

CS133

Computational Geometry

Instructor: Ahmed Eldawy

TA: Samriddhi Singla

Welcome back to UCR!



Class information

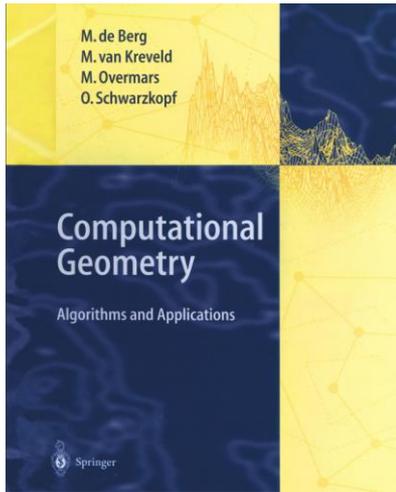
- › Classes: Tuesday and Thursday 8:10 AM – 9:30 AM at WCH 142
- › Instructor: Ahmed Eldawy
- › TA: Samriddhi Singla
- › Office hours:
Tuesday and Thursday 9:30 AM – 10:30AM
@357 WCH
- › Conflicts?
 - › You can set a meeting by email

Class Information

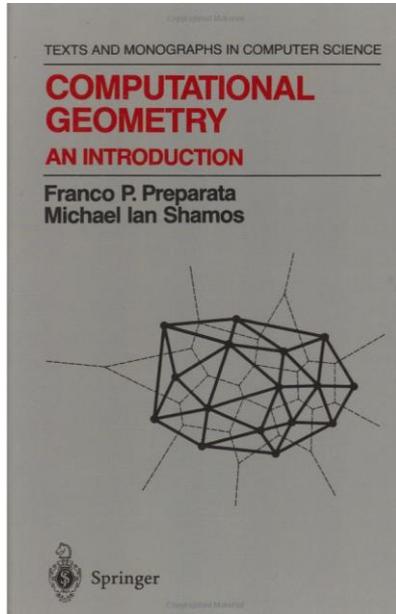


- Website:
<http://www.cs.ucr.edu/~eldawy/19SCS133/>
- Email: eldawy@ucr.edu
- Subject: “[CS133] ...”

Textbook



Computational Geometry: Algorithms and Applications
3rd Ed, Springer By Mark de Berg, Otfried Cheong,
Marc van Kreveld, and Mark Overmars
ISBN: 9783642096815
Free electronic version provided by UCR



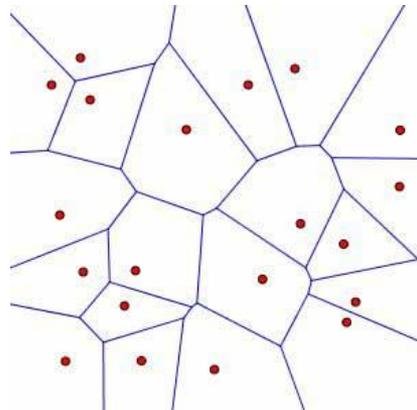
(Optional) Computational Geometry: An Introduction,
Springer, 2nd Ed By Franco P. Preparata and
Michael I. Shamos
ISBN : 0387961313
Available at Orbach Library

Course work

- (5%) Active participation in the class
- (10%) 5 assignments (Lowest one discarded)
- (30%) 10 labs (Lowest two discarded)
- (10%) First midterm (Tuesday, April 23rd)
- (10%) Second midterm (Thursday, May 23rd)
- (35%) Final exam
 - Date: Saturday, June 8th, 2019
 - Time: 8:00 a.m. - 11:00 a.m.
 - Location: WCH 142

Course goals

- › What are your goals?
- › Sharpen your algorithmic skills
- › Understand a new type of algorithms
- › Play with points, lines, and polygons
- › Generate some nice-looking figures



