CS 381 – FALL 2019

Week 1.1, Monday, August 19

Lectures

- Questions
  - I welcome clarification questions during lectures
- Remote Lecture?
  - I am attending CRYPTO in Santa Barbara
  - Prof. Atallah will teach class on Wednesday
  - I will be back on campus on Friday (Skype won't be the norm!)
  - Kevin Xia (GTA) can relay questions today

Wait List

- Maximum Enrollment*: 150
- Wait List: 17 (as of 8/18/2019)
- I will speak to the CS registrar to see if it is possible to open up additional slots after the first week
  - Seniors who still need to take the course would receive priority
  - I cannot make definitive promises

Course Personnel

Instructor

- Professor J. Blocki

Graduate TAs

- Kevin Xia *(head TA)*
- Tunazzina Islam
- Hai Nguyen
- Ahammed Ullah

Undergraduate TAs

- Michael Cinkoske
- Noah Franks
- Hiten Arun Rathod
- Abhishek Sharma (Head UTA)
- Himanshi Mehta
- Utkarsh Jain

Office Hours will be posted on Piazza
(Office Hours Begin 2nd Week)

Instructor Office Hours (Week 1): Fri, 2:30-3:30 PM

Course Resources

Course website

- www.cs.purdue.edu/homes/jblocki/courses/381_Fall19/
- Course policies, syllabus, course work, links to related material

Piazza

- https://piazza.com/class/jyk8rg9el1s5m6
- For discussion on course material, assignment questions
- Slides, assignments and solution sketches are posted
- Sign up!

Course Resources

Gradescope

- submitting typed assignments
- View graded exams
- Submit re-grade requests*
  (re-grade policy discussed later)

Blackboard

- register your clicker before Friday!
- Grades
- (Optional) CS580 Lectures

Coursework and Grades

- **Assignments:** 20%
  - 7-8 written assignments
  - Must be typed, submitted on Gradescope
- **Clickers:** 5%
  - You can communicate with your neighbors
  - No makeups (lowest score dropped)
- **Exams**
  - closed book & notes, cheat sheet allowed
  - Midterm 1: 20% (Sep 25th. 8PM)
  - Midterm 2: 20% (Oct 30th. 8PM)
  - Final exam: 35%

Prerequisites for 381

- **CS 182**
  - Applications of discrete math in CS
  - Proof techniques: direct, indirect, induction
  - Abstractions, recursion, counting
- **CS 251**
  - Very good understanding data structures (their use, implementations, limitations, tradeoffs)
  - Ability to judge and think through an implementation without coding
  - No programming assignments in 381

More on prerequisites

- Data structures
  - Stacks, queues, search trees (binary, balanced), priority queues, hashing, trees, graphs
  - Operations on data structures under different implementations

More on prerequisites

- Algorithms
  - Searching and sorting
  - Graph and tree traversals (BFS, DFS, pre, post, inorder)
  - Computing graph properties
  - Examples of greedy algorithms: Shortest path, min spanning tree
  - Analyze asymptotic performance of given code

Course Highlights

- Introduction to the Analysis of Algorithms
  - Central to all of Computer Science!
- Techniques to Design Efficient Algorithms
  - Greedy, Divide and Conquer, Dynamic Programming, Network Flow, Reductions etc…
  - Desiderata: Efficient, Concise and Correct
- Analysis
  - Analyze required resources to execute (space/time)
  - Prove that the algorithm is correct

LIFE-CRITICAL SYSTEM VERIFICATION

"If it fails, people die."

Theoretical computer scientists harness the power of logic and mathematics
to provide a provable guarantee of safety.

Course Highlights

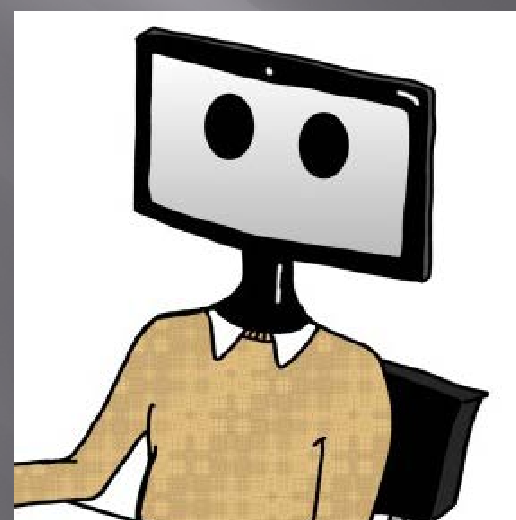
- Problem Solving!
  - Abstracting the essential features of a problem
  - Developing creative, efficient, and non-obvious solutions to problems.
  - Analyzing an algorithm's performance and resource usage in a machine and language independent way.

- Understanding computational limitations
  - Are there problems that don't permit efficient algorithmic solutions
  - P vs. NP (Million Dollar Problem)

Homework Solutions

- What you submit needs to be understandable (and typed)
- We want human readable pseudo code
  - Target audience is a human TA not a compiler!

