Professional Activities for Research Scientists

AMSC/CMSC 663
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Outline

1. Comments on how to conduct research
2. Writing
3. Presenting results
4. Professional activities
5. Ethical issues

1. How to Conduct Research

How do I identify a research problem?

How do I begin doing research?

How do I know if what I'm doing is any good?

How do I know when I've actually accomplished something?

MS with thesis vs. PhD

Much more

- independence
- depth
- work

for doctoral project than for masters

How do I Identify a Research Problem?

Learn a discipline:

- Coursework
- Read papers
- Talk to people

Ask questions:

- No question is too stupid
- **Look for what is *not* said and ask (yourself) about it**
- Talk to other people (faculty, students) who might know

Read critically:

- Again: look for what is not said
- Ask yourself: Are these results clean & elegant?
Can they be made more so?
Can they be made simpler?

How do I Begin Doing Research?

Perform simple tests

- You've identified something that wasn't said
- Design an experiment to see why it wasn't mentioned
  Does the idea in the paper fail? Why?
- Be playful
- Talk to people who might know, follow their suggestions
  Don't think you have to come up with all the ideas
- Do simple things
- Build on previous results:
  Most research is *incremental*

How do I Know if What I'm Doing is Any Good?

How do I Know When I've Accomplished Something?

This is a ***social*** enterprise
You are not a solitary scientist
Talk to people, get their feedback
+
Sell it

Critical Components of the Research Life
Writing
Presenting

Ideas are hard to come by

To be successful, you need to communicate your ideas so people understand them

For writing: it's ***very*** difficult to start with a blank page
Strategy: Put ***something*** down on paper

Then: it's also ***very*** difficult to make your ideas clear
Strategy: on the next day, or later: edit
then edit again
then edit again
then edit again

2. Writing

Step 0: Staring at a blank page

Writing

Step 1: Start with something

It is a truth universally acknowledged that a single man in possession of a good fortune, must be in want of a ~~dog.~~ wife.

(Jane Austen, ***Pride and Prejudice***)

Happy families are all alike; ~~unhappy families are exceedingly rare.~~ every unhappy family is unhappy in its own way.

(Leo Tolstoy, ***Anna Karenina***)

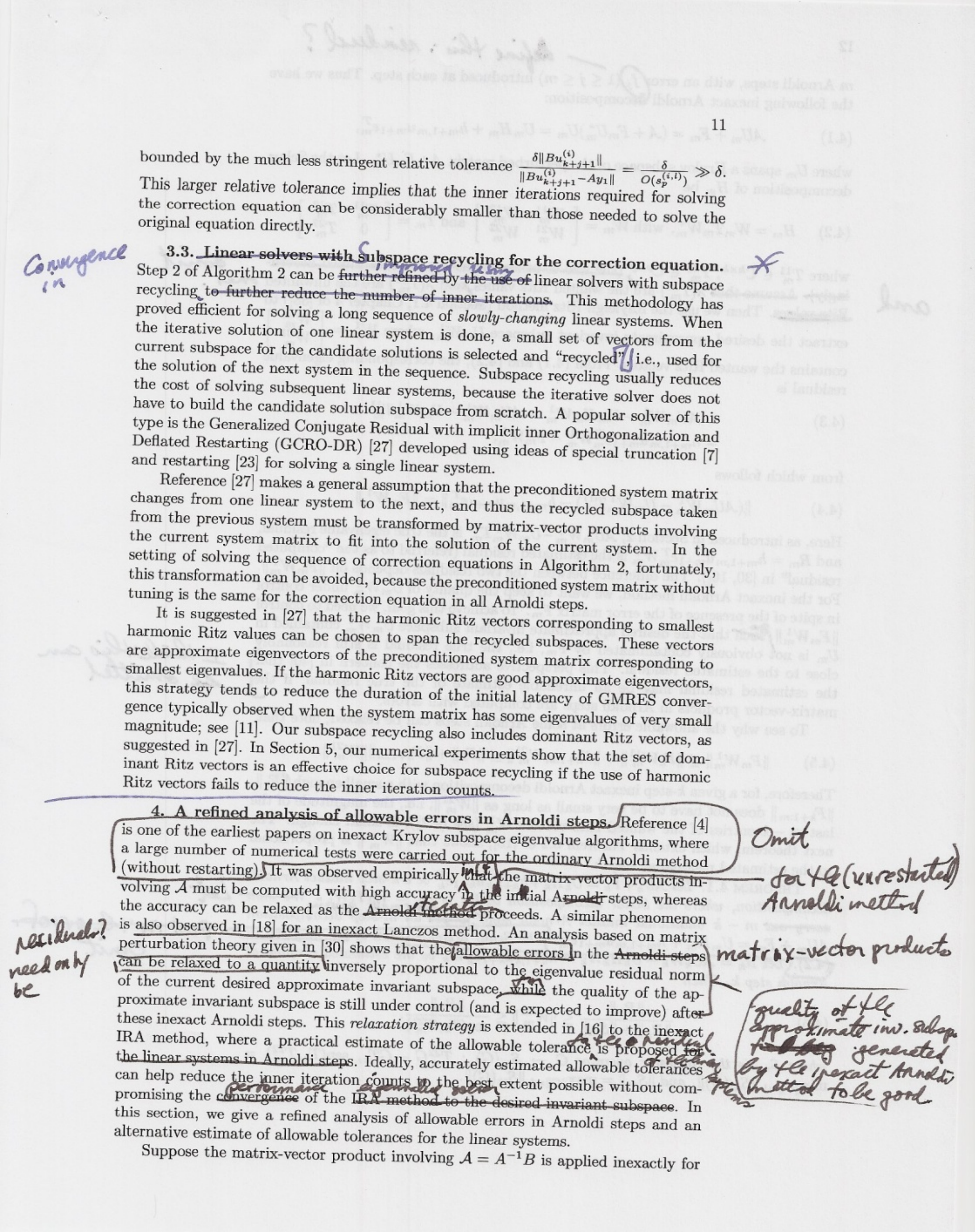
When he was nearly thirteen my brother Jem got his arm badly broken at the elbow.