The Rise of Spatial Data

The home of the U.S. Government's open data

Here you will find data, tools, and resources to conduct research, develop

GET STARTED

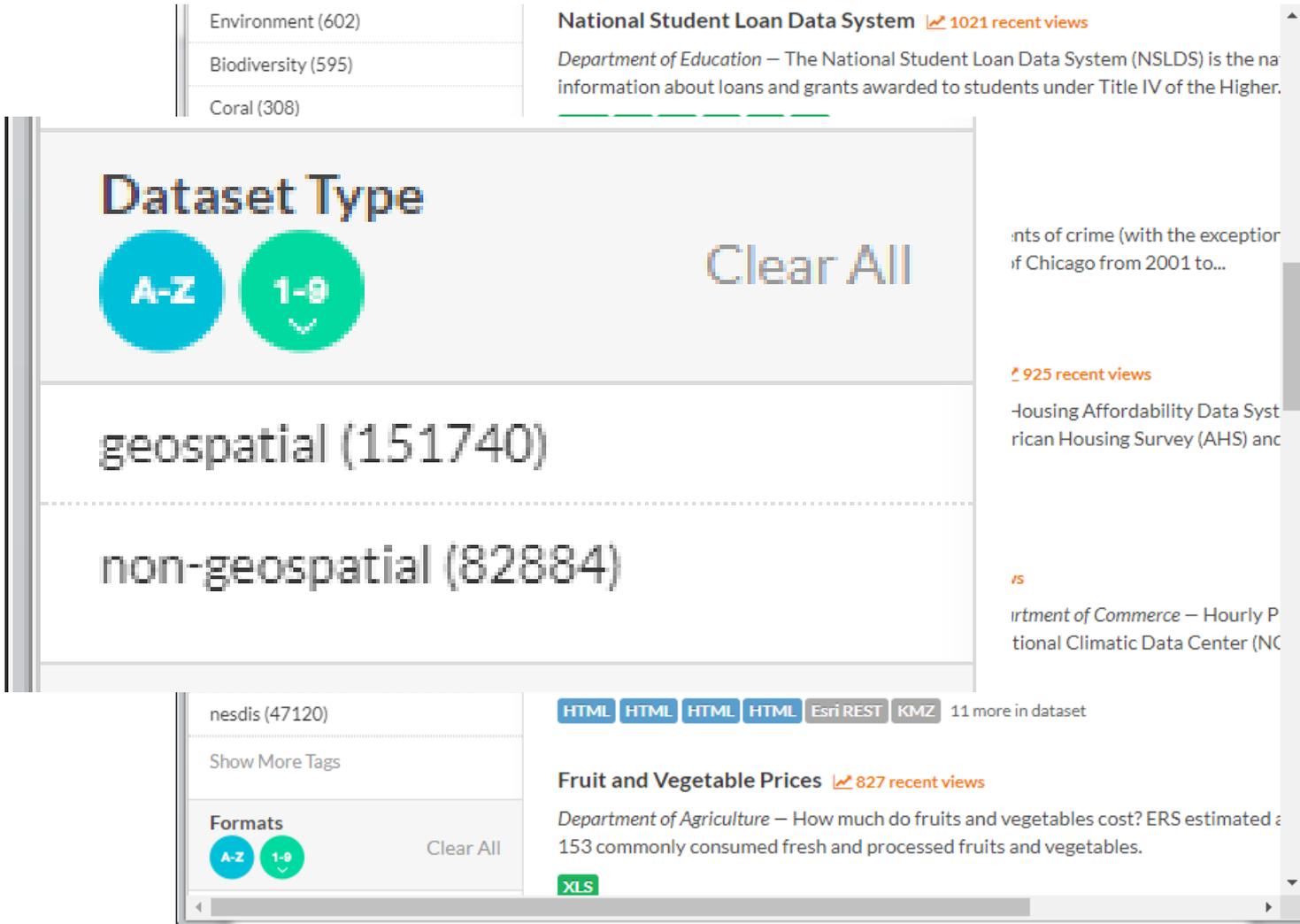
SEARCH OVER 234,623 DATASETS



BROWSE TOPICS



The Rise of Spatial Data



Environment (602)
Biodiversity (595)
Coral (308)

National Student Loan Data System 1021 recent views

Department of Education – The National Student Loan Data System (NSLDS) is the national information about loans and grants awarded to students under Title IV of the Higher Education Act.

Dataset Type

A-Z **1-9** Clear All

geospatial (151740)

non-geospatial (82884)

