Linear Algebra

CSCI 2820

Prof. Alexandra Kolla

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ECES 122

Add a picture.

Why are we here?

- Linear algebra is a main underlying tool for a lot of computer science applications
- Machine learning
- Robotics
- Operations research
- Theory
- Quantum Computing

- **This class:** you will learn the basic tools of Linear Algebra and how they apply to various aspects of computer science

Add a picture.

Why are we here, meta?

- The world obeys Quantum Theory (old news!)
- Computers that fully harness quantum effects could outperform classical ones.
- Building quantum computers is very hard, but not ridiculously, impossibly hard.
- We are at a special moment: beginning to build nontrivial quantum computers
- It all begins with Linear Algebra…

Today

- Logistics
  - Who are we?
  - Who are you?
  - Grading
  - Outline

Who are we

- Instructor: Alexandra Kolla (Alexandra.kolla@Colorado.edu)
- GSS:
  - Nivetha Kesavan (Nivetha.Kesavan@colorado.edu)
  - Rick Gentry (Rick.Gentry@colorado.edu).
- CA: Zachary Jorquera (Zackary.Jorquera@colorado.edu)

Who are we

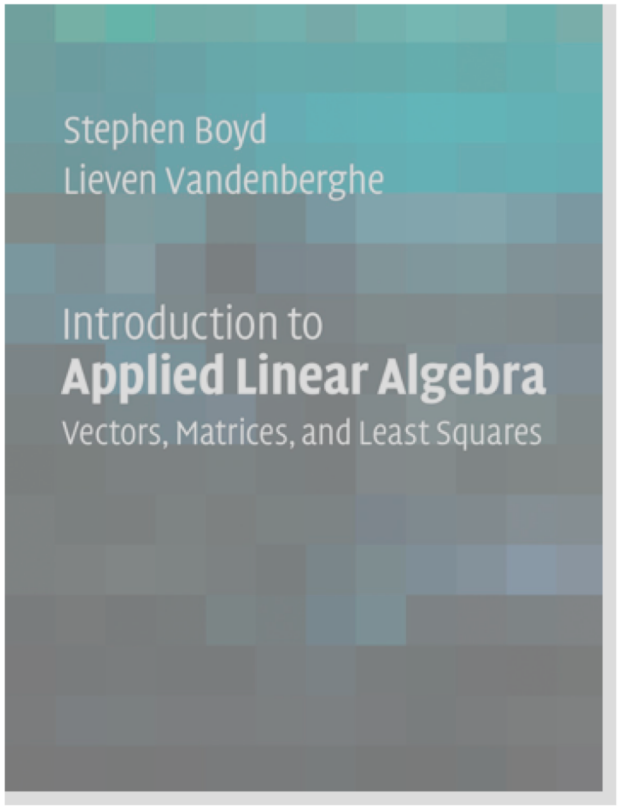
- Class webpage: https://home.cs.colorado.edu/~alko5368/indexCSCI2820.html
- Canvas shortly
- Office hours: TBD this week

Grading Scheme

- 60% Weekly Problem sets
- 15% Midterm 1 (take-home)
- 15% Midterm 2 (take-home)
- 20% Final (take-home)

- Absolutely no late homeworks, will drop 2 worst grades.

Textbook


Stephen Boyd
Lieven Vandenberghe
Introduction to
Applied Linear Algebra
Vectors, Matrices, and Least Squares

What we'll cover

- Vectors:
  - Definitions and notations, vector operations, inner product, linear functions, norm and distance, linear independence, bases, Gram Schmidt, vector spaces, complexity of computations.
- Matrices:
  - Definitions, Zero and Identity, operations, examples of matrices. Linear equations, matrix multiplication, QR factorization, matrix inverse.
- Spectra:
  - Diagonalization, eigenvalues and eigenvectors, invariant spaces.
- Least Squares
  - Least Squares problem, solution, data-fitting, classification (time permitting…)

To discuss

- Flip classroom?
- Expectations
- Pace of material
- Background (who knows what a vector is?)