(Harper Lee, ***To Kill a Mockingbird***)

The point: it's hard to get it right the first time but easier to get it right when you have something other than a blank page.

Edit, edit, edit

20th draft:



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bounded by the much less stringent relative tolerance $\frac{\delta\|Bu_{k+j+1}^{(i)}\|}{\|Bu_{k+j+1}^{(i)}-Ay_1\|} = \frac{\delta}{O(s_p^{(i,l)})} \gg \delta$. This larger relative tolerance implies that the inner iterations required for solving the correction equation can be considerably smaller than those needed to solve the original equation directly.

Convergence in

3.3. ~~Linear solvers with~~ Subspace recycling for the correction equation. Step 2 of Algorithm 2 can be ~~further refined by the use of~~ improved using linear solvers with subspace recycling ~~to further reduce the number of inner iterations~~. This methodology has proved efficient for solving a long sequence of *slowly-changing* linear systems. When the iterative solution of one linear system is done, a small set of vectors from the current subspace for the candidate solutions is selected and "recycled", i.e., used for the solution of the next system in the sequence. Subspace recycling usually reduces the cost of solving subsequent linear systems, because the iterative solver does not have to build the candidate solution subspace from scratch. A popular solver of this type is the Generalized Conjugate Residual with implicit inner Orthogonalization and Deflated Restarting (GCRO-DR) [27] developed using ideas of special truncation [7] and restarting [23] for solving a single linear system.

Reference [27] makes a general assumption that the preconditioned system matrix changes from one linear system to the next, and thus the recycled subspace taken from the previous system must be transformed by matrix-vector products involving the current system matrix to fit into the solution of the current system. In the setting of solving the sequence of correction equations in Algorithm 2, fortunately, this transformation can be avoided, because the preconditioned system matrix without tuning is the same for the correction equation in all Arnoldi steps.

It is suggested in [27] that the harmonic Ritz vectors corresponding to smallest harmonic Ritz values can be chosen to span the recycled subspaces. These vectors are approximate eigenvectors of the preconditioned system matrix corresponding to smallest eigenvalues. If the harmonic Ritz vectors are good approximate eigenvectors, this strategy tends to reduce the duration of the initial latency of GMRES convergence typically observed when the system matrix has some eigenvalues of very small magnitude; see [11]. Our subspace recycling also includes dominant Ritz vectors, as suggested in [27]. In Section 5, our numerical experiments show that the set of dominant Ritz vectors is an effective choice for subspace recycling if the use of harmonic Ritz vectors fails to reduce the inner iteration counts.