esdis (47120)
Show More Tags

Formats Clear All

A-Z **1-9**

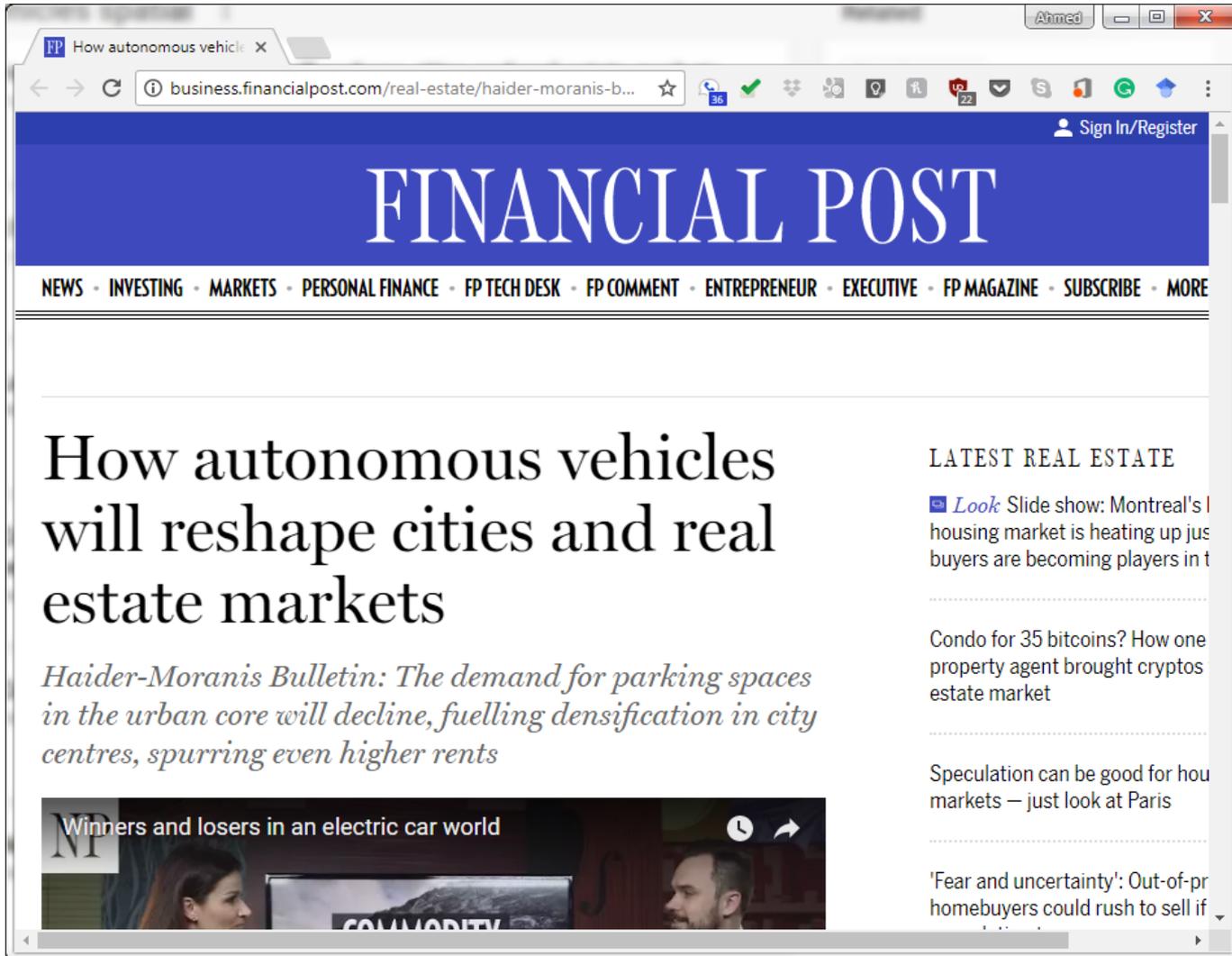
HTML **HTML** **HTML** **HTML** **Esri REST** **KMZ** 11 more in dataset

Fruit and Vegetable Prices 827 recent views

Department of Agriculture – How much do fruits and vegetables cost? ERS estimated the average prices for 153 commonly consumed fresh and processed fruits and vegetables.

XLS

Autonomous Vehicles



The screenshot shows a web browser window with the URL `business.financialpost.com/real-estate/haider-moranis-b...`. The page features the Financial Post logo and a navigation menu with categories like NEWS, INVESTING, MARKETS, PERSONAL FINANCE, FP TECH DESK, FP COMMENT, ENTREPRENEUR, EXECUTIVE, FP MAGAZINE, SUBSCRIBE, and MORE. The main article title is "How autonomous vehicles will reshape cities and real estate markets". Below the title is a sub-headline: "Haider-Moranis Bulletin: The demand for parking spaces in the urban core will decline, fuelling densification in city centres, spurring even higher rents". A video player is visible at the bottom of the article with the title "Winners and losers in an electric car world". On the right side, there is a "LATEST REAL ESTATE" section with several article teasers, including "Slide show: Montreal's housing market is heating up just as buyers are becoming players in the market", "Condo for 35 bitcoins? How one property agent brought cryptocurrencies into the real estate market", "Speculation can be good for housing markets — just look at Paris", and "'Fear and uncertainty': Out-of-province homebuyers could rush to sell if interest rates rise".

