~ Invitation to Turing M/Cs.

TM ~ addition.

↓

Unary Representation {1}

Binary {0,1} > Quan

Decimal

Quad {00, 01, 10, 11}

{0, ..., 9}

5 = 11111

3 = 111

5+3 = 11111111

Turing M/c ~ Pattern Matching

$a^n b^n c^n$

$a^n b^{2n}$

{ a+b, a-b, a! }

Modern day Computing M/cs

$\Sigma = \{1\}$

I/p Tape : 1 1 1 1 1 0 1 1 1 1 $

a b

a+b 1's

R/W

I/p 1 1 1 1 1 0 1 1 1 $

O/p 1 1 1 1 1 1 1 1 $

→ 1 1 1 1 1 1 1 1 1 $ $ $

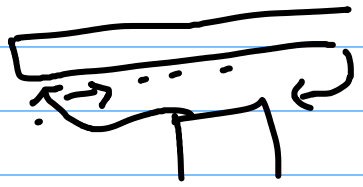
$\delta(q_0, 1) = (q_0, 1, R)$ } To scan 'a' 1's

$\delta(q_0, 0) = (q_1, 1, R)$ } Flip 0 → 1

$\delta(q_1, 1) = (q_1, 1, R)$ } Scan 'b' 1's

$\delta(q_1, \$) = (q_2, \$, L)$ (a+b+1) 1's

$\delta(q_2, 1) = (q_f, \$, \text{Halt})$



$a_1 + a_2 + a_3 + \cdots + a_n$

$\underbrace{3}_{a_1} + 2 + 1 + 5 + 6 + \cdots + 10$

$\Sigma = \{1\}$

$\Gamma = \{0, \$, \ldots\}$

$3 + 2 - 5 + 6 \ldots$

1110 110 10 11110 1111110 ...

a = 5

? 101

TM → Simulate → Computers

TM: ∞-Addition is possible

Computers: Finite Add^n; ∞-Addn is NOT possible.

Theoretical HLCs (Hypo)

Circuitry: Digital logic +5V | 0V {1,0}

Unary Rep ~ add^n

? a + b

5 0 =

? 5 − 2

5 + (−2)

Sign bit | Magnitude ? Negative number

? 5 · 3

? 5 · 3125

$\Gamma = \{0\}$

5 = 1111 1

−5 = 00 11111

a − b [a ≥ b]

11111 − 111

I/p: 11111011 $

O/p: 111 $ − − − $ (a − b 1's)

a₁ a₂ a₃ a₄

111 0 11 0 11 0 1111 $

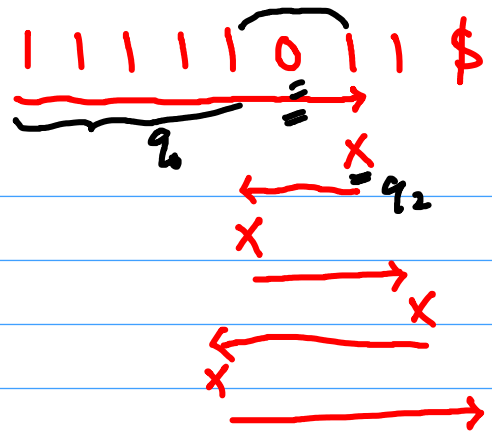
① ② ③

1 1 1

a₁ 0 a₂ 0 ... $$$

1 1 1 11 0 1 1 1

a − b 1's X X X X X X



$\delta(q_0, 1) = (q_0, 1, R)$ | Scan 'a' 1's

$\delta(q_0, 0) = (q_1, 0, R)$

$\delta(q_1, 1) = (q_2, X, L)$

$\delta(q_2, 0) = (q_2, 0, L)$

$\delta(q_2, 1) = (q_1, X, R)$ ✓

$\delta(q_1, X) = (q_1, X, R)$

$\delta(q_1, 0) = (q_1, 0, L)$

$\delta(q_3, X) = (q_3, X, R)$

$\delta(q_3, 1) = ($

$Q \times \Sigma$

To Scan 'a' 1's | $\delta(q_0, 1) = (q_0, 1, R)$

$\delta(q_0, 0) = (q_1, 0, R)$

| $\delta(q_1, 1) = (q_1, X, L)$ ①

$\delta(q_1, 0) = (q_1, 0, L)$ Non-Det ≈

$\delta(q_1, 1) = (q_1, X, R)$ ②

1 1 1 1 0 1 1 1 $

X

X

① NTM + Stack = DTM

② NTM ≡ DTM ≡

$\delta(q_1, \$) = (q_f, \$, Halt)$

✓ $\delta(q_1, 0) = (q_1, 0, R)$ }

✓ $\delta(q_1, X) = (q_1, X, R)$ }}

✓ $\delta(q_2, X) = (q_2, X, L)$ ✓

$\delta(q_0, 1) = (q_0, 1, R)$ | a 1's

$\delta(q_0, 0) = (q_1, 0, R)$ |

$\delta(q_1, 1) = (q_2, X, L)$ |

✓ $\delta(q_2, 0) = (q_2, 0, L)$ | ✓

$\delta(q_2, 1) = (q_1, X, R)$ //

1 1 1 1 0 1 1

q_0 q_1 X q_2

1 1 1 1 X 0 X 1 $

q_1

1 1 1 1 X 0 X X $

q_2

$Q \times \Sigma$ < $q_1, 0, R$) $q_2, 0, R$ }

$q_1, 0, L$ $q_1, 0, L$ }

1 1 1 1 1 1 1 0 1 1 1 1 1 $

! X X X 0 X X X !

1 1 1 1 1 0 1 1 1 $

x 0 x

1 1 1 1 1 0 1 1 1 $

x 0 x

x x x

x x

1 1 x x x 0 x x x $

q_1

$a \geq b$

$\delta(q_1, \$) = (q_f, \$, L)$

$\delta(q_f, x) = (q_f, \$, L)$

$\delta(q_f, 0) = (q_f, \$, L)$

$\delta(q_f, 1) = (q_f, 1, \text{Halt})$

$x \in L$) valid

$x \notin L$

$\in \Sigma^* \setminus L$) Invalid

$b \geq a$

1930 - 1936

1 1 1 0 1 1 1 1 1 $

0 0 1 1 1 0 1 1 1 1 1 $

$ $ 1 1 1 0 1 1 1 1 $

Logic :

1 1 1 0 1 1 1 1 1 $

$ 1 1 1 0 1 1 1 1 1 $

$ . . $ (b-a) 1's $$

P_1 P_2

1 1 1 0 1 1 1 1 1 $

x x

x x

x x (b-a) 1's

TM ~ Shift

~ Subtraction

Modular Prog.

Fib

a + b

a - b

a^2, a^3

a/b

a ? b

a!

a * b

a^b