4. A refined analysis of allowable errors in Arnoldi steps. Reference [4] is one of the earliest papers on inexact Krylov subspace eigenvalue algorithms, where a large number of numerical tests were carried out for the ordinary Arnoldi method (without restarting). It was observed empirically that the matrix-vector products involving $\mathcal{A}$ must be computed with high accuracy in the initial ~~Arnoldi~~ steps, whereas the accuracy can be relaxed as the ~~Arnoldi method~~ iteration proceeds. A similar phenomenon is also observed in [18] for an inexact Lanczos method. An analysis based on matrix perturbation theory given in [30] shows that the allowable errors in the ~~Arnoldi steps~~ can be relaxed to a quantity inversely proportional to the eigenvalue residual norm of the current desired approximate invariant subspace, ~~while~~ the quality of the approximate invariant subspace is still under control (and is expected to improve) after these inexact Arnoldi steps. This *relaxation strategy* is extended in [16] to the inexact IRA method, where a practical estimate of the allowable tolerance is proposed ~~for the linear systems in Arnoldi steps~~. Ideally, accurately estimated allowable tolerances can help reduce the inner iteration counts to the best extent possible without compromising the ~~convergence~~ performance of the IRA ~~method to the desired invariant subspace~~ eigenvalue solver. In this section, we give a refined analysis of allowable errors in Arnoldi steps and an alternative estimate of allowable tolerances for the linear systems.

Suppose the matrix-vector product involving $\mathcal{A} = A^{-1}B$ is applied inexactly for

Omit

for the (unrestarted) Arnoldi method

matrix-vector products

residuals? need only be

quality of the approximate inv. subsp. generated by the inexact Arnoldi method to be good

Edit, edit, edit

20th draft:

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Critical Components of the Grad Student's Life
Writing a thesis

How will I ever do this?

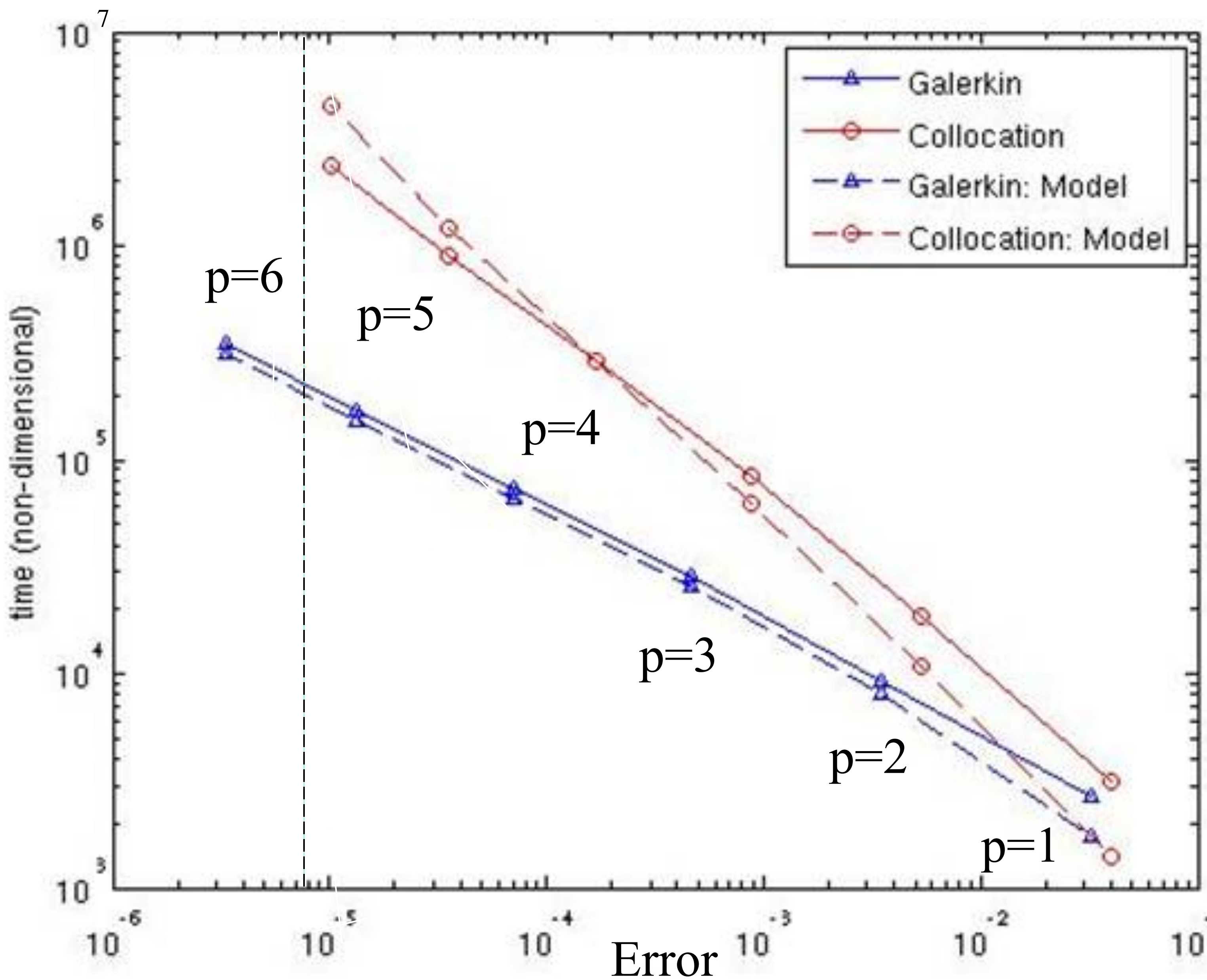
Most important thing (or one of them):
Put one foot in front of the other