How autonomous vehicles will reshape cities and real estate markets

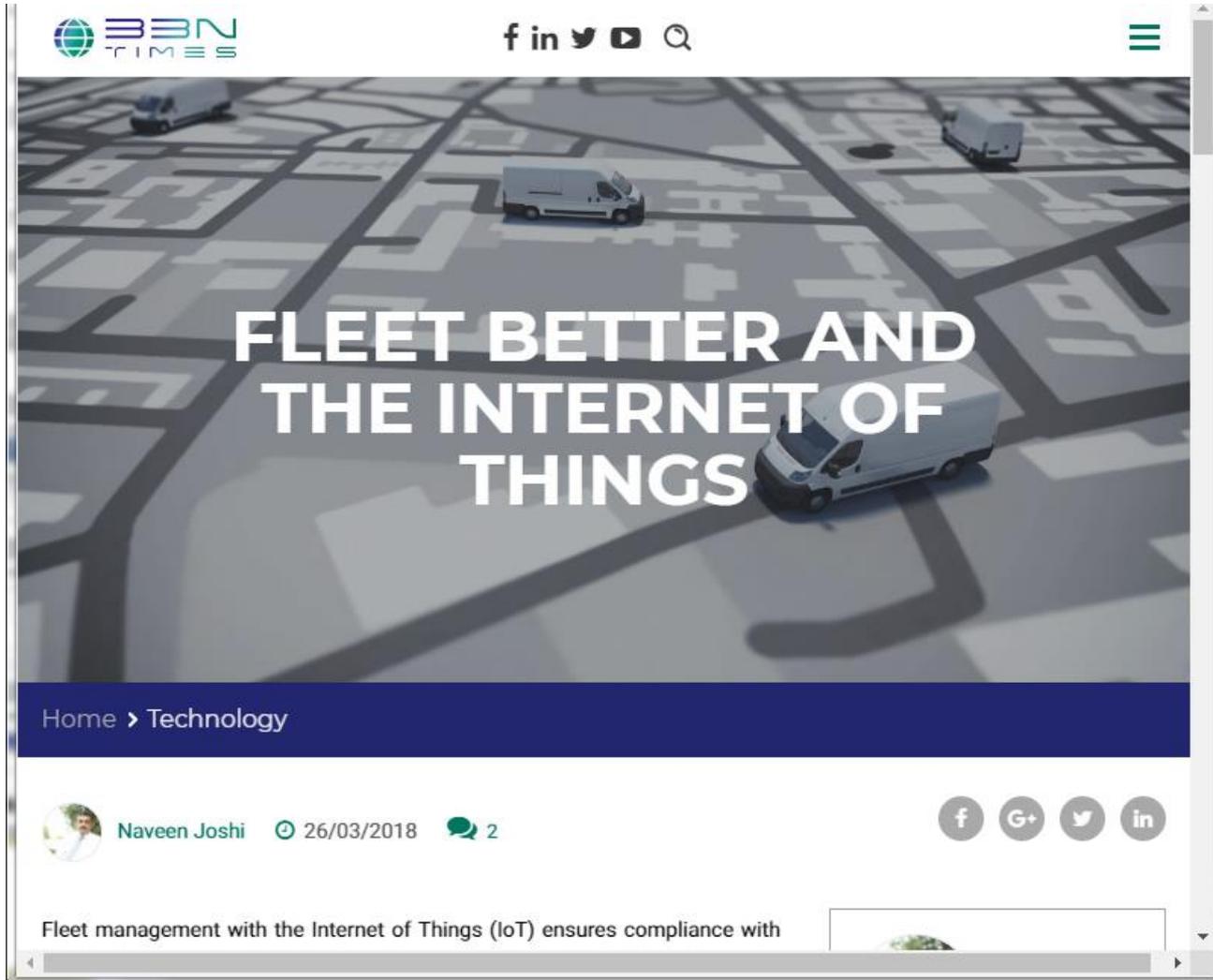
Haider-Moranis Bulletin: The demand for parking spaces in the urban core will decline, fuelling densification in city centres, spurring even higher rents

Winners and losers in an electric car world

LATEST REAL ESTATE

- [Look](#) Slide show: Montreal's housing market is heating up just as buyers are becoming players in the market
- Condo for 35 bitcoins? How one property agent brought cryptocurrencies into the real estate market
- Speculation can be good for housing markets — just look at Paris
- 'Fear and uncertainty': Out-of-province homebuyers could rush to sell if interest rates rise

