered the Internet because of the World Wide Web and often WWW is used as a synonym for the network itself, and vice-versa. So it is usually believed that the Internet is no more than five or six years old.

On the contrary, the history of the Internet is quite long, especially if related to computer history. Robert E. Kahn and Vinton G. Cerf published their first paper on TCP protocol in 1974, so in 1999 the 25th anniversary of the Internet was celebrated (TCP/IP is the basic communication protocol of the Internet).

However, the network really became important in the 80s although, for about ten years, it involved mostly academic and research environments (mainly technological and scientific areas). The crucial innovation that made the Internet one of the most important and popular events in communication (perhaps similar to the telephone, radio or television) was the HTTP protocol introduced by Tim Berners Lee in the early 90s to implement the World Wide Web.

Today's popular image of the Internet consists mainly of fancy images, animation, sound, movies, advertisement, all kinds of information, easy downloading and many more tools for fun. However, few people know that all of this has been realised thanks to the thousands of researchers who have contributed anonymously for many years to improve the network's technical characteristics as well as to enrich it with software tools, procedures, data, discussion lists, etc. (all of them free of charge) and who have changed the way academics are working today. In fact, all the main services that have become fundamental for the network have arisen from the scientific Internet community (e-mail, discussion lists, Usenet, anonymous ftp archives and the World Wide Web itself).

The Internet Software Consortium has estimated that in January 2000 there were more than 72 million computers connected to the Internet all over the world. This number is not so interesting in itself, but it becomes much more significant when we consider that in 1993, just before the WWW era, the number of computers connected

was only 1,313,000. Furthermore, the "Messaging Online" estimated 569 million e-mail accounts globally at year-end 1999, up 83 percent on the previous year.

Many facts are helpful for understanding the importance of what is happening. Today we use the term "new economy" to talk about the business born around the network; almost all the Universities have their own network connected to the Internet (even though the situation in some developing countries cannot be compared with that of the more advanced ones). In the 1996 State of the Union Address President Clinton said:

"In our schools, every classroom in America must be connected to the information superhighway, with computers and good software, and well-trained teachers. We are working with the telecommunications industry, educators and parents to connect 20 percent of California's classrooms by this spring, and every classroom and every library in the entire United States by the year 2000".

During the last State of the Union Address (January 27, 2000) the President said:

"We know we must connect all our classrooms to the Internet, and we're getting there. In 1994, only 3 percent of our classrooms were connected. Today, with the help of the Vice President's E-rate program, more than half of them are. And 90 percent of our schools have at least one Internet connection".

All these elements are drawing a scenario for the near future where the networks will become a fundamental medium for most activities: commercial, social and, of course, scientific.

2. THE INTERNET FOR STATISTICS

The Internet can be considered as the biggest database ever built and it grows day by day. Information spreads out in all directions and it is available in real time. Today we can say that there is no scientific field that has not yet been influenced in some way by the network facilities. Sometimes the benefits may simply be a more powerful way of communicating and of reducing distances. Sometimes, there are more important advantages depending on the specific field.

However, considering the Internet resources for statistics, we must take account of two different kinds of people: actors and spectators. In the first category we find mainly statisticians who provide knowledge on statistical methods, software tools, examples, etc., showing various kinds of useful ways to profit from this technology.

The second category includes people looking for such information (i.e. researchers interested in experimental fields, teachers, and young statisticians). However, while some of them are enthusiastic, some others do not care much about it. In any case there are many important facts that must be taken into account, especially if we consider training for young researchers.

The future tasks of young researchers consist of research itself and teaching activities. Both areas have recorded improvements using the network, even though in different forms and with different effects. Faster communication, electronic journals, discussion lists, data and case study archives, paper archives, distributed processing, scientific software distribution, etc. all contribute to improving research activities.

2.1. ELECTRONIC JOURNALS

Many scientific journals accept only papers in electronic form and the most important publishers have their own templates for several text-processors so that authors can submit articles in the right form ready for printing. The proceedings of many national and international conferences are often published only on CD-ROM. Moreover, the main journals make online versions available at reduced subscription rates and, since 1993, a growing number of electronic journals are available completely free or at a very low cost. Electronic journals are not well known yet, so it is useful to provide a list of some of them concerning Statistics and/or Education in Table 1.

