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Comment

Jessica Utts

My discussion will be divided into two parts. The first part consists of a treatise on the responsibility which accompanies the use of computers in statistical research. I offer several recommendations to complement those in the article.

The second part is a short description of a setup which works fairly well at the University of California at Davis and was not mentioned in the report. It might be of interest to other statistics departments.

1. SCIENCE FICTION OR FUTURE FACT?

There has been a science fiction novel living in my head for the past 10 years or so. It started when I was a graduate student studying robustness and I realized that most users would think of the computational aspects of robust procedures as a black box. This story occurs 30 to 40 years in the future. There are no more statisticians. There are statistical clerks, and every university department has at least one. Research is done by collecting data and giving it to the statistical clerk, who takes it from there. The clerk feeds the data into the computer and out pops the appropriate model, estimate, or whatever, complete with the associated significance or confidence levels. These are sent to journals, along with a post hoc explanation for the results of any of the tests which turned out to be "significant." Everyone is quite happy with this arrangement. No one knows how the computer generates these answers, but everyone knows that if the computer produced them, they must be right. All sorts of interesting (and not so interesting) hypotheses are being proved this way, and when they don't agree with common sense, everyone knows that common sense must be wrong.

In the current version of the story, something finally goes wrong. I haven't worked out the details, but it is a result which contradicts common sense so much that someone (a fresh young scientist, of course) actually has the audacity to question what is happening in the computer. In order to determine what the computer should be doing, a team of scholars attempts to decipher the statistical literature. To their dismay, they find that the literature is unreadable to them. Finally, they locate a few old statisticians who have long since retired, and with their help they piece together the story. It seems that when the computer software was being developed, most statisticians didn't pay much attention. The packages which were eventually implemented were written by people who were good at selling, but who didn't really understand the concepts involved. A few statisticians tried to protest, but since they were advocating the use of their own services, no one took them seriously. After all, the journals were much more likely to publish the computerized version of the results, so why bother with the more cautious and complicated interpretations the statisticians were trying to sell?

Of course I will never write this novel, but if things continue on their present course I may very well watch it unfold from science fiction into future fact. There are even those who believe that it is already well under way. One of our graduate students told me that a recent cocktail party response to his statement that he was studying statistics was "aren't you afraid of being replaced by a computer?"

So am I against the use of computers in statistical research? Of course not. In fact, I embrace these developments. After all, the world is a complex, nonnormal, non independent and identically distributed place and complex models are much more likely to accurately describe reality. Tools like the bootstrap, high resolution graphics, and interactive data analysis programs are important and useful for applied statisticians.

What I advocate is that we as research statisticians begin to play a greater role in determining that our work is properly applied. Our techniques are simultaneously becoming more complex and more automated. They are less and less likely to be understood by nonstatisticians. I was concerned when people started using calculators which give regression coefficients without producing plots. But the potential for misuse

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is far greater with a computer program which automatically selects a model, as some do now. Anyone who has taught or consulted in statistics knows that basic mistakes such as fitting ordinary regression models to highly correlated dependent variables, or accepting point null hypotheses without examining power, are very common. Computer programs which automate these procedures have only made things worse. It is easier to analyze data without the help, and therefore without the guidance, of a statistician. If these basic techniques are being applied and interpreted incorrectly, what can we expect for more complex procedures?

Coupled with the problem of incorrect use and interpretation of software packages is the fact that the results printed are not always right. Major packages have been known to contain serious flaws which were not detected and/or corrected for several years. As the software market becomes more competitive and packages for microcomputers become more prevelant, the problem is bound to get worse.

The recommendations given in the above report, for the acquisition and planning of computing resources, are timely, important, and well thought out. I would like to augment them with a list of recommendations for making sure that these resources add to the proper use of statistics. I will address my recommendations to the same four groups, i.e., statistics departments, university administrations, professional organizations, and research sponsors. To these I am adding a list of recommendations for individual statisticians, since it is with each of us that the ultimate responsibility lies. As they say, if you aren't part of the solution, you're part of the problem.

Recommendations to Statistics Departments

1. Teach a course on the proper use of statistical packages. This should not be a cookbook course; it should place the main emphasis on understanding what should (or should not) be used as input, and how to interpret output. Impress upon students that they should never hand over responsibility to the computer. Encourage graduate students from all relevant majors to take this course.

2. Teach a nontechnical undergraduate course on the ideas underlying statistical thinking. We will not produce a statistically literate society by merely teaching the mechanics of computing means, standard deviations, and t tests. If the general principles are well understood then it isn't as dangerous to have the calculations done by the computer.