Internet of Things (IoT)



Satellites

Make a contribution

The Guardian

News Opinion Sport Culture Lifestyle

US World Environment Soccer US politics Business Tech More

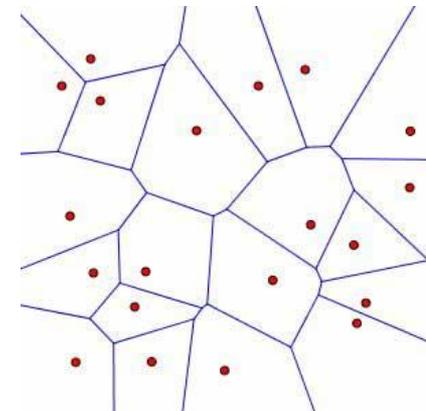
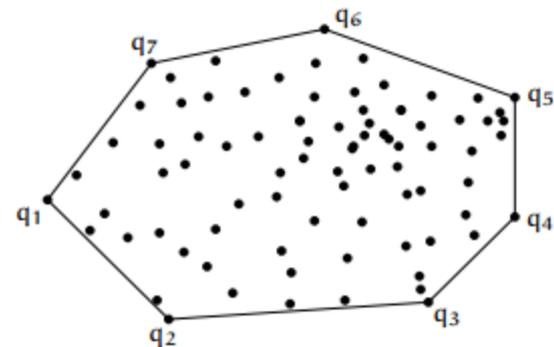


Elon Musk's SpaceX gains formal approval for satellite broadband network

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Course Overview

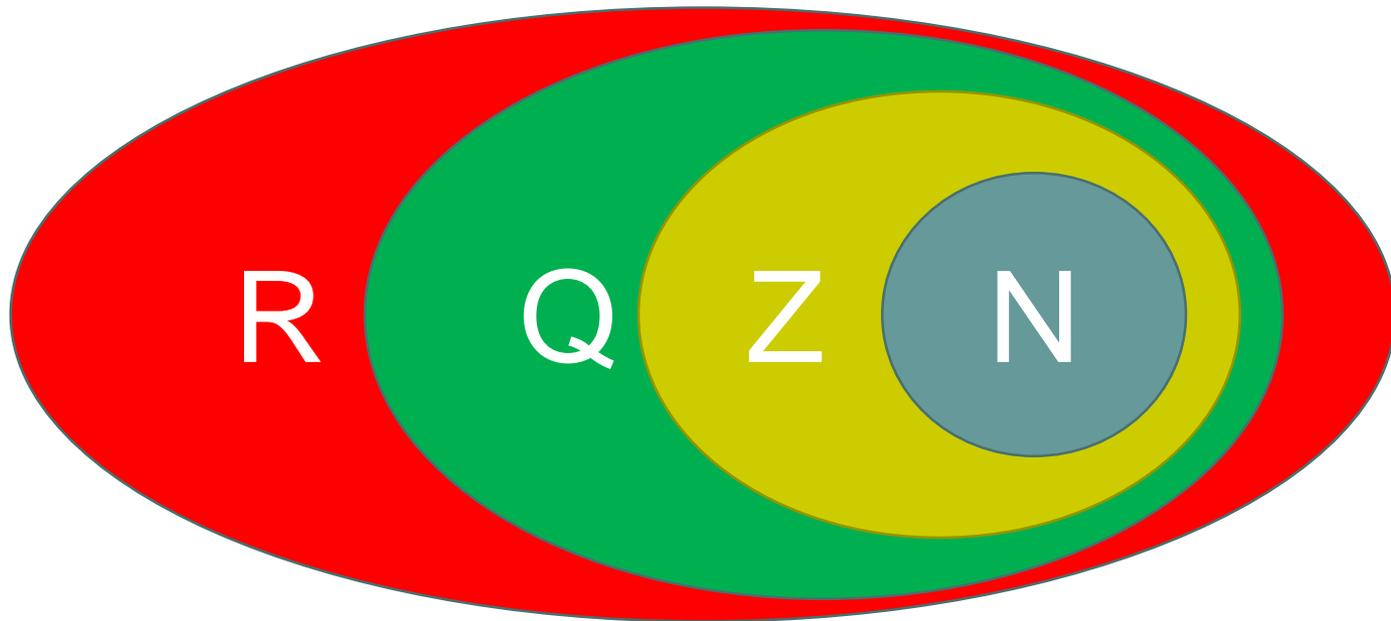
- Background on algorithms, floating point calculations, and linear algebra
- Computational geometry primitives
- Convex hull algorithms
- Search problems
- Intersection problems
- Polygon simplification
- Voronoi diagram
- Delaunay triangulation