Table 1. Statistics and Education Electronic Journals

Journal	First issue	URL
The Educational Technology Journal	1991	http://www.fno.org/
Journal of Statistics Education	1993	http://www.amstat.org/publications/jse/
Compute-Ed	1995	http://computed.coe.wayne.edu/
ESAIM: Probability and Statistics	1995	http://www.edpsciences.com/ps/
Interstat	1995	http://interstat.stat.vt.edu/interstat/intro.html-ssi
Electronic Communications in Probability	1996	http://math.washington.edu/~ejpecp/
Electronic Journal of Probability	1996	http://math.washington.edu/~ejpecp/
Journal of Statistical Software	1996	http://www.stat.ucla.edu/journals/jss/
Studies in Nonlinear Dynamics and Econometrics	1996	http://mitpress.mit.edu/e-journals/SNDE/
The Electronic Journal of Science Education	1996	http://unr.edu/homepage/jcannon/ejse/ejs.html

In addition, many newsletters are published by Scientific Associations both as paper and electronic versions, such as the *Newsletter of the Statistical Computing and Graphics* (<http://cm.bell-labs.com/cm/ms/who/cocteau/newsletter/index.html>), the *Newsletter of the ASA Section on Statistical Education* (<http://renoir.vill.edu/~short/StatEd/>), the *Newsletter of the International Study Group for Research on Learning Probability and Statistics* (<http://www.ugr.es/~batanero/iase.html>), the *IASE Statistical Education Research Newsletter* (<http://www.ugr.es/~batanero/sergroup.htm>). Furthermore, many departments of statistics have now a repository for technical reports, internal drafts and PhD thesis, freely available in PostScript or PDF formats. This organisation offers a solution to an old problem. As everyone has experienced, till a few years ago this material was mostly unavailable or unreachable without unacceptable delays, even though it often represented a valuable part of the scientific literature.

2.2. STATISTICS AGENCIES

National and International Statistics Agencies are investing in many directions to profit from the network technology. Among the fields more involved in this effort are the channels used to disseminate information: Podehl (1999) has recently written that electronic publishing via the Internet has supplemented and is now starting to overtake paper publishing. Furthermore, the World Wide Web is a very efficient tool FOR PRESENTING statistical information in a new fashion which contributes to attracting

THE interest of ordinary people: the classic social facts (economy, demography, etc) are often presented exploiting the "technological appeal" as much as possible.

Data, so boring for non-insiders, are indirectly used to describe a country, a population, etc., from a new perspective. The discovering of this information by computer is something like a game which contributes to disseminating a statistics mentality and to making the new languages of the so-called information society more friendly. The effort required to implement these ideas is greater, the simpler and friendlier the final result actually is. Furthermore it requires a serious research effort in technological, statistical and socio-psychological areas.

Many agencies are today investing strongly in order to set up Web environments which allow a quick search of statistical information, online computation and graphing, webcasting, etc. Some good examples are already available: The U.S. Census Bureau has carried out a very efficient, advanced and attractive mapping system known as TIGER (Topologically Integrated Geographic Encoding and Referencing system). Another example is the American FactFinder (Reference Maps service, for displaying maps at different scale level, from the whole country level to the street level, and Quick Thematic Maps service, for creating of geographic patterns for commonly requested statistics).

Statistics Canada has set up E-Stat, a very friendly educational environment, and CANSIM (CANadian Socio Economic Information Management System), a professional data-searching engine. Eurostat is working on VIROS (Virtual Institute for Research in Official Statistics) and is experimenting a number of alternative approaches with the purpose of facilitating access to information. They rely on advanced technologies and, as a consequence, specific technical requirements must be met to view them. A remarkable Eurostat project is the Virtual European Statistical Laboratory, which involves state of the art techniques in many fields of computer science. The goal is to facilitate web-based collaboration and teleconferencing by setting up an intuitive three-dimensional multi-user environment (see the Eurostat pages and look for Miscellaneous in the research section).

2.3. ELECTRONIC BOOKS AND VIRTUAL LABS

Statistical education seems to be another field where network technologies can provide new settings: distance learning, virtual labs, electronic texts and books, automatic student assessment and much more. Conferences on teaching statistics always host sessions for discussing new proposals and experiences and during the last few years various experimental sites have revealed what can be done in this field. The description of all the different approaches and technologies used in this field would be too long and not so useful (a list of the most important sites has been included among the WWW References). Therefore, we will discuss the main ideas only to underline those elements which justify efforts in this direction because of their significant contribution for some categories of Web user.

Some educational sites have been produced for teaching purposes, having in mind college or university students, and specific course requirements. Moreover, authors often decided to invest in this direction to prepare practice materials for autonomous use by the students wherever they are. More recently, on the other hand, various sites offer a "virtual lab" developed as a part of a specific teaching project. Sometimes they also take into account pedagogical and psychological aspects besides the statistical methods (a good example is TILE, a project carried on at the Statistics Department, Berkeley).

Today many electronic texts, electronic books and virtual labs are available from the network. The scientific literature has not yet reported on experiments which show whether such tools are effective and really improve the student's learning processes; that is, there are no data which can be used to test them for teaching effectiveness. However they provide valuable support for non-statisticians who need statistics in their experimental research. Generally this kind of material takes more care of applications than many classical books do. From this point of view the Web represents an important starting point for identifying examples and for guided training on data analysis using appropriate software.

