Peer-review in the Internet age

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Abstract

The importance of peer-review in the scientific process cannot be overestimated. Yet, due to increasing pressures of research and exponentially growing number of publications the task faced by the referees becomes ever more difficult. We discuss here a few possible improvements that would enable more efficient review of the scientific literature, using the growing Internet connectivity. In particular, a practical automated model for providing the referees with references to papers that might have strong relationship with the work under review, based on general network properties of citations is proposed.

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I. INTRODUCTION

The process of validation of scientific results, especially at the stage of publication is one of the most important parts of scientific methodology, ensuring quality of the published work. Current discussions aimed at improving peer-review methods point out several problems that face the journal editors and referees (Alberts et al. [1], Raff et al. [2]). Moreover, the continuously increasing competitive pressure of securing own job, grants, publications, gives the task of reviewing others’ work an odium of a chore. Both technical and ethical problems connected with the peer-review process are widely recognized, and there are publications and web sites aimed at giving guidance to those who, either as the authors or as the referees, participate in the process, for example Rockwell [3], Wager et al. [13].

One way of improving the process is in helping the editors is selection of the referees who would have knowledge necessary to assess the submitted publications. Such solutions have been discussed already, for example by Rodriguez et al. [4]. These ideas are based on the networked nature of the scientific communications.

In this paper we turn to the other side of the process, namely providing the already chosen referees with tools aimed at improving the speed and quality of the review process. Exponential growth of scientific literature, expressed both in terms of the page counts of individual journals and in the growth of the numbers of the journals themselves makes the task of conscientious publication review ever more difficult. Following current literature, even within one’s own field(s) of research, is quite difficult. Doing the same for fields that are somewhat remote is close to impossible. How then can a reviewer be asked to judge if an article contains enough new discoveries to warrant publication? How can the editors manage the review process with the necessary attention to detail and yet with speed and flexibility required by the growth of data? There are some initiatives, at both organizational and technical levels, that can improve the situation.

II. RANDOM CITING SCIENTIST

The model of Random Citing Scientist, introduced by Simkin and Roychowdhury [5, 8, 9] has been quite successful in modelling the popularity of research based on the number of quotations — using assumptions that have had nothing (or almost nothing) to do with actual
content, merit, and novelty. It was sufficient to assume a very simple citing process, in which when a scientist is writing a manuscript he picks up $m$ random articles, cites them, and also copies some of their references, each with probability $p$. It turns out that the statistics of citations obtained within such model are very close to the actual data. Much better than in a purely statistical model. For example, there was — as in real life — a large fraction of papers with high number of citations. In fact, the model has reproduced remarkably well network structure of connections between the publications.

The model has broken an unwritten taboo, treating scientists as subjects of research. Worse yet, Simkin and Roychowdhury [6, 7] have analysed the occurrences of errors in real citations, such as misprinted age numbers, or misspelled names. It turned out that quite often there are whole chains of such wrong citations, showing clearly that the assumption of copying without actually reading may well be a valid one. One of the papers was titled: Read before you cite!. If the authors do not read the papers they refer to, what can be expected from the reviewers?

The initial model has been later expanded to allow for preference to cite recent articles by Vazquez [11, 12], giving even better fit to observed citation statistics. One may ask: what are these models and proofs that scientists sometimes do cite without reading have to do with peer-review process?

The answer is that the simple model might teach us how to improve the process of finding how the reviewed paper stands in comparison to its “competitors” — works dealing with similar subjects. The network structure of links suggested by the model allows some degree of automation of the process of looking for works that share the same background with the checked one, and which might share the research directions and relevant results.

III. AUTOMATING THE DISCOVERY OF COMPETITIVE WORKS

We expect that the author(s) should be well versed in the current state of literature dealing with the subject of their own research. We also expect the list of references for each article to provide complete information necessary to position the work with respect to other developments in the field. Unfortunately, as the previous section indicates, these assumptions may be invalid. In my experience as a referee I have found quite often that what I thought to be crucial papers for a given topic were missed by authors of submitted
articles. Not because of ill-will or disrespect towards someone’s work, but because the authors genuinely missed some work, that should be considered and cited. In the age of Internet search engines, databases and electronic libraries the task of looking up what may be relevant and important is much easier than, say, 30 years ago. On the other hand the sheer number of publications makes it difficult to find and read all the truly important works. When such omission is been pointed out by the referee, in most cases the authors agree to extend their list, acknowledging “valuable suggestion”. Is it because agreeing with the referees is seen as the best way to ensure speedy publication?

