CSE 373 Optional Section

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Today

- Proof by Induction
- Big-Oh
- Algorithm Analysis

Proof by Induction

Base Case:

1.Prove P(0) (sometimes P(1))

Inductive Hypothesis

2.Let k be an arbitrary integer ≥ 0

3.Assume that P(k) is true

Inductive Step

4. …

5. Prove P(k+1) is true

Examples

$$\sum_{i=1}^{N} i^2 = 1 + 2^2 + 3^2 + 4^2 + \cdots + \mathrm{n}^2 = \frac{N(N+1)(2N+1)}{6}$$ for all n≥1

$$\sum_{i=0}^{N} 2^i = 2^0 + 2^1 + 2^2 + \ldots + 2^n = 2^{n+1} - 1$$

Extra

$$\sum_{i=1}^{n} \frac{1}{i(i+1)} = \frac{n}{n+1}$$ where $n \in Z^+$

Logarithms

- log in CS means log base of 2
- log grows very slowly
- logAB=logA+logB; log(A/B)=logA-logB
- $\log(N^k) = k \log N$
  - Eg. $\text{Log}(A^2) = \log(A*A) = \log A + \log A = 2\log A$
- distinguish log(log x) and $\log^2 x$ --(log x)(log x)

Big-Oh

- We only look at worst case
- Big input
- Ignore constant factor and lower order terms
  - Why?
- Definition:

g(n) is in O(f(n)) if there exist constants
c and n0
such that $g(n) \le c\, f(n)$ for all $n \ge n0$

- Also lower bound and tight bound

We use O on a function f(n) (for example n^2) to mean the set of functions with asymptotic behavior less than or equal to f(n)

Big-Oh Practice

- Prove that $5n^2+3n$ is $O(n^2)$
  - Key point

    Find constant c and n_0

Math Related

- Series

$$\sum_{i=1}^{N} A^i = A + A^2 + A^3 + A^4 + \cdots = \frac{A^{N+1} - 1}{A - 1}$$

$$\sum_{i=1}^{N} i = 1 + 2 + 3 + 4 + \cdots = \frac{N(N+1)}{2} \approx \frac{N^2}{2}$$

$$\sum_{i=1}^{N} i^2 = 1 + 2^2 + 3^2 + 4^2 + \cdots = \frac{N(N+1)(2N+1)}{6} \approx \frac{N^3}{3}$$

  - Very useful for runtime analysis
  - On your textbook, p4

How to analyze the code?

Consecutive statements	Sum of times
Conditionals	Time of test plus slower branch
Loops	Sum of iterations
Calls	Time of call's body
Recursion	Solve recurrence equation

Examples

```
1.int sunny (int n) {
        if (n < 10)
                return n - 1;
        else {
                return sunny (n / 2);
        }
}

2.int funny (int n, int sum) {
        for (int k = 0; k < n * n; ++k)
                for (int j = 0; j < k; j++)
                        sum++;
        return sum;
}

3.int happy (int n, int sum) {
        for (int k = n; k > 0; k = k - 1) {
                for (int i = 0; i < k; i++)
                        sum++;
                for (int j = n; j > 0; j--)
                        sum++;
        }
        return sum;
}
```