Algorithms and Data Structures for Data Science

Sorting

CS 277
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UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN
Department of Computer Science

mp_train due Wednesday!

Optional extra credit will be worth extra credit, currently 0 points

Can request a 24-hour extension policy

https://forms.gle/1KreTgcfJb1fXQeQ6

Request one-on-one office hours by emailing with a list of times

Reminder: Sign up for exam 1!

Sign up at: https://cbtf.engr.illinois.edu/sched

Email DRES accomodations: http://cbtf@illinois.edu/

Exam 1: Python Fundamentals

Conditionals: How to write, how to read, relation to logic

Lists: How to look up elements, how to write 1D and 2D lists

Loops: How to write and evaluate loops

Exam 1: Logic

Logic Operators: Understand truth tables and underlying meaning

Logic Equivalencies: Negation, converse, contrapositive

How to write, read, evaluate and code:

Compound propositions and predicates

Quantifiers and compound quantifiers

Exam 1: Lists

List ADT: How to write and use common list functions

Linked List: How to write and use, Big O efficiency of methods

Array List: How to write and use, Big O efficiency of methods

Exam 1: Stacks and Queues

How to write and use, Big O efficiency, how order is maintained

Exam 1: Coding Questions

You will have a choice of coding questions on exam

1. Code up a compound predicate with quantifiers

2. Create a 2D matrix with a specific set of values

Learning Objectives

Motivate the need for sorting

Sample the space of available sorting algorithms

Introduce recursion

The Sorting Problem

Given a collection of objects, C, with comparable values, order the objects such that $\forall x \in C, x_i \leq x_{i+1}$

Input:

8	4	3	1	2	5	6	9	0	7

Output:

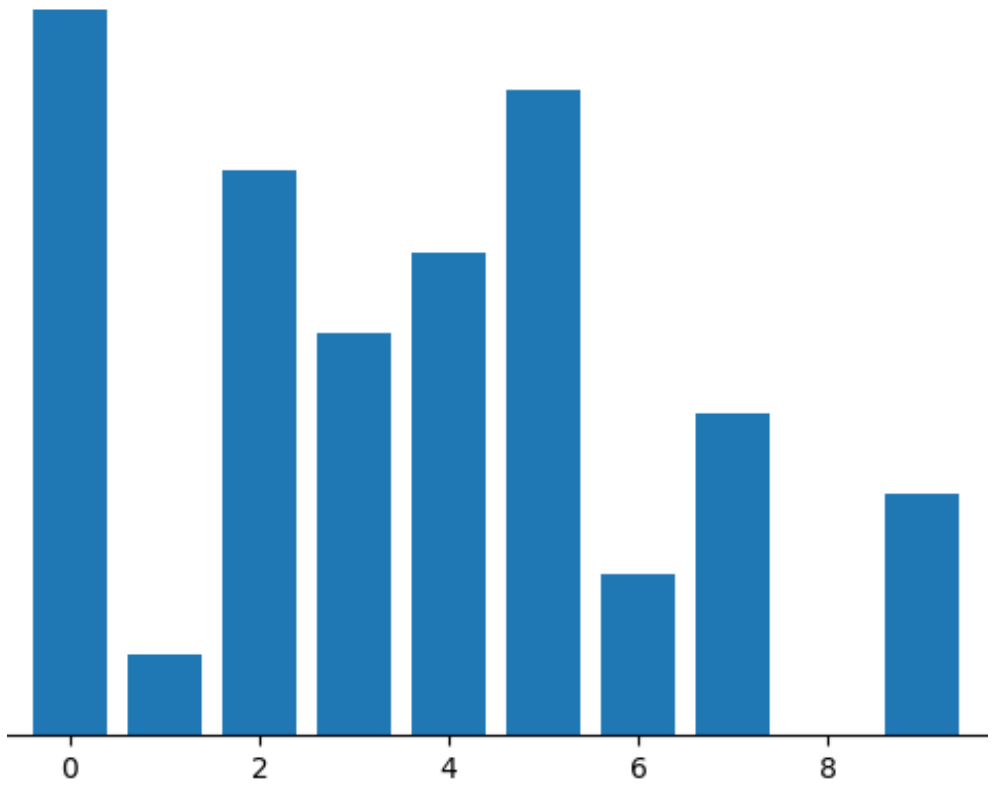
0	1	2	3	4	5	6	7	8	9

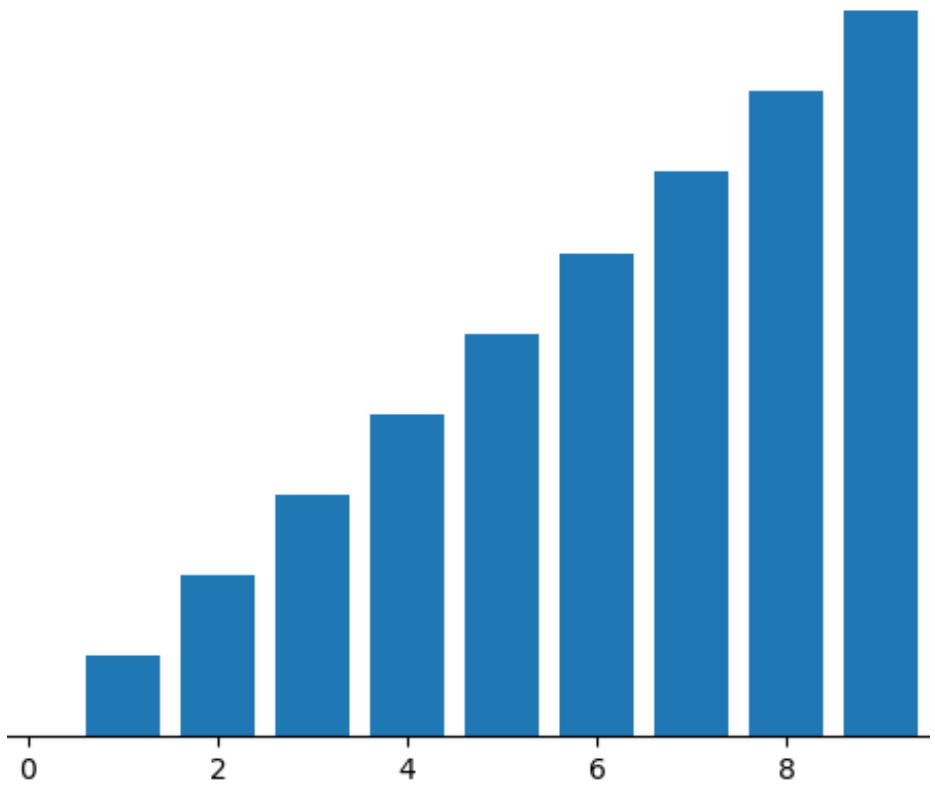
Sorting leads to efficient searching `Search(7)`

8	4	3	1	2	5	6	9	0	7

0	1	2	3	4	5	6	7	8	9

Sorting leads to better visualization





Sorting is a fundamental problem in CS

Many algorithms begin with or include a sorting step

Fundamental sorting algorithms are great for mastering concepts

Sorting algorithms are a classic introduction to algorithms

Optimizing sort is an ongoing challenge

GraySort: Sort rate (TBs / minute) achieved while sorting a very large amount of data (currently 100 TB minimum).

CloudSort: Minimum cost (Dollars) for sorting a very large amount of data on a public cloud. (currently 100 TB).

MinuteSort: Amount of data that can be sorted in 60 seconds or less.

TeraByeSort: Elapsed time to sort 1 TB of data

Competition details: http://sortbenchmark.org/

Sorting Algorithms we will discuss:

SelectionSort

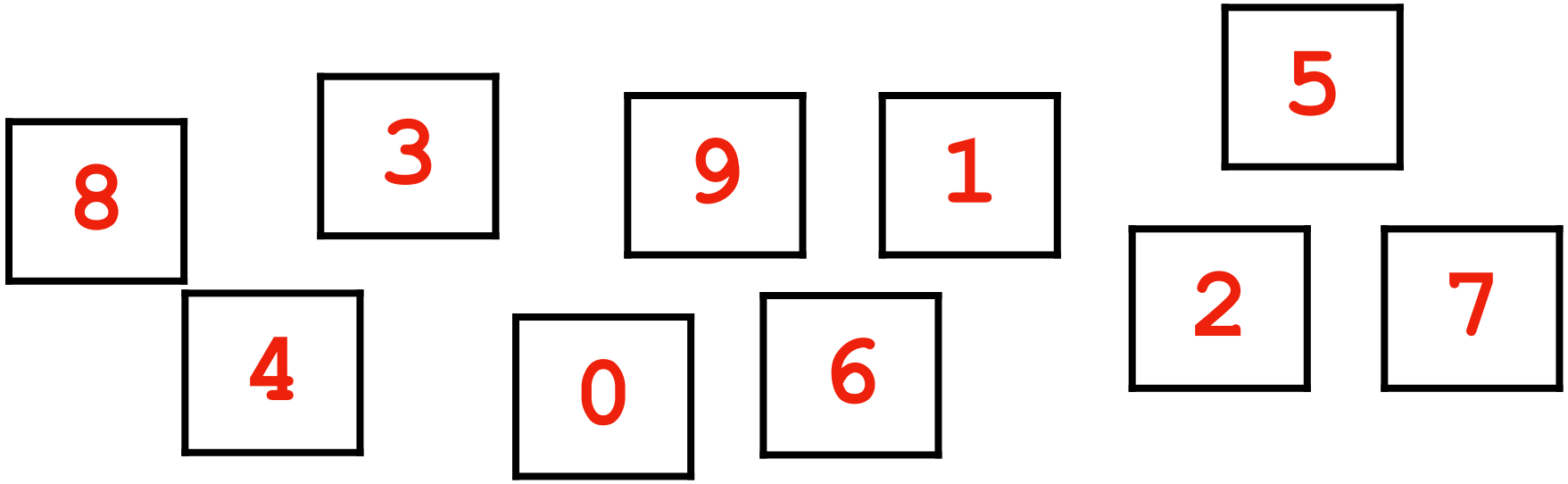
InsertionSort

MergeSort

QuickSort

Sorting by hand (humanSort)

Input:



Output:

Optimal Sorting

Claim: Any deterministic comparison-based sorting algorithm must perform $O(n \log n)$ comparisons to sort n objects.