If missing vital references happens to authors, who know their subject by heart, the situation must be worse for the reviewers. They are usually chosen from scientists working in fields of research close to the paper’s subject. Not too close though, to avoid conflict of interest. This forces the referees to brush up on the topic of the reviewed paper to provide real insight. When we recall that many journals give very small time windows for the referee answer, the task becomes quite difficult. The practical question becomes: how can we ensure that the reviewer has access to as much as possible of current literature dealing with the same subject (or very close ones) as the work he has to check?

In many cases the referee relies not only on his own experiences, but mainly on the quotations provided by the authors of the reviewed paper. This is fine, as the first step, but not enough. As noted above, the authors might miss, whether accidentally or on purpose, some papers. For example those that show “the other side of the story”, especially if the subject is controversial. And if the referee plans to spend limited time to complete the review, he or she might simply not have the time to hunt down the missing links. Thus, the evaluation of the innovativeness and creativity of the reviewed work has to be compromised. For example some results might be treated as novel, even though they have been published elsewhere — but missed by the referee.

Let’s consider how to use the network-based model of Random Citing Scientist to our advantage. What we propose is that the journal editors do a little preparatory work before sending the paper to the referee. What kind of work? Simply take one step down the citation network and then one step up and in this way find the papers that share a subset of the same references as the article submitted for review. Such search and selection is rather easy, and in some research fields (for example physics) it can be done with freely accessible Internet engines. Where no such engines are available, the editors might use more advanced, fee-
based databases. The search should be directed, reflecting the network structure of citation statistics. An example of such method is given below.

Usually, any scientific work cites some “ground breaking”, classical papers in their field, or comprehensive reviews — for the purpose of establishing the research topic within a more general framework. Quite often there’s little “direct” link between these papers and the results of a publication. It is likely, that these “general” references are exactly those that the authors copy from other papers in the field. The unwritten rules that state “if you write about such and such topic they you should cite this or that review” are quite natural and human. These references therefore add only a little little to the truly novel aspects of the publication under review.

The second class of references consists of much more recent works, cited because of their direct relevance to the research. They would contain sources of data, details of experiments or proposed theories used in analysis. Any competitive work would likely refer to the same works, to answer similar questions.

How to automatically tell which of the references belongs to each group, without involving human intelligence? One of the ways of approximating the split might be via very simplistic criterion of the age of the paper. We might assume that the second group would contain all references not older than 3 years. This number is, of course, completely arbitrary, and might be different in physics than in biochemistry. But it provides a good starting point in automating the analysis. Moreover, it is easily incorporated in any search engine.

After selecting the “active” references the next step is to search for the papers that use the same sources, and to order the results of the search by the degree of commonality of the whole set of references. In an ideal world, two “competitive” papers on the same subject would have the same set of starting blocks. In practice, this does not happen, but the results of such search can be quite helpful. The networked structure reveals often more information than keyword based search.

To test the described method I have done a small scale “home experiment”. I have chosen one of my own solid state physics papers [10] to try to look into what papers would be found by the process described above and if such results would be valuable to a hypothetical referee. This exercise had all the benefits of hindsight, and thanks to long time that has passed since publication it was possible to see “future” developments. Technically the search was made possible thanks to the SAO/NASA ADS Physics Abstract Service
By following the procedure described above, I was not only able to find most of the works of my “competitors” of that time that I was aware of. I found also one interesting article that I have missed at the time of writing. The results from the automatic down-and-up search were in fact much better than a Google Scholar search based on keywords from the paper’s title. Of course nothing prevents from combining the selection tools for better results. I would encourage all Readers to try this method at least once, either for a paper that they were asked to review or for one of their own works. Especially if the field of research is far from physics — my lack of knowledge makes it impossible to evaluate the usefulness of the method for disciplines such as bio-sciences or medicine.[14]

Comparative success of the initial experiment suggests that the process might be useful for the process of peer review. The list of papers found could be attached automatically by the editors in their requests for the referee’s opinion. This would speed up the review, by making it easier to compare the various approaches to the reviewed topic. Perhaps in disciplines other than physics the scope of the search should be chosen differently, by looking back into longer periods or by using more stringent culling of papers found, for example by enforcing at least some keyword conditions as well. The results will never be perfect. But on the other hand, I can imagine that a referee who gets from a journal editor, attached to a request for a review, a sorted list of possible suggestions of comparative works, might find it helpful in any discipline. At worst he or she would ignore the list. At best, it would help him or her to provide a more accurate evaluation and positioning of the reviewed work within the current field.

