Math Camp 2020: Programming (part 1)

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Outline

Structure of today's session

1. General programming advice ($\approx$ 30 min)

2. Julia walkthrough ($\approx$ 60 min)

3. Open time for questions ($\approx$ 30 min)
   - Feel free to ask questions throughout!

All materials from today's presentation are on GitHub at `https://github.com/fpinter/math-camp-coding`

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Basic principles

1. Learn by doing (practice!)
2. Always keep your future self in mind
3. Your time is valuable
4. Talk to people about programming

Learn by doing

- Especially early in grad school, treat learning about programming as an investment
- Practice new skills as often as you can

Always keep your future self in mind

- When you return to a project later on, you should be able to:
  - Figure out what's going on
  - Not screw things up
- Write clear readme files (don't rely on your memory)
- Clearly written code $\gg$ over-commenting
  - Use good variable names
  - Use good function names
  - Use functions to simplify things
- Write comments with a specific audience in mind
  - Typically your future self and your collaborators

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- A classic quote in computing:

  "Programmers waste enormous amounts of time thinking about, or worrying about, the speed of noncritical parts of their programs, and these attempts at efficiency actually have a strong negative impact when debugging and maintenance are considered. We should forget about small efficiencies, say about 97% of the time: premature optimization is the root of all evil."

  –Donald Knuth

Talk to people about programming

- There might be ways to solve your problem you hadn't thought of
- Talk to your cohort, talk to people you know
- Stay up to date on tools

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When writing code

- Don't repeat yourself
  - Don't copy and paste; write functions
- Write (and save) formal tests
  - Write tests for functions *when you write the functions*
  - Write checks your data should pass
- Know and use the idioms of your language
  - Know *why* your code works the way it does
  - Know the common gotchas
  - Nothing should be magic!
- Understand all unexpected results
  - Learn how to read the error messages

When organizing your project

- Aim for full reproducibility, including a detailed readme file instructing a replicator *exactly what to do*
  - Keep this file continuously updated as you work
  - Fewer steps for the replicator = better
- Don't write critical parts of your code under time pressure
  - If you do, go back and clean it up later
- Use version control to track changes over time
- Split your code into steps, with a clear order
  - You should be able to clear all your outputs/intermediate files and run the master script

Note on choosing programming languages

- Tired: wars between programming languages on Twitter
- Wired: using the right language for the task at hand
- There's no rule saying you have to use the same language for everything (even within a project)
- Questions to ask yourself:
  - What do your coauthors use?
  - In what language do you work most efficiently?
  - What functionality do you need?
    - e.g., data cleaning, web scraping, heavy computation

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First year vs. research

	G1 coursework	Research/real life
Day to day work	Numerical computation with clean or simulated data	Mostly wrangling real-world data (unless you're a theorist)
Maintainability	Submit and you're done	Return to your code many times, sometimes years later
Accuracy	Nice to have	Be obsessive about making sure your results are correct

First year vs. resarch

	G1 coursework	Research/real life
Testing	Smell test + write formal tests for basic debugging	Smell test + write lots of formal tests
Collaboration	Discuss with group, but write code independently	Depends on your style and your coauthors' styles
Version control	Nice to have, but optional	Very important

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Further resources

- LJ Ristovska's presentation
- Jesús Fernández-Villaverde's lecture notes
- QuantEcon
- Harvard IQSS training materials

How to get help

1. Check the built-in help in the language
2. Google
   - Often the result will be a Stack Overflow answer – these are often helpful but not always
   - Watch out for out-of-date info (especially for Julia)
3. Ask someone
   - Plug for the econ department Slack
4. Ask a question on Stack Overflow
   - Stack Overflow has guidance on how to ask a good question; read that first

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Why Julia today?

- The focus of math camp: skills you'll use in first year
  - Numerical computation, matrix algebra, optimization

- Julia excels at these and its matrix syntax is clean

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- The focus of math camp: skills you'll use in first year
  - Numerical computation, matrix algebra, optimization
- Julia excels at these and its matrix syntax is clean
- Historically the dominant language for first year PhD was Matlab
  - Julia syntax is closely based on Matlab
  - Unlike Matlab, Julia is free and open-source, with a growing community, and many of the advantages of modern languages
  - You can switch back to Matlab anytime if you want

Alternatives to Julia

- R
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- R
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- Python
  - De facto standard in physical sciences, engineering, and the tech industry
  - Great all-purpose language ("Swiss army knife")
  - Matrix syntax has improved but is still less intuitive than Julia's

Downsides of Julia

- Generally harder to use than R or Python for manipulation of real data
- The language is unstable (most help files online before 2018 are useless)
- The community is less active than R and Python