Number Representation

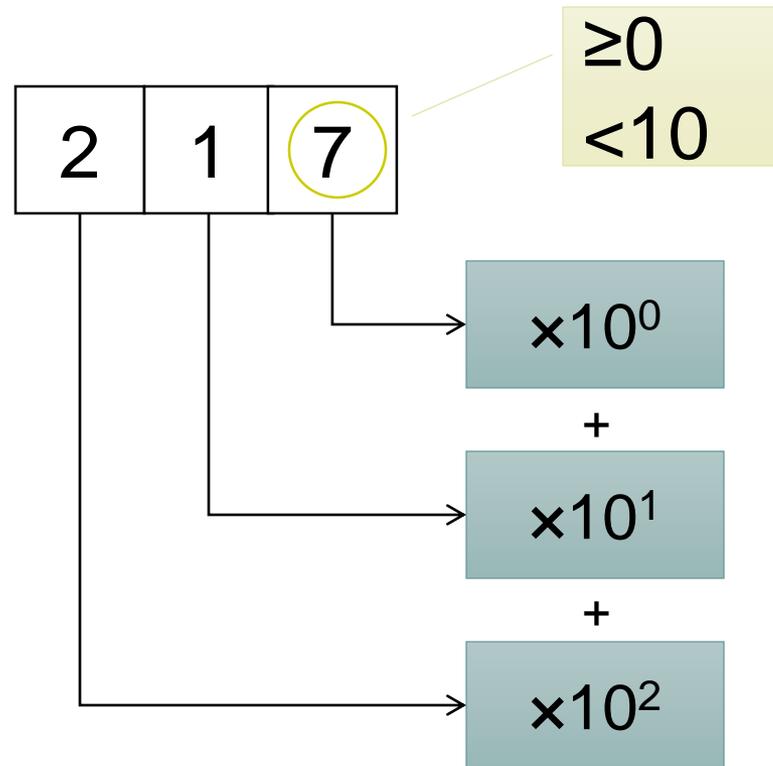
Number Representation

› Number sets



Natural Numbers (N)

› Decimal representation



Binary Representation

› Base-2 representation

1	1	0	1	1	0	0	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

$$(11011001)_2 = (217)_{10}$$

Integer Numbers (Z)

- We use a negative sign
- The computer can only represent 0 or 1 (no signs)
- Sign-magnitude representation (not used)
 - Reserve a bit for sign (0: +ve, 1: -ve)
 - Advantage: Simplicity of representation
 - Drawbacks: Two representations for the zero, and complexity of addition and subtraction operations
- Two's complement (Designer's choice)
 - $-x = \sim x + 1$

Rational Numbers (Q)

