Outline

• Announcements:
  – Homework IV due Wed. 10/8 by 5, by e-mail
  – Extra week for projects
  – Absolutely no exceptions!
  – Answers will be posted on web
  – I will be available during office hours & by appt.
  – Homework III: answers on web
• Homework III
  – AdvDiff1D example
• What you know
• What I haven’t told you, & where to find out more
• Course Evaluations

Homework

• Solution to 6 was harder than I thought
  – x=[1 2 3 3 3]
  – d=diff(x)-->[1 1 0 0]
  – d=diff(d)-->[0 -1 0]
  – find(d==0)-->[1 3]
• Need to do the diff and scan for n-1 0’s.
  – I=[]
  – for j=1:length(d)-n+2
    • if(sum(d(j:(j+n-2)))
      • I=[j];
    • end
  – end
Numerical Solution

- This is a matrix problem
  - $A*C_{t+dt}=f(C_t)$
- Each grid point will have a row in matrix $A$
  - $A(j,:)=[0 \ldots 0,-s,(1+2s),-s,0 \ldots 0]$
- All rows are the same except for first and last
  - We need to specify what happens at end points
- Boundary conditions are a big problem
  - We'll use periodic BC's
    - $C(0)=C(1)$, so first and last rows are:
      \[
      \begin{bmatrix}
      (1+2s) & -s & \cdots & -s \\
      -s & (1+2s) & -s & \cdots \\
      \end{bmatrix}
      \]

Numerical Solution

- Algorithm:
  - build $A$
  - for $j=1:n$
    - build RHS=$f(C_j)$
      - $C_{t+dt}=A\cdot$RHS
        - very time consuming!
  - end

Numerical Solution

- Same $A$ used in each iteration
- Factor once:
  - build $A$
  - $[L,U]=lu(A);$ chol would be better..
  - for $j=1:n$
    - build RHS=$f(C_j)$
      - $y=L\cdot$RHS; ---forward substitution
      - $C_{t+dt}=U\cdot y;$ ---back substitution
  - end
Sparse Matrices

- A is sparse
  - the only non-zero elements are immediately above, below, and on the diagonal
  - corners for periodic BC’s
- Matlab has special sparse matrices
  - much less memory (don’t need space for 0’s)
  - faster to process
  - A=sparse(I,J,S) forms A s.t.
    A(I(j),J(j))=S(j)

AdvDiff1D.m

- Uses slightly more complicated procedure for advection known as “Lax-Wendroff” method
- Must specify
  - Initial concentration C0
  - parameters (u, k)
  - size of domain L
  - length of time T
  - dx, dt
- Returns x, t, and C(x,t)

What Do You Know?

<table>
<thead>
<tr>
<th>Data</th>
<th>Program</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currents</td>
<td>Static</td>
<td>Geostrophic eq.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TC/T plot</td>
</tr>
<tr>
<td>Weather</td>
<td>TC/T</td>
<td>Wave def</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TC/T in future</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>DNA</td>
<td>Search for genes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Location of genes</td>
</tr>
<tr>
<td>Electronics</td>
<td>Signal</td>
<td>FFT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plot of spectrum</td>
</tr>
</tbody>
</table>

- You know enough Matlab to solve any of these problems
What Do You Know?

• You know how to
  – get ASCII and binary data into Matlab
  – data are stored in arrays (vectors, matrices, ND-arrays)
  – Manipulate data with array operations
    • find, relational and logical operators
  – get data out of Matlab

What Do You Know?

• You know that Matlab has built in functions for
  – statistics
  – graphics
  – solving ODE’s
  – optimization
  – linear algebra

What I Haven’t Told You

• Matlab has lots of functions, and you’ll never know them all
  – learn about functions through
    • help, helpwin, or help browser (through GUI)
    • www.mathworks.com
**What I Haven’t Told You**

- Other important packages
  - splines (turn anything into a smooth function)
  - signals (beyond FFT)
  - finance (follow the money)
  - mapping (explore your world)
  - Simulink (GUI for creating dynamical systems)

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**What Do You Know?**

- You know how to extend Matlab’s capabilities through functions
  - function [outputs]=fname(inputs);
- And that Matlab is a procedural programming language
  - Iterations with for & while loops
  - Conditionals with if-elseif-else-end
  - error(estring)
- And that Matlab functions can be polymorphic
  - nargin, varargin, etc.

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**What Do You Know?**

- Matlab is more than just arrays of doubles
  - structs--similar to C-structs or Java objects
  - cell-arrays-- arrays of anything
What Do You Know?

• Matlab can do graphics
  – plot—plots of 1D functions
  – bar—bar plots
  – surf, pc_color—plots of 2D functions with color
• Matlab’s graphics can be programmed
  – Build functions for specialized graphics

What I Haven’t Told You

• There are lots of graphics functions
  – patch, imagesc, plot3, fill, isosurface
• Graphics have lots of properties to play with
  – color, light, markers, text, size, position
• Matlab has a system for working with graphics
  – handle graphics
• Shameless plug for CIS 402!

Other Scientific Computing Courses

• CS421—Introduces basic concepts and issues in scientific computing and numerical analysis
• CS621, CS622, CS624—Advanced scientific computing and numerical analysis (Matrices, Optimization, ODE/PDE’s)
• Math and Applied Math offer courses on linear algebra, ODE/PDE’s
• Domain-specific courses in your department
Evaluations

- Please give me as much data as you can
  - specific lecture/topics you liked & those you didn't
  - other topics to cover?
  - were tutorials useful?
- Thanks!