CS381 GTAs



Not a TA

Homework Solutions

- Graded for correctness, clarity, conciseness, rigor, and efficiency
- Type using any software supporting math notations (good opportunity to learn LaTeX)
- Read homework guidelines on course webpage

Cannot Solve Problem?

- Partial Credit
  - Clearly identify a reasonable approach to solve the problem
  - Maximize partial credit by identifying gaps in your attempted solution
- Better to acknowledge that you don't know than to pretend you solved it.
  - 15% credit for simply admitting "I could not solve the problem"
  - Can receive 0% credit for bad/obfuscated ``solutions"

Exams

- Closed Book (No Phones, Laptops, Calculators, Smart watches etc…)
  - Allowed one sided page of handwritten notes
  - Communicate only with course staff during exam

- Disability Requiring Special Accommodation:
  - Contact instructor promptly (first 3 weeks of class)
  - Need official letter from Disability Resource Center

- Final Exam (TBD)
  - Do not book travel before last possible date (Dec 14^{th})

Regrade Requests

- Graders are human, please be patient!

- Submit on Gradescope
  - Within 14 days of return of assignment (exception for final exam)
  - Should clearly explain what you think the grader missed
  - Not an opportunity to expand your answer!
  - Double Check Carefully
    - Your grade can go up or down!
- Appeal Rejected Regrade?
  - 2 points bonus I agree you are correct (for your trouble)
  - 2 points deduction if I agree with TA (most common outcome)

Course standards and policies

- Collaborations is allowed, but you must acknowledge collaborators on your homework
- Don't cheat yourself out of learning how to solve problems!
  - Suggestion: spend at least 15 minutes thinking about each problem yourself before collaborating
- Reference all sources used
  - Failure to acknowledge a collaborator or key source is cheating!
- All submitted solutions must be written entirely in your own words!
- You must understand your solution completely
  - If you could not explain your solution to course staff that is considered cheating!

https://www.cs.purdue.edu/homes/jblocki/courses/381_Fall19/syllabus/syllabus.pdf

Late Homework

- Not Late
  - No Penalty
- Less than 24 hours late
  - 10 point penalty (out of 100 possible points)
  - Subtracted from final score
- 24 to 48 hours late
  - 25 point penalty (out of 100 possible points)
  - Subtracted from final score
- More than 2 days late
  - No Credit ☹

About Copyright

- Course materials, including slides, tests, and other course materials, are protected by copyright.
  - I am the owner of the copyright in the materials I create.
  - CLRS/KT/W/Susanne etc… are the owners of the material I use from the slides they provide.
- You may make copies of course materials for your own use.
- You may not and may not allow others to reproduce or distribute lecture notes and course materials publicly without written consent.
- Similarly, you own copyright in your answers to assignments.
  - If I am interested in posting your answers on the course web site, I will ask for your written permission.

Piazza Rules of Conduct

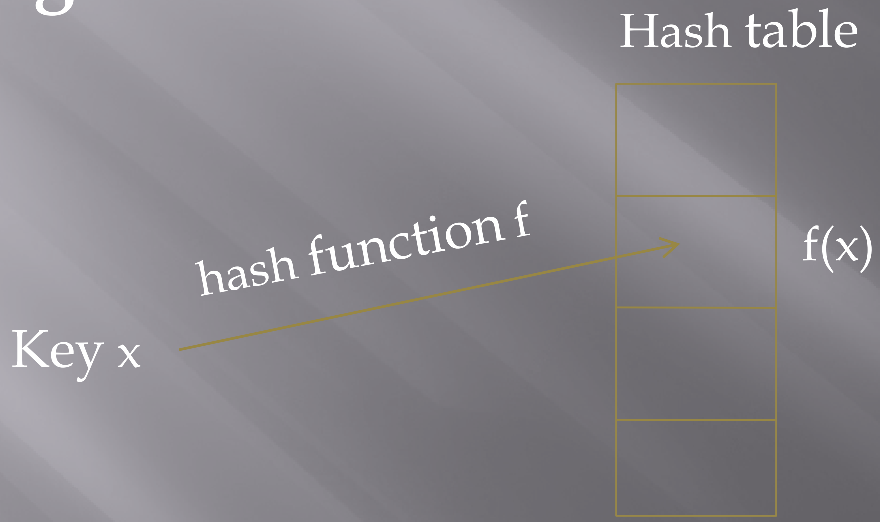
- Piazza is intended for clarification of questions of general interest.
- Piazza cannot be used to post answers to assignments, detailed descriptions of solutions, or hints.
- Piazza is not the forum for complaints about an assignment, exam, or the class.
  - Any concerns should be brought to the attention of the instructor.
- Be courteous and professional when posting/emailing and use appropriate language.
- If you are not sure whether a posting is appropriate, make sure it is made private or e-mail us.