0	1	2
0	2	1

1	0	2
1	2	0

2	0	1
2	1	0

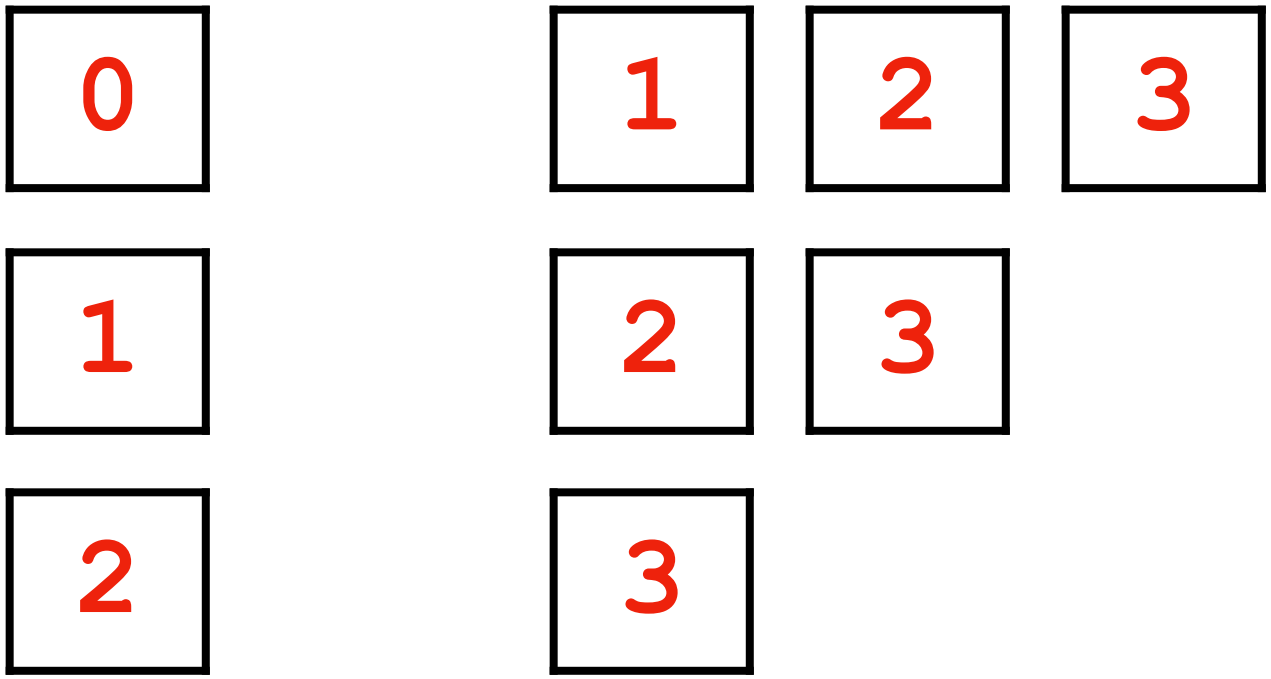
SelectionSort

4	3	6	7	1

1. Find the i-th smallest value
2. Place it at position i via swap
3. Repeat for $0 \leq i \leq n - 1$

SelectionSort Efficiency

(n=4)



SelectionSort Efficiency (large n)

SelectionSort

```
def selectionSort(inList):
    n = len(inList)

    for i in range(n):
        mindex = i
        for j in range(i+1, n):
            if inList[j] < inList[mindex]:
                mindex = j

        inList[i], inList[mindex] = inList[mindex], inList[i]
```

InsertionSort

4	3	6	7	1

1. Divide array into two parts

2. Insert the first unsorted item into the sorted position

3. Repeat until all items are sorted

InsertionSort "Insert"

1	2	4	5	7	3	8

1	2	4	5	3	7	8

1	2	4	3	5	7	8

1	2	3	4	5	7	8

InsertionSort

```
def insertionSort(inList):
    n = len(inList)

    for i in range(_____, _____):

        val = inList[i]

        j = i - 1


        while __________ and _______________:

            inList[j+1]=inList[j]
            j -= 1

        inList[j+1]=val
```

Selection vs InsertionSort

```
def selectionSort(inList):
    n = len(inList)

    for i in range(n):
        mindex = i
        for j in range(i+1, n):
            if inList[j] < inList[mindex]:
                mindex = j

        inList[i], inList[mindex] =
inList[mindex], inList[i]

```

```
def insertionSort(inList):
    n = len(inList)

    for i in range(1, n):

        val = inList[i]

        j = i - 1
        while j >= 0 and val < inList[j]:
            inList[j+1]=inList[j]
            j -= 1

        inList[j+1]=val
```

Sorting Algorithms we will discuss:

SelectionSort

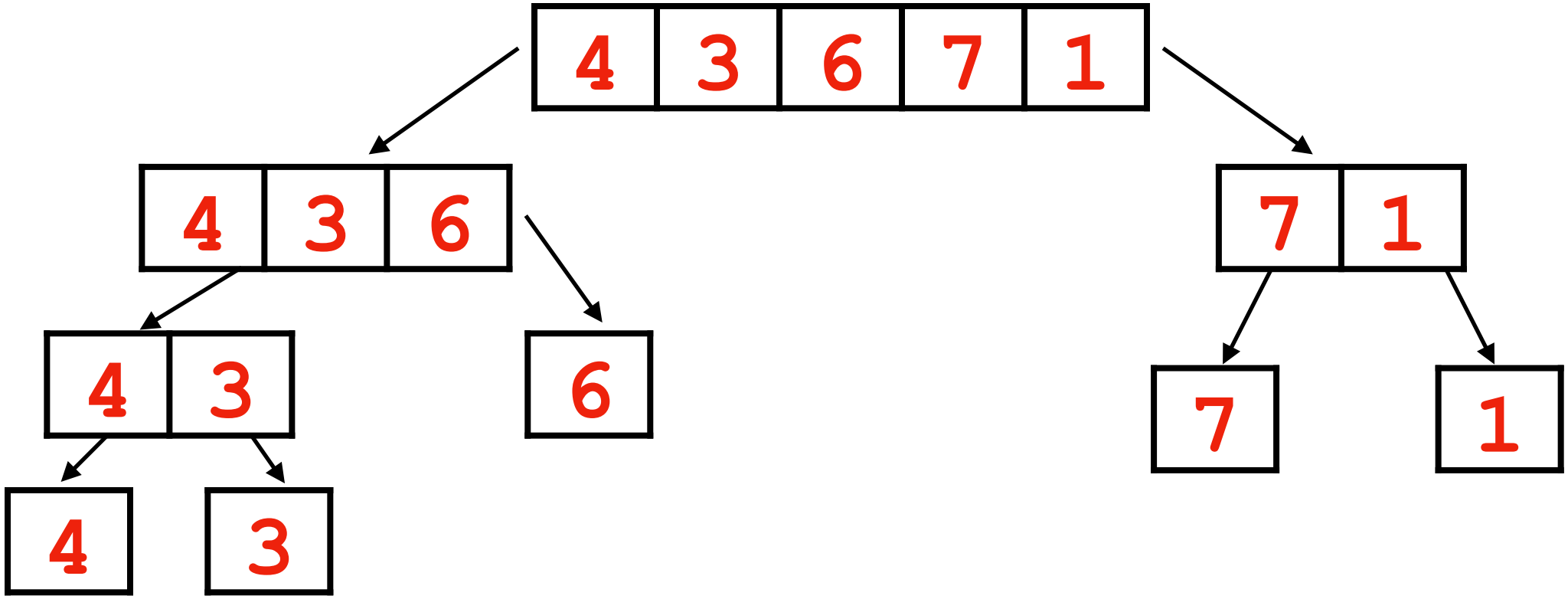
InsertionSort

MergeSort

QuickSort

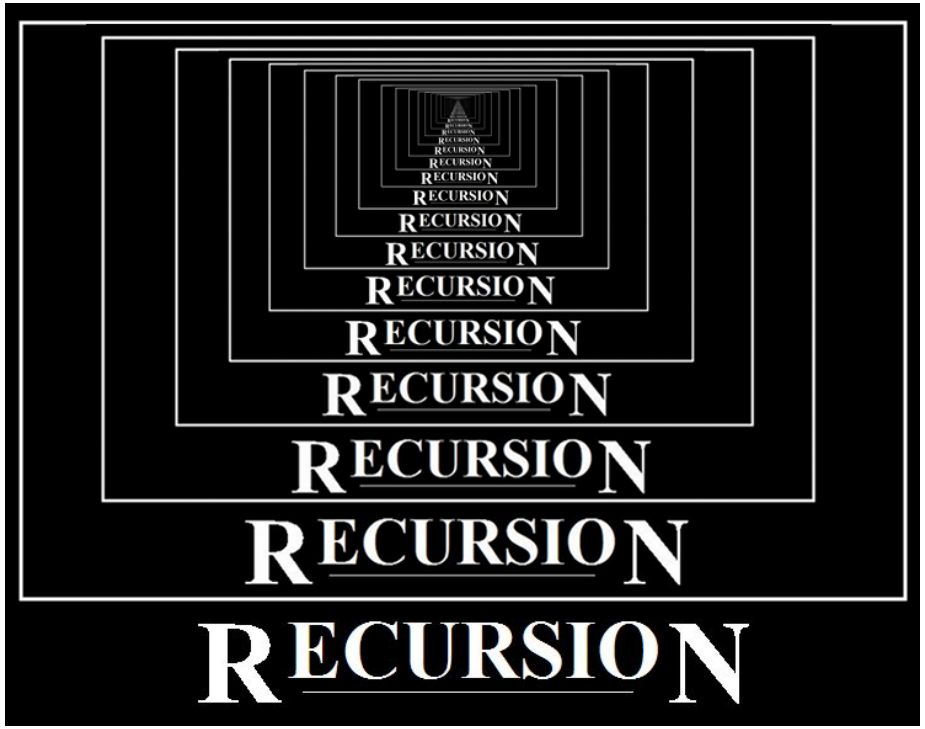
Divide and Conquer Algorithms

Recursively break a problem into sub-problems until the the problems become simple enough to solve directly



Recursion

The process by which a function calls itself directly or indirectly is called ***recursion.***



Recursive For Loop

```
for i in range(10):
    print(i)
```

```
def recursiveFor(n):

    if n == 0:
        print(n)
        return

    recursiveFor(n-1)

    print(n)
```

Recursion

Base Case: What is the smallest sub-problem? What is the trivial solution?

Recursive Step: How can I systematically reduce my problem to an easier one?

Combining: How can I build my solution from recursive pieces?

Recursive findMax

```
def findMax(inList):
```

Recursive Fibonacci

```
def fib(n):
```

Recursive Array Sorting

0	3	7	5	8	9	2	1	4	6

Base Case:

Recursive Step:

Combining: