THE PUBLIC IS MORE FAMILIAR WITH BAD DESIGN THAN GOOD DESIGN. IT IS, IN EFFECT, CONDITIONED TO PREFER BAD DESIGN, BECAUSE THAT IS WHAT IT LIVES WITH. THE NEW BECOMES THREATENING, THE OLD REASSURING.

PAUL RAND

A DESIGNER KNOWS THAT HE HAS ACHIEVED PERFECTION NOT WHEN THERE IS NOTHING LEFT TO ADD, BUT WHEN THERE IS NOTHING LEFT TO TAKE AWAY.

ANTOINE DE SAINT-EXUPÉRY

. . . THE DESIGNER OF A NEW SYSTEM MUST NOT ONLY BE THE IMPLEMENTOR AND THE FIRST LARGE-SCALE USER; THE DESIGNER SHOULD ALSO WRITE THE FIRST USER MANUAL. . . IF I HAD NOT PARTICIPATED FULLY IN ALL THESE ACTIVITIES, LITERALLY HUNDREDS OF IMPROVEMENTS WOULD NEVER HAVE BEEN MADE, BECAUSE I WOULD NEVER HAVE THOUGHT OF THEM OR PERCEIVED WHY THEY WERE IMPORTANT.

DONALD E. KNUTH

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Dedicated to those who appreciate LaTeX

and the work of Edward R. Tufte and Donald E. Knuth.

Introduction

This is a collection of psuedocode for classic algorithms.

Basic Iterative and Recursive Algorithms

Algorithm 1 Horner rule for polynomial evaluation.

```
1: procedure HORNER(A[0...n], x)                    ▷ A : {a_0 ... a_n}
2:     p ← A[n]
3:     for i ← n − 1 downto 0 do
4:         p ← px + A[i]
5:     return p
```

Algorithm 2 Integer Multiplication.

```
1: procedure INT-MULT(y, z)
2:     if z = 0 then
3:         return 0
4:     return INT-MULT(cy, ⌊z/c⌋) + y(z mod c)
```

Sorting

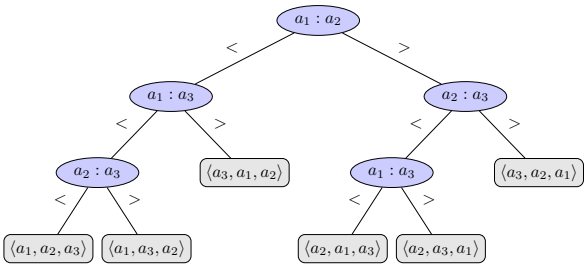

Figure 1: 3-element sorting algorithm represented by a decision tree.

Algorithm 3 Bubblesort (Bubble the smallest element each time.).

```
1: procedure BUBBLESORT(A[1 ··· n])
2:     for i ← 1 to n − 1 do
3:         for j ← n downto i + 1 do
4:             if A[j] < A[j − 1] then
5:                 SWAP(A[j], A[j − 1])
```

Algorithm 4 Bubblesort (Bubble the largest element each time.).

```
1: procedure BUBBLESORT(A[1 ··· n])
2:     for i ← n downto 2 do
3:         for j ← 1 to i − 1 do
4:             if A[j] > A[j + 1] then
5:                 SWAP(A[j], A[j + 1])
```

Algorithm 5 Bubblesort (An improved version; from wiki).

```
1: procedure BUBBLESORT(A[1 ··· n])
2:     repeat
3:         newn ← 0
4:         for i ← 1 to n − 1 do
5:             if A[i − 1] > A[i] then
6:                 SWAP(A[i − 1], A[i])
7:                 newn ← i
8:         n ← newn
9:     until n = 0
```

Algorithm 6 Selection Sort.

```
1: procedure SELECTION-SORT(A, n)
2:     for i ← 1 to n − 1 do
3:         for j ← i + 1 to n do
4:             if A[j] < A[i] then
5:                 SWAP(A[j], A[i])
```

Selection

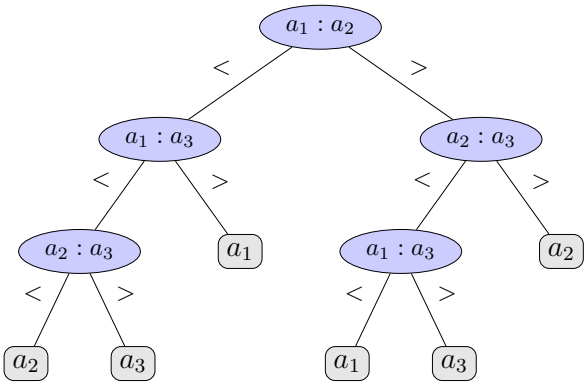

Figure 2: 3-element median selection algorithm represented by a decision tree.

Dynamic Programming

Algorithm 7 Computing $\binom{n}{k}$ recursively.

```
1: procedure BINOM(n, k)                    ▷ Required: n ≥ k ≥ 0
2:     if k = 0 ∨ n = k then
3:         return 1
4:     return BINOM(n − 1, k) + BINOM(n − 1, k − 1)
```

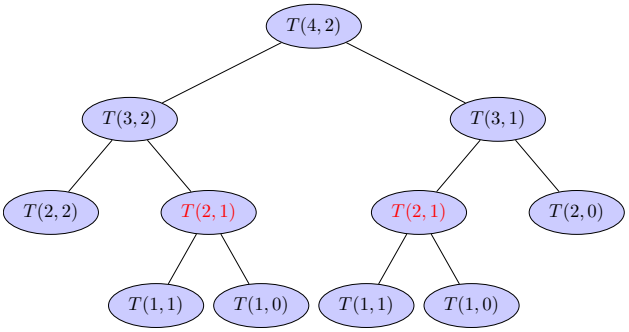

Figure 3: Calculate $\binom{4}{2}$ recursively.

$$
\begin{array}{ccccccccccc}
 & & & & \binom{0}{0} & & & & & & \\
 & & & \binom{1}{0} & & \binom{1}{1} & & & & & \\
 & & \binom{2}{0} & & \binom{2}{1} & & \binom{2}{2} & & & & \\
 & \binom{3}{0} & & \binom{3}{1} & & \binom{3}{2} & & \binom{3}{3} & & & \\
\binom{4}{0} & & \binom{4}{1} & & \binom{4}{2} & & \binom{4}{3} & & \binom{4}{4} & & \\
\binom{5}{0} & & \binom{5}{1} & & \binom{5}{2} & & \binom{5}{3} & & \binom{5}{4} & & \binom{5}{5}
\end{array}
$$

Figure 4: Pascal triangle for binomial coefficients.

Algorithm 8 Computing $\binom{n}{k}$ by dynamic programming.

```
1:  procedure BINOM(n, k)                          ▷ Required: n ≥ k ≥ 0
2:      for i ← 0 to n − k do
3:          B[i][0] ← 1
4:      for i ← 1 to k do
5:          B[i][i] ← 1
6:      for j ← 1 to k do
7:          for d ← 1 to n − k do
8:              i ← j + d
9:              B[i][j] ← B[i − 1][j] + B[i − 1][j − 1]
10:     return B[n][k]
```

$$(n-k+1)+(k)+k(n-k)=nk-k^2+n+1$$

Traversal on Trees

DFS on Trees

Algorithm 9 Calculate the sum of depths of all nodes of a tree T.

```
1: procedure SUM-OF-DEPTHS()
2:     return SUM-OF-DEPTHS(T, 0)

3: procedure SUM-OF-DEPTHS(r, depth)          ▷ r: root of a tree
4:     if r is a leaf then
5:         return depth
6:     sum ← depth
7:     for all child vertex v of r do
8:         sum ← sum + SUM-OF-DEPTHS(v, depth + 1)
9:     return sum
```

Algorithm 10 Count the number of nodes in T at depth K.

```
1: procedure NODES-AT-DEPTH()
2:     return NODES-AT-DEPTH(T, K)

3: procedure NODES-AT-DEPTH(r, k)             ▷ r: root of a tree
4:     if k = 0 then
5:         return 1
6:     if r is a leaf then
7:         return 0
8:     num ← 0
9:     for all child vertex v of r do
10:        num ← num + NODES-AT-DEPTH(v, k − 1)
11:    return num
```

Algorithm 11 Check whether a tree T has any leaf at an even depth.

```
1: procedure LEAF-AT-EVEN-DEPTH()
2:     return LEAF-AT-DEPTH(T, even = 0)

3: procedure LEAF-AT-DEPTH(r, parity)                ▷ r: root of a tree
4:     if r is a leaf then
5:         return 1 − parity
6:     result ← 0
7:     for all child vertex v of r do
8:         result ← result ∨ LEAF-AT-DEPTH(v, 1 − parity)
9:     return result
```

BFS on Trees

Algorithm 12 Calculate the sum of contents of nodes of a tree T at each depth.

```
1: procedure SUM-AT-DEPTH(r)                         ▷ r: root of the tree T
2:     r.depth ← 0
3:     Q ← ∅
4:     ENQUEUE(Q, r)
5:     while Q ≠ ∅ do
6:         u ← DEQUEUE(Q)
7:         sumAtDepth[u.depth] += u.content
8:         for all child vertex v of u do
9:             v.depth ← u.depth + 1
10:            ENQUEUE(Q, v)
```

Algorithm 13 Count the number of nodes of a tree T at each depth.

```
1: procedure NODES-AT-DEPTH(r)                    ▷ r: root of the tree T
2:     r.depth ← 0
3:     Q ← ∅
4:     ENQUEUE(Q, r)
5:     while Q ≠ ∅ do
6:         u ← DEQUEUE(Q)
7:         nodesAtDepth[u.depth] += 1
8:         for all child vertex v of u do
9:             v.depth ← u.depth + 1
10:            ENQUEUE(Q, v)
11:    return argmax_K nodesAtDepth[k]
```

Bibliography