Your tasks

- Register your clicker
- Sign up on Piazza
- Suggested Reading
  - CLRS: Sections 10 and 12 (data structures)
  - CLRS: Appendices A and B (discrete math)
- Assignment 1 will be posted by Friday
  - Review of material needed for algorithm analysis
- Attend PSOs to review proof techniques

A Remark about Hashing

- Hashing (for insert, delete, search) is important and effective
- **Algorithms in CS381 do not use hashing**



Collisions can lead to poor worst case performance

- To get O(1) expected performance per operation, one needs the right table size, a good hash function and good collision resolution

Warm Up: Sorting

Input: n numbers $a_1, \ldots, a_n$ stored in an array A

Output: sorted sequence of size n

(increasing = non-decreasing)

Algorithms you should know

- *Bubble sort, Insertion Sort, Selection Sort*
- Merge Sort, Quicksort, Heapsort

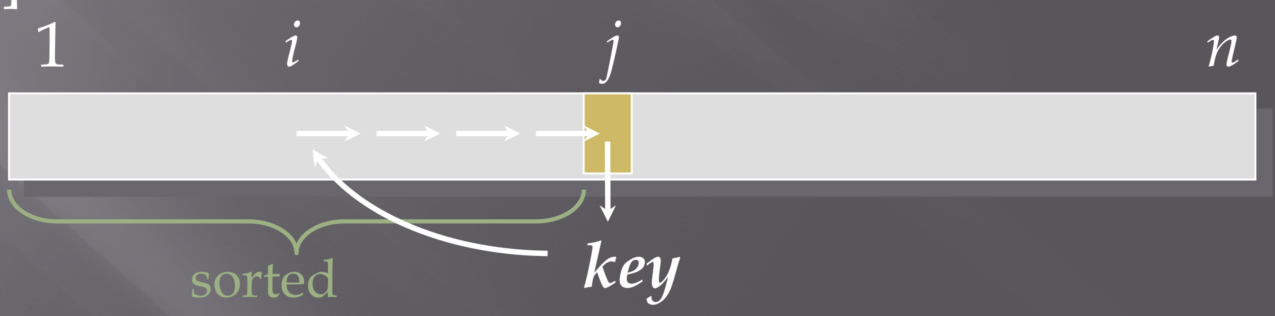
Review

- asymptotic performance, stable sorting, in place sorting

Insertion Sort

- create the sorted sequence in an incremental way
- start with a sorted sequence of length 1 and insert one more element in each iteration

INSERTION-SORT (A, n)
for $j \leftarrow 2$ to n do
    $key \leftarrow A[j]$
    $i \leftarrow j - 1$
    while $i > 0$ and $A[i] > key$ do
        $A[i+1] \leftarrow A[i]$
        $i \leftarrow i - 1$
    $A[i+1] = key$



What is the running time of Insertion Sort?

Number of times the while-loop is executed depends on the input

- increasingly sorted input is fast; decreasing is slow.
- Worst case? $\sum_{j=2}^{n} j \; < \; n^2$
- Average case?

What all do we count/have to count when analyzing time?

- In (internal) sorting algorithm we generally count the number of comparison

Asymptotic Performance

Pseudo code has two nested loops

- while loop moves left from j to 1
- total time won't be more than quadratic.

Note: A doubly nested loop does not necessarily result in quadratic time

Worst case: $T(n) = O(n^2)$

- Work is bounded by summing the first n-1 integers which is equal to $n(n-1)/2$
- Time is proportional to n^2
- Also, $T(n) = \Theta(n^2)$

Insertion Sort: Correctness

INSERTION-SORT (A, n)

for $j \leftarrow 2$ to n do

Pre-Condition: A[1]≤ A[2] … ≤ *A*[*j* − 1]

$key \leftarrow A[j]$

$i \leftarrow j - 1$

while $i > 0$ and $A[i] > key$ do

$A[i+1] \leftarrow A[i]$

$i \leftarrow i - 1$

$A[i+1] = key$

Post-Condition: A[1]≤ A[2] … ≤ A[*j*]

Insertion Sort: Correctness

INSERTION-SORT (A, n)
for $j \leftarrow 2$ to n do
Pre-Condition: $A[1] \leq A[2] \ldots \leq A[j-1]$
$key \leftarrow A[j]$
$i \leftarrow j - 1$
while $i > 0$ and $A[i] > key$ do
$A[i+1] \leftarrow A[i]$
$i \leftarrow i - 1$
$A[i+1] = key$
Post-Condition: $A[1] \leq A[2] \ldots \leq A[j]$

Post-Condition when j=n → entire array A is sorted.

Insertion Sort: Correctness

Pre-Condition: $A[1] \leq A[2] \ldots \leq A[j-1]$

$key \leftarrow A[j]$

$i \leftarrow j - 1$

Define $A_{orig}[1,\ldots,j\text{-}1] := A[1,\ldots,j\text{-}1]$

while $i > 0$ and $A[i] > key$ do

$A[i+1] \leftarrow A[i]$

$i \leftarrow i - 1$

Invariant: $A[1,\ldots,i\text{-}1] = A_{orig}[1,\ldots,i\text{-}1]$ (untouched)

$A[i+2,\ldots,j] = A_{orig}[i+1,\ldots,j\text{-}1]$ (shift once*)

$key < A[i+2]$

$A[i+1] = key$

Post-Condition: $A[1] \leq A[2] \ldots \leq A[j]$