AMS 595: Fundamentals of Computing: Part II

Lecture 6: Array Computation and Curve Plotting

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Outline

1. Array Computations with NumPy

2. Curve Plotting

3. File I/O for Arrays

Introduction to NumPy

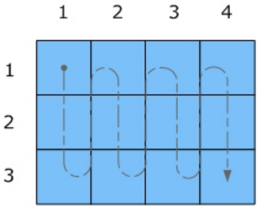
- NumPy provides multidimensional arrays
  - All elements must be the same data type
  - Many different data types supported
  - Size is fixed (memory is allocated for the size specified)
- Arithmetic operations work on arrays
- Provides MANY functions that operate on whole arrays
  - These operations are written in a compiled language, and run fast
  - Generally speaking, you want to avoid loops to get the best performance, although it may make code unreadable

Intro to NumPy: Array Operations

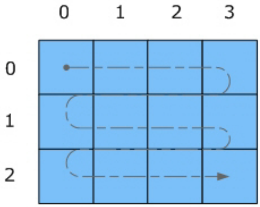
- Arithmetic operator (+, –, /, *) work element-wise
  - A * B is not a matrix product, but is element-wise multiplication, similar to .* in MATLAB
  - instead multiples the corresponding elements in each array together
  - dot(A, B) does a dot product
- Universal functions (sin, cos, exp, ...) work element-wise
- NumPy has a matrix class, which is a subclass of array
  - For matrix objects, A*B is matrix-matrix multiplication
  - For array objects, A*B is element-wise multiplication
  - Note: However, A/B is still element-wise division for matrix objects
- See NumPy for MATLAB users for mapping from MATLAB to NumPy
- Many linear-algebra functions are provided by SciPy (next lecture)
- See Jupyter notebook on NumPy

Key Differences Between NumPy and MATLAB

- 1-based (MATLAB) vs. 0-based (Python) indexing
- Pass by value (MATLAB) vs. pass by reference (Python)
  - In Python, slicing creates a "view" into an array
- Column major vs. row major
  - MATLAB (like Fortran) uses *column major*
  - Python (like C) uses *row major*
  - This is important to understand for efficiency and for passing data between different languages



A: Column-major order (Fortran-style)



B: Row-major order (C-style)

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Plotting using Matplotlib

- Matplotlib is standard plotting library for scientific python
  - Mostly for 2-D data
  - Can use LaTeX commands for equations
  - Can produce "publication-quality" plots; see gallery for examples
- Importing Matplotlib
  - matplotlib is the entire package
  - matplotlib.pyplot is a module within matplotlib that provides easy access to the core plotting routines
  - pylab combines pyplot and numpy into a single namespace to provide MATLAB-like interface
- In Jupyter Notebook, make sure you add `%matplotlib inline`
- See Jupyter notebook on Matplotlib with this sample data

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Text and Binary File

- numpy.loadtxt() provides easy way to load rows of data from text file
- SciPy's scipy.io module provides methods to read and write MATLAB's MAT files, which are binary files