IV. SHARED LIBRARIES AND HISTORY OF REVIEWS

The prevailing requirement: publish or perish forces most scientists to focus on getting their work in print. Moreover, in most countries the work of a scientist or institution is evaluated not by what they publish[15] but where it is published. Placing the article in one of the high impact journals “earns” in some places much more “merit” than publication in a journal that has small, local circulation or is too limited in scope. The ISI Impact Factor from Thomson Scientific or Article Influence™ Score(AI) from http://www.eigenfactor.org measure of a journal’s prestige based on per article citations. Many governing bodies use these to rank the achievements of individual researchers. Should we wonder that the high
influence journals are flooded with submissions? As the scientists are fighting, literally, for their (scientific) life, to expect self-restraint is preposterous.

In such situation the task of the referees becomes even harder. The rejection level of these high impact journals is very high. What is the advice given to authors of rejected papers? Most often: re-work and re-submit — to a journal with lesser impact. Sometimes this process is repeated quite a few times. The optimists would say: until the right journal for the work in question is found. Pessimists: until one finds referees that are friendly or simply too lax to bother with detailed reviews.

While the proper matching of articles and journals is a desirable and valuable goal, we have to remember that the mechanisms to ensure this goal must take into account the fact that we are dealing with people, with their individual intentions and emotions, and not just mechanical process of purely objective evaluation. Thus the processes should be resilient to most human weaknesses. Automation and procedural improvements shall not be successful in recognition of great, ground breaking scientific contributions, but there is a lot that can be improved in the iterative process of repeated submissions and reviews. The most obvious action would be to break down the barriers between separate journals and publishers. While in some cases the referee pools are separate, the assumption that for a given field of expertise there are only so many experts that have the necessary knowledge. This would allow re-use of the work already done, for example the evaluation done for Nature or Science, where the referee may have disqualified the paper in question for a particular journal, but suggested other venue. Not only the number of iterations could be lessened, but the changes requested at each stage would be more coherent, ideally leading to an article of improved quality finding the right journal faster. Such solution is already in place in some journals which are owned by the same publisher, as mentioned by Alberts et al. [1].

The second issue is the reviewer anonymity. While there are arguments for such anonymity, there are also reasons to shift to non-anonymous reviews. What is lost in the openness and candour of review due to lack of anonymity, may be balanced by increase of responsibility that comes when you sign any document. Additionally we may think about using the flexible nature in Internet publications to attach (anonymous or not) peer reviews and authors’ responses alongside research articles. This is already done by some journals, for example by those from BioMed Central. While quite difficult in the “paper age”, the documented flow of comments, corrections and improvements is quite easy to present in
electronic form. Moreover, it could become the seed for discussion forums related to the published work. The review and ranking done on-line can bring huge advances. A good example is *Faculty of 1000 Biology and Medicine* where over 4500 leading researchers and clinicians share their expert opinions by highlighting and evaluating the most important articles in biology and medicine (http://www.facultyof1000.com/). All these ideas use of technologies available today and would improve the quality of published scientific work.

V. CONCLUSIONS

None of the solutions for smooth-lining the peer-review described in this paper is revolutionary. For all of them the technical basis already exists, maybe in limited form, but certainly applicable. The ideas of pooling reviews for a group of journals and of sharing the results as well as co-publishing the reviews and original papers are already present. The key to improvement lies in the widespread usage of the tools for sharing information that are available thanks to today’s technologies. The secondary outcome of this would be the improvement in the workflow of the referees, which would enable more people to participate meaningfully in the process without undue effort. Both younger and senior researchers would benefit from such tools and methods. The goal would be to give the referees all the help to allow them to concentrate on in-depth evaluation of the papers in question. This would allow, hopefully, to keep the scientific standards high, despite the exponential growth in volume of our “production”.

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[14] The author would be grateful for information on results of such individual experiments, for example through e-mail.

[15] It is clear that the committees and administrators who are responsible for the evaluation can not check the scientific content themselves. They rely on the very process of peer-review of publications.