Introduction

CS 205A:
Mathematical Methods for Robotics, Vision, and Graphics

Justin Solomon

Instructor

Justin Solomon

Office: Clark S297

Telephone: (650) 725-6521

Email: justin.solomon@stanford.edu

Office hours: W, 10am-12pm

Course Assistants

Joongyeub Yeo

Email: yeo@stanford.edu
Office hours: T, 1pm-3pm
Location: Gates B26A

Yang Zhao

Email: yzhao3@stanford.edu
Office hours: F, 2pm-4pm
Location: Gates B26A

Section

Fridays, 4:15pm-5:05pm
Hewlett 102

On the Web

Course website:
http://cs205a.stanford.edu

Piazza:
http://piazza.com/stanford/fall2013/cs205a

Office hours (GChat):
cs205a.ta

Texts

- **Official text:** *Scientific Computing*, Heath
- **Course notes:** On website
  - *Warning:* May contain typos!
  - Responsible for textbook material
  - Corrections, comments, and suggestions encouraged

Course Breakdown

- **Homeworks (approx. weekly):** 60%
- **Midterm:** 15%
- **Final exam:** 25%
- **Participation:** $\pm 5\%$
    - Corrections or comments on notes
    - Participation in lecture, office hours, and Piazza

Course Topics I

1. Numerics
   - ▶ Stability and error analysis
   - ▶ Floating-point representations

2. Linear algebra
   - ▶ Gaussian elimination and LU
   - ▶ Column spaces and QR
   - ▶ Eigenproblems
   - ▶ Applications

3. Root-finding and optimization
   - ▶ Single-variable
   - ▶ Multivariable
   - ▶ Constrained optimization

Course Topics II

- ▶ Iterative linear solvers: Conjugate gradients and friends

4. Interpolation and quadrature
- ▶ Approximating integrals
- ▶ Approximating derivatives

5. Differential equations
- ▶ ODEs: time-stepping, discretization
- ▶ PDEs: Poisson equation, heat equation, waves
- ▶ Techniques: Differencing, finite elements (time-permitting)

Two Roles

- **Client** of numerical methods

- **Designer** of numerical methods

Variational Viewpoint

Minimize objective **subject to** constraints

- $A\vec{x} = \vec{b} \iff \min \|A\vec{x} - \vec{b}\|^2$
- $A^\top A\vec{x} = \lambda\vec{x} \iff \min \|A\vec{x}\| \text{ s.t. } \|\vec{x}\| = 1$

Official Prerequisites

Math 51 and **CS 106B**

Typical Linear Algebra

$$\|A\vec{x} - \vec{b}\|^2 = (A\vec{x} - \vec{b}) \cdot (A\vec{x} - \vec{b})$$
$$= (A\vec{x} - \vec{b})^\top (A\vec{x} - \vec{b})$$
$$= (\vec{x}^\top A^\top - \vec{b}^\top)(A\vec{x} - \vec{b})$$
$$= \vec{x}^\top A^\top A\vec{x} - x^\top A^\top \vec{b} - \vec{b}^\top A\vec{x} + \vec{b}^\top \vec{b}$$
$$= \|A\vec{x}\|^2 - 2(A^\top \vec{b}) \cdot \vec{x} + \|\vec{b}\|^2$$

Course Information
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Course Overview
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Course Themes
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Background Material
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Necessary Calculus

- Gradient vector ∇f for $f : \mathbb{R}^n \to \mathbb{R}$
- Jacobian Df for $f : \mathbb{R}^m \to \mathbb{R}^n$
- Lagrange multipliers for minimizing $f(\vec{x})$ subject to $g(\vec{x}) = \vec{0}$

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Homework 0

Due one week from today!

To review:

- Linear algebra
- Calculus

> Next