Today

- What is a vector
- Vector addition
- Scalar-vector multiplication
- Examples

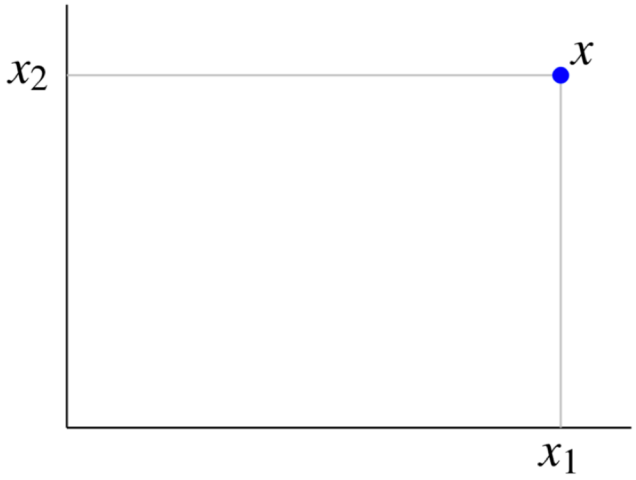
Vectors

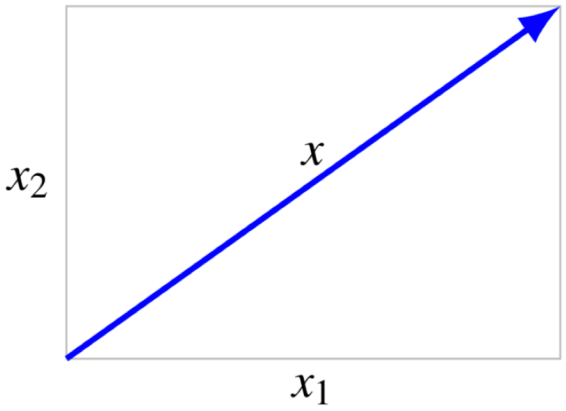
Vectors

Vectors

Location or displacement in 2-D or 3-D

2-vector (x_1, x_2) can represent a location or a displacement in 2-D





Word count vectors

- a short document:

> **Word** count vectors are used **in** computer based **document** analysis. Each entry of the **word** count vector is the **number** of times the associated dictionary **word** appears **in** the **document**.

- a small dictionary (left) and word count vector (right)

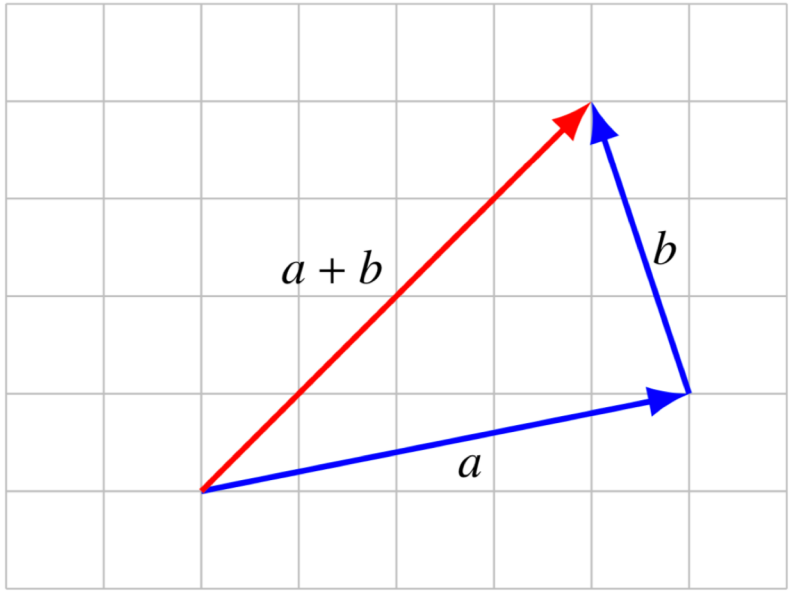
$$\begin{array}{ll} \text{word} & \begin{bmatrix} 3 \\ 2 \\ 1 \\ 0 \\ 4 \\ 2 \end{bmatrix} \\ \text{in} & \\ \text{number} & \\ \text{horse} & \\ \text{the} & \\ \text{document} & \end{array}$$

Vector addition

Vector addition

Adding displacements

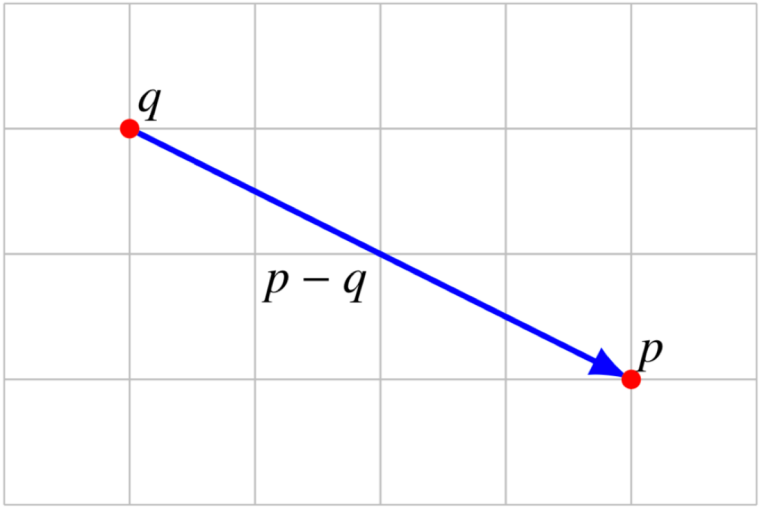
if 3-vectors a and b are displacements, $a + b$ is the sum displacement



Vector addition

Displacement from one point to another

displacement from point q to point p is $p - q$



Scalar-Vector multiplication

Scalar-Vector multiplication

Scalar-Vector multiplication

Scalar-Vector multiplication

Scalar-Vector multiplication

Example

two vectors a_1 and a_2, and linear combination $b = 0.75a_1 + 1.5a_2$