Part II Exercises

Comprehensive Questions to discuss in the groups

Are finite-difference-based approximations of partial-differential equations unique (give arguments)?
What strategies are there to improve the accuracy of finite-difference derivatives? Give the procedures in words.

Which propagation direction is most accurate on a rectangular (square) grid? Can you suggest any reasons why this might be so?

Explain the meaning of the term *pseudospectral*. What is so *spectral* about the pseudospectral method?

The pseudospectral method appears simple, elegant, and very accurate. Why is it not the preferred method of choice today? Could the pseudospectral concept in 2(3)D be combined with the finite-difference method (for space derivatives)?

Simple theoretical Problems to try

Show that

$$\frac{f(x+dx) - 2f(x) + f(x-dx)}{dt^2}$$

is an approximation for the second derivative of $f(x)$ with respect to x at position x. Hint: Use Taylor series

$$f(x+dx) = \sum_{n=0}^{\infty} \frac{f^{(n)}(x)}{n!} dx^n,$$

Develop a finite-difference algorithm for this equation. Replace partial derivatives by finite-difference approximations. Extrapolate to u(x,to+dt). Is the solution unique?

$$\partial_t u(x,t) = v \partial_x u(x,t),$$

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Programming exercises (Choice)

"Open" on "fd_first_derivative" , extend to 5 point operator

"Open" on "fd_ac1d", extend to 5 point operator

Run any FD, PS or FE method and increase the time step dt until the solution turns unstable. Try to understand the codes inside the time extrapolation loop.

Run the fd2d_heterogeneous notebook and play with the various heterogeneous models. Invent your own velocity model!