Several sites provide this kind of support either for elementary statistics and probability or for advanced methods (i.e. analysis of variance, linear models, etc.). The organisation of online material varies from site to site depending on the aim of the project. Virtual labs consist of software packages that can perform statistical computations directly from the WWW pages; generally written in Java, XlispStat, Perl, etc., they often use the dynamic graphic approaches and allow a fully online interaction with graphs. Some of them (Webstat, Statlets, etc.) are also able to get input data from everywhere on the network just declaring the URL. Similar features are absolutely innovative and make these kinds of tools much more friendly and more intuitive than most of the commercial products (XploRe, Härdle & others 1995, is the only one that has been built using some of these approaches). It seems reasonable to say that these prototypes are establishing new paths for future statistical software architectures.

Electronic texts and books may consist either of sets of simple notes on course topics with examples or of much more complex environments which provide both theoretical aspects and built-in software tools. Some of them (i.e. HyperStat) exploit other sites (mainly the virtual labs) for practical sessions by using links to these Web pages. Moreover, videos and 3D Virtual Reality examples are often available with charming examples.

As a final consideration on this matter, we have to keep in mind that the network actually offers all the best we can do with new technologies at the present time. Not everything may be considered useful, important and scientifically relevant; some are only attractive because of technology fashion. However the World Wide Web represents today a very important place for finding information and support.

2.4. DATA AND SOFTWARE ARCHIVES

The growth of the Internet during the '80s, when it was an academic network only, occurred for many reasons: First of all the technical characteristics of the TCP/IP protocol, secondly the new kind of services made possible by the protocol itself. During this period one of the most important services was the anonymous FTP, which allowed for the setting up of archives where researchers collected their software prototypes for free downloading. Perhaps most people today no longer understand the meaning of "anonymous FTP" because now this service is part of the facilities provided directly by the World Wide Web and hence is almost completely hidden as an autonomous service, even though it remains one of the most important ones.

The first relevant general purpose archive for statisticians is Statlib, set up by Mike Mayer at the Carnegie Mellon University at the beginning of the '90s. It is a public repository for statistical issues open to everyone both for storing and getting information. Now Statlib collects lots of famous data sets, which have appeared in

statistical journals or books, computer programs and macros for the most common statistical packages, and much more.

Nowadays all the universities, and perhaps all their departments, have a Web site so that people often prefer to control and to personalise their home pages. Therefore the number of statistical archives has quickly increased and it is day by day more difficult to have a realistic overview of what is available on the network. For many reasons (see the next paragraph) search engines are often unable to retrieve what you are looking for, and in any case the research is time wasting. A good solution is still offered by those sites containing ordered and classified lists of statistical resources. These sites are courteously maintained by people who, having a wide knowledge of the network, have freely decided to give a contribution to the scientific community by sharing their knowledge (such sites are listed among the "World Wide Web References" in the section "Links to Statistical Resources").

Data, case studies, software and all the related information represent an invaluable scientific heritage for the researcher's training as well as for some teaching purposes.

3. STATISTICS FOR THE INTERNET

Engineers and computer scientists have recently coined the new term *datamind* for embracing all the strategies concerned with non-homogeneous databases. They are working to make information compatible, but there are lots of statistical problems in this field that concern statisticians only.

The Internet is a container for all kinds of information, completely confused, randomly reachable and, for these reasons, unreliable for more advanced uses. Even though it could seem strange, this is a substantial advantage for the "health" of the network itself. In fact it stimulates researchers to develop new efficient methods for managing information coming from hundreds of millions of documents distributed on tens of millions of computers and contributes to the improvement of the Internet and the quality of the services offered.

Today, thanks to the WWW, it is very easy to create Web sites and archives on whatever computer or operating system is available so that anyone can publish their own information by himself. Unfortunately, the information spreads out all over the world and it is impossible to "organise" it in a reasonable way. Though Web searching engines are becoming more and more efficient, selective and powerful, they fail when the documents do not contain enough elements for quick retrieving (i.e. keywords and HTML meta-data). In fact, the easiness of HTML document building often encourages people to organise their sites without caring for the basic rules of the WWW and ignoring how to make the information retrievable.

Some computer scientists and statisticians are now trying to extend data-mining technologies to this area in order to deal with all the problems connected with the network growth.

4. CONCLUSIONS

The researcher's background must always include a good knowledge of the Internet facilities for different reasons. First of all, the network provides information and various kinds of materials that are very important for personal research activities.

Secondly it is necessary for everyone to be able to participate in this effort sharing their own knowledge. Moreover, the quick revolution of the past few years has already shown the advantages of the new means of communication so, in this period of transition, the task of exploring and drawing new paths to exploit the network opportunities is entrusted to researchers.

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