0. Introduction
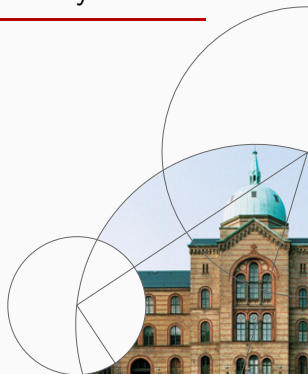
Introduction to Programming and Numerical Analysis

Jeppe Druedahl
Asker Nygaard Christensen

Plan

Intended learning goals

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- **In a nutshell:** *Learn how to use numerical analysis to improve your understanding of economic problems*
  1. Visualize solutions and simulations of well-known models
  2. Explore alternative assumptions regarding functional forms and parameter choices
  3. Solve more realistic models with constraints, uncertainty and non-convexities, where algebraic solutions are not available
  4. Work with online data and do programming based statistics and descriptive economics

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    $\Rightarrow$ very relevant when writing your bachelor and master theses
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- You will learn a **set of important tools**, but it is equally important that you **learn how to acquire new tools** for problems you will face in the future (in your studies or work-life)

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  A good work-flow is very important
    1. Clear structure reduces the number of bugs
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- **Programming is more than writing code:** Structuring, testing, documenting and collaborating on code is a central aspect of this course

Active learning

- **Active learning:** To learn scientific programming you need to work on actual problems yourself
  - We can show you examples
  - We can guide you in terms of where to start
  - We can answer questions
  - But you need to work with the material on your own
  - Programming is not a spectator sport!

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- **Work-in-progress:** All of your feedback is very important for optimizing and improving the course!

Your teachers

- **Jeppe Druedahl**, Associate Professor
  research: macro questions, micro data, computational methods
  web: sites.google.com/view/jeppe-druedahl/
  e-mail: jeppe.druedahl@econ.ku.dk

- **Asker Nygaard Christensen**, PhD student
  research: labor economics, job search, unemployment
  e-mail: anc@econ.ku.dk

Numerical analysis in action

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- We work with **Python 3.9**
- **Suggested environment:**
    1. **Distribution:** Anaconda
    2. **Editor/IDE**: VSCode
- **I will show** how to use VSCode
    1. Run python *code* and *notebooks*
    2. Solve the consumer problem from microeconomics

Infrastructure

Getting started

- **Web-page:** The course is organized around
  https://sites.google.com/view/numeconcph-introprog/home

- **DataCamp:** Online courses on Python (requires no installation)
  $\Rightarrow$ you get 6 months free access (see e-mail with details)

- **Installation of Python:** Follow the installation guide

Lectures, classes and exam

- **Lectures:** 3 physical lectures (see calendar)

  Videos: https://www.youtube.com/@numeconcph/

  Questions? Ask them as a Github-issue

- **Classes:** Week 6 to 20

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- **Exam requirements** (see deadlines)
  1. Basic programming test (on DataCamp.com, see e-mail)
  2. Inaugural project + 2x useful peer feedback
  3. Data analysis project + 2x useful peer feedback
  4. Model analysis project + 2x useful peer feedback

- **Exam:** Portfolio of projects + exam problem (48 hours)

- **Grading:** Pass or fail

- **Groups:** All projects can be done in *fixed* groups (maximum of 3)

Course plan - lectures

Four parts:

1. **Fundamentals** (primitives, optimize, print and plot, random numbers and simulation, structure and documentation, workflow and debugging)
2. **Working with data** (load/save and structure data, basic data analysis)
3. **Algorithms** (searching and sorting, solving equations, numerical optimization)
4. **Further perspectives** (canonical economic models, structural estimation, speed-up with comprehensions, generators, vectorization and paralllization, numba, EconModelClass, BabyMAKRO)

