How to Conduct a Literature Review and Collect Information on Topics in Science and Engineering – some personal thoughts.

In this note I want to lay down some thoughts I have on conducting a literature review. What I will talk about today I will expand upon over subsequent versions of this course so that one day it will form a Teaching Unit in the Biomedical Engineering module to be titled

“Arming yourself for research and development roles : interpretation of the scientific literature in medicine and the life sciences – a guide for all. ”

While this is a rough and ready guide I hope that you will find the info useful. You may find you put some of this tricks into action sooner than you might think when you are conducting your BE/ME project.

For those of you who would like to have an idea what the final Teaching Unit might look like ultimately I am currently quite inspired by the book


So to begin …

Biomedical Engineers need to generate science when required. To do this we must first stand on the shoulders of giants. This entails becoming acquainted with the collective memory of science as available through the corpus of published peer-reviewed material available through journals and published conference proceedings. One can also make use of hearsay and personal communication but this is not respected!

So in the next few lectures (uhmm not in this document but this is a placeholder for future work!) we are going to learn how to interpret and appreciate and judge research papers. It is through such research papers that you will find the bleeding edge of science, engineering and technology.

In a research and development led environment you will all need to be aware of results published in peer-reviewed literature. This is particularly true for those of you seeking enhancement of your research ability through a PhD degree program. No-one wants to re-invent the wheel especially as there is little credit for such activity either in industry or academia. Innovation is key to growth and intellectual property or ownership of ideas is becoming an increasingly valuable commodity. So before you can hack out your new device or publicise some science you had better make sure no-one else has already done this (you waste effort/energy/time/money) and you had better learn as well how to do a good patent search!

For now we will learn how to build a literature review
For absolute starters, you might ask what is a “paper” in the context I have described? Generally we are referring to journal papers. Journals are periodical publications (ie once per month, 4 times per year etc) containing articles on a particular subject which have undergone scrutiny and quality review by experts in the area. It is the benchmark for scientific quality and truth…with some obvious human-induced limitations.

Useful reference at this point:
http://en.wikipedia.org/wiki/Academic_journal

Let us imagine your boss sets you on a project to investigate the feasibility of building a simple brain-computer interface as an interface to allow users control a video game. OK that sounds a biggie!
Where do you begin?
Well for starters you need to tap into the scientific literature. How do you do this? Just “google” it? Well that’s not a bad start but there are more structured ways.
Before the internet gained such a stranglehold on dissemination of knowledge journals and periodicals in physical form were the way to gather together scientific thought and opinion.

So how do you tap into this body of knowledge? Where are these papers? Well in the olden days they were (and of course in many discipline still are) physical publications which took up space on a library shelf. Go to the Maynooth library and go to the top floor. There you will find many journals. Browse through a few. How are you mean to find an article in them?
Perhaps by luck you might find an article you are interested in through browsing an issue of the journal.

*Design of electrode layout for motor imagery based brain–computer interface, Y. Wang, B. Hong, X. Gao and S. Gao in Electronics Letters, vol 43, no. 10*

Perhaps then through checking through the references at the back you might find related papers on your topic of BCI. Perhaps you find some of these useful
So you can check these journals and find related articles and see who they cite

Citing:
“Whenever you quote, paraphrase, summarize, or otherwise refer to the work of another, you are required to cite its source, either by way of parenthetical citation or by means of a footnote. “

“Most style manuals require you to assemble a list of the works that you have cited in your paper. This list, included at the end of your paper, may be termed "Works Cited," a "Reference List," or a "Bibliography."

Taken from http://library.duke.edu/research/citing/

While this above approach is doable and should certainly form part of your arsenal of tricks in extracting the appropriate literature it is time consuming and all depends on you finding a well connected paper – a topic in itself which is very interesting.

So when I was a grad student in the olden days third party organisation would take a summary of authors and keywords and form a meta-journal of a sort, an index of all published papers which served as a huge ordered physical database of the contents of these journals. This was a physical set of books!!!!! These were the first citation indices!

“A citation index is an index of citations between publications, allowing the user to easily establish which later documents cite which earlier documents.

The first citation indices were legal citators such as Shepard's Citations (1873). In 1960, Eugene Garfield's Institute for Scientific Information (ISI) introduced the first
citation index for papers published in academic journals, starting with the Science Citation Index SCI, and later expanding to produce the Social Sciences Citation Index (SSCI) and the Arts and Humanities Citation Index (AHCI).”