3. Encourage your graduate students to develop computer skills akin to the level of mathematical skills currently required. This could include requiring a certain number of computer science courses before entering the program, as well as at least one course in statistical computing taught by the department.

4. Make sure that statistics is being properly applied on your campus. Encourage researchers in other departments to collaborate with individual statisticians and to include them when applying for grants. Give appropriate credit for good collaborative work.

Recommendations to University Administrations

1. Encourage the inclusion of a statistician on all appropriate research grants, especially during the planning stages. This should be done on grants for both external and internal funding.

2. Support statistics departments in their efforts to establish good consulting. Encourage and support easy access to interactive computer facilities as part of this consulting.

3. Designate the responsibility for acquiring new statistical software to an individual or committee with statistical expertise. Develop a mechanism through which users of microcomputers can get advice on software, especially since quality control is apt to be more of a problem with those smaller packages.

Recommendations to Professional Societies

I have only one recommendation here. I don't think it should be carried out by any individual society, but perhaps by a joint committee.

Establish a publication, updated annually, which reviews statistical software packages. Ideally, this would become the authoritative source of information about such packages, and could be sold to cover costs. Reviews should discuss such things as accuracy, level of expertise required, availability of printed and online help, versatility, underlying assumptions for the procedures, how up to date it is, cost, ease of use, and potential for misuse. In addition, programs could be cross-referenced by statistical technique, level of expertise required, type of machine, cost, etc. Finally, this manual could suggest references where one might find a readable discussion of each particular technique, if one exists. These reviews should be done by having both sophisticated and novice users try the programs.

Recommendations to Research Sponsors

1. Encourage collaborative grants on topics similar to those listed in Section 3.5 of the report, which include scholars from more than just statistics. It is especially important to ascertain that these grants are properly reviewed, since it may be difficult to find

single reviewers with the appropriate combination of expertise.

2. For grants in other disciplines, make certain that a statistical plan is outlined at the outset, and that the grant includes personnel with appropriate statistical expertise. Have the grant reviewed by a statistician if it seems appropriate.

Recommendations to Individual Statisticians

1. Read the recommendations under the previous four headings and do your best to see that the ones you agree with are carried out.

2. Do not be too narrowly focused in your evaluation of what constitutes good work on the part of yourself and your colleagues. Good scientific collaboration and interaction will most likely occur when they are amply rewarded. The ability of statisticians to interface with the scientific community should be viewed as important; as a scholarly activity such interactions should be seen on a par with more traditional forms of research in statistics. Our best students should be encouraged to do interdisciplinary work. Research papers should be evaluated on the ingenuity of the basic ideas, and not merely on the mathematical sophistication.

3. When consulting with scientists in other disciplines, insist on joint authorship unless the consultation was very routine. Argue that all parts of the paper should be defensible by at least one author, and if no other author can defend the statistics, you should be included. Also, encourage them to mention which package was used in the analysis.

4. Consider writing a textbook for one of the courses mentioned in the recommendations to statistics departments.

5. Choose an area which interests you and approach someone in that field to discuss the possibility of collaborating. Don't wait for them to come to you.

6. Take some responsibility in ensuring that my science fiction story does not come true.

2. ANOTHER MODEL FOR MAINTENANCE

In the Division of Statistics at the University of California at Davis, we have 2.25 (1.0 + .85 + .40) full-time equivalents of computer programming and maintenance support available, while only paying for a small fraction of that from our own budget. We are able to do this by sharing resources with the Statistical Laboratory. The "Statlab" is our consulting unit. It is a subunit of the Division, but operates with its own budget and staff. It employs a full time Ph.D. statistician, the above mentioned programmers, and secretarial staff. Our faculty and graduate students rotate into the Statlab on a quarterly basis.

The budget for the Statlab, and thus for the support of our computing resources, comes partly from the administration and partly from the recharge work we do. In particular, we do programming work for various units on campus, always on a recharge basis. It is this work which pays the salaries of the programmers.

Two of our programmers are also enrolled in our Ph.D. program and much of the programming they do is writing custom made statistical software. Thus, the statistician and programmers work together. They are also available to write programs for faculty research. This work is charged to external grants if possible, otherwise internal sources of funding are available.

Our basic hardware consists of an LSI 11/73, for which we paid about $68,000 originally and $32,000 for an upgrade, 7 Tandy 1200XT microcomputers, and various terminals, printers, and plotters. The microrcomputers are in faculty offices and are accompanied by modems so that we can connect with the LSI or the main campus computers. All of this equipment was purchased with internal funding.

While the current hardware configuration may not be adequate in the future, the current system of maintenance will allow for expansion. Sharing programmers with the consulting unit and thus having maintenance support available at all times has worked very well for us.