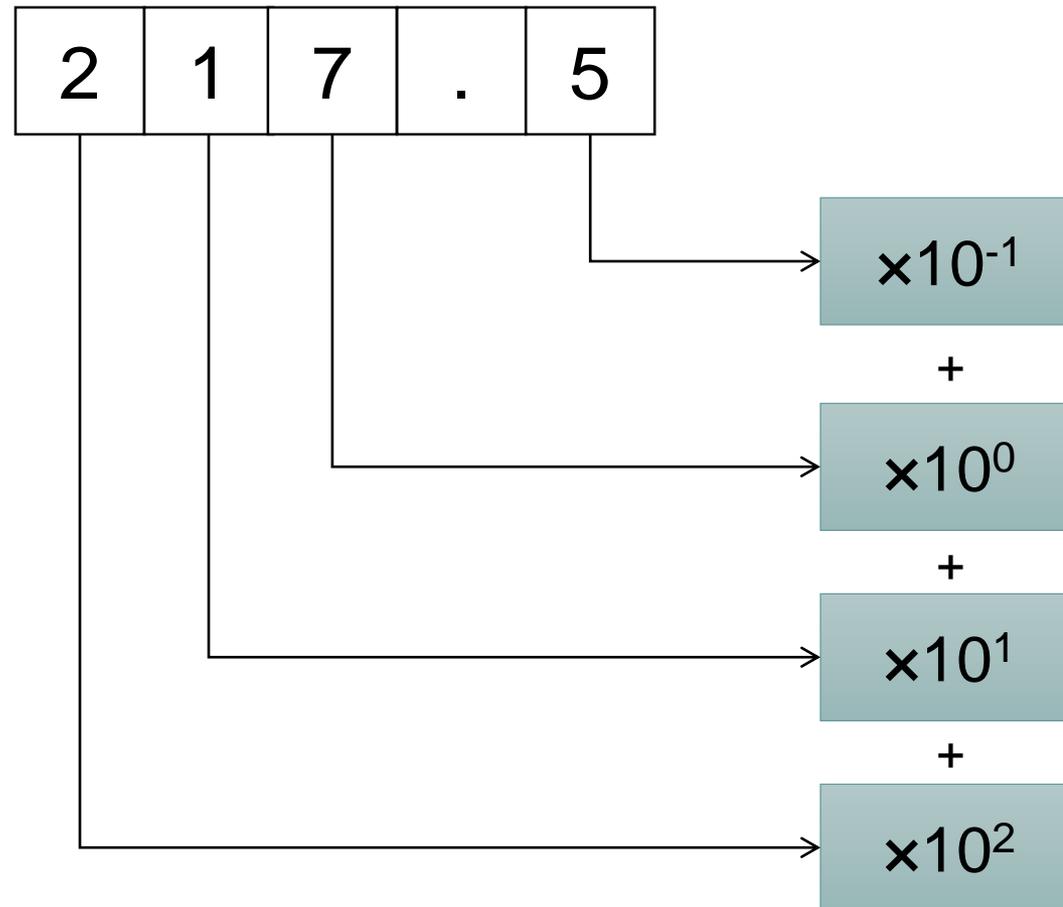
- ▶ $q = \frac{a}{b}$
- ▶ Where a and b are integers and $b > 0$
- ▶ Advantages
 - ▶ Simple representation
 - ▶ Simple calculations
 - ▶ Closed under most operations
 - ▶ Can be 100% accurate
- ▶ Disadvantages
 - ▶ Not closed under certain operations

Operations

- ▶ Addition/subtraction: $\frac{a}{b} \pm \frac{c}{d} = \frac{ad \pm bc}{bd}$
- ▶ Multiplication: $\frac{a}{b} \cdot \frac{c}{d} = \frac{ac}{bd}$
- ▶ Reciprocal: $\left(\frac{a}{b}\right)^{-1} = \frac{b}{a}$
- ▶ Division: $\frac{\frac{a}{b}}{\frac{c}{d}} = \frac{ad}{bc}$
- ▶ All the above operations are accurate
- ▶ Some might produce +/- ∞ or NaN

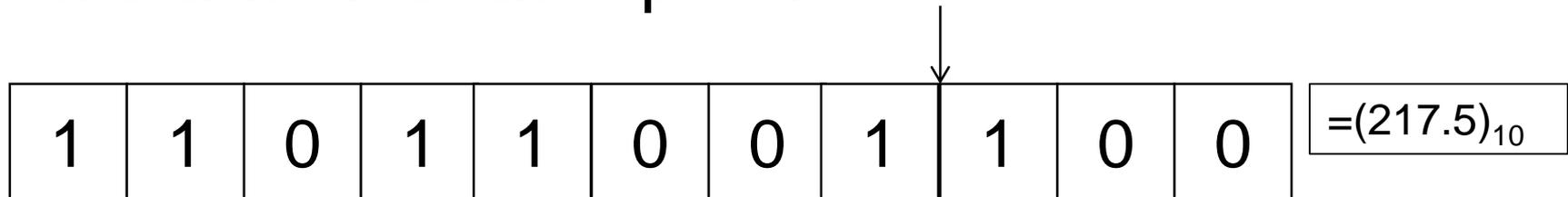
Real Numbers (R)

