# CS510: Image Computation

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# Course Theme

- Stage I : Text-based Computers
  - Manual data entry, command-line int **Done**
- Stage 2 : Image Output (graphics on screens)
  - Gaming computers (e.g. Xbox)
  - Window-based operating systems **Ending**
  - Applications: Maps, YouTube, etc.
- Stage 3 : Image Input (cameras everywhere)
  - Gaming (e.g. Kinect)
  - Security (e.g. Face recognition, **Beginning!**
  - Ubiquitous Computing (e.g. Self-driving cars)

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# Course Goals

- Prepare students for graduate level research in computer vision
  - Note: no one on the current CSU faculty does (or advises) Ph.D.-level research in graphics.

- Prepare students to integrate vision into new applications (Stage 3!)

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# Prerequisites

- You are assumed to know:
    1) Geometric primitives: points, lines, vectors …
    2) Homogeneous coordinates
    3) 3D transformations & their compositions
    4) Perspective Projection
    5) Geometry of camera models
    6) Lighting models & material properties

- Note that this material will not be reviewed: it is assumed that you know it and can build on it.

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# Course Outline

1. Images & Image Matching
   A. Image Transformations
      - Geometric Transformations
      - Photometric Transformations
   B. Template matching
      - Pearson's correlation
      - Linear correlation
      - Convolution
   C. Fourier Transforms
      - 1D & 2D Discrete Fourier Transforms
      - Image space interpretation
      - Correlation & convolution in frequency domain

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# Course Outline (II)

1. Images & Image Matching (cont).
   D. Scale
      - Scale-space theory
      - Image pyramids
      - Super-resolution
   E. Correlation filters
      - MACH filters
      - ASEF/MOSSE filters
   F. Principal Components Analysis
      - Covariance minimization & compression
      - Gaussian process model
      - Subspace projection

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# Course Outline (III)

2. Image Features & Feature Matching
   A. Correspondence-free approaches
      A. Local Features
         – Edges (Sobel, Canny)
         – Corners (Harris)
         – DoG (Lowe)
      B. Feature Descriptors
         – SIFT
         – HoG
         – Color spaces & color histograms
      C. Matching
         – Bag of Words
         – Deformable Shape Models

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# Course Outline (IV)

2.  Image Features & Feature Matching (cont).

   A.  Correspondence-based Approaches

- RANSAC & Geometric Hashing

- Active Shape Models

- Pose estimation

- SLAM

  – Simultaneous Localization and Mapping

# Textbooks

- No single textbook covers these topics.
- Nonetheless,
  - We will mostly use Rick Szeliski's text
    - http://szeliski.org/book
    - free & online
  - We will also use CVOnline
    - http://homepages.inf.ed.ac.uk/rbf/CVonline/
    - Free & online, but less well edited
  - Simon Prince's book is also available (but…)
    - http://www.computervisionmodels.com/
  - I will sometimes reference Shapiro & Stockman's text
    - Outdated, but good on basics
    - Unfortunately, not on line, so I must summarize…

# Requirements

- 1) Four programming assignments (75%)
  - Each section has an "easy" assignment, then a hard one
  - In C, C++, or Python
    - Java OpenCV interface is still incomplete
  - Use of OpenCV recommended
    - Qt OK for GUIs.
    - Any other library : ask me first!
  - Variations on assignments are encouraged -- but check with me first!

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# Requirements (II)

- Midterm (10%)
- Final exam (10%)
  - Non cumulative
- In class participation (5%)
  - Subjective on my part
  - Discussions, questions, etc.
  - So be pro-active! Get involved!

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# Class Slides

- Class slides (lectures) go on the class web page.
  - As soon as the current bug is fixed.

- The class web page is a general source of useful information, including links to interesting computer graphics and/or computer vision web sites:
    - http://www.cs.colostate.edu/~cs510

# Discussion

- What can a computer use a camera for?
- Examples:
  - iPhoto
  - Google Image Search
  - Star Walk (constellation finder)
  - Augmented reality
    - Subway finder, etc.
  - Driver assist
    - Lane changes
    - Obstacle avoidance
    - Automatic parking
  - Security / HCI
    - Is the person sitting at the computer the person who is logged in?

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# One last thing…

- Send me an email from the account you read most often, with the subject line "Spring CS510"
  - I will use this to make a real class mailing list
  - (Aries web emails are too often not real)

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