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8.3.1 Solving $Ax = b$

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Week 8 due Nov 26, 2023 15:12 IST

8.3.1 Solving $Ax = b$ via LU Factorization

Around minute 1:30 there a few problems...

A comparison

Solving $Ax = b$ via LU factorization:

Factor $A = LU$	$\frac{2}{3}n^3$ flops
Solve $Lz = e_j$	n^2 flops
Solve $Ux_j = z$	n^2 flops

Total cost: $\frac{2}{3}n^3 + 2n^2$ flops.

Solving $Ax = b$ via invert and multiply

Invert A	$2n^3$ flops
Multiply $b = A^{-1}x$	$2n^2$ flops

Total cost: $2n^3 + 2n^2$ flops.

$Lz = e_j$ should be $Lz = b$.

$Ux_j = z$ should be $Ux = z$.

$\mathbf{b} = \mathbf{A}^{-1}\mathbf{x}$ should be $\mathbf{x} = \mathbf{A}^{-1}\mathbf{b}$.

(This video was made during a busy time last spring...)

Thanks to "bzeckel" for pointing this out.

Summary

- ▶ Usually, you don't invert a matrix!
- ▶ If someone talks about inverting a matrix, be suspicious!
- ▶ Some people use the term "inverting a matrix" interchangeably with "solving $Ax = b$ ".
- ▶ These comments may not apply for small matrices.
- ▶ There is also an issue with numerical stability.

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4:21 / 5:26

2.0x

Video

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Reading Assignment

0 points possible (ungraded)
Read Unit 8.3.1 of the notes. [LINK]

Done

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Topic: Week 8 / 8.3.1

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<div><div>?</div><div>Question</div><div>Hi! I just took an algorithm course last semester, and the algorithm analysis here is a bit different from what I learned in the algorithm course. Fr...</div><div>2</div></div>	
<div><div>?</div><div>Inverting flops</div><div>Why does inverting matrix A cost $2n^3$? flops?</div><div>2</div></div>	

Homework 8.3.1.1

1/1 point (graded)
Let $A \in \mathbb{R}^{n \times n}$ and $x, b \in \mathbb{R}^n$. What is the cost of solving $Ax = b$ via LU factorization (assuming there is nothing special about A)? You may ignore the need for pivoting.

approximately $\frac{2}{3}n^4 + 2n^2$ flops

approximately $2n^3 + 2n^2$ flops

approximately $\frac{2}{3}n^3 + 2n^2$ flops

LU factorization requires approximately $\frac{2}{3}n^3$ flops and the two triangular solves require approximately n^2 flops each, for a total cost of

Calculator

$\frac{2}{3}n^3 + 2n^2$ flops.

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i Answers are displayed within the problem

Homework 8.3.1.2

1/1 point (graded)
Let $A \in \mathbb{R}^{n \times n}$ and $x, b \in \mathbb{R}^n$. What is the cost of solving $Ax = b$ if you first invert matrix A and then compute $x = A^{-1}b$? (Assume there is nothing special about A and ignore the need for pivoting.)

☐ approximately $\frac{2}{3}n^4 + 2n^2$ flops

☒ approximately $2n^3 + 2n^2$ flops

☐ approximately $\frac{2}{3}n^3$ flops



Inverting the matrix requires approximately $2n^3$ flops and the matrix-vector multiplication approximately $2n^2$ flops, for a total cost of, approximately,

$2n^3 + 2n^2$ flops.

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