2. Presenting results

A main topic of this class

Issues to consider:

- How much material to put on a displayed page
- How technical should the presentation be
- Use of figures, tables, other things to present data
- Other tools: movies, colors, transition (in PowerPoint)
- Personal components: posture, loudness of speech, standing position



Galerkin
Collocation
Galerkin: Model
Collocation: Model
p=6
p=5
p=4
p=3
p=2
p=1
time (non-dimensional)
Error

4. Professional Activities

Submitting papers to journals and conferences

The process:

- Get the results (!) and write them up (edit, edit, edit)
- Decide on a place to submit
  Requires critical self-evaluation
- Wait for some time (seems interminable)
- Get comments back
  These come from reviewers and editors
- Are the comments favorable? If so:
  - Respond to editor's and reviewers' requests
    Generally speaking: don't argue with them
  - Revise: edit, edit, edit

Submitting grant proposals and requests for funding

The process:

- Generate some ideas (sounds easy, right)
- Generate some preliminary results:
  the aim here is to demonstrate "proof of concept"
- Write them up (edit, edit, edit)
- **Leave enough time to meet deadlines**

Much of the time (NSF, NIH): peer review
Sometimes: you can establish relationships with funding agencies

Salesmanship

You need to convince

the world

your advisor

listeners

readers

that your ideas are worth listening to

How:

Do you have a faster algorithm? Show timings

Do you have a provably faster algorithm? Provide the proof

Are your ideas comprehensible?

Say them clearly, write them clearly, provide graphical evidence that is easy to see

5. Some Ethical Issues in Research

I. Plagiarism

a. Unacknowledged use of other work

b. Unacknowledged use of one's own work

Every paper submitted to SIAM journals is checked for plagiarism with a program called *Crosscheck*

≈ *5%* (171 in a recent year) of submissions are flagged

Of these:

≈ 50% are flagged for *self-plagiarism*

≈ 50% are flagged for other reasons

118/171 = 62% are rejected outright

In some (other) cases: papers about to be accepted were later rejected after duplication was discovered

Some Ethical Issues in Research

I. Plagiarism

c. Use of proprietary material:

You receive a paper/proposal to review

Don’t like most of it, reject

Like one part of it, use it yourself

Completely inappropriate

Some Ethical Issues in Research

II. Reproducibility of experimental results

a. Serious problems have arising in medical research
Statements about safety of experimental results have been shown to be invalid and not reproducible, led to very bad outcomes
One example: Patients suffered collapsed lungs due to errors in MATLAB codes

b. At least one journal, *Biostatistics,* has criteria "*reproducibility*" to which papers are subjected. Papers meeting the criteria are marked **R**

c. Can't use only "good" outcomes of experiments

Some Ethical Issues in Research

III. Improper statement of one's record

a. Paper under review cited in a CV as having been accepted

b. More generic overstatement of accomplishments, record

Exaggeration of teaching record, responsibilities, class sizes

Makes you look bad

Makes University of Maryland look bad

Some perks of the research life:

- The opportunity to study interesting questions
- Independence:
  You have considerable flexibility in deciding what to work on
- Travel
  This is an exciting endeavor of worldwide interest
- Meet interesting people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