Course plan - classes

1. DataCamp
2. DataCamp
3. DataCamp
4. Problem Set 1: Solving the consumer problem
5. Problem Set 2: Finding the Walras equilibrium in a multi-agent economy
6. Work on your inaugural project
7. Problem Set 3: Loading and combining data from Denmark Statistics
8. Problem Set 4: Analyzing data
9. Work on your data project
10. Problem Set 5: Writing your own searching and sorting algorithms
11. Problem Set 6: Solving the Solow model
12. Problem Set 7: Solving the consumer problem with income risk
13. Work on your model analysis project
14. Work on your model analysis project
15. Feedback on model project

GitHub.com (code hosting platform)

- **All course materials will be shared on GitHub**
- **Organization:** www.github.com/NumEconCopenhagen

  Repositories:
  1. **IntroProg-lectures**: slides, course plan, guides etc.
  2. **IntroProg-exercises:** problem sets, solutions etc.

- **Git:** A version-control system for tracking changes in files and coordinating work $\Rightarrow$ integrated in VSCode

Download course content guide

1. Follow the installation guide
2. Open *VScode*
3. Pres *Ctrl+Shift+P* to *command control palette*
4. Write *Git: Clone*
5. Use *https://github.com/NumEconCopenhagen/IntroProg-lectures*
6. Repeat with
   https://github.com/NumEconCopenhagen/IntroProg-exercises
7. Create copies of the folder to work in
8. You can update later with *Git: Sync*

Work-flow

Your work-flow

- **Lectures:**
    1. Watch videos and *try out the code yourself*
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  1. Solve tasks and problems
  2. Fill the missing code
  3. Find the error
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    Note: OK to peak at answers, but write the solution yourself
- **In between classes and lectures:**
    1. Go through lecture notebooks (curriculum)
    2. Solve the problem set
    3. Experiment with your own ideas

Getting help

- **Observation:** Programming is the slow and painful removal of tiny errors in your code – one at a time

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  1. Look in the documentation
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- **Help each other!!** You will learn a lot.
  Remember to be constructive and polite!

Projects

Basic programming test

- **You must complete the following courses on DataCamp**
    1. Introduction to Data Science in Python
    2. Intermediate Python
    3. Python Data Science Toolbox (Part 1)
    4. Python Data Science Toolbox (Part 2)
- **First 3 exercise classes:** Reserved for your work on DataCamp

Inaugural project

- **Objectives:**
    1. Apply simple numerical solution methods
    2. Structure a code project
    3. Document code
    4. Present results
    5. Use GitHub
- **Content:**
    1. Solution of pre-specified economic model
    2. Visualization of solution
- **Structure:**
    1. A self-contained single notebook presenting the analysis
    2. Fully documented python files
- **Hand-in:** Create and commit folder called "inauguralproject" in your GitHub repository

Data analysis project

- **Objectives:**
  1. Apply data cleaning and data structuring methods
  2. Apply data analysis methods
  3. Structure a code project
  4. Document code
  5. Present results in text form and in figures

- **Content:**
  1. Import data from an online source
  2. Present the data visually (and perhaps interactively)
  3. Apply some method(s) from descriptive economics
     (»samfundsbeskrivelse«)

- **Structure:**
  1. A self-contained single notebook presenting the analysis
  2. Fully documented python files

- **Hand-in:** Create and commit folder called "dataproject" in your
  GitHub repository

Model analysis project

- **Objectives:**
    1. Apply model analysis methods
    2. Structure a code project
    3. Document code
    4. Present results in text form and in figures

- **Content:**
    1. Describe an algorithm on how to solve a simple economic model
    2. Solve (and perhaps simulate) a simple economic model
    3. Visualize results across e.g. parametrizations
    4. Analyze one or more extensions of the baseline model

- **Structure:**
    1. A self-contained single notebook presenting the analysis
    2. Fully documented python files

- **Hand-in:** Create and commit folder called "modelproject" in your GitHub repository

Summing up

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- **I hope your have:**
    1. An idea of why learning numerical analysis is important
    2. What you will learn in this course
    3. How you will learn it by working actively and interact with your fellow students
    4. How you will qualify for and pass the exam

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4. **Fourth priority:** Run the example code from this lecture yourself