Taken from http://en.wikipedia.org/wiki/Citation_index

These were a pain as for one thing they were searched by hand! Then along came computer databases and made life so much easier (the books were now searchable and formed a database).

Then came the internet and information dissemination really exploded.

Nowadays most libraries subscribe to online editions of journals so as to save shelf space – also most people find this a more convenient means of looking for material. Correspondingly there are online tools for searching the contents of journals in an electronic version of citation indices. These are very convenient and have a lot more power than the old copy versions. Some of these are dedicated research-oriented services.

Useful reference you should turn to right now:
http://en.wikipedia.org/wiki/Academic_databases_and_search_engines

An excerpt

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<td>BASE [1] (free index to academic content, mainly free)</td>
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<tr>
<td>EBSCO/EPNET [3] (subscription index to subscription articles in a variety of fields)</td>
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<tr>
<td>Google Scholar (free index to mostly subscription articles)</td>
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<td>Ovid Technologies (subscription-based collections and indexes)</td>
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The differences pertain to journals they cover and search capabilities … it’s a business so its innovation/need led.

ie Science Direct has about 2000 top journals indexed.

Web of Science has about 6,400 journals indexed.

These may not give you access to the journal article itself though unless you have a subscription or your library has or its fee access anyway …remember this!

There are also more subject specific ones:

Such as IEEE Xplore which also contain all their conference material.
You pay huge amounts of money to subscribe to these!

For biomedical engineering one of the best is Entrez. http://en.wikipedia.org/wiki/Entrez using Entrez one can search many health sciences databases in one go. I would be lost without it. One of the great things about Entrez is that it is free!

As you find papers you might need to add them to your own personal database so as to keep a copy of the full citation and a note on its contents and relevance to your research. I recommend a program called endnote but there are many more. Check them out. The best of them allow you to compile your own database of papers which will allow easy citation of such work in ways that suit the idiosyncrasies of the editor you might be writing for. By this I mean if I want to cite a paper I had used to support an argument in a new research paper of my own I would reference it in the text. I would use notation such as [1] for an IEEE journal and say (Blah et al, 1995) for the journal Medical and Biological Engineering and Computation and perhaps something else for some other journal where the bracketed notation provides an index into a set of references at the end. It all depends on the journal guidelines that you are writing for.

Searching for papers requires good choice of keywords to find all the related papers. Lets say I was following up on research we have been doing on measurement of moments of occurrences of audio perceptual events. Rudi Villing, Joe Timoney and I have worked in this area. How did we trawl up all the relevant paper? For example searching for P-centres (a common term we encountered in the area) might cause you to miss papers which deal with “Perceptual centres “ or papers using terms like “…temporal perception of …” it’s a bit of an art and requires reading yes reading the help associated with the search facility for your database/search engine. Advanced options are often useful. Some databases have notoriously stupid search facilities though so best of luck with that.

Try to keep your list of papers manageable (except for PhD students – you need to know them all!) if it gets very large it may drain your enthusiasm for reading them.

How do you prune them? Good question. For starters read the most cited papers these are the papers that the research community has found most valuable. Well a citation index is what you need. A summation of all the times a paper has been cited. Science Citation Index is a database which will do this for us. Check it out…

Citations lead to the concept of impact factors – impact factors are measures of a journals connectedness to other articles - essentially the more often articles from a particular journal are cited the more important scientifically the journal must be.

What happens though if your library does not subscribe to the journal you want? In such a case you may need to buy the paper online or preferable ask the library to do it via them getting you an inter library loan request for the article. Or if you do not live too far from a university that does not have it go there. Your library card from Maynooth should get you into other universities around Ireland…then you photocopy
the paper. Of course check the library database of the other universities (online) before hoping on your bike.

What if it is a conference paper whose proceedings are not so widely available? For some and I mean some areas such articles if they have sufficient importance will find their content in journal form at some stage so look our for authors work again in a journal. If the work never progressed much further or if, in the case of conferences where full papers are reviewed (some conferences just review abstracts) then you will need to find access to the conference proceedings. You should find these online through some of the databases and remember when stuck just email the author.

I provide a very rough and ready screen cast demonstrating some of these points on my website. Check it out.

**PART 2: READING THE PAPERS**

So you find a paper that looks modern and promising that seems to deal with the topic you have been tasked with investigating.

Here the first problem emerges. The paper seems inscrutable! As students who have used textbooks or even as ordinary individuals accustomed to help pages and instruction manuals research papers seem to be written in rather unfriendly ways! There is little background on the topic or gentle tutorial examples given, you are thrown in at the deep end! Indeed reading a 6 page engineering paper can quickly entail you reading several more previous papers plus sections from various textbooks in order to fully extract all the information in the article. Thankfully though you may not need to know all the information in the article – this really all depends on whether the techniques, methods and results look germane to your requirements. If you find that you are looking for a new technique say to segment digitised speech into segments automatically and you find a paper such as “An algorithm for automatic segmentation …” then you better read and understand it thoroughly with all the background reading that it might entail. This is important. However in many cases you will find papers which are closely related but not germane in such cases you only need to be able to read the paper to the depth that allows you to make this relevant/not-relevant judgment.

Why are so many journal papers so difficult to read for the newcomer?

Its because they can be full of jargon that even reviewers do not understand. This can have hilarious consequences!

(Check out the joke CS paper generator [http://pdos.csail.mit.edu/scigen/](http://pdos.csail.mit.edu/scigen/)

The problem is quite simple. Space in journals is limited so all concerned aim to cut out as much redundant information as possible based on the average audience for the particular publication. So obviously an EE journal detailing a new circuit design for a radio may assume that readers are au-fait with terminology common in the EE field such as modulation, coding and signal to noise ratios, etc and need not explain them any further.

Authors will expect their audience to be fairly familiar with the field and will give but cursory treatment to background, larger research context and terminology.
That's fine for their expert peers but how about the young PhD student starting out? How do you bootstrap yourself in the area?

Let's look at our example paper [1] by Wang et al.:

Ok, so there is a lot of background assumed above. What is x? What is Y? Why are they doing this experiment at all? Or why have they built this device at all?

*The Abstract should give a brief summary of the results* but may not state why the research was necessary. (Even if it did it would probably be a one-liner unless the line of enquiry itself is not widely appreciated)

*The introduction should inform us as to why the experiment/device is a good idea.* In case you are in the dark over such motivations the introduction should be read and read carefully. You may also see sections titled “Background” etc. These are all good places for those new to an area.

OK, that is a start but often even at this stage the title/abstract/introduction could be surfeit with many technical terms and techniques that only the initiated would know about. What now?
Clearly this is where one has to read around the area based on any references cited after the introduction of these terms. What if there are none or the references themselves make things no clearer?
Clearly we need sources of information and for the lazy among you I do not just mean a quick google and a wikipedia session.
Peer-reviewed and accepted knowledge is important and for these one had better go to their sources or more commonly a recognised textbook on the area. (you can always google up later and use your own powers of discernment to filter the chaff from the wheat)

A quick skim of the relevant textbooks will get you what you need.
For biomedical engineering there are many good textbooks. There are sub-fields again within the BE discipline that merit textbooks of their own. For example biomedical imaging, or biomedical signal processing or medical device design and so on.
Having access to half a dozen such textbooks spread out over the range of your discipline will keep you well covered for the basics. If you don’t know a good textbook for an area ask your lecturer or general experts in the area.
You should also do so by searching your library database. Again here picking good keywords is useful.

Exercise: I want a textbook on brain computer interfaces. There is one in the library in Maynooth. Can you find it? (Search yourself) (Answer: handbook of neuroprosthetic methods)

With the pace and which new results are produced in some fields today you may not find it available in a textbook or the specialism is too specialised to have generated a textbook - what then? Hopefully you can find a review or a survey paper A review
paper gives an overview of a research area and will contain all the important references which together have formed the field. Review papers will save you a lot of work if you can find them.

If I wanted to find out about Near Infrared Spectroscopy I would see that there is no textbook that covers it well but when it comes to a review paper we have several to choose from…see if you can find them!

In the case of both reviews and textbooks you can save a lot of effort by skimming through to find the relevant details you require.

After you have gleaned all you can from review papers and textbooks any remaining ambiguities are best resolved through reading original research papers cite. As we mentioned earlier this process can quickly explode until suddenly you are having to read a lot of papers just to acquire a complete integrated view of the subject. For PhD students this is an essential process anyway for folks who intend just to discern the results of the paper in a high level fashion skimming again may suffice at such a stage. A further process at this stage is to look at previous work by the authors, usually the senior author (research group leader) is the last name on the paper and the active researcher usually a grad student is the first author. At this stage if the research group has a home page it is a good place to look as they may include background blurb there or perhaps even online material such as seminar presentations, etc.

For any remaining ambiguities you may have to email the author of the paper! We have done this before and it is the last port of call. Authors generally enjoy the fact that people are interested in their work. That’s all we can cover on this topic for the moment. I will try to add to this document over time.

Tomas