- ▶ A decimal (or radix/fraction) point



Fixed-point Representation

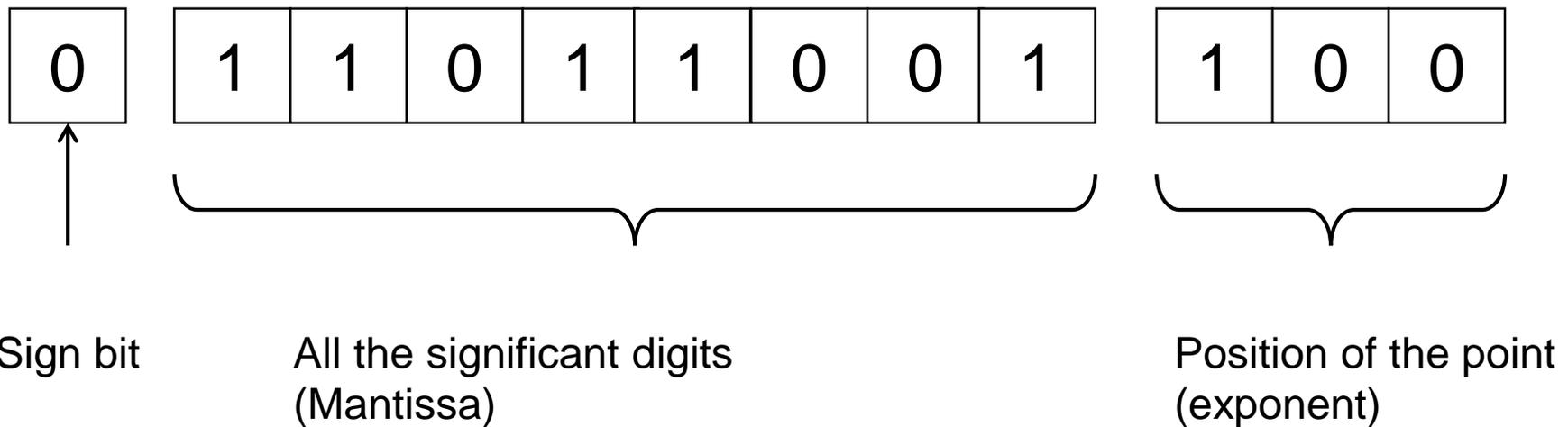
- ▶ Always assume that the n-right-most digits are after the radix point



- ▶ The radix point is *fixed* at that position
- ▶ Advantages: Simplicity of representation and +/- operations
- ▶ Disadvantages: Cannot represent very large or very small numbers

Floating-point Representation

- ▶ The position of the radix point is variable (that point can float around)



$$\text{Value} = (-1)^S \times \text{Mantissa} \times 2^{\text{exponent}}$$

IEEE 754 Standard



Single-precision floating point (32-bits)

1-bit: sign

8-bits: exponent

23-bits: Mantissa



S: 0 for +ve and 1 for -ve numbers

E: 8 bits can represent 256 different exponents

To represent both +ve and -ve exponents, these 8-bits store the exponent plus 127

$E=127$ indicates an exponent of zero

$E=200$ indicates an exponent of $200-127=73$

Normalization

- ▶ If we are not careful, we might end up with redundant representations
 - ▶ E.g., $1.5 \times 10^2 = 15 \times 10^1 = 150 \times 10^0$
- ▶ In IEEE standard, the fraction point is always placed right next to the first significant (binary) digit
- ▶ Since the left-most digit is always one, it is not stored
- ▶ This is called normalization

Normalization Examples

➤ $x_1 = 001011001.110$

➤ $x_1 = 00 \mathbf{1.011001110} \times 10^{\mathbf{110}}$ Exponent

Mantissa

➤ $x_2 = 0.0000001110$

➤ $x_2 = \mathbf{1.11} \times 10^{\mathbf{-111}}$ Exponent

Mantissa

32 Floating Point Example

- › $x=125.375$
- › $x=1111101.011$
- › $x=1.111101011 \times 10^{110}$ (That's 2^6)
- › Fraction=111101011
- › Fraction=111101011000000000000000
- › Exponent= $6+127=133=10000101$
- › Sign=0

0 1 0 0 0 0 1 0 1 1 1 1 1 0 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Special Cases



› Zero

- › Represented by all zeros in the exponent and fraction
- › Two distinct but equivalent representations: +0 and -0

› Infinity

- › Exponent of all 1's and fraction of all 0's
- › Two distinct representations of $+\infty$ and $-\infty$

› Not-a-number (NaN)

- › Exponent is all 1's and fraction is non-zero

Denormalized Numbers

- $X=0.00001 \times 10^{-126}$
- Normalized = 1.0×10^{-131}
 - ✖ We cannot represent an exponent of -131
- Exponent=0 (Special marker for denormalized numbers)
- Fraction=000010000000000000000000

Arithmetic

- Multiplication
 - Multiply the signs (XOR)
 - Multiply the mantissas
 - Add up the exponents
- Division
 - Similar to multiplication but can produce infinity or NaN
- Addition/Subtraction
 - Aligns the two mantissas and add/subtract them
 - Adjust the exponent to the result

Summary



- Floating points cannot represent all possible numbers
- It can represent both very small and very large numbers
- Number of significant digits is upper-bounded
- We can represent zero, ∞ , and NAN
- The result of any